# ICST 2023

# Proceedings of Papers

# 3rd International Conference on Science and Technology 2023

# December 12th, 2023

## "SUSTAINABLE ECONOMIC DEVELOPMENT THROUGH EMPOWERING RESEARCH ON SCIENCE AND TECHNOLOGY"

# Faculty of Technology
# South Eastern University of Sri Lanka
# Sri Lanka

# ICST 2023

## 3<sup>RD</sup> INTERNATIONAL CONFERENCE ON SCIENCE AND TECHNOLOGY

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# MESSAGE FROM THE VICE CHANCELLOR

I extend my warmest greetings to all participants of the International Conference on Science and Technology (ICST 2023) organised by the Faculty of Technology, SEUSL. It is indeed an honor for me to send the message to the book of abstract of ICST 2023.

The Annual International Conference on Science and Technology has become a hallmark of academic excellence, providing a platform for scholars to showcase their innovative research and contribute to the collective advancement of knowledge.

The abstracts reflect a wide spectrum of disciplines, and it is evident that the researchers have delved into cutting-edge topics that have the potential to make substantial contributions to their respective fields. The commitment to excellence in research demonstrated by the contributors is commendable, and I believe that the knowledge disseminated through these proceedings will undoubtedly have a positive impact on our academic community and beyond.

I would like to express my sincere appreciation to the Organizing Committee for their tireless efforts in coordinating this event. Your dedication to fostering a culture of research and academic inquiry is a testament to the commitment of the South Eastern University of Sri Lanka to advancing knowledge and promoting scholarly endeavors.

To the researchers, I extend my heartfelt congratulations on your achievements and the valuable contributions you have made to the scientific community. Your dedication to pushing the boundaries of knowledge is inspiring, and I am confident that your work will pave the way for further advancements in your respective fields.

As we navigate the challenges of our rapidly evolving world, it is through events like ICST that we strengthen the foundations of our academic community and forge new paths of discovery. I encourage all participants to engage in fruitful discussions, exchange ideas, and establish connections that will foster collaborative efforts in the pursuit of knowledge.

Once again, congratulations to everyone involved in the success of International Conference on Science and Technology-2023 including Chairman, Coordinator and Secretary of the Conference . I look forward to witnessing the impact of the research presented and to the continued success of the academic community at the South Eastern University of Sri Lanka.

Best regards,

**Professor A. Rameez, PhD (NUS)**
Vice Chancellor
South Eastern University of Sri Lanka

# MESSAGE FROM THE CHAIRMAN

I am much delighted to write this message to the third International Conference on Science and Technology-ICST 2023, proudly organised by the Faculty of Technology. This conference has been themed "Sustainable Economic Development through Empowering Research on Science and Technology." The theme is timely and need of the hour as far as Sri Lanka is concerned. Sri Lanka is gradually reviving from the impact of unprecedented scenarios like Easter Sunday attack, Global Pandemic of Covid 19 and economic bankruptcy. The country has to find its own pathways to rebuild the already fallen socio-economic development amidst the challenges that are interlocked globally.

Science, technology and research are the three pillars for a country to move towards the sustainable socio-economic development in the competitive world. In achieving the sustainability, a holistic approach has to be used to critically examine the inter-relationship between the natural, the governmental, the economic and the social dimensions of our world, and how science, technology and research can contribute to solutions. Technological development through research has a profound and long-term impact on income distribution, economic growth, employment, trade, environment, industrial structure and defence and security matters.

The scientific and technological community can make a leading contribution for tackling major problems, such as fighting disease; overpopulation and urbanisation; the digital/information divide and the impacts of information technology systems on world financial markets; coping with climate change; confronting the water crisis; defending the soil; preserving forests, fisheries and biodiversity; trade in biotechnological products and building a new ethic of global stewardship.

Moreover, I strongly believe that technological conferences like ICST 2023 provide a common platform for research scientists, academicians, professionals and students to share their experiences. I hope the ICST 2023 would be a great success.

I am deeply honoured and pleased to welcome all the participants and presenters to this conference. I would like to extend my sincere gratitude to all who are party to this conference.

**Dr. U. L. Abdul Majeed**
Dean
Faculty of Technology
South Eastern University of Sri Lanka.

# MESSAGE FROM THE COORDINATOR

I extend a warm welcome to you as the coordinator of the 3rd International Conference on Science and Technology 2023 (ICST2023), adding your esteemed company to our distinguished Conference Organizing Committee. This flagship international event, graciously hosted by the Faculty of Technology at the South Eastern University of Sri Lanka, stands as a testament to the unwavering commitment and collaborative spirit that defines our academic community.

The conference theme, "Sustainable Economic Development Through Empowering Research on Science and Technology," is designed to foster meaningful interactions among researchers from both academia and industries. It provides a robust platform for the exchange of groundbreaking innovations and inventions that align with this year's central theme.

The global challenges compounded by the recent pandemic have undeniably left a profound impact on economies worldwide. Developing nations, including Sri Lanka, have faced unique economic crises, necessitating sustainable solutions. ICST2023 aligns its focus with this theme, underscoring the pivotal role of science and technology research in constructing a resilient and sustainable economy.

With a notable submission of 76 full papers spanning eight distinct tracks, each subjected to a rigorous double-blind review process, we are delighted to inform you that initially 51 papers have been accepted with some comments in ICST2023, among these, 35 papers have been incorporated into the book of abstracts publication, and presentation following revisions accommodated by the authors, aligning with the reviewers' suggestion.

The compiled abstracts will be available in both hardcopy and electronic format through the university e-repository and conference site. Furthermore, all presented papers will be published in full papers, with outstanding contributions featured in the esteemed journals—Sri Lankan Journal of Technology and the Journal of Information and Communication Technology, both open-access publications of the Faculty of Technology, SEUSL. The remaining papers will be published as an ebook hosted on our repository.

The success of this conference owes much to the unwavering support and collaboration of numerous individuals. My heartfelt gratitude goes to the Vice Chancellor, Dean, Registrar, and Bursar of the South Eastern University of Sri Lanka for their invaluable support in organizing this event. Special appreciation is extended to our distinguished Keynote speakers, Senior Professor Gamini Senanayake, and Professor Gihan Dias for their enlightening addresses.

I would also like to express my sincere appreciation to Chairman Dr UL Abdul Majeed for his energetic support in organizing every activity relevant to this conference. Next, my gratitude goes to Dr ANM Mubarak, our dedicated Secretary, who played a pivotal role in communication and coordination with authors and track coordinators. Treasurer Dr G Nishanthan for his financial coordination, & budget preparation, etc for the conferences.

The efforts of the track coordinators and valuable reviewers across the eight tracks deserve commendation for their exceptional task of ensuring a meticulous paper selection process, I also express my thanks to the Editorial Team for their timely support in editing the conference books.

A special acknowledgement is extended to all the Conference Committee members, the academic and non-academic staff of the Faculty of Technology, South Eastern University of Sri Lanka, Also, I would like to express immense gratitude to our sponsors, Suganth Sea Farm Pvt Ltd, Hemsions International, and MicroTech Biological, for their generous financial support.

In conclusion, I extend my best wishes to all presenters and participants for a successful, dynamic, and memorable experience at the 03rd International Conference on Science and Technology, hosted by the Faculty of Technology, South Eastern University of Sri Lanka.

**Mr. S.L. Abdul Haleem**
Coordinator
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Faculty of Technology
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# ABSTRACT OF KEYNOTE SPEECH

## Can ChatGPT do your Research?

Gihan Dias

*Dept. of Computer Science and Engineering, University of Moratuwa*

### Abstract

ChatGPT, and other AI systems have become incredibly powerful. You can ask them any question, and they will answer. For example, if you ask "Write a paper on soil erosion in Ampara District", it replies, "Absolutely! Here's an outline for a paper on soil erosion in the Ampara District:" and gives a reasonable outline.
So can we just get them to do all our work for us?

No, not yet, though we don't know what the future holds.

ChatGPT is an example of *Generative Artificial Intelligence.* Given a request – called a prompt – it produces an output.

How does it work? It uses *Machine Learning* (ML). A system is *trained* with a *large* number (trillions) of examples. It learns patterns in them and uses them to produce output. For example, a machine translation system will see that in the input, the word "මගේ", may be translated *"vdJ"* or *"vd;Dila"* but "මගේ නම" is always *"vdJ ngau;"*. Therefore, when given a new text to translate, it will choose an appropriate output.

Machine learning is used for other tasks as well. It can recognise faces in images, detect fraud, predict future outcomes, etc.

How has ML become so powerful?

Current machine learning is based on *Large Models*. These models are *pre-trained* using huge amounts of data, from vast and diverse datasets. We can then fine-tune a model using a smaller amount of data, so the model becomes more of an expert in a particular area. For example, a model containing geological and rainfall data can be fine-tuned with rainfall and landslides in a particular area to allow it to predict landslides.

Machine learning is becoming common in research. An ML model can contain the results of past work. We then enhance it using data generated by us, and use it to generate predictions. ML models are not omniscient – they "know" many things, but are also often wrong. While they are good for a broad overview, details must be carefully verified.

Machine learning has become an essential part of research. If you write a paper, you should use an AI tool to improve the grammar and readability of your paper, and identify points you may have missed. However, it cannot – yet – write an entire paper for you.

# ABSTRACT OF KEYNOTE SPEECH

## Importance of Investing on Research and Development to Achieve Sustainable Bio-Economic Development in Sri Lanka

Gamini Senanayake

*University of Ruhuna*

## I. Introduction

Innovations through research and development (R&D) enable a country to achieve its economic development through improving the competitiveness and productivity. Technological innovations lead to use limited natural resources and bio-wastes in more productive and efficient manner. This will help to achieve a higher standard of living and a better quality of life. Therefore, budget allocation of a country on research and development is considered as an indicator of the country's innovative efforts in research. It also describes a country's efforts towards science and technology. Not only can investments in science and technology increase the competitiveness of an economy, but it can also provide positive spillover effects on the overall economy, such as increasing the standard of living. Many economists, including Romer (1990) and Solow (1957) argue that technological progress enhances economic growth. Therefore, it is proved that research and development have a positive relationship with GDP. After studying the economies in 87 countries, Sana Surani *et al* (2017) have reported that a one percent increase in research and development expenditure increases GDP per capita by 5 percent (with an r-squared of 0.874).

The Republic of Korea and Japan spend 4.5% and 3% of their GDP on research and development respectively. In contrast, Sri Lanka's contribution to research and development is very low and it was only 0.12% of the GDP of the country in 2020 (CBSL, 2020). In Sri Lanka the highest gross expenditure on Research and Development (GERD) was incurred by Business Enterprises (37.94%) followed by Government Research Institutes (34.12%), Higher Education Sector (26.7%), and Private Non-Profit Organizations (1.25%). The highest proportion of funds for R&D was devoted for Applied Research 47.45% of GERD while Basic and Experimental Developments accounted 29.30% and 23.25% of GERD respectively. The top three fields of Science which have the highest GERD are Engineering and Technology (27.65%), Agricultural sciences (24.20%) and Natural sciences (22.46%).

## II. Technology and the Knowledge Based Bio-economy

The concept of a knowledge-based bio-economy (KBBE) has been introduced by the European Commission in 2004 (Albrecht *et al*., 2010). It is estimated that the European bio-economy currently has an approximate market size of over 2 trillion Euro, employing around 21.5 million people, with prospects for further growth looking more than promising. The increasing demand for a sustainable supply of food, raw materials and fuels, together with recent scientific progress, is the major economic driving force behind growth of the KBBE. The bio-economy – the sustainable production and conversion of biomass, for a range of food, health, fiber and industrial products and energy, where renewable biomass encompasses any biological material to be used as raw material - can play an important role in both creating economic growth, and in formulating effective responses to pressing global challenges. In this way it contributes to a smarter, more sustainable and inclusive economy. Therefore, to create a KBBE, technology can play a significant role. With technological advances, biological raw materials can be converted to more value added ready to consume products which will lead to earn more forex to the country. However unfortunately, Sri Lanka still export only raw biomass

with very little value addition. This is mainly because Sri Lanka has not converted its economy to a KBBE using bio-system technological advances. In this context, Departments of Bio-system Technology in Sri Lankan Universities have a major role to play in converting Sri Lankan economy into a more sustainable KBBE.

III. Impact of Bio-system research on Sri Lankan Economy

The share of the agricultural sector's contribution to global GDP has declined from 4.3% to 3.3% for the period 1970 to 2013 (FAO, 2015). According to the Central Bank of Sri Lanka, there was a noticeable decline in the contribution of the agricultural sector to GDP, which has fallen from 47% to 7% between 1950 and 2019 in Sri Lanka (CBSL, 2020). If so, should we reduce or stop the investment on agricultural research? If we cut down the investment on Agricultural R&D, how we feed the growing population with limited resources such as land and water? Is it possible to feed the growing population only with already available Science and Technology? What are the alternative solutions? Can we import R&D findings carried out elsewhere and apply to our country? Only way to find appropriate solutions to our local issues is investing continuously on R&D activities. We have significantly increased our yields of main crops through agricultural research. However, postharvest technologies and value additions have not developed to the level of expectations. This is mainly because our conventional Faculties of Agriculture have mainly concentrated on agronomic practices which increase the biomass production. Therefore, investing specially on bio-system research in agriculture is a must to ensure food safety and sustainable economic development.

IV. The reason for underinvestment on research in Sri Lanka

The underinvestment in research in Sri Lanka continues because the political economy of public expenditure decisions tends to emphasize short-term payoffs and subsidies that are "politically visible," whereas investments in agricultural R&D are long-term (10 years or more) and risky. (World Bank. 2007) Trade subsidies and inconsistent national policies are other reasons for low investment in R&D. Low productivity, lack of accountability and irresponsibility of some of the researchers and conducting research for personal interest are the other contributing factors for underinvestment in research. Therefore, understating the "Valley of Death in R&D process" is important in investing in research. Thorough knowledge on this concept is important for all actors in the process of R&D, including researchers, financial managers, policy makers, politicians etc.

V. The way forward

According to the statistics, there is a huge potential for the government as well as for the private sector to expand their R&D in the country. Improving R&D could be the turning point to improve Sri Lanka's global competitive ranking in order to be successful. At a time when the country is suffering from lack of foreign reserves it needs to look beyond traditional export income sources. As a country we have a long way to go even when compared with our neighboring countries. Our investment on R&D is the lowest in the Asia and Pacific region and it is even lower than Tajikistan and Kyrgyzstan. Therefore, the government budget allocation for technological innovations should be immediately increased to direct the country toward a technology driven bio-economy. At the same time, all researchers and academics should carry out their research to find out practical solutions instead of conducting research on their personal interest.

VI. How to create a successful R&D eco-system?

When the European Union developed the concept of the KBBE, they developed a technology platform including academics, researchers and industry to deliver innovation, world leadership in food

technologies and products and animal breeding technologies. Through this platform they developed a chemical and manufacturing industry base to process biomass into value added products.

Similarly, the Sri Lankan Government should take an urgent initiative to formulate a policy for a vibrant R&D culture. Policies, regulations, and incentives have to be in place to promote and develop the R&D eco-system. Investment in human capital and capacity building should be a top priority. R&D is mostly science and technology driven. Therefore, technically sound, postgraduate qualified human capital is a must to achieve economic sustainability through empowering research on Science and Technology.

Collaborating universities and research institutes with entrepreneurship is very essential as commercializing of new technological findings is critical to succeed in R&D. There is no point in creating a new product or a service if it cannot be commercialized. Therefore, it is important that a mechanism to be developed to closely work with private sector to commercialize the research findings of the universities.

Traditionally private sector has been termed as the 'Engine of Economic Growth'. In this scenario private sector could be the catalyst of changing the ecosystem to obtain economic sustainability of the country. They can contribute more towards R&D. According to the statistics private sector contribution to R&D is round 30%. Availability of treasury funds for R&D is always the issue. Therefore, there must be multiple sources of funding for research. As a solution to this funding issue, commercially focused equity investment platform (Something similar to European Technology Platforms (ETP)) should be created with the co-funding from treasury and private sector to provide funding for outcome based research.

## VII.     References

Albrecht, J., D. Carrez and P. Cunningham (2010) The Knowledge Based Bio-Economy (KBBE) in Europe: Achievements and Challenges. Clever Consult BVBA (Belgium) - www.cleverconsult.eu

CBSL (2020) Economic and Social Statistics of Sri Lanka, Central Bank of Sri Lanka, 197p.

FAO (2015), Eradication of Hunger and Improving Food and Nutrition Security FAO Annual Summary Report 2015

Romer, P. (1990). Endogenous Technological Change. Journal of Political Economy, 98(5), S71-S102.

Solow, R.M. (1957). Technical Change and the Aggregate Production Function. The Review of Economics and Statistics, 39(3) 312-320.

Surani S., W. Gendron, S. Maredia (2017). The Economic Impact of Research and Development. Econometrics 3161, 1-20.

World Bank (2007). World Development Report 2008: Agriculture for Development. Washington, DC. http://hdl.handle.net/10986/5990

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# TRACK - SOFTWARE TECHNOLOGIES (SWT)

# DENGAR: AN ANONYMOUS GPS-BASED DENGUE AND GARBAGE REAL-TIME SMART REPORTER

Hamna Nizar[1] and M.A.C. Akmal Jahan[2]

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## Abstract

*An Unhealthy environment causes infectious and non-infectious diseases to the living beings. Human plays an important role in controlling disease spread, requiring every individual to maintain environmental cleanliness. One measure is to inform the relevant government authorities about Dengue breeding sites and improper waste management practices. Currently, there is no practical mechanism to lodge complaints anonymously, causing informers to face various challenges. To address this gap, an Android based prototype called 'DenGar Reporter' is introduced in this work, where any general public can inform authorities about untidy and health-risky locations during their travels. Authorities, including Public Health Inspector (PHI), MOH offices, Municipal councils and police stations, can receive reports through this prototype. This prototype will not reveal the details of the informer as it operates anonymously, instead it will report the scenario with graphical information, supporting media, and real-time GPS location. This system ensures that the anonymity of the user will be protected and he/she will not get any retaliation and negative impressions. The government's sole purpose is to eradicate dengue outbreaks and improper garbage disposal in Sri Lanka, necessitating information regarding the ignorant but not the details of the informer. The system is an Android application developed with Java and Firebase, establishing a centralized system to report the Dengue breeding sites and improper waste management nationwide. Government administrators monitor the automated system, ensuring informer details are used solely for data storage. The prototype has been tested with several user groups and demonstrates a positive impact in the society.*

**Keywords: Dengue, Garbage, Anonymous, Ignorant, Android, GPS**

## I. INTRODUCTION

The increasing spread of Dengue poses a growing threat to our society, yet many cases stay hidden and go unnoticed because some people are afraid to speak up, and as such these issues remain out of sight. The importance of addressing Dengue outbreaks necessitate the need for effective solutions, and this is where the concept of anonymous reporting apps comes into play. Anonymous reporting apps can motivate individuals to step up and share these issues proactively before it becomes too critical. This motivation is rooted in the concept of psychological safety, as highlighted in the research studies by Harvard professor Amy Edmondson, which emphasizes its importance in organizations. Anonymous reporting apps can make it easier for them to share information without revealing who they are. Anonymous reporting let you send a report without telling anyone your name and identity. To keep the person's identity a secret, the government should make sure they can't be found through the aspects like their IP address of the device, phone number, voice, or writing style. Also, all the information the person sends should be kept safe and encrypted so that no one can read it without permission.

As Dengue continues to spread, it is the responsibility of general public to assist the government and the medical officers in controlling this issue. Although some people are aware of the Dengue spreading, yet they are unable to control it. And there are some other people who are unaware of this and also neglect the rules and regulations.

To understand the crucial need for anonymous reporting, let's consider specific scenarios where individuals might hesitate to report health and environmental concerns. For instance, imagine a scenario where a resident identifies a Dengue

breeding site in their neighborhood but fears potential backlash from community members or local authorities for raising the issue. In such cases, the lack of anonymity can stop individuals from reporting, preserving the cycle of unreported cases.

Similarly, improper waste management practices in certain areas may be overlooked due to residents' concerns about facing social stigma or potential consequences for reporting on their neighbors. The DenGar Reporter app addresses these challenges by providing a secure and anonymous platform, encouraging individuals to share information without any fear of reprisals.

DenGar Reporter is a user-friendly app that caters to individuals across all technological skill levels. The app's accessible interfaces make it easy for anyone to use, regardless of their technological expertise. It serves as a motivational tool, encouraging citizens to provide valuable information about issues such as improper waste management and dengue breeding sites.

Therefore, the objective of this work is to build a smart, robust, flexible and real-time anonymous reporting android app based on GPS which meets the following criteria:

- Public Safety: One of the main reasons for the anonymous information collection is to protect the people and the society from the risk of dengue spreading and improper waste management.
- Anonymous Reporting: Enable individuals to report Dengue breeding sites and improper waste management anonymously, fostering a culture of open communication without fear of reprisals.
- Real-time Information: Provide a platform for real-time reporting, ensuring timely responses from authorities to address reported issues promptly.
- User-Friendly Interface: An user-friendly interface accessible to individuals with varying levels of technological expertise, promoting widespread usage.
- Geospatial Accuracy: Utilize GPS technology to ensure precise location reporting, aiding authorities in efficiently locating and addressing reported concerns.

- Community Engagement: Motivate citizens to actively participate in public health and environmental initiatives, creating a sense of collective responsibility for the well-being of the community.
- Moral Responsibility: Informing the ignorant of a sense of moral obligation is generally regarded as the best reason to do so.
- Faster Processes: Online reporting is easier and faster than offline reporting. That is when a person wants to contact a PHI, this takes more time to reach them but this app allows faster process where the informer need not to spare more time over the phone.
- Manageable: The system is not only easy for users but also easy for administrators as the system provide all the reports and update it on time.
- Increased service: A person can inform or report the dengue related issues without revealing their identity and this protects them from retaliation and revenge.
- Exposing Ignorant Activity: By exposing those people who are the root cause for the Dengue spreading and improper waste management will help the Medical Officers and PHIs to control the ignorant activities in the society or country by warning them.
- Preventing false information: As the app asks for the proof and the location of the situation, the informer cannot give any false information.
- Cost-Effective: Installing *'DenGar* Reporter' incurs a one-time-data-cost, but when we have to deal with other offline systems, we must pay our phone bills for contacting the Medical Officer or PHI. Therefore, no cost at all when comparing to the offline reporting systems.

The beauty of 'DenGar Reporter' lies in its dual purpose: not only does it enable reporting, but it also educates users about the spread of dengue and waste management practices, their consequences, and effective control methods. This smart, real-time app acts as a catalyst for a safer and cleaner Sri Lanka, with interconnected technologies working in harmony.

## II.  LITERATURE REVIEW

A detailed study has been done related to the ways in which Dengue mosquito breeding places and improper waste disposal are reported and how mobile apps contribute to it. DenGar Reporter, our proposed system, not only draws inspiration from these studies but also introduces distinctive features that addresses specific challenges in the Sri Lankan context.

Automated Waste Control Management System (AWCMS) (Furqan Durrani et al., 2019) includes an electronic waste detection device and a central control unit for waste monitoring and detection in the bins placed in an area or a city. Different technologies like infrared sensors, GPS, microcontroller and GSM Module are used for this purpose. Location and the status of the bin are displayed in the GUI of the software. This mainly focuses on timely and automatic waste collection. DenGar Reporter extends this concept by integrating user-friendly interfaces for anonymous reporting, fostering increased public engagement in waste management beyond automated collected system.

The application of Unmanned Aerial Vehicles (UAVs) for mosquito-breeding site identification (Dias et al., 2018) and the comparative study with the Global Positioning System (GPS) (Schenkel et al., 2020) offers some valuable insights into efficient data collection methods. DenGar Reporter capitalizes on this knowledge by incorporating GPS functionalities for precise location reporting while ensuring a user-friendly mobile interface tailored to the Sri Lankan population.

Chaak (Lozano–Fuentes et al., 2013) serves as a model for mobile-based, real-time mosquito surveillance. DenGar Reporter builds upon this foundation by incorporating a centralized system and anonymous reporting features, aiming to enhance the speed and accuracy of dengue-related data collection.

Deep Learning and Image Processing in waste classification (Nowakowski & Pamuła, 2020) and IoT-based waste sorting (Haldi Widianto et al., 2021) showcase technological advancements. DenGar Reporter strategically employs user-friendly interfaces and efficient data processing methods to verify and classify reported scenarios, enhancing the accuracy and efficiency of waste

and mosquito-breeding site identification without the need for a complex deep learning model.

The CryHelp App (Kayem et al., 2015) stands out as a mobile-based crime reporting platform designed to ensure anonymity and privacy. Leveraging Java and the Eclipse SDK for Android development, this application has achieved an accuracy rate of 77.06%. DenGar Reporter draws inspiration from the principles of CryHelp, emphasizing the importance of anonymous reporting to encourage widespread public participation in reporting Dengue breeding sites and improper waste management practices.

The study on Dengue breeding container detection (Prachyabrued et al., 2020) introduces the use of Deep Learning and Google Street View (GSV) for accurate identification. While DenGar Reporter does not utilize Deep Learning, it acknowledges the effectiveness of technologies like GPS in recording the exact location. DenGar Reporter innovates by adopting a user-friendly approach for reporting, ensuring broad accessibility and simplicity for users.

In the realm of garbage detection systems (Patel et al., 2021), the use of Artificial Intelligence and Deep Learning for garbage sorting presents a technological leap. DenGar Reporter strategically refrains from the complexity of Deep Learning models but aligns with the objective of efficient waste management. It incorporates advanced image processing techniques and user-friendly interfaces to achieve automated garbage detection and reporting.

SpotGarbage (Mittal et al., 2016) highlights the ability of citizen-driven reporting through a smartphone app. DenGar Reporter extends this concept by emphasizing anonymity, ensuring users can report environmental concerns without fear of reprisal, contributing to a safer and cleaner community in Sri Lanka.

## III. METHODOLOGY

The *DenGar* Reporter project employs an observational study design to evaluate the Android application in real-world settings. This approach was chosen to ensure a user-centric assessment, focusing on usability, impact, and ethical considerations. The design allows for a comprehensive understanding of how the app functions in diverse situations, contributing

valuable insights to its practical implementation and effectiveness in dengue prevention and waste management. The study's participants include a diverse range of individuals across Sri Lanka. The app is designed to be accessible to people from various age groups, technological proficiency levels, and backgrounds. The key independent variables in this study are the users' interactions with the *DenGar* Reporter app, including their reporting of dengue breeding sites and improper waste disposal. The dependent variables include response times to reported issues, issue resolution, and the overall impact on dengue prevention and waste management. Data is collected through the *DenGar* Reporter mobile application. The app allows users to report issues in real-time, and it collects various data types, including text input, images, and precise GPS coordinates. A cloud-based system manages the data, which is then made accessible to administrators for further action. Analytical techniques applied to the collected data involve assessing the frequency of reported issues, measuring response times for issue resolution, and analyzing trends in dengue prevention and waste management improvements. Statistical methods will be used to identify patterns and correlations in the data. Ethical approvals have been obtained to ensure the privacy and anonymity of app users, reducing the risk of retaliation for reporting. All data collected is strictly used for the purpose of dengue prevention and improving waste management practices, with user privacy and ethical considerations being paramount.

An overview of the *DenGar* Reporter is shown below.
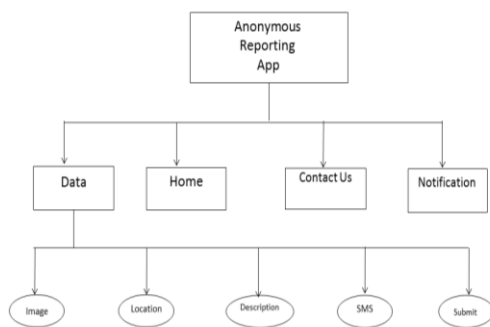


Figure 01: Overall Component of the *DenGar*

The overall mobile app consists 4 integrated components with sub parts.

i.   Data: The Data component contains 5 main-modules. They are:

✓ Image: The informer is asked to add one or more images of the scenario in order to avoid fake reporting. Also, there is an option for the user to add images either by capturing it directly or to select from gallery. It is believed that, adding multiple images may clarify the scenario.

✓ Location: The informer is asked to add the exact Google Map location of the scenario. So that it will be informed to the relevant area PHI or Medical Officer to handle the situation.

✓ Description: The informer is asked to describe the situation in words and it is optional.

✓ SMS: The current location added by the informer will be sent automatically to the relevant authority as latitude and longitude to their mobile number as an SMS, where the informer details will not be revealed.

✓ Submit: The Submit button will be valid only if the images and the location are attached, where the description is optional. This information will be stored in Firebase cloud storage with the button click.

ii.   Home: The Home page provides some information about the Dengue Breeding Sites, Proper Waste Management, Social Mobilization, Preventing Measures, Registered Mosquito Repellents and many others.

iii.   Contact Information: The Contact Information provides the user with more and more ways to contact National Dengue Control Unit, Colombo Municipal Council and the area PHI which includes their Hotline, E-mail, Fax, Address and Website details.

iv.   Notification: The Notification page shows the status of the report that is sent to the relevant authority by the user via this app. And it will notify the user when it is reviewed by the relevant authority.

The methodology of the system is a systematic way used to collect information and data in order to make and arrive at final decisions.
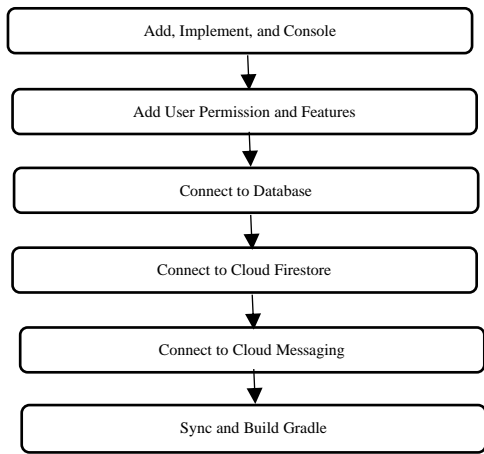
Figure 02:
Developmental Outline of the DenGar Reporter

## IV. DESIGN AND IMPLEMENTATION



Figure 03: Interface for Making Selections
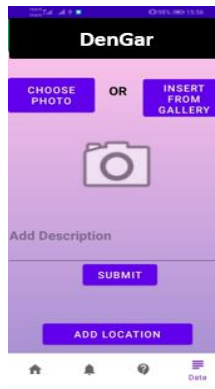


Figure 04: Interface for Managing Data
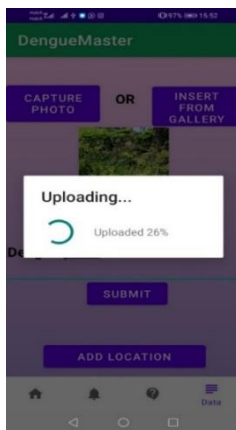


Figure 05: Processing Image
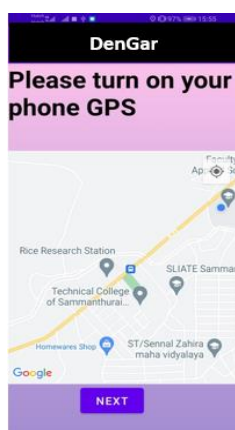


Figure 06: Interface for Locating GPS Position
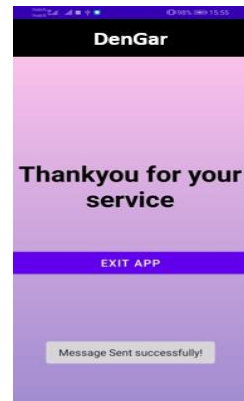


Figure 07: Interface Showing Appreciation
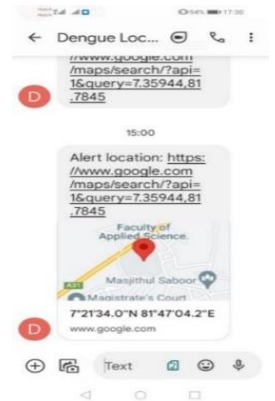


Figure 08: Receiving Location Alert via SMS in PHI Phone
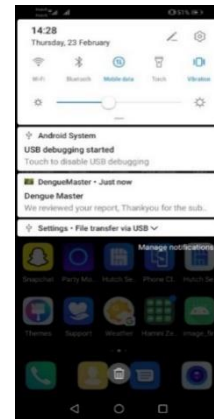


Figure 09: Real-time Push Notification of Reviewed Message from the Application
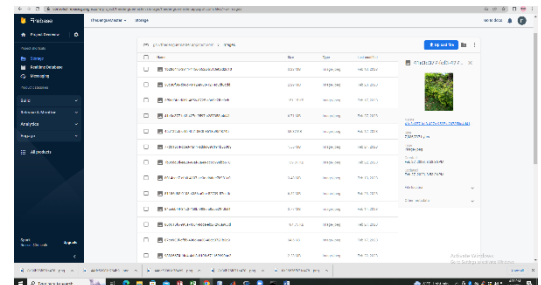


Figure 10: Realtime Firebase Storage where the images and media sent by the user is saved.
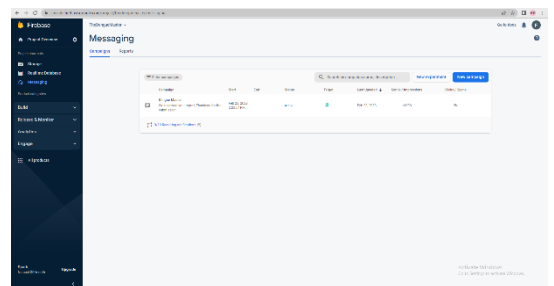


Figure 11: Realtime Firebase Cloud for Real-Time Push Messaging
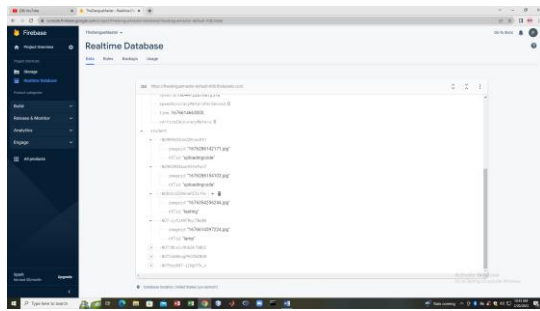
Figure 12: Realtime Firebase Database
where all the data are saved

## V. DISCUSSION

This study was focused on developing an Anonymous Reporting App where people can submit the dengue breeding places and improper waste management activities without revealing their identity. This app needs the information regarding the ignorant and not the details of the informer. The *DenGar* Reporter is a free, responsive app which could be available on all the types of Android Mobile Phones. Each and every Android user in Sri Lanka can install this app. This is app can be used by all the people in the society irrespective of their technological skills and knowledge. This is a user-friendly app where the interfaces are designed in an easy, accessible manner and understandable by both the expert users and the novice users. To avoid fake reporting, this app requests the informer for the exact GPS location and the picture or video or any media type of the scenario for the confirmation of the report.

According to a statistical analysis conducted as a part of this prototype's evaluation focused on the impact of anonymous reporting. The results indicate that, allowing people to submit reports anonymously does not increase the number of mean or harmful reports. It just shows that what matters most is addressing the issue, not finding out who reported it. This prototype uses Java in Android Studio and uses Firebase as its Database. The future work of this prototype will include the addition of new features and introduction to IOS and all the other types of Operating Systems and Computers.

For the evaluation of the *DenGar* Reporter, a graphical interpretation of the results and feedbacks are collected using a questionnaire to test the prototype with multiple users is shown below. Different groups of user groups are selected to acquire various opinions of the prototype.
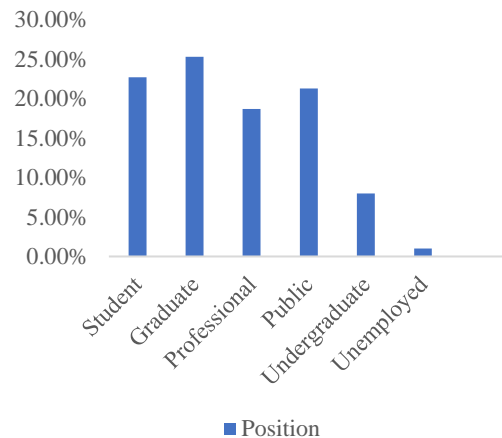


Figure 13: User Satisfaction of the Dengar with Different User Groups
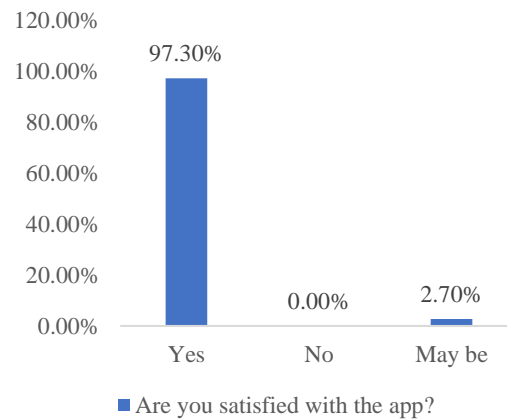


Figure 14: User Satisfaction Rate of the Dengar
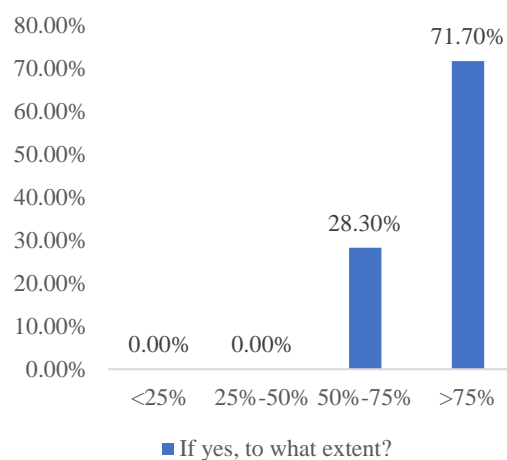


Figure 15: User Satisfaction Range of the Dengar
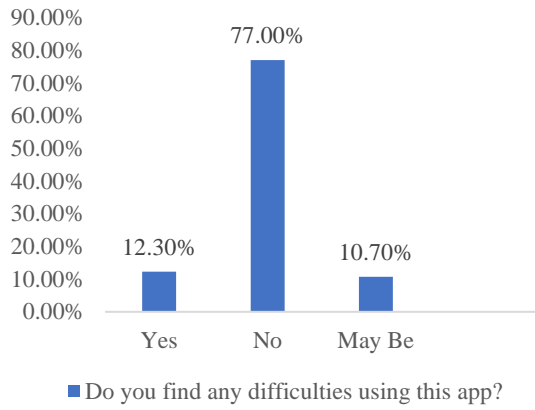
Figure 16: User Difficulty Rate of the Dengar.
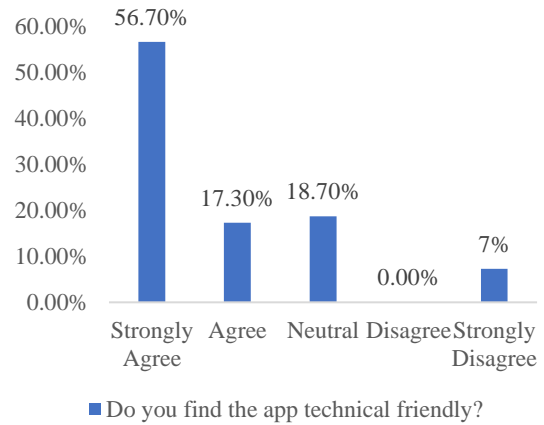


Figure 18: The Technical Friendliness of the App with the User.
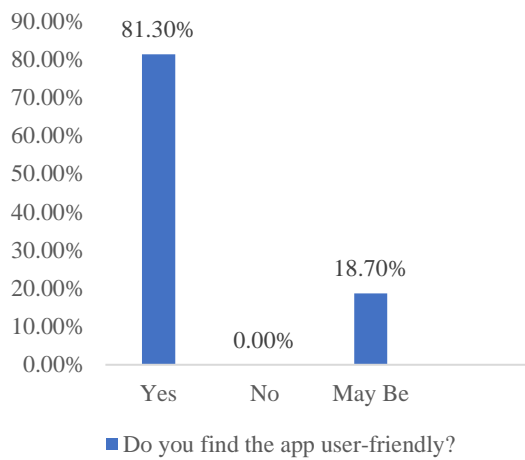


Figure 17: User Friendly Rate of the App
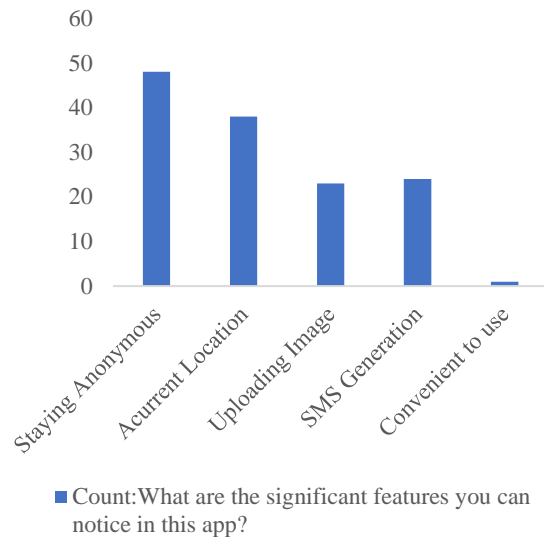


Figure 19: The Count of People Who Noticed the Significant Features in the App.
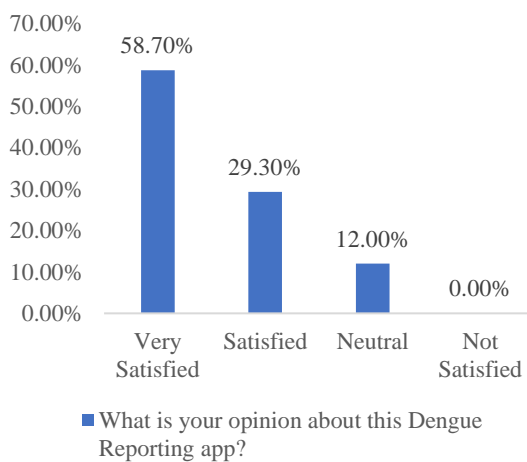


Figure 20: Overall User Satisafaction of the Dengar Reporter.

# VI.CONCLUSION

The current work presents the development of an Android App, a prototypical approach for the Sri

Lankan to provide anonymous information about Dengue breeding places, improper waste management and the activities of the ignorant. The *DenGar* Reporter is a new digital app, which protects the informer identities and enable two-way follow-up interactions. These mechanisms also permit informers to securely share supporting files and documents. This app accepts the report at any time, without causing any inconvenience to the informer or the reporter. If an informer is worried about-facing retaliation and negative consequences, it makes sense that they might hesitate to report. In such cases, the government could miss out on incredibly important information, leading to potentially significant harm for both the government and the medical sector. However, when anonymous reporting is allowed, it removes these barriers and encourages a larger number of people to come forward. Therefore, this provides the highest level of protection to society against various risks. Anonymity makes it easier for people to overcome their hesitations. Typically, making a report is a one-time event, often filled with uncertainty. People might be afraid of facing consequences, so speaking out is an incredibly brave step to take. Yet, with the help of this anonymous reporting app, they can inform the dengue related and waste management activities easily without any fear. This prototype is evaluated with various users such as Undergraduate, Working Professionals, and General Public, resulting a positive outcome towards introducing its use within the community. DenGar Reporter has shown success in making a real-time impact, providing an easy-to-use interface, and involving the community effectively. However, our evaluation mainly looked at specific groups of users, so more research is needed to see how well the app works for a broader range of people. Also, we should explore using new technologies to make the app even better and study how it might affect public health and the environment over a longer time.

In Future, DenGar Reporter plans to enhance user capabilities with new features, by integrating the latest technologies for improved performance, and to explore platform expansion (iOS and web versions). These future initiatives reflect our commitment to continuous improvement, ensuring DenGar Reporter remains an effective tool for a healthier and more sustainable Sri Lanka.

## REFERENCES

Dias, T. M., Alves, V. C., Alves Junior, H. M., Pinheiro, L. F., Pontes, R. S. G., Araujo, G. M., Lima, A. A., & Prego, T. M. (2018). 'Autonomous Detection of Mosquito-Breeding Habitats Using an Unmanned Aerial Vehicle.' In 2018 *Latin American Robotic Symposium,* 2018 *Brazilian Symposium on Robotics (SBR)* and 2018 *Workshop on Robotics in Education (WRE)* (pp. 351-356). João Pessoa, Brazil. doi: 10.1109/LARS/SBR/WRE.2018.00070.

Furqan Durrani, A. M., Rehman, A. U., Farooq, A., Meo, J. A., & Sadiq, M. T. (2019). 'An Automated Waste Control Management System (AWCMS) by Using Arduino.' In 2019 *International Conference on Engineering and Emerging Technologies (ICEET)* (pp. 1-6). Lahore, Pakistan. doi: 10.1109/CEET1.2019.8711844.

Haldi Widianto, M., Wibowo, A. P., & Gusna, D. (2021). 'Prototype Design Internet of Things Based Waste Management Using Image Processing.' *Advances in Science, Technology and Engineering Systems Journal*, 6, 709-715. https://doi.org/10.25046/aj060282.

Kayem, A. V. D. M., Sakpere, A. B., & Ndlovu, T. (2015). 'A Usable and Secure Crime Reporting System for Technology Resource Constrained Context.' https://doi.org/10.1109/WAINA.2015.97.

Lozano–Fuentes, S., Wedyan, F., Hernandez–Garcia, E., Sadhu, D., Ghosh, S., Bieman, J. M., Tep-Chel, D., García–Rejón, J. E., Eisen, L. (2013). 'Cell Phone-Based System (Chaak) for Surveillance of Immatures of Dengue Virus Mosquito Vectors.' *Journal of Medical Entomology,* 50(4), 879–889. https://doi.org/10.1603/ME13008

Mittal, G., Yagnik, K. B., Garg, M., & Krishnan, N. C. (2016). 'SpotGarbage: Smartphone App to Detect Garbage Using Deep Learning.' In *UBICOMP '16* (pp. 940-945). https://doi.org/10.1145/2971648.2971731.

Nowakowski, P., & Pamuła, T. (2020). 'Application of deep learning object classifier to improve e-waste collection planning.' *Waste Management*, 109, 1-9. https://doi.org/10.1016/j.wasman.2020.04.041.

Patel, D., Patel, F., Patel, S., Patel, N., Shah, D., & Patel, V. (2021). 'Garbage Detection using Advanced Object Detection Techniques.' In 2021 *International Conference on Artificial Intelligence and Smart Systems (ICAIS)* (pp. 526-531). Coimbatore, India. https://doi.org/10.1109/ICAIS50930.2021.9395916.

Prachyabrued, M., Haddawy, P., Tengputtipong, K., Su Yin, M., Bicout, D., & Laosiritaworn, Y. (2020). 'Immersive Visualization of Dengue Vector Breeding Sites Extracted from Street View Images.' In 2020 *IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR)* (pp. 37-42). https://doi.org/10.1109/AIVR50618.2020.00016.

Schenkel, J., Taele, P., Goldberg, D., Horney, J., & Hammond, T. (2020). 'Identifying Potential Mosquito Breeding Grounds: Assessing the Efficiency of UAV Technology in Public Health.' *Robotics*, 9(4), 91. https://doi.org/10.3390/robotics9040091

# Exploring Usability and Accessibility of Educational Mobile Apps for Mathematics Learning: A Preliminary Literature Review

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## Abstract

*Educational mobile applications have emerged as powerful tools for enhancing mathematics learning experiences. This literature review synthesizes findings from 22 research papers focused on the usability and accessibility of educational mobile apps for mathematics learning. The study delves into the contexts, investigating the effectiveness of these apps in accommodating the needs of learners with varying abilities. Through a preliminary literature analysis of the selected papers, this review explores the challenges faced by learners and identifies the strategies employed in these applications to address these challenges. The synthesis reveals insights into user preferences, design elements, and pedagogical approaches that optimize usability and accessibility. By evaluating the existing literature, this review not only provides an overview of the current state of research but also offers recommendations for the future development of educational mobile apps, ensuring inclusivity and effectiveness in mathematics education.*

***Keywords: Educational Mobile Apps, Mathematics Learning, Usability of math apps, accessibility***

## I.    INTRODUCTION

In the realm of education, mobile applications have emerged as pivotal tools, revolutionizing learning experiences. With a specific focus on mathematics education, these applications have the potential to address a myriad of challenges faced by students, ranging from dyscalculia and autism spectrum disorder to difficulties in slow learning processes. As educational paradigms shift towards blended and independent learning, the role of mobile technology becomes increasingly crucial, offering tailored solutions to complex educational obstacles (Sari & Zamroni, 2019). This literature review embarks on an exploration guided by three review questions:

- What are the prevailing patterns and emerging trends in the guidelines for developing educational mobile apps specifically designed for mathematics learning?
- How have these guidelines evolved over time?
- What pedagogical theories and technological advancements have influenced their development?

Within this framework, this literature review analyzes existing studies, unravelling the foundational principles, design strategies, and user experience intricacies embedded in educational mobile apps for mathematics education. The review encapsulates the aspects including challenges faced by students, ranging from dyscalculia to autism spectrum disorder and slow learning capabilities. Each challenge demands specialized attention, innovative pedagogical approaches, and sophisticated technological integration. As educators and developers navigate this complex terrain, the synthesis of existing literature offers a roadmap, illuminating the way forward.

## II. METHODOLOGY

### A.  Formulation of Search Strings

The first step involved constructing comprehensive search strings tailored to the research focus. Utilizing relevant keywords such as "educational mobile apps," AND "mathematics learning".

### B.  Selection of Databases and Search Engines

As an initial stage of the main research to develop design guidelines for creating a mobile app for mathematics for slow learners, the articles were selected from the Google Scholar database. In selecting Google Scholar as the primary source for this review, practical considerations guided the choice. During the initial stages, it provided a broad perspective, identifying key themes. Its inclusive access to open resources contributed to the review's

comprehensiveness. Limited access to specialized databases and financial constraints made Google Scholar the most viable option, for overcoming barriers to information.

### C. Screening and Selection Process

Upon retrieving the articles, an initial screening process was implemented. Titles and abstracts were reviewed to assess their relevance to the review topic. A total of 22 articles that met the pre-defined criteria, focusing on educational mobile applications for mathematics learning were selected for review.

### D. Full-Text Review and Inclusion Criteria

Selected 22 articles underwent a thorough full-text review. Inclusion criteria encompassed studies that specifically addressed the usability and accessibility of educational mobile applications in teaching mathematics.

### E. Data Extraction and Synthesis

Data pertinent to the review objectives were extracted from the selected articles. Key findings related to the usability challenges, preferences, and barriers hindering the effective use of educational mobile apps were discussed. The resulting synthesis of findings provides insights into the usability and accessibility of educational mobile applications for mathematics learning, thereby contributing to the field of inclusive education and educational technology.

### F. Inclusion Criteria

1. Relevance to Educational Mobile App Usability.
2. Focus on Mathematics Education.
3. Publication in Peer-Reviewed Journals
4. Open Access Articles in English.

Figure 01 below illustrate the criteria for inclusion and exclusion of articles choosen for the literature review.

### III. DISCUSSION

The study of mobile applications for educational purposes, especially catering to specific learning needs such as dyscalculia and autism, has gained significant attention. This section delves into various aspects of these studies and discusses their findings in relation to the broader context of educational mobile applications. The framework

for evaluating children's educational mobile apps underscores the importance of comprehensive usability evaluation, task checklists, and satisfaction questionnaires. It addresses the need for a more holistic approach to assessing novel features, usability, and pedagogical aspects, which are often overlooked in existing evaluations (Hamid et al., 2022).

Moreover, the incorporation of machine learning tools in mobile health technology, particularly for visually impaired individuals, showcases the potential of enhancing accessibility and usability. These advancements simplify UI interactions and improve task accuracy, aligning with the overarching goal of inclusive design in educational apps (Tahir and Arif, 2014).

The studies on autism care and intervention apps highlight the necessity of bridging behavioural and neuroimaging literature to understand the relationship between visual motion perception and math ability. By utilizing fMRI to assess brain activity, these studies contribute valuable insights into the neurological aspects of learning disabilities and the potential avenues for tailored interventions (Liu et al., 2023; Valencia et al., 2022).

Additionally, the development and evaluation of apps specifically designed for users with Autism Spectrum Disorder (ASD) emphasize the need for formal evaluation methods tailored to the unique characteristics of individuals with ASD. These studies introduce methodologies that encompass diverse factors, ensuring a positive and relevant user experience for this user group (Hersh and Leporini, 2013). In the context of dyscalculia, challenges arise in developing suitable educational apps. The creation and validation of the Calculic Model demonstrate efforts to comprehend dyscalculia challenges and design apps catering to the unique learning styles of dyscalculia children. However, these studies acknowledge the limitations in practical implementation and integration into educational settings (Abd Halim et al., 2018; Laws et al., 2022).

Educational game development also faces challenges related to accessibility, usability, and pedagogy. While guidelines prioritize collaboration, mobile access, and universally accepted heuristics, studies highlight the necessity of considering diverse learners, particularly disabled students. This inclusive approach, demonstrated through real-world engagement with
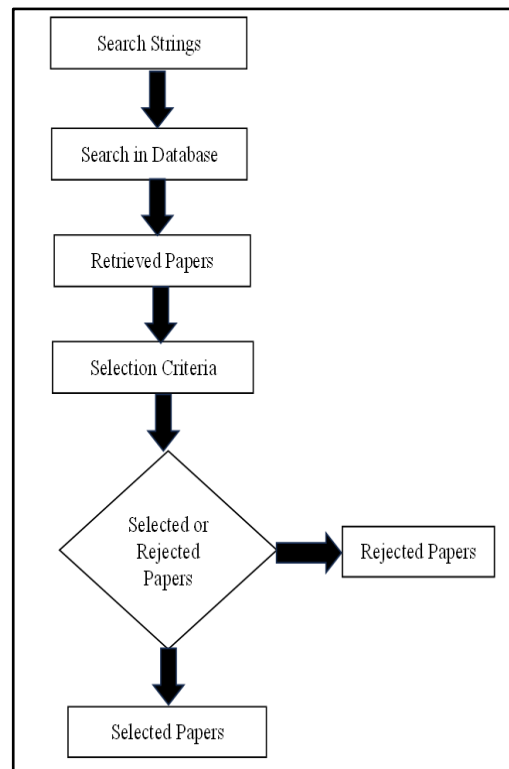
Figure 01:  Criteria for Inclusion and Exclusion of Articles

disabled students, parents, teachers, and experts, provides valuable insights into the development of accessible educational games (Gocheva and Somova, 2015). The effectiveness of mobile game-based learning, especially in the context of primary education, is a topic of considerable interest. Studies emphasize the need for adaptability and customization in learning models, integrating micro-lessons and games. Positive feedback from real classroom settings indicates the potential of mobile game-based learning to engage students and enhance their educational experience (Rohizan et al., 2020).

The reviewed scientific studies shed light on diverse strategies, challenges, and solutions concerning the education of students with learning disabilities in mathematics. The scarcity of research addressing the usability of mobile apps in healthcare education is a vital issue that the studies attempted to address (Perera et al., 2014). Various studies focused on different aspects of this problem, highlighting the significance of usability attributes and methods in the context of healthcare education (Orbon & Sapin, 2022). A crucial outcome of these studies was the emphasis on user-centred design principles and the development of comprehensive and inclusive learning tools for children with Dyscalculia (Khaira & Herman, 2020). These findings align with the broader understanding of

how technology can be harnessed to support personalized learning experiences for students with learning disabilities.

The integration of Information and Communication Technology (ICT) in special education represents a paradigm shift in the approach towards supporting students with special needs (Maloy et al., 2023). The studies discussed the effectiveness of game-based activities, aiming to provide practical evidence of ICT's impact on the educational outcomes of students with special needs (Gulliford et al., 2021). It was observed that ICT-based learning significantly enhances learning outcomes, emphasizing the importance of customized game-based activities (Gulliford et al., 2021). While these findings are promising, they also underscore the necessity of addressing challenges such as resource constraints and the need for customized approaches for specific disabilities.

The use of tablet technology in early childhood education, especially for children with learning delays, emerged as a critical area of study (Murdiyanto et al., 2023). Understanding the interactions between the child, the application, the facilitator, and the learning environment played a central role in the effectiveness of tablet-based learning tools (Murdiyanto et al., 2023). The findings highlighted the complexity of technology

in education, emphasizing the need for a broader understanding of the interaction between technology and context for educational benefits. The development of usable arithmetic platforms using NoCode technology demonstrated the potential of innovative approaches to elementary math instruction (Cabatuan & Dales, 2022). The use of instructional games also emerged as a promising avenue, providing engaging practice and support for students, thereby improving their problem-solving skills (Obina et al., 2022). However, the need for continuous improvements and the importance of covering a broader range of elementary math concepts were acknowledged as limitations in these studies.

Identifying and supporting slow learners, especially in resource-constrained environments, were key themes in several studies (Mukhlis et al., 2023; Sutomo & Herman, 2023). Alternative methods for identifying slow learners, such as teacher interviews, analysis of student report cards, and examination administration, proved to be successful in rural schools (Sutomo & Herman, 2023). The involvement of various stakeholders, including guidance and counselling counsellors and parents, was crucial in supporting slow learners' education (Ilzam & Purwoko, 2023). The study on the Realistic Mathematics Education (MRE) method illuminated the impact of different learning environments on slow learners' performance, suggesting the potential benefits of utilizing MRE at home (Hafidah & Rukli, 2022).

In summary, these studies collectively underscore the importance of comprehensive usability evaluation, inclusive design principles, and tailored interventions in educational mobile applications. While advancements have been made in understanding learning disabilities and designing apps for specific user groups, challenges in practical implementation, long-term impact assessment, and integration into educational curricula persist. Continued research and collaboration between researchers, educators, app developers, and users are essential to address these challenges and create truly inclusive educational mobile applications. These studies collectively contribute valuable insights into the diverse challenges and innovative solutions in the realm of mathematics education for students with learning disabilities.

However, it is essential to acknowledge the limitations of individual studies, such as small sample sizes, specific focus areas, and potential biases in self-reported data. Future research should aim to address these limitations, focusing on longitudinal studies, larger and more diverse samples, and the development of standardized assessment tools. Collaborative efforts between researchers, educators, and policymakers are crucial to implementing evidence-based practices and fostering inclusive mathematics education for all students.

*A. Answers to review questions*
*1) Prevailing Patterns and Emerging Trends in Educational Mobile Apps for Mathematics Learning:*
The studies reviewed provide a comprehensive overview of the evolving guidelines for developing educational mobile apps, particularly tailored for students with specific learning needs such as dyscalculia and autism. These studies emphasize the importance of comprehensive usability evaluation, task checklists, and satisfaction questionnaires (Hamid et al., 2022). Usability, pedagogical aspects (Ariffin et al., 2017), and novel features are focal points in the framework for evaluating children's educational mobile apps, emphasizing a holistic approach often overlooked in existing evaluations.

Furthermore, advancements in machine learning tools for visually impaired individuals are transforming the landscape of app accessibility (Tahir & Arif, 2014). Machine learning enhances UI interactions and task accuracy, aligning with the overarching goal of inclusive design. The necessity of bridging behavioural and neuroimaging literature to understand learning disabilities is highlighted in studies focusing on autism care and intervention apps (Liu et al., 2023; Valencia et al., 2022). Utilizing fMRI to assess brain activity provides valuable insights into the neurological aspects of learning disabilities, paving the way for tailored interventions.

Incorporating formal evaluation methods tailored to the unique characteristics of individuals with ASD is crucial in app development for this user group (Hersh & Leporini, 2013). Specialized evaluation methodologies ensure a positive and relevant user experience for individuals with ASD, addressing their unique needs. Despite these advancements, challenges persist in practical implementation, long-term impact assessment, and integration into educational curricula, necessitating continued research and collaboration between stakeholders.

## 2) Evolution of Guidelines Over Time

The evolution of guidelines for educational mobile apps is evident in the studies reviewed. Efforts to comprehend the challenges faced by dyscalculia children have led to the creation and validation of the Calculic Model (Abd Halim et al., 2018; Donevska-Todorova et al., 2020; Laws et al., 2022). While these studies contribute significantly to understanding dyscalculia, challenges in practical implementation and integration into educational settings remain, highlighting the need for continuous refinement.

Educational game development, with its emphasis on collaboration, mobile access, and universally accepted heuristics, illustrates the evolving nature of app guidelines (Gocheva & Somova, 2015). These studies emphasize the importance of considering diverse learners, particularly disabled students, ensuring inclusivity in educational games. Moreover, the effectiveness of mobile game-based learning, especially in primary education, is a topic of considerable interest (Rohizan et al., 2020). Positive feedback from real classroom settings indicates the potential of mobile game-based learning in engaging students and enhancing their educational experience, showcasing the evolution of educational strategies over time.

## 3) Pedagogical Theories and Technological Advancements:

The incorporation of pedagogical theories and technological advancements is a central theme in the studies. The integration of ICT in special education represents a paradigm shift, emphasizing the effectiveness of customized game-based activities (Maloy et al., 2023; Gulliford et al., 2021). These studies underscore the importance of adapting pedagogical methods to technological advancements and tailoring interventions for specific disabilities.

Tablet technology's introduction in early childhood education represents a significant technological advancement, emphasizing the need for a broader understanding of the interaction between technology and context for educational benefits (Murdiyanto et al., 2023). The development of usable arithmetic platforms utilizing NoCode technology showcases innovative approaches, providing engaging practice and support for students (Cabatuan & Dales, 2022). However, continuous improvements and the need to cover a broader range of elementary math concepts are

acknowledged, highlighting the importance of technological advancements in pedagogical tools.

Identifying and supporting slow learners, particularly in resource-constrained environments, necessitates innovative solutions (Mukhlis et al., 2023; Sutomo & Herman, 2023). Alternative methods for identifying slow learners, such as teacher interviews and examination administration, have proven successful, demonstrating the integration of technological tools in pedagogical approaches (Sutomo & Herman, 2023). Additionally, the study on the Realistic Mathematics Education (MRE) method provides insights into the impact of different learning environments on slow learners' performance, emphasizing the need for adaptability in pedagogical methods (Hafidah & Rukli, 2022).

## IV. CONCLUSION

In this preliminary literature review, the diverse studies explored have provided invaluable insights into the intricate realm of educational mobile apps for mathematics learning. The trajectory of this field is marked by innovative research endeavours, deeply rooted in the principles of inclusivity and accessibility. These studies have illuminated specific facets of this dynamic landscape, addressing the unique needs of students with dyscalculia, autism, and slow learning processes. One of the prominent trends discerned is the growing emphasis on comprehensive usability evaluations and holistic approaches, filling gaps overlooked in previous assessments. The integration of machine learning tools and the synergy between behavioural and neuroimaging research have significantly enhanced app accessibility and interventions for students with learning disabilities, heralding a transformative era in the field. Moreover, the tailored evaluation methods designed for students with ASD exemplify a steadfast commitment to crafting meaningful and relevant learning experiences for diverse user groups.

The evolution of guidelines for educational mobile apps is evident in the strides made by these studies. From innovative solutions stemming from an understanding of dyscalculia challenges, as showcased by the Calculic Model, to the collaborative and inclusive approach in educational game development, these studies have highlighted the adaptability and engagement that form the core of effective pedagogy. The integration of

pedagogical theories with technological advancements is at the heart of these endeavours, demonstrated by the integration of ICT in special education, the introduction of tablet technology in early childhood education, and the development of importance of adaptability and customization in pedagogical strategies.

but also underscores the imperative of sustained collaboration among researchers, educators, app developers, and policymakers. The journey toward truly inclusive mathematics education continues, with challenges serving as stepping stones toward innovative solutions. As technology advances and pedagogical theories evolve, the future of educational mobile apps holds the promise of equitable learning opportunities for all, regardless of learning abilities. Through persistent research efforts and a collective commitment to inclusivity, the transformative potential of educational mobile apps in shaping the educational landscape for students with learning disabilities becomes increasingly tangible, paving the way for a more inclusive and accessible educational future.

## A. IMPLICATIONS AND PATH FOR FUTURE RESEARCH

In light of the insights gleaned from the reviewed studies, several key areas merit attention in future research endeavours. Longitudinal studies with extensive and diverse participant pools should be conducted to unravel the sustained impact of educational mobile apps on students with learning disabilities. Standardized assessment tools, tailored to accommodate various learning abilities, are essential in gauging app effectiveness accurately and guiding educational strategies. Collaborative efforts between researchers, educators, and policymakers are vital to the successful implementation of evidence-based practices, ensuring inclusive mathematics education for all.

Also, exploring emerging technologies, such as virtual reality and artificial intelligence, holds promise for creating personalized, adaptive learning experiences. These technologies can be harnessed to meet the unique needs of diverse learners, ushering in a new era of inclusive education. Furthermore, the dissemination of successful app implementations and best practices should be prioritized, fostering widespread adoption and maximizing the positive impact of educational mobile apps on diverse learning communities.

usable arithmetic platforms using cutting-edge NoCode technology. Furthermore, alternative methods for identifying and supporting slow learners, such as the MRE method, underscore the

In conclusion, this review not only illuminates prevailing patterns and emerging trends in educational mobile apps for mathematics learning

## B. CONTRIBUTIONS AND BENEFITS

This review consolidates diverse studies, providing a deep understanding of educational mobile apps for mathematics. It not only highlights challenges and innovative solutions but also offers practical implications for educators and developers. By emphasizing usability, inclusivity, and tailored interventions, it guides future research and underscores the transformative role of mobile apps in inclusive education.

## REFERENCES

Abd Halim, F. A., Ariffin, M. M., & Sugathan, S. K. (2018). Towards the development of mobile app design model for Dyscalculia children in Malaysia. *MATEC Web of Conferences, 150,* 05016.

Ariffin, M. M., Halim, F. A. A., & Abd, N. (2017). Mobile application for dyscalculia children in Malaysia. *Proceedings of the 6th international conference on computing & informatics,* 467-472.

Cabatuan, J. M., & Dales, Z. I. (2022). Learning Portfolio in Mathematics: Its Effects on the 21st Century Learning Skills of the Grade 8 Learners. *Zenodo (CERN European Organization for Nuclear Research).* [Online] Available at: https://doi.org/10.5281/zenodo.6910811

Donevska-Todorova, A., Lieban, D., & Gonçalves, B. (2020). Fostering heuristic strategies in mathematical problem solving with virtual and tangible manipulatives. *Mathematics Education in the Digital Age (MEDA),* 175.

Gocheva, M. V., & Somova, E. (2015). Mobile game-based math learning for primary school. *Sino-US English Teaching, 12*(1), 20-25.

Gulliford, A., Walton, J., Allison, K., & Pitchford, N. (2021). A qualitative investigation of implementation of app-based maths instruction for young learners. *Educational & Child Psychology, 38*(3), 90-108.

Hafidah, H., & Rukli, R. (2022). Treatment Slow Learner Learning Repetitive Addition with Realistic Mathematics Learning Approach. *Mimbar Sekolah Dasar.* https://doi.org/10.53400/mimbar-sd.v9i3.48586.

Hamid, K., Iqbal, M. Waseem, Muhammad, H., Basit, M., Fuzail, Z., † Z., Ahmad, S. (2022). Usability

Evaluation of Mobile Banking Applications in Digital Business as Emerging Economy. *International Journal of Computer Science and Network Security, 22*(2), 32. https://doi.org/10.22937/IJCSNS.2022.22.2.32

Hersh, M. A., & Leporini, B. (2013). An overview of accessibility and usability of educational games. *Student usability in educational software and games: Improving experiences,* 1-40.

Ilzam, A., & Purwoko, B. (2023). The Role of Guidance Counseling Teacher and Parents in the Learning Process of Children with Special Needs of Slow Learners. *International Journal of Social Science and Religion.* https://doi.org/10.53639/ijssr.v4i3.186

Khaira, U., & Herman, T. (2020, April). Assessment processes for slow learners in mathematics learning. *Journal of Physics: Conference Series, 1521*(3), 032097.

Laws, M. L., Matejko, A. A., Lozano, M., Napoliello, E., & Eden, G. F. (2022). Dorsal visual stream activity during coherent motion processing is not related to math ability or dyscalculia. *NeuroImage: Clinical, 35,* 103042.

Liu, X., Zhao, W., Qi, Q., & Luo, X. (2023). A Survey on Autism Care, Diagnosis, and Intervention Based on Mobile Apps: Focusing on Usability and Software Design. *Sensors, 23*(14), 6260.
Maloy, R.W., Gattupalli, S., & Edwards, S.A. (2023). Developing Usable Math Online Tutor for Elementary Math Learners with NoCode Tools.

Mukhlis, A., Havida, B. K. N., & Nurani, A. A. (2023). Special Assistance Teachers Learning Strategies for Slow Learner Students in Inclusive Elementary Schools. *Jurnal Inovasi Pendidikan Dan Pembelajaran Sekolah Dasar.* https://doi.org/10.24036/jippsd.v7i1.122424

Murdiyanto, T., Wijayanti, D.A., & Sovia, A. (2023). Identify Slow Learners in Math: Case Study in Rural Schools. *International Journal of Interactive Mobile Technologies, 17*(6).

Obina, J.E., Gabe, J.B., Angcon, S.M.D., Diaz, B.T.R., Largo, V.J.Y., Chiva, M.C., & Bolaňos, J.G. (2022). Math Apps Utilization: Its Perceived Effects To The Academic Performance Of Mathematics Major Students. *European Journal of Education Studies, 9*(9).

Orbon, C. R., & Sapin, S. B. (2022). Effectiveness of Game-Based Learning Instructional Materials in Enhancing the Mathematics Performance of Grade 8 Learners. *The Asian Journal of Education and Human Development (AJEHD), 3*(1).

Perera, N. T., Wijerathne, I. S., Wijesooriya, M. M., Dharmarathne, A., & Weerasinghe, R. (2014). A game based learning approach to enrich the special education

in Sri Lanka. *The International Journal on Advances in ICT for Emerging Regions, 7*(2).

Rohizan, R., Soon, L. H., & Mubin, S. A. (2020). MathFun: Examining the Effectiveness of Calculic Model in Designing App for Dyscalculia Children. *Journal of Physics: Conference Series, 1712*(1), 012031.
Sari, E.N. and Zamroni, Z., 2019. The impact of independent learning on students' accounting learning outcomes at vocational high school. *Jurnal Pendidikan Vokasi, 9*(2), pp.141-150.

Sutomo, W. A. B., & Herman, T. (2023). Mathematics Learning for Slow Learners at Regular Schools. *Al Fikrah,ÄØ: Jurnal Manajemen Pendidikan.* https://doi.org/10.31958/jaf.v11i1.6767

Tahir, R., & Arif, F. (2014). Framework for evaluating the usability of mobile educational applications for children. *Society of Digital Information and Wireless Communications,* 156-170.

Valencia, K., Rusu, C., Botella, F., & Jamet, E. (2022). A Methodology to Evaluate User Experience for People with Autism Spectrum Disorder. *Applied Sciences, 12*(22), 11340

# TRACK - COMPUTING AND INFORMATION SYSTEM (CIS)

# In-Depth Exploration of LLM's Adoption in Shaping Future Expectations among Sri Lankan Undergraduates

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## Abstract

*An extensive language model called ChatGPT created by the OpenAI Foundation, has created a significant impact in academia and industries, especially due to its impressive performance, particularly in synthesizing human-like results from vast amounts of data. Despite numerous research efforts on top of ChatGPT, there is a paucity of literature providing in-depth analysis among undergraduates, the group that utilizes ChatGPT the most. Thus, this study addresses this gap through an in-depth analysis based on data collected through a structured questionnaire administered to 171 undergraduates. The questionnaire covered various aspects related to the usage of ChatGPT, including awareness, frequency of usage for learning, accuracy of information, perceived improvements, and future expectations from language models. Results indicate that ChatGPT is well-known and used frequently for academic reasons, especially for preparing assignments and exams. While most students appreciate LLMs, appropriately half have encountered partially accurate answers, revealing limitations in information accuracy. Some students emphasize the importance of promoting individual study and critical thinking skills, while others advocate for more comprehensive responses, including visuals and video lectures. Many students claim that LLMs have improved their academic performance, and LLMs tend to be favored among these undergraduates. These insights underscore the potential for LLMs like ChatGPT to transform learning and research experiences, emphasizing the need for ethical surveillance and adaptation to shifting student expectations while addressing issues of accuracy and bias. This positions LLMs as useful tools for knowledge acquisition and exploration in academia's changing digital landscape.*

*Keywords: Large Language Models (LLMs), ChatGPT, Chatbots, Undergraduates, Ethical Surveillance*

## I. INTRODUCTION

Technology developments have brought forth a new era of interaction and learning in the contemporary higher education landscape. The application of artificial intelligence (AI) in education is rapidly widening in response to changes in the teaching, learning, and assessment processes at all educational levels, from elementary to higher (Gamage et al., 2023). The potential for LLMs to have a big impact on undergraduate students' academic experiences makes them one of these developments to watch out for. Developments in the LLM's space have been accelerating at breakneck speed since late November 2022 (Rudolph, Tan and Tan, 2023). A variety of platforms have emerged as a result of LLM's technology being used by educational institutions; each is trying to provide the best user experience for supporting and engaging students.

The use of LLMs, which are built on the foundation of Natural Language Processing (NLP), which has the ability to engage students in lively conversational exchanges while answering questions, streamlining administrative procedures, and promoting engaging learning experiences. An important model in this field is ChatGPT, which is powered by the powerful language model created by OpenAI. A spectrum of other solutions, each positing certain strengths and features, has nevertheless also arisen in the dynamic environment of LLM's development. Therefore, it is crucial to thoroughly examine these alternatives, evaluating their efficacy, accuracy, and user happiness. This study conducts a thorough investigation into the effects of ChatGPT on higher education, focusing specifically on comparing ChatGPT with other LLM strategies. The emphasis is on evaluating their impacts and discerning the future expectations of undergraduate students. This investigation aimed to perform both analytical and empirical research, with the goal of conducting a detailed comparative analysis. It aims to compare

and contrast ChatGPT with the approaches of different LLMs while clarifying how undergraduate students' perceptions of ChatGPT and LLMs have become an essential element of their educational environment changes. This study strives to significantly impact to the conversation about the use of technology in education by contrasting its current impact with its future potential and highlighting how it aligns with the changing requirements of the digitally savvy undergraduate generation.

## II. RELATED LITERATURE

The literature extensively covers the utilization of Language Models (LLMs) by undergraduates and the associated benefits. This section presents recent research findings specifically related to ChatGPT in the education domain. Additionally, it offers an overview of research conducted using ChatGPT across various academic disciplines, including Medicine, Computer Science, Engineering, and other applied sciences. ChatGPT having made significant strides in recent years, as a top AI language model, has a significant impact on scientific research in a variety of fields (Ray, 2023). Ray (2023) uncovers its history, uses, difficulties, and prospects for the future while highlighting the substantial ethical difficulties, including biases and privacy concerns. The study also cautions that while ChatGPT has the potential to bring about complete transformations in scientific research, as it garners increasing attention in academia, research, and enterprises, ethical issues must be carefully considered.

### A. Ethical Considerations and the Possibility of Getting Caught

Khalil and Er (2023) discussed that ChatGPT is capable to produce complex text outputs without being easily detected by any plagiarism detection technologies. They further confirmed that the content produced by ChatGPT on a variety of subjects are very creative and appears to have been produced originally by someone which would eventually help students in accomplishing their tasks without great effort. This behavior underscores the necessity for institutions to adopt highly effective and efficient plagiarism detection tools.

Meanwhile, Perkins (2023) also highlighted the concerns towards academic integrity of students' usage of Artificial Intelligence (AI) tools

especially of the usage of Large Language Models (LLMs) such as ChatGPT in formal assessments. The potential of these tools for producing unique, cogent material that can resist detection by both skilled academic personnel and present technological means of detection highlights a serious issue for academic integrity regarding the usage of these tools. Similarly, Rahman and Watanobe (2023) discussed about the services provided by ChatGPT and the risks to the conventional research and education system, such as the potential for online exam cheating, the creation of text that resembles human writing, the loss of critical thinking abilities, and the challenges associated with evaluating the material produced by ChatGPT. The research mainly targeted the programming related contents generated from ChatGPT and judged the accuracy of them while conducting a survey on how undergraduate, graduate, and doctorate students and instructors use ChatGPT to enhance their programming learning and teaching. Meanwhile, in a recent work by Malinka et al (2023) expounded upon the acceleration of the learning process by students through the utilization of ChatGPT. This observation serves as a noteworthy indication of the preparedness of artificial intelligence tools to contribute significantly to the attainment of a university degree.

### B. ChatGPT and other Alternative LLMs

Students employ ChatGPT not only as a supplementary tool for academic and research purposes but also actively explore alternative platforms, including Bing Chat, Bard, and Ernie (Motlagh et al., 2023). Motlagh et al. (2023) compared these platforms as how those models were trained and how other platforms are being used while highlighting the meteoric rise of ChatGPT to one million users in just five days.

Another qualitative case study pinpointed ChatGPT as a fine and recent example of AI-powered LLMs using three steps (Tlili et al., 2023). The steps included social network analysis of tweets, content analysis of interviews, and investigation of user experiences. A further sentiment analysis on the data collected demonstrated that positive sentiments (5%) outweigh negative sentiments (2.5%) with regards to the usage of Chatbots. Another research proposed a framework with the concept of changing pedagogical activities and facilitating interactive guidance between students and

instructors through intelligent chatbots built on generative artificial intelligence (GAI) technology (Ilieva et al., 2023). The framework showed that chatbots can help overcome the difficulty of providing tailored learning experiences for students. The researchers have further explored and compared the main characteristics of existing educational chatbots with advantages of the proposed framework for enabling the successful application of AI chatbots in education and offers a comprehensive grasp of their transformational potential. This study not only provides a comprehensive approach to improve the quality of education generally, but also harmonizes the use of intelligent chatbots in university teaching and learning activities.

## III. MATERIALS AND METHODS

This study used a quantitative research strategy and collected data solely through a structured questionnaire. The main target group was the undergraduates of Sri Lankan state universities. The total number of data collected for the sample was 171. It is in line with the study of Ilieva et al. (2023) where they used a sample of 131 to develop a framework based on the response from students. All the participants were approached to receive the responses as higher as possible. The study utilized a structured questionnaire approach to limit the responses from only the undergraduate students of Sri Lanka in place of scraping data from social media in order to carry out a controlled study. Each administered with the study instrument via WhatsApp after validating that the respondent is an undergraduate. All these responses were received between 13th of September to 24th of September, 2023.

The survey included a series of questions to collect both demographic details and various factors related to the use of ChatGPT such as their awareness regarding the LLMs, the frequency of using ChatGPT for their learning and academic works, the accuracy of the information that they derived from ChatGPT for their intended work, the improvements that they have gained, and their future expectations from the LLMs with their satisfaction of this support. In addition to the above, we were interested to collect their opinions on security issues as well. The collected data were analyzed using basic statistical software and the results are presented in the following section.

## IV. RESULTS AND DISCUSSION

This section presents the obtained results and their respective interpretations. Figure 01 depicts the field of study of the respondents of this survey, and majority of them are from the field of Computer Science and IT, where others are from applied sciences and medical related backgrounds. It could be seen that out of the respondents, 8.77% are first year undergraduates, 30.40% are second year undergraduates, 45.02% are third year undergraduates, 9.35% are fourth year undergraduates from all fields mentioned below. 2.33% of them are 5th year medical faculty undergraduate students and remaining students have just completed their degree and waiting for graduation.

The awareness of ChatGPT among the students were also assessed where we found that 93% of the students know what ChatGPT was where only 4% claimed that they have no idea. We also found that around 3% of the respondents were aware of this platform, yet have not used it. This indicates that ChatGPT has become quite popular among the undergraduates within a short period from its launch and many students have utilized for varying academic purposes.  It has been consistently claimed that the accuracy of the ChatGPT was practically low. Thus, to assess the accuracy and reliability of ChatGPT, we were interested to obtain the feedback from its real users. The results showed that nearly 53.21% of the respondents have experienced partially inaccurate answers which raises concerns on the reliability of ChatGPT for academic purposes. It is also worthy of note that 3.05% of respondents have received fully inaccurate responses as well. The frequency of using the ChatGPT was also assessed using this questionnaire. The results were surprising to see that majority have used it even several times in a week as shown in Figure 02. While the assessment on main purpose of using ChatGPT was found to be for completing assignments as given in Figure 03.

In addition to the use of ChatGPT, we were interested in investigating the usage about other alternative LLMs available similar to ChatGPT and their awareness about them. The results depicted in Figure 04 reveals that they were aware of Google Bard, Microsoft Bing AI as well. In addition, it is noteworthy that 56.72% of the surveyed students expressed a preference for further development of Large Language Models

(LLMs) and the inclusion of more comprehensive information, including visual aids and embedded video tutorials within the responses they receive. This inclination toward enhanced LLM capabilities was met with a contrasting viewpoint, as 21.05% of the respondents disagreed with the concept, asserting that they would prefer a more research-oriented and self-driven approach to learning, rather than relying on a single-click solution.
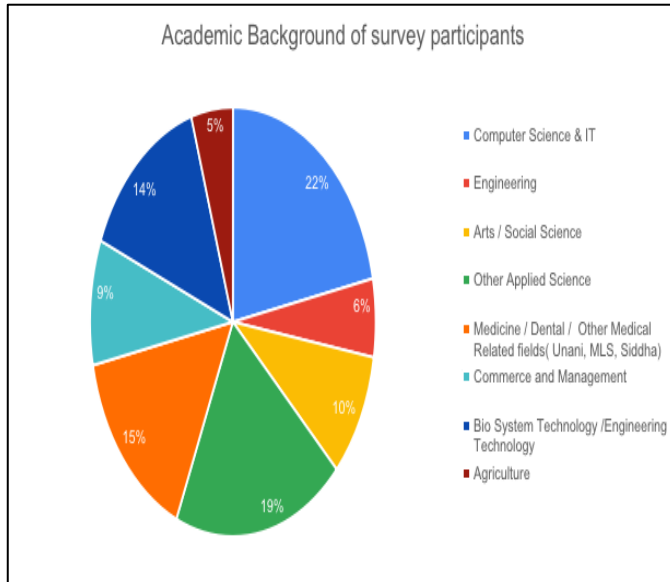


Figure 02: Academic Background of Participants
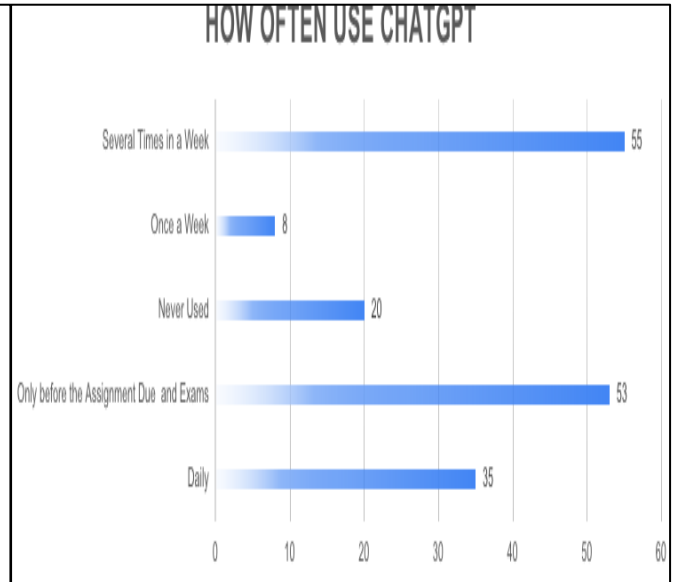


Figure 02: Frequency of using ChatGPT
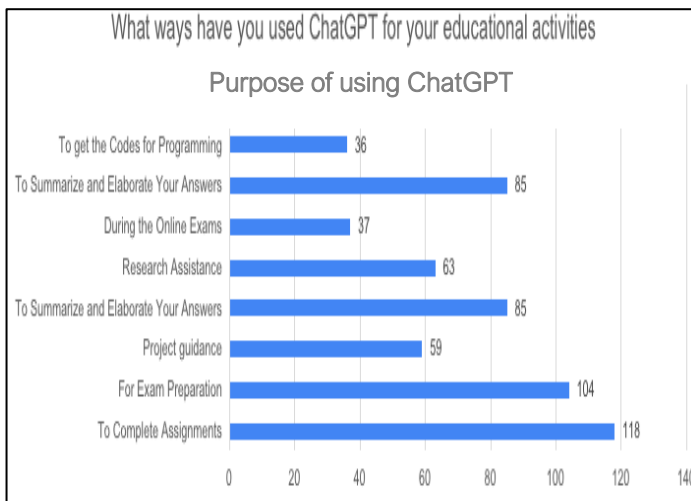


Figure 01: Purpose of using ChatGPT
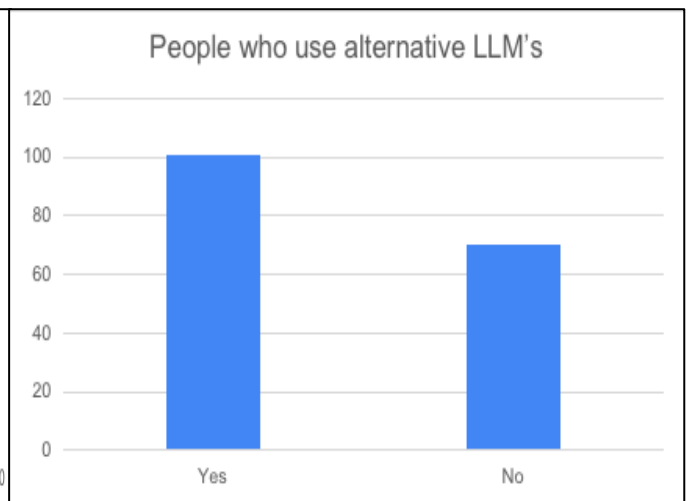


Figure 04: Usage of alternative LLMs
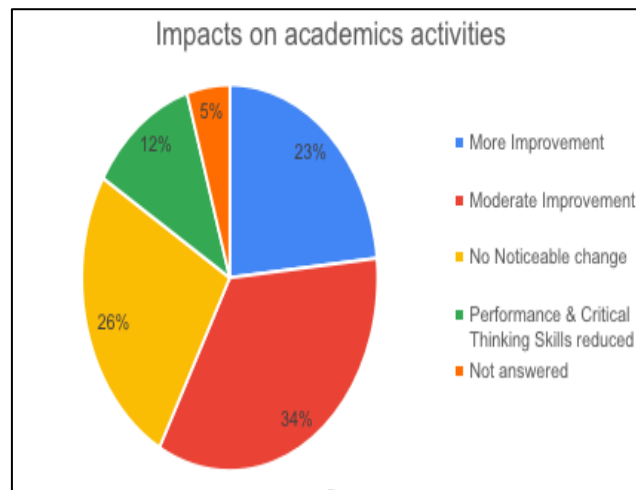
Figure 05: Impact on Academic Activities

While concerns have been raised regarding the potential impact of LLMs on students' critical thinking abilities, it remains significant that the majority of students are inclined towards the convenience offered by these technologies. This inclination suggests the possibility of a future generation that may rely more heavily on technology for knowledge acquisition, potentially at the expense of fostering innovation and critical thinking skills.

The impact of using ChatGPT for academic works was also assessed by querying on the various improvements, critical thinking skills etc. where majority of respondents observe moderate improvement while it was surprising to witness that around 12% of the respondents claimed that their critical thinking and performance gradually deteriorated upon using ChatGPT for their academic purposes (Figure 05). This also raises concerns where the use of ChatGPT for every need of the academic activities require a serious caution and we advise the limited use of this platform. Finally, the overall satisfaction of using ChatGPT was assessed where more than three fourth of the respondents have rated 3 or above which indicates that the acceptance of ChatGPT among the undergraduate students is quite high.

IV.CONCLUSION

The arrival of Large Language Models (LLMs) like ChatGPT into the world of learning and research has resulted in a revolutionary period marked by improved accessibility and support for a wide range of undergraduates from different field of studies. These LLMs, have the capacity to engage in complex discourse and generate text that simulates human speech, have proven essential in tackling a variety of educational tasks, including responding to inquiries, assisting with research, and enabling teaching and learning. To be clear, LLMs do have several limitations in addition to their exceptional talents. They still provide several inaccurate results and provide the students with wrong understandings incase if they fail to analyze the results that they obtained. These include bias susceptibility, difficulty with complicated reasoning, and a constrained capacity for processing visual data. The ethical considerations of using LLMs, since our survey proves that majority of the students rely on ChatGPT's assistance with their assignments doubts the originality along with the worries about bias elimination, privacy protection, accountability, and wider societal effects, call for thorough investigation. Despite these obstacles, our data indicates a positive future for LLMs in undergraduate education, reflecting changing student expectations. While adhering to strict ethical guidelines, educational institutions and developers must be flexible in developing LLMs to meet these changing demands. However, we would also like to highlight the negative impact that ChatGPT has on the deterioration of critical thinking and certain other skills along with its questionable reliability that require caution for the users. In conclusion, while acknowledging the difficulties and ethical nuances inherent in LLM deployment, we argue that LLMs like ChatGPT hold the potential to significantly improve undergraduates' educational and research experiences by providing them with potent tools

for knowledge acquisition and exploration in the rapidly changing digital landscape of academia.

## V. LIMITATIONS AND FUTURE WORKS

It is crucial to point out that the research undertaken in this study used ChatGPT as its base, which is now undergoing active development. During our survey conducted with in a very short period of time we have only able to get the response from only 171 undergraduates which is not much sufficient when we consider about the overall count of the undergraduates in Sri Lankan state universities. We believe that more amazing results can be derived if we focus on some more respondents. Meanwhile developing a framework which can suggest some better ways to utilize these LLMs for teaching and learning could be more beneficial since there is more thirst among the undergraduates regarding the advancement of these chatbots. Therefore, we could focus more on creating an effective framework as our future scope which will aid in analyzing the accuracy of response receive from these chatbots.

REFERENCES

Gamage, K.A., Dehideniya, S.C., Xu, Z. and Tang, X., (2023) 'ChatGPT and higher education assessments: more opportunities than concerns?', *Journal of Applied Learning and Teaching*, 6(2).

Gravel, J., D'Amours-Gravel, M. and Osmanlliu, E. (2023) 'Learning to Fake It: Limited Responses and Fabricated References Provided by ChatGPT for Medical Questions', *Mayo Clinic Proceedings: Digital Health*, 1(3), pp. 226–234. DOI: 10.1016/j.mcpdig.2023.05.004.

Ilieva, G. *et al.* (2023) 'Effects of Generative Chatbots in Higher Education', *Information*, 14(9), p. 492. DOI: 10.3390/info14090492.

Khalil, M. and Er, E. (2023) 'Will ChatGPT Get You Caught? Rethinking of Plagiarism Detection', *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, 14040 LNCS, pp. 475–487. doi: 10.1007/978-3-031-34411-4_32.

Malinka, K. *et al.* (2023) *On the Educational Impact of ChatGPT: Is Artificial Intelligence Ready to Obtain a University Degree? Annual Conference on Innovation and Technology in Computer Science Education, ITiCSE*. Association for Computing Machinery. DOI: 10.1145/3587102.3588827.

Motlagh, N. Y. *et al.* (2023) 'The Impact of Artificial Intelligence on the Evolution of Digital Education: A Comparative Study of OpenAI Text Generation Tools including ChatGPT, Bing Chat, Bard, and Ernie'.

Perkins, M. (2023) 'Academic Integrity considerations of AI Large Language Models in the post-pandemic era: ChatGPT and beyond', *Journal of University Teaching and Learning Practice*, 20(2). DOI: 10.53761/1.20.02.07.

Rahman, M. M. and Watanobe, Y. (2023) 'ChatGPT for Education and Research: Opportunities, Threats, and Strategies', *Applied Sciences (Switzerland)*, 13(9). DOI: 10.3390/app13095783.

Ray, P. P. (2023) 'ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope', *Internet of Things and Cyber-Physical Systems*, 3(March), pp. 121–154. DOI: 10.1016/j.iotcps.2023.04.003.

Rudolph, J., Tan, Shannon and Tan, Samson (2023) 'War of the chatbots: Bard, Bing Chat, ChatGPT, Ernie and beyond. The new AI gold rush and its impact on higher education', *Journal of Applied Learning and Teaching*, 6(1), pp. 364–389. DOI: 10.37074/jalt.2023.6.1.23.

Tlili, A. *et al.* (2023) 'What if the devil is my guardian angel: ChatGPT as a case study of using chatbots in education', *Smart Learning Environments*, 10(1). DOI: 10.1186/s40561-023-00237-x.

# A Comprehensive Introduction to Convolutional Neural Networks: A Case Study for Leaf Image Classification

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## Abstract

*Most of the today's new and innovative artificial intelligence applications are based on the artificial neural types of networks to capture, interpret and analyze various kind of data. A Convolutional Neural Network is a type of artificial neural network used primarily for image recognition and processing due to its ability to patterns in images. A deep learning algorithm is adopted to classify images and detect objects in an image with the neural network. In this study, Convolutional Neural Networks Model is used for performing automatic feature extraction on binary classification with leaf image dataset. It works by investigating and processing large amount of data in a grid format and then extracting important features for classification detection. It is discussed in this study the use of deep learning techniques to automatically detect diseases in plants. Further, it emphasizes the working principles of Convolutional Neural Networks. Hence, the study intends to present a comprehensive way of the modeling techniques. Moreover, the study seeks fundamentals on deep learning mechanisms which is useful to beginners on the area of artificial intelligence. Therefore, this study is carried out intentionally as a case study which emphasizes the automatic leaf image binary classification. The findings of the present study showed 81.3% of the maximum accuracy of the modeling.*

*Keywords: Artificial Intelligence, Binary Classification, Convolutional Neural Networks, Deep Learning, Disease Identification, Feature Extraction*

## I. INTRODUCTION

The Convolutional Neural Network (CNN) models can be used to determine diseases in plants based on leaf images, since CNNs have performed higher accuracy results in the machine vision (Barbedo, J.G.A., 2016). It is a very difficult task of determining healthiness of plant leaves based on image, as it is difficult to extract leaf features exactly. It also affects the capturing of environment. Healthiness of leaf leads to the healthiness of its plant (Wallelign, Polceanu and Buche, 2018). There is a continuous development in predicting plant diagnosis with digital image processing and computer vision techniques. In the proposed approach, there are two phases which follows firstly reviewing the existing literatures of necessities on developing framework of CNN models and then illustrating the model with a leaf image dataset. The study investigated and analyzed the most recent methods for recognizing and practicing of an algorithm with CNN model on classifying leaf categories.

There may be an error visually when identifying diseases by human. The detecting and classifying diseases which is the great importance in a timely manner (Barbedo, 2016). The classification of data is graded by employing Fuzzy Logic to determine a particular class. In this analysis, a high computational effort is required for such an image processing-based method but some initiatives can reduce the computational cost Hassan *et al.*, 2021. We also investigated the role of image analysis in automated process and recognition, regardless the object of the images.

The present study aims to develop a profile of CNN classification algorithm tailored for image classification techniques. In addition, the secondary objectives are to determine the set of employed features and the framework for the image restoration and to evaluate the influencing characteristics of the images. Making it more difficult for an automatic algorithm to perform a meaningful analysis on a ground level, a comprehensive view of the modeling techniques has been incorporated in this study.

It is important to notify since the identification of plant diseases is considered as a timely needed study for taking wise decisions on protecting the plant and its quality, the automated disease identification may help in finding a remedy at the earliest stage to control the damages in plant.

Deep learning seems to be a better option to resolve this challenge (Zhang, Zhang and Lv, 2022). Most of the methods are only capable for discriminating particular type of diseases. The present study intended to learn how CNN classification algorithm determines a crop healthy or not.

## II. LITERATURE REVIEW

Wallelign, Polceanu, and Buche in 2018 described the feasibility of CNN for plant disease classification in leaf images taken under the natural environment. The model was designed based on the LeNet architecture to perform the soybean plant disease classification. A large number of samples containing leaf images of four classes, including the healthy leaf images, were obtained from the Plant Village database. The images were taken under uncontrolled environment. The classification accuracy of 99.32% is achieved through this implemented model which shows clearly that CNN can extract important features and classify plant diseases from images taken in the natural environment.

Barbedo in 2016 used a method for disease identification, based on color transformations, color histograms and a pairwise-based classification system. Its performance was tested using a large database containing images of symptoms belonging to 82 different biotic and abiotic stresses, affecting the leaves of 12 different plant species. By analyzing the above literatures, present study intend to perform CNN analysis with binary classification on leaf disease identification because CNNs are used in a variety of computer vision tasks due to their flexibility.

## III. MATERIALS AND METHODS

### A. Materials

Firstly, the digital images were acquired from the environment by using smart phone cameras. Figure 01 shows some sample images from dataset.

Then the image-processing techniques were applied to the acquired images to extract useful features that are necessary for further analysis. After that, several analytical discriminating techniques were applied to classify the images according to the specific problem in hand. Figure 02 depicts the basic procedure of the proposed vision-based detection algorithm in this research (Zhang et al.,2015).



Figure 01: Sample Images
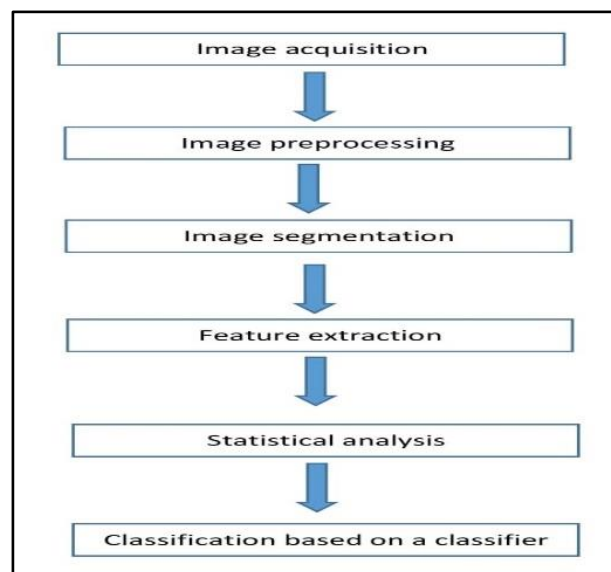


Figure 02: Overall Framework of the Study

*B. Methods*

Leaf image data were collected from different home gardens in various weather conditions, at different angles, and daylight hours with an inconsistent background mimicking practical situations (Barbedo, J.G.A., 2016). The Table 01 shows the sample collections of leaf images.

The dataset contains over 200 images (Table 01), the multiple plant types and lesion types and the staggering differences in the images make it difficult to perform feature extraction. Nevertheless, deep learning, particularly the CNN model, necessitate numerous data to undertake the training process (Wallelign, Polceanu and Buche, 2018). Therefore, it is necessary to adopt data augmentation on the dataset before performing feature extraction. The sample images after data augmentation is shown in Figure 03.

IV. CASE STUDY

In this section, it is considered the problem of recognizing several sources to illustrate the application of CNN. It consists of four main layers: convolutional layer, pooling layer, activation function layer and fully connected layer (Wallelign, Polceanu and Buche, 2018). This model is developed in Python language by using the deep learning libraries: NumPy, and Keras. The experimental environment is Jupyter Notebook, with Python 3.7. Researchers used a batch size of 32 that is a hyper-parameter to adjust in deep learning. The sample data generation for training is shown Figure 04.

Table 01: Details of Leaf Image Dataset

| Type | Leaf Image | |
| --- | --- | --- |
| | Class | No. of Images |
| Common | C | 66 |
| Damaged | D | 74 |
| Good | G | 69 |

Source: Developed by Researchers



Figure 03: Sample Images After Augmentation
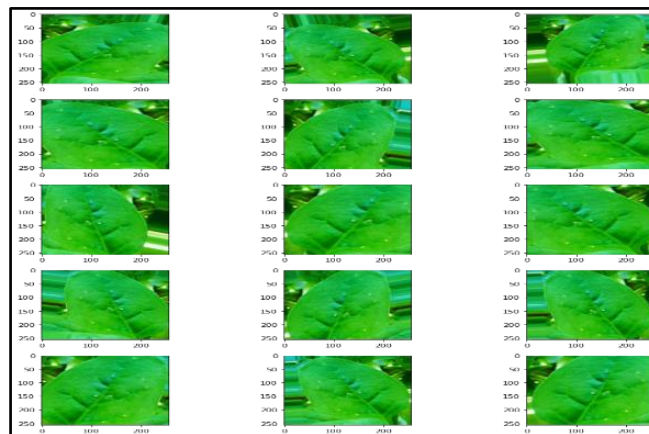


Figure 04: Example of Validated Images

## V. RESULTS AND DISCUSSION

This section presents the results individualized for each plant species, which are labeled in alphabetical order without considering the original plant species categories. It is found from the validation that the algorithm provided reasonably good estimates in 80% of the cases. Table 02 shows that the comparison of modeling approach with related studies. The breakdown list of extracted output is shown in Table 03 and The proposed algorithm for training accuracy versus validation accuracy is shown in Figure 05.

Table 02: Results Comparisons with Related Studies

| Reference | Year | Used Architecture | Limitations |
|---|---|---|---|
| Barbedo | 2016 | LeNet | Limited effectiveness for sequential data. |
| Hassan *et al.* | 2021 | VGG-16, VGG-19, | Needs large amount of labeled data. |
| Wallelign et al. | 2018 | VGG-16, VGG-19, ResNet, InceptionV3 | Needs large amount of labeled data. |
| Zhang *et al.* | 2022 | ResNet-50, SE-ResNet-50 | High computational requirements. |
| Zhang *et al.* | 2015 | AlexNet Fuzzy-SVM, CNN, R–CN | No real-time web-based deployment |
| Our proposed approach | - | CNN | Single model applied, No deployment |

Table 03: Model Fit Generator

| |
|---|
| 22/22 [======] - 20s 932ms/step - loss: 0.6815 - accuracy: 0.6509 - val_loss: 1.0714 - val_accuracy: 0.6400 - lr: 1.0000e-05 |
| Epoch 2/30 |
| 22/22 [======] - 20s 910ms/step - loss: 0.7877 - accuracy: 0.6132 - val_loss: 1.0674 - val_accuracy: 0.6000 - lr: 1.0000e-05 |
| Epoch 3/30 |
| 22/22 [======]- 20s 912ms/step - loss: 0.7242 - accuracy: 0.6887 - val_loss: 0.9475 - val_accuracy: 0.6400 - lr: 1.0000e-05 |
| Epoch 5/30 |
| 22/22 [======]- 20s 907ms/step - loss: 0.7424 - accuracy: 0.6226 - val_loss: 1.0236 - val_accuracy: 0.5600 - lr: 1.0000e-05 |
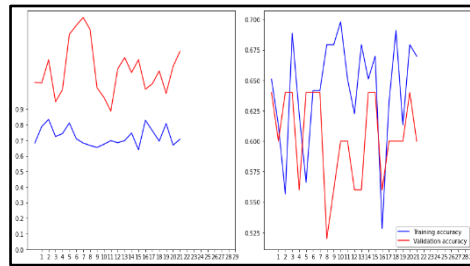
Figure 05: The Model Training Accuracy Versus Validation accuracy

## VI. CONCLUSION

The present study provided guidelines and procedures to follow in order to maximize the potential of CNNs deployed in real-world applications. Accordingly, the overall accuracy of the algorithm for leaf image classification was 81.3%. The binary classification applied intentionally in order to make quick decision. Based on the results, controlling the trade-off between accuracy and training speed, it is recommended that slowly increase the number of kernels and add new layers would be a successful process. Findings from this research can be extended in future studies by incorporating more practical implications for real time classification tasks in massive and small level in the field of agriculture.

## REFERENCES

Barbedo, J.G.A., (2016) "A review on the main challenges in automatic plant disease identification based on visible range images", *Biosystems engineering*, 144(7), pp.52-60.

Hassan, S.M., Maji, A.K., Jasiński, M., Leonowicz, Z. and Jasińska, E., (2021) "Identification of plant-leaf diseases using CNN and transfer-learning approach", *Electronics*, 10(12), pp.126-138.

Wallelign, S., Polceanu, M. and Buche, C., (2018) May. "Soybean plant disease identification using convolutional neural network", *FLAIRS conference*, 12(3), pp. 146-151.

# TRACK - FOOD SCIENCE AND TECHNOLOGY (FST)

# Determination of Curcumin Content, Moisture and Color of Powdered Turmeric Obtained from Turmeric Accessions Grown Under Coconut in Low Country Intermediate Zone in Sri Lanka

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## Abstract

*Turmeric (Curcuma longa) is a prominent spice, colorant, and preservative, belongs to the family Zingiberaceae, widely cultivated in Asian countries including India, China, and Sri Lanka. Curcumin is the most imperative fraction of turmeric, responsible for its biological activities. Study the variation of curcumin content in turmeric accessions grown in Sri Lanka is important to produce more and more turmeric with higher curcumin contents. This study was mainly focused to determine the curcumin content of different turmeric accessions collected from different locations of Sri Lanka and cultivated under coconut at the Intercropping and Betel Research Station, Department of Export Agriculture at Dampallassa, Narammala with similar agronomic practices. Curcumin content was evaluated dry weight basis using the spectrophotometer. The results clearly revealed that there were significant differences (p<0.05) among turmeric accessions in curcumin contents. Curcumin contents were ranged from 0.3458±0.037% to 4.9881±0.0141%. From the results, it was evident that the curcumin content of T12, T26, T3, T2, T8, and T5 complies with the range identified in the Sri Lankan standard level (3-6%). Further, turmeric powder found in world market have marked the average curcumin content from 2% to 6% by weight. Locally grown accessions also resulted in between curcumin contents and it proves that Sri Lankan turmeric is suitable for exports. Moisture contents of all turmeric accessions were in the agreement of standards of Sri Lanka Standards Institute (SLSI) which is 12% in maximum. Moreover, cluster analysis revealed that all accessions were classified into three groups which will be extremely useful to initiate breeding programs.*

**Keywords: Turmeric, Curcumin, Spectrophotometer**

## I. INTRODUCTION

Turmeric (*Curcuma longa*) is a herbaceous perennial plant belongs to the family Zingiberaceae native to tropical South Asia, mainly cultivated in India, China, Bangladesh, and Indonesia. The rhizomes of turmeric are mainly used as a condiment and coloring agent in the food industry. Additionally, it has a great demand in cosmetics, pharmaceutical industry, and Ayurvedic medicine (Abeynayaka et al., 2020). Turmeric is grown in many parts of Sri Lanka as a mono-crop and as an intercrop under coconut. In Sri Lanka, major growing districts are Kurunegala, Gampaha, Kalutara, Kandy Matale, and Ampara. Though there are several locally grown accessions, they are not yet genetically identified.

Turmeric contains 69.4% carbohydrates, 6.3% protein, 5.1% fat, 3.5% minerals, and 13.1% moisture. Curcumin (3–4%) is responsible for the yellow color, and comprises curcumin I, II and III (Nasri et al., 2014). Curcumin is the main active compound as well as the main coloring agent of turmeric. Curcumin is a yellow color hydrophobic polyphenolic derivative with both biological and pharmaceutical advantages. Curcumin content directly effects on determining the color of turmeric. The turmeric types with a high curcumin content appear in bright yellow color while the turmeric with a low curcumin content appears in pale yellow color (Madhusankha et al., 2018).

Curcumin content in turmeric varies from 2-6%. Turmeric contains more than 5% of curcumin have good demand for the export market. Turmeric which is grown in Sri Lanka has a good export market due to its higher curcumin percentage (4%-6%) (DEA, 2021). Curcumin has various useful properties with antioxidant activities and is useful in conditions such as

inflammation, ulcer, diabetes, allergies, arthritis, Alzheimer's disease, and cancer. Therefore, the development of modern drugs from curcumin has been emphasized for the control of various diseases (Nasri et al., 2014). Curcumin content in turmeric depends on the accession, use of fertilizers, location, agricultural practices, and degree of maturity. The amount of curcumin content in the turmeric effects both the quality and the price. Turmeric has a long history of use in food as a spice, mainly as an ingredient in many varieties of curry powders and sauces, where curcumin is the main coloring substance (Joshi, Kulkarni and Cherekar, 2021). In Southeast Asia, turmeric is used not only as a principal spice but also as a component in religious ceremonies (Prasad and Aggarwal, 2011). It is also used in social and religious ceremonies in Ayurvedic and folk medicines. (Tanvir et al., 2017). Traditionally turmeric was called "Indian saffron" because of its deep yellow-orange color. (Joshi, Kulkarni and Cherekar, 2021).

As many as 133 species of *Curcuma* have been identified worldwide. (Prasad and Aggarwal, 2011). It is a perennial, leafy, and erect plant. Turmeric is usually grown as an annual crop. It needs warm and slightly humid atmosphere. Optimum temperature for turmeric growth is between 20-35 °C and optimum annual rainfall is 1500mm or higher (DEA). The rhizomes of turmeric possess finger-like projections and segmented skin (Yadav et al., 2013). The turmeric rhizomes are branched and fleshy. The primary rhizome is ovate and mostly pear-shaped, known as "bulb" and the secondary one is cylindrical, known as fingers. The rhizome color varies yellow to orange. But externally rhizomes are brownish and scaly. As the rhizomes are matured, it is harvested, cleaned, boiled, dried and ground to a fine powder to make turmeric powder (Prasad and Aggarwal, 2011).

Turmeric, being an annual crop, it is harvested annually for the rhizomes and reseeded from some of those rhizomes in the following season (Prasad and Aggarwal, 2011). Matured finger rhizomes are the most suitable planting material. A piece of the rhizome should be 30-50g in weight. Planting material should be disease free and selected from high-yielding cultivation. Before planting, rhizomes should be immersed in a fungicide (Mancozeb 30g/10L of water) for about 5 minutes to avoid fungal growth during planting. The planting material requirement is 1500-2000kg/ha (DEA, 2021).

Curcuminoids consist of curcumin demethoxycurcumin, 5'-methoxycurcumin, and dihydrocurcumin, which are found to be natural antioxidants (Prasad and Aggarwal, 2011). Natural curcumin from the turmeric rhizome consists 77% of Curcumin I, 17% of Curcumin II, and 3% of Curcumin III (Hettiarachchi et al., 2021). Curcumin was initially isolated in 1815 and its actual chemical configuration was determined in 1973 (Yadav et al., 2013). As a food additive, its E number (codes for substances used as food additives) for use within the European Union (EU) and European Free Trade Association (EFTA) is E100 (Jiang, Ghosh and Charcosset, 2021). Curcumin is a safe to use as a food cosmetic additive and pharmaceutical product.

Obtaining pure curcumin from plant sources is very important for fundamental research as well as for the above applications. There are two methods for obtaining curcumin: by means of synthesis and by extraction from plants. Obtaining curcumin, which is naturally present in plants by means of extraction still represents the most economical way for curcumin production. It is stated that the extraction procedure plays a critical role in determining the quantity and quality of bioactive compounds (Jiang, Ghosh and Charcosset , 2021).

Extraction is the first and foremost step in the recovery of curcumin from plant materials. Many different extraction methods ranging from conventional techniques to advanced extraction technologies have been exploited to obtain curcumin from plant materials (Jiang, Ghosh and Charcosset, 2021). Conventional extraction methods, such as Soxhlet extraction, maceration, or solvent extraction, are widely used to extract curcumin from plants. These methods are simple but are generally non-selective, time-consuming and in some cases cause the degradation of heat-sensitive substances (Liu et al., 2019). To surmount such obstacles, novel extraction methods such as ultrasound-assisted extraction, microwave-assisted extraction, enzyme-assisted extraction, and supercritical liquid extraction have been developed as more efficient alternatives to conventional extraction (Jiang, Ghosh and Charcosset, 2021).

It is important to determine the curcumin contents to choose turmeric accessions which are more suitable for further cultivations under coconut in the low country intermediate zone in Sri Lanka.

## II.    METHODOLOGY

The research was conducted at the Intercropping and Betel Research Station, Department of Export Agriculture at Dampallassa, Narammala, and sample analysis was carried out at the Central Research Station, Department of Export Agriculture, Matale.

Dried rhizomes of twelve different accessions of *Curcuma longa* were taken as the plant materials which had been planted in separate experimental plots at the same location under similar agronomic practices.

### A.   Sample Preparation

Twelve samples of turmeric accessions having a high yield were selected. Around one kilogram of fresh turmeric rhizomes was collected. Turmeric rhizomes were washed thoroughly and unwanted stem parts were removed.  They were left for one day in room temperature. Rhizomes were boiled in a closed pot for 20 minutes until they become tender. Boiled rhizomes were cut into small slices and put for sun drying. In first three days, drying was limited for 3-4 hours and after that continuously dried until the slices break easily. The whole sun drying process took 10 days. Polishing was done to reduce the rough appearance and dull surface color. The different accession types of turmeric samples were grounded using a grinder. Turmeric rhizomes were grounded for 2 minutes until passing through a 1mm diameter aperture. Then the samples were labeled and preserved in dry containers for curcumin extraction.


Figure 01: Fresh turmeric rhizomes


Figure 02: Cleaned turmeric rhizomes


Figure 03: Boiled turmeric rhizomes


Figure 04: Sliced turmeric rhizomes


Figure 05: Sun-dried turmeric rhizomes

Figure 06: Power form of turmeric

### B. Determination of the Moisture Content

The moisture content was determined by distillation method using toluene which is immiscible with water. Moisture content is calculated based on the amount of water which is collected into the graduated trap in the Dean and Stark apparatus.

*Procedure*

40 grams of turmeric powder samples were weighed from all accessions to the nearest 0.01g and the exact weights were taken (for calculations).

The weighed samples were transferred separately to the distill flasks and 150ml of toluene was added to cover turmeric portions completely. Receiving tubes were filled with toluene by pouring it through the top of the condenser until it begins to overflow into the distillation flask. Loose cotton plugs were inserted into the top of the condenser to prevent condensation of atmospheric moisture in the tube. A few pumice stones were added to maintain the even heating of the solution. The apparatus was commenced to boil and distilled slowly about 2 drops per second until most of the water distills over, then the rate of distillation was increased to 4 drops per second.

Distilling was continued until 2 similar consecutive readings are received at 15-minute intervals. Any water holds up in the condenser was dislodged with a wire loop. Condenser was rinsed carefully with 5 ml toluene. Distillation was continued for 3-5 minutes; the receiver was cooled to room temperature, allowing it to stand in air or cool in water. Solvent and water layers were kept aside until clearing occurred. The volume of water was recorded to the nearest 0.1ml and the percentage of moisture content was calculated. The test was carried out for three replicates for all accessions.

A correction blank for toluene was conducted by adding 1 ml of distilled water to 150 ml of toluene in the distillation flask. Refluxing was done at a rate of 2 drops per second until consecutive readings at 15-minute intervals showed no difference.

*Calculation*

Moisture content(%) =

$$\frac{\text{Volume of water}}{\text{Correction factor}} \times \frac{100}{\text{Dry weight of the sample}}$$

$$\text{Correction factor} = \frac{\text{Distilled volume mL}}{\text{Added volume mL}}$$

Dry matter content=100-Moisture percentage

(Ref - A.O.A.C 17th edition 2000 Official Method 986.21, Moisture in Spices/ I.S Specification No I.S 1797 – 185 Methods of Test for Spices and Condiments)

### C. Determination of the Curcumin Content

According to ASTA method 18.0, 0.1g of turmeric powder was weighed and put into a round-bottomed flask. Then 30ml of Ethanol was added and the round bottom flask was connected with a refluxing condenser. The reflux was done for two and a half hours and the apparatus was allowed to cool down. After that, it was filtered into a 100ml volumetric flask and was washed with Ethanol up to the mark. Then 2ml were pipetted out and put into a 25ml volumetric flask. Then the flask was topped up with 95% Ethanol. Finally, the absorbance was measured from the spectrophotometer at 425nm wave length, using alcohol as the blank.

*Calculation*

$$\text{Curcumin \%} = \frac{\text{Absorbance of the extract} \times 125}{\text{Cell length(cm)} \times \text{Dry weight of the sample}}$$

(ASTA Method 18.0)

## D. Determination of the Colour Composition Using Munsell Chart

Colour of twelve accessions of turmeric powder samples were determined using a Munsell plant color chart. Once identified the closest match on the Munsell chart with turmeric powder, it was recorded. Process was repeated for all twelve turmeric accession types.

## E. Statistical Analysis

The statistical analysis of data was determined using Analysis of Variances (ANOVA) at 0.05 level of probability and means were compared

in this solvent. Priyadarshani (2014) similarly indicated that ethanol is the preferred organic solvent for curcumin extraction. The estimation of curcumin was conducted using the spectrophotometer method, chosen for its simplicity, ease of use, cost-effectiveness, and practicality. The data were statically analyzed and the results are given in the Figure 07, 88 and 09.

The mean values of curcumin content were statistically analyzed. Analyzed data were envisaged that the P value was 0.00 and since P< 0.05, the null hypothesis was rejected. Therefore, there was a significant difference curcumin



| | T12 | MT23 | MT6 | MT26 | MT19 | MT3 | ET2 | ET8 | T9 | MT31 | MT33 | MT5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ■ Mean | 3.62963 | 0.34577 | 2.5728 | 4.2714 | 2.046 | 4.98807 | 4.18263 | 3.2297 | 2.83633 | 2.5381 | 2.96263 | 4.03823 |

Turmeric accession types
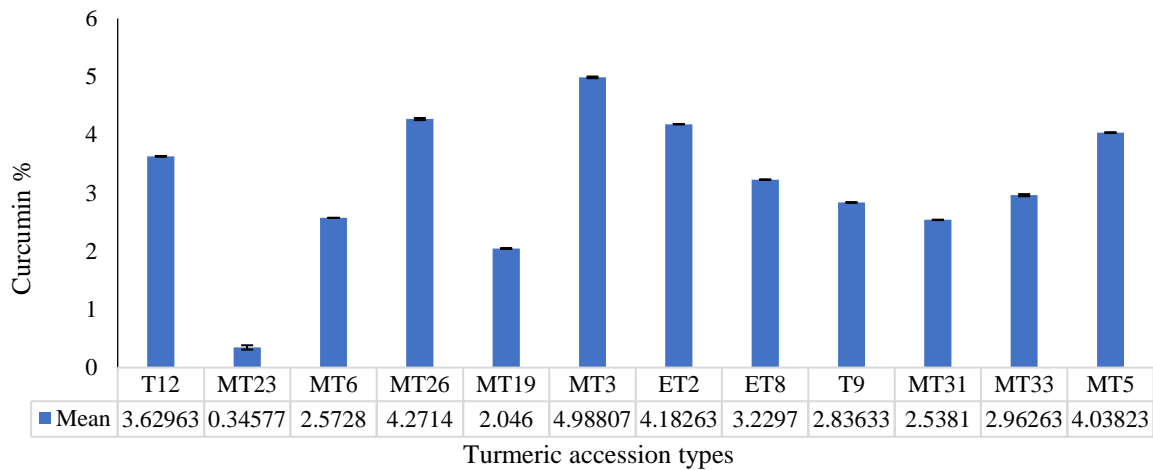
Figure 07: Curcumin content of dried turmeric accessions (SD = 1.23)

with the Tukey Test. Statistical analysis was performed with MINITAB 17 software. Graphical illustrations were done by the Microsoft Excel 2016 and cluster analysis was done using MINITAB 17 software.

## III. RESULTS AND DISCUSSION

### A. Determination of the Curcumin Content in Twelve Different Turmeric Accessions

Curcuminoids play a significant role as constituents of turmeric. Among curcuminoids, curcumin is the most important constituent. Curcumin is a symmetric molecule, also known as diferuloylmethane. One of the distinct features of curcumin is its vibrant yellow-orange color, which also serves as a key indicator of turmeric's quality. It is the major polyphenolic compound and the phenolic groups in the structure of curcumin contribute to eliminate oxygen derived free radicals.

Curcumin extraction involves the refluxing process with Ethanol due to its complete solubility

content of turmeric accessions. These statically analyzed data in the Figure 07 are shown that the accession type MT3 contains the highest curcumin percentage (4.9881±0.0141%) and accession type MT23 contains the lowest curcumin percentage (0.3458±0.037%).

According to Geethanjali et al. (2016), their study demonstrated that curcumin, a crucial nutrient in turmeric, is highly sensitive to light and can undergo rapid degradation. Due to its light-sensitive nature, the researchers took precautions during curcumin extraction by covering the flasks with aluminum foil to minimize its degradation.

Akamine et al. (2007) conducted a study where they observed a direct influence of geographical factors in cultivating regions and the quantities of Nitrogen and Potassium fertilizers on the promotion of curcumin content and yield in turmeric. Curcumin content can be enhanced by providing potassium alone.

Similarly, Kumar et al. (1992) found that curcumin content can be vary based on factors such as soil organic carbon, available nitrogen, and manganese in the soil. Considering that all turmeric accessions were cultivated in the same location and under similar agronomic practices, both geological factors and fertilizers seemed to have a comparable effect on the curcumin content. In another study, Sandeep et al. (2016) reported that genetic factors played a significant role in

10% and 9% respectively. According to the results (Figure 08), moisture content in T12, T4, T6, and T7 turmeric accessions is lower than the maximum level. Present results of moisture content of turmeric accessions were in the agreement of standards of Sri Lanka Standards Institute (SLSI) which is 12% in maximum.

The variation in moisture content among different turmeric accessions can be attributed to several
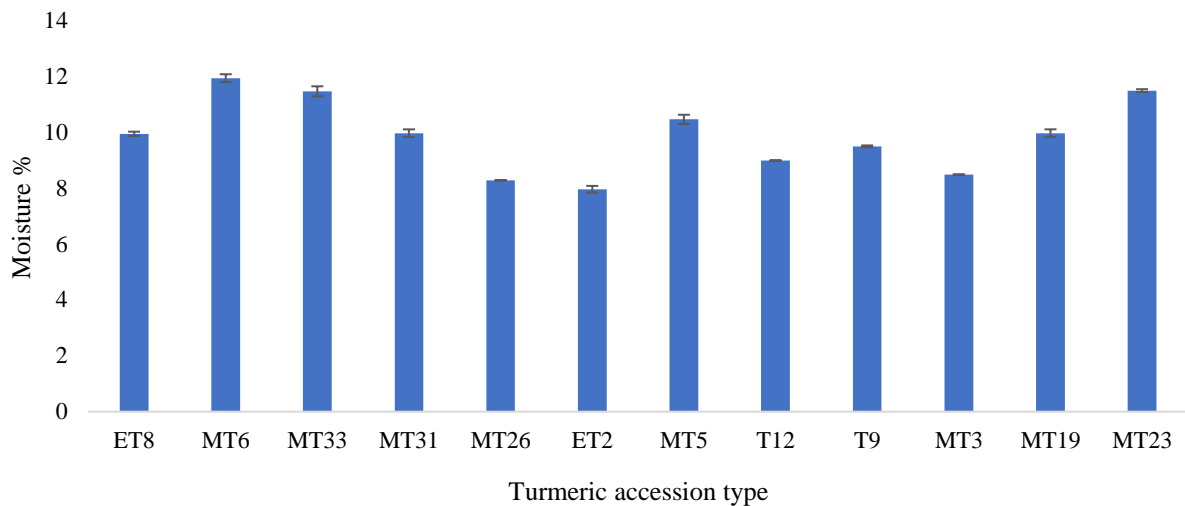


determining the variation in curcumin content among different genotypes, even under similar climatic conditions. This indicates that phytoconstituents are attributes influenced by

factors, such as differences in soil, climate conditions, temperature, humidity, geography, seasonal changes, growing conditions, and post-harvest techniques. However, the primary

Figure 08: Moisture content of dried turmeric accessions (SD= 1.30)

biosynthetic gene expression pathways operating in the context of similar agroclimatic conditions.

These observed difference in curcumin content among turmeric accessions is mainly due to the different expression levels of genes encoding important enzymes of the pathway. Thus, an understanding of the gene expression involved in the biosynthesis of curcuminoids would be a great significance for breeding programs of *curcuma longa* L. varieties. On this context, the results of curcumin content can be concluded that specific genetic makeup is the major responsible factor which effect on curcumin content in all turmeric accessions.

*B. Determination of the Moisture Content in Twelve Different Turmeric Accessions*
Maximum amount of moisture content given by the standard in Indian Standards Institute and ASTA recommendation of ground turmeric is

contributing factor for these moisture content variations lies in the processing techniques employed. While all turmeric accessions were cultivated at the same location and subjected to Similar agronomic practices, the differences in moisture content can be attributed to the specific drying time, drying method, drying pattern, and humidity levels applied during the post-harvest process.

*C. Determination of Colour Composition Values*
Under the determination of color composition, results obtained from Munsell chart for colour value hue, value and chroma given in the Table 01. According to a study by Prathapan *et al.* (2009), it was observed that both heat treatment and sun drying contributed to the enhancement of color values in dried turmeric powder compared to fresh turmeric rhizomes.

Table 01: Colour composition of Turmeric Powder

| Accession type | Hue | Value | Chroma |
|---|---|---|---|
| T12 | 7.5 YR | 6 | 8 |
| MT23 | 5 Y | 7 | 10 |
| MT6 | 7.5 YR | 6 | 8 |
| MT26 | 7.5 YR | 6 | 10 |
| MT19 | 7.5 YR | 5 | 8 |
| MT3 | 7.5 YR | 6 | 10 |
| ET2 | 7.5 YR | 6 | 8 |
| ET8 | 7.5 YR | 6 | 10 |
| T9 | 7.5 YR | 7 | 10 |
| MT31 | 2.5 Y | 7 | 10 |
| MT33 | 7.5 YR | 7 | 10 |
| MT5 | 7.5 YR | 6 | 10 |



Figure 09: Dendogram obtained from the agglomerative hierarchical cluster analysis of twelve turmeric accessions

The uniform application of heat treatment and sun drying to all turmeric accessions resulted in an overall improvement in their color. Also, colour can be affected by the curcumin content, fertilizer application and environmental conditions. All the turmeric accessions were cultivated under similar agronomic practices at the same location and followed similar processing practices. On this content, these turmeric accessions mainly affected by the genes present for the particular trait.

*D. Cluster Analysis of Dried Turmeric Accessions*

Cluster analysis plays a significant role in hierarchically classifying various accessions by utilizing a similarity matrix classification. Its purpose is to identify accessions that exhibit similar characteristics and are closely associated with one another. In the present study, agglomerative hierarchical cluster analysis classified the accessions into three significant clusters based on the curcumin percentage, moisture percentage and colour composition of turmeric powder. First cluster consist accessions: T12, ET2, MT26, MT3. Second cluster consist of: MT6, ET8, MT5, MT33, T9. Third cluster consist of: MT23, MT19, MT31 (Figure 09).

The final partition denotes the outcome of the cluster analysis. In this case, the analysis culminated in a single cluster, suggesting that the observations within the dataset exhibit significant similarities in terms of their curcumin composition, moisture content, and color measurements. The presence of a single cluster implies a high degree of uniformity among the samples, pointing towards a consistent curcumin profile within the dataset.

According to the dendrogram, T12, MT26, ET2, MT3 cluster together with the contribution of all the parameters at a similarity level of 72.2806%. The sample of MT6, MT33, ET8, T9, MT5 cluster tighter with the contribution of all the parameters at similarity level of 52.6705%. The samples of MT23, MT19, MT31 cluster tighter with the contribution of all the parameters at similarity level of 53.9236%.

Given the challenges associated with conventional breeding in the turmeric crop, cluster analysis has emerged as a valuable technique for grouping turmeric accessions. This clustering process can aid in the effective utilization of accessions in crop improvement programs by enabling targeted selection. However, the current cluster analysis falls short in distinguishing between high-quality and low-quality clusters within these turmeric accessions. To address this limitation and accurately identify groups based on their quality, it is necessary to develop the constructed virtual model into a practical model. Consequently, further research is required to establish and evaluate the quality of the three clusters of turmeric accessions.

## IV. CONCLUSION

Curcumin is a parameter which determines the quality of *Curcuma longa* and, its composition displays variations across different accessions. The results of this study clearly revealed that there were significant differences ($p<0.05$) among turmeric accession types based on curcumin content. Curcumin percentage of turmeric powder ranged from 0.3458±0.037% to 4.9881±0.0141%. From the results it was evident that the curcumin content of turmeric grown under coconut in intermediate zone complies with the range identified in the Sri Lankan standard level (3-6%). Moreover, cluster analysis revealed that all accessions which were classified into three groups will be extremely useful to initiate breeding programs of locally grown *Curcuma longa* varieties.

## REFERENCES

Abeynayaka, A. A. S. L., Bandara, A. M. K. R., Lankapura, A. I. Y., and Idamekorala, P. R. (2020) "Economics of Turmeric Production in Sri Lanka: An Empirical Analysis in Major Turmeric Growing Districts", *Asian Journal of Agricultural and Horticultural Research*, 6(4), pp. 10–17.

Department of Export Agriculture (DEA) Turmeric. (2021) Retrieved March 5, 2023.

Hettiarachchi, S.S., Dunuweera, S.P., Dunuweera, A.N. and Rajapakse, R.G. (2021) "Synthesis of curcumin nanoparticles from raw turmeric rhizome", *American Chemical Society omega*, 6(12), pp. 8246-8252.

Jiang, T., Ghosh, R., and Charcosset, C. (2021) "Extraction, purification and applications of curcumin from plant materials-A comprehensive review", Trends in food science & technology, 112(1), pp. 419-430.

Joshi, N. D., Kulkarni, A. A., and Cherekar, M. N. (2021) "Extraction and Purification of Curcumin from Turmeric", *Asian Journal of Plant Science and Research*, 8(1), pp. 256–259.

Liu, Y., Li, J., Fu, R., Zhang, L., Wang, D. and Wang, S. (2019) "Enhanced extraction of natural pigments from Curcuma longa L. using natural deep eutectic solvents", *Industrial Crops and Products*, 140(2), pp. 1-5.

Madhusankha, G., Thilakarathna, R., Liyanage, T., and Navaratne, S. B. (2018) "Analysis of curcumin content in Sri Lankan and Indian turmeric rhizomes and investigating its impact on the colour", *International Journal of Food Science and Nutrition*, 3(4), pp. 03-05.

Prasad, S., and Aggarwal, B. B. (2011) Chapter 13 *Turmeric, the Golden Spice from Traditional Medicine to Modern Medicine*. Landon: Taylor and Farancis Group, LLC.

Nasri, H., Sahinfard, N., Rafieian, M., Rafieian, S., Shirzad, M., and Rafieian-Kopaei, M. (2014) "Turmeric: A spice with multifunctional medicinal properties", *Journal of HerbMed Pharmacology*, 3(1), pp. 5-8.

Tanvir, E. M., Hossen, M. S., Hossain, M. F., Afroz, R., Gan, S. H., Khalil, M. I., and Karim, N. (2017) "Antioxidant properties of popular turmeric (*Curcuma longa*) varieties from Bangladesh", *Journal of Food Quality*, 17(1), pp. 8-16.

Yadav, D., Yadav, S. K., Khar, R. K., Mujeeb, M., and Akhtar, M. (2013) "Turmeric (*Curcuma longa* L.): A promising spice for phytochemical and pharmacological activities", *International Journal of Green Pharmacy*, 7(2), pp. 85–89.

# The Impact of Food Safety Knowledge and Attitude of Food Handlers on Street Food Quality: The Mediating Impact of Food Safety Practice

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## Abstract

*Street food is a growing segment of gastronomic tourism. The quality of street food continues to the stage in society as a source of foodborne diseases. Therefore, this study examined the quality level of street foods in Sri Lanka and how street food handler's knowledge and attitude of food safety effects on food quality when food safety practices play the mediating role. Data were collected using a structured questionnaire from 200 street food handlers from the Colombo district of Sri Lanka using convenience sampling technique and analyzed using descriptive statistical analysis and structural equation modeling. Research findings revealed that the current level of street food quality in Sri Lanka is at a satisfactory level and the knowledge, attitude and practices on food safety of street food handlers also proven to be positive. Moreover, food safety knowledge, attitude and practices positively impacted on street food quality and food safety practices mediate the association. Therefore, the values of Sri Lankan street foods should be promoted in order to avoid criticism of street foods. Training and development programs should be implemented by responsible parties while strengthening the rules and regulations related to food quality to improve the status of street foods as there is still room for improvements. The results of this study will be useful to public health professionals, government agencies, destination promoters, food tourism promoters, future researchers and all other parties interested in street food.*

*Key words: Street foods, Food safety knowledge, Food safety attitude, Food safety practice, Food quality*

## I.    INTRODUCTION

Street foods have a great capability to cater to domestic and foreign tourists as well as residents of the country. Street food refers as f*ood and beverages sold by the vendors on the street or in public areas.* 2500 million people around the world daily eat street foods (Perera, Nawarathne and Kulathunga, 2018). Recently, street food has emerged as a trending topic in Sri Lanka since street food vendors are filling nearly 50 per cent of food requirements of the urban population in developing countries (Perera, Nawarathne and Kulathunga, 2018).

Although street food is a growing segment of gastronomy tourism, the quality of street food always comes to the stage in society as foodborne diseases are affecting one in three people in developing countries and increase deaths (Ahamad, 2015). Many researchers around the world have focused on the street food handlers' food safety knowledge, food safety attitude, and food safety practice since food handlers are playing a major role in food quality (Omemu and Aderoju, 2008). However, few baseline studies have provided evidence for the lack of street food quality and street food handlers' knowledge and practices on food safety are not at an adequate level in urbanized areas such as Colombo and Kandy in Sri Lanka (Karunapema, 2021; Wickrematilake, 2022). Hence, researchers need to find out the level of street food quality in Sri Lanka and how is food handlers' food safety knowledge, attitude and practices impact on street food quality. The negative side of street foods is low food quality and high food contamination because of poor food safety conditions and a lack of understanding of food handlers on food safety in developed and developing countries (Cortese and Cavalli, 2016).

## II.    LITERATURE REVIEW

Millions of people are satisfying their hunger daily with a wide variety of street foods and street foods are playing a significant role in the diet of poor people in metropolitan areas. Many low-income families in developing countries would not be able

to meet their nutritional needs without street foods (Riet, 2002). Street foods have become an attraction to a country that promotes tourism as it is carrying a message about a region's culture and traditions, authenticity and history to other nations. Not only street foods but also street food handlers and their foods have become cultural icons and tourist attractions (Mudunkotuwa and Arachchi, 2020). Not only do people with less education engage in the street food trade, but also graduates. Smart investors are turning to the street food sector as a way to make more money at a lower cost (Iriguler and Ozturk, 2016). As a multiethnic nation in Asia, Sri Lanka has rich food cultures that can delight the world. There are different street food traditions in Sri Lanka that are unique to the destination of origin and sale. Since there is no seasonality for street foods, they can be promoted among locals and foreigners throughout the whole year (Mudunkotuwa and Arachchi, 2020). According to Karunapema (2021) and Wikrematilake (2022), street food handlers' knowledge and practices are not in a sufficient level in most urbanized areas in Sri Lanka such as Colombo and Kandy.

Food safety knowledge is the degree of understanding on food safety practices and food safety problems. Food handlers should have information on the way to guaranteeing food quality and preventing food poisoning by correct food manufacturing, preserving and serving methods (Oraedu, 2016). Previous researchers have used knowledge of personal hygiene, cross-contamination and temperature control as dimensions to measure the food handlers' food safety knowledge (Taha et al., 2020). Attitude is a broad impression or assessment of a person that may be good or bad/right or wrong about something (Mudunkotuwa and Arachchi, 2020). Self – improvements and food safety concerns have been mostly utilized as determinants to measure the food safety attitude of food handlers by previous researchers in different sectors (Ko, 2013). Food well-being has also recently been used to measure the attitudes of food handlers in the street food sector (Tuglo *et al.*, 2021). Food safety practices are a crucial element to guarantee that manufactured foods are safe for consumption. There are four factors to determine the street food handlers' food safety practice level according to the literature, they are food hygiene practices, personal hygiene practices, environmental hygiene practices and storage practices (Rosmawati, Manan, Izani and Nurain, 2015).

The inability to maintain food quality is one of the biggest reasons for business failure, since food quality can influence food businesses' image positively. Previous researchers had revealed diversified attributes to measure food quality such as the presentation of the food, temperature of the food, taste of the food, freshness of the food and healthy options as the most significant food quality determinants (Namkung and Jang, 2008). The KAP (Knowledge, Attitude and Practice) model determines a person's attitude and knowledge toward a practice. Many researchers have measured street food handlers' KAP on food safety in modified forms adding new variables such as "Risk perception", "Training", "Commitment". There is a possibility to modify KAP model using "food quality" (Taha et al., 2020).

From one country to another and one circumstance to another KAP model is yielding varied results on food handlers' food safety knowledge, attitude and practices. For examples; although Griffith and Clayton (2005) had stated that food safety knowledge improvements positively affect food safety practices while attitude restrains improvements of food safety practices of caterers in UK, Baser (2016) has found that there is no relationship between food safety knowledge and food safety practices and there is a positive relationship with food safety attitude and food safety practices among hotel food handler in Turkey; when a study in Indonesia had found that poor food safety knowledge leads to poor food safety practices and food contamination of mobile food handlers (Ismail et al., 2016), a study in Nepal has found that improvements in food safety knowledge and food safety attitude have not affected on food safety practices since local food handlers are influenced by other factors such as poor infrastructure, lack of resources, negative economic and social factors (Pokhrel et al., 2016). Hence, it is very important to use KAP model in different contexts for critical evaluations. Based on discussions of relevant literature, it is apparent that street food quality is a pertinent factor to study modifying KAP model. The research hypotheses were generated based literature as follows;

$H_1$: Food safety knowledge positively impacts on food safety practice.

$H_2$: Food safety attitude positively impacts on food safety practice.

H<sub>3</sub>: Food safety knowledge positively impacts on food quality.

H<sub>4</sub>: Food safety attitude positively impacts on food quality.

H<sub>5</sub>: Food safety practice positively impacts on food quality.

H<sub>6</sub>: Food safety practice mediates the association between food safety knowledge and food quality.

H<sub>7</sub>: Food safety practice mediates the association between food safety attitude and food quality.
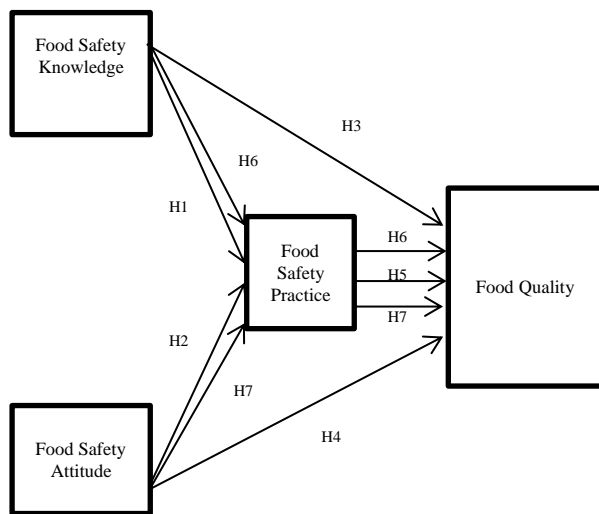


Figure 01: Developed Conceptual Framework

## III. PROBLEM SPECIFICATION

Since most of studies dispensed a general idea that street food handlers' are the responsible party for the street food quality, numerous studies have examined the level of street food handlers' food safety knowledge, food safety attitude, and food safety practice. However, the food handlers' food safety knowledge, food safety attitude, and food safety practice how effect on food quality is an under-researched area, particularly in the context of street foods. Although the KAP model (Knowledge, Attitude, and Practice model) has been used in other sectors to evaluate how the food handlers' food safety knowledge and attitude effect on their food safety practice, there are no published studies that have used KAP model on street food handlers' food safety knowledge, attitude and practice. Hence, there is a remaining theoretical gap to address. At a time when

consuming street food and taking part in street food festivals are trending in Sri Lanka, the street food quality and food handlers knowledge, attitude and practices on food safety is said to be problematic. However, there is lack of scientific findings on street food quality and food handlers' knowledge, attitude, and practices on food safety in Sri Lanka, there is also an empirical gap to fill.

## IV. METHODOLOGY

### A. Research Design
Quantitative research method was used to achieve the research objectives of this study as quantitative research methods are used to test or confirm theories and hypothesis (Allwood, 2012).

### B. Population and Sample
Street food is not limited to one region of Sri Lanka. However, street foods are mostly famous in urban cities and Colombo district is the most urbanized city in Sri Lanka and Colombo district has a large migratory population that considerable proportion patronage the street foods than other districts in Sri Lanka (Karunapema, 2021). Therefore, this study has been employed the Colombo district as the reference area. The population of this study would include all the street food handlers scattered throughout the Colombo district in Sri Lanka. Since the street food industry is an unstable informal sector due to an improper licensing and registration system, the number of street food handlers has not been accurately calculated (Wickrematilake, 2022). Hence, the population is unknown.

Daniel Soper's a priori sample size calculator for the structural equation model was used to determine the minimum sample size for this study. According to the result, the minimum sample size to detect an effect is 137. Therefore, this study recruited 200 street food handlers from three sites in Colombo district as the sample following the convenient sampling technique. Street food vendors in Colombo Fort area effectively fulfill the dietary needs of economically active city dwells (Liyanarachchi and Weerakkody, 2003). Pettah has been identified as a place where food tourism can be well promoted in Sri Lanka since street foods are diverse in Pettah due to people who engage in food businesses are belong to different religions, sub-cultures, castes and races (Embuldeniya and Embuldeniya, 2019). Many tourists and people who are living in the urban city of Colombo use Galle face as a venue to do

recreational activities. Galle face is home to a variety of street vending foods (Tedd, Liyanarachchi and Ranjan, 2018). Hence, street food handlers in Colombo Fort, pettah and Galle face who are engaged in very busy transactions were the sampling units of this study.

## C. Data collection
Self-administrated structured questionnaire was used to collect data for the study and the survey determined the food safety knowledge (FSK), food safety attitude (FSA), food safety practice (FSP) and street food quality (FQ).

## D. Data analysis
SPSS (Statistical Package for Social Science) was utilized for demographic factor analysis and descriptive statistical analysis and Smart PLS tool utilized for structural equation modeling (SEM) to achieve objectives of the study.

## V. RESULTS AND DISCUSSION

### A. Reliability Analysis

Table 01: Cronbach's Alpha values

| Variables | Cronbach's Alpha | N of Items |
|---|---|---|
| Food quality (FQ) | 0.969 | 7 |
| Food safety attitude (FSA) | 0.916 | 7 |
| Food safety knowledge (FSK) | 0.939 | 9 |
| Food safety practice (FSP) | 0.958 | 10 |

The items that Cronbach's Alpha coefficient is closer to 1.00 has a better internal consistency and a reliability coefficient (Alpha value) of 0.7 or higher is considered as acceptable reliability (Tavakol and Dennick, 2011). The Cronbach's Alpha coefficient of food safety knowledge, food safety attitude, food safety practice and food quality are all high and above 0.9 showing accepted with excellent reliability values. It indicates that the constructs are internally consistent in the questionnaire.

### B. Composite Reliability (CR)
The composite reliability is mostly calculated in coincidence with structural equation modeling. Composite reliability value should be in be higher than 0.7 to be acceptable and it is a less biased measure of dependability than Cronbach's alpha (Robert and Yeolib, 2013). According to the

results of the analysis, Table 02 shows that all the variables are acceptable according to the Composite reliability test since all the values are above 0.7. Cronbach's coefficient alpha is the commonly used measure of the reliability of scales and tests.

### C. Average Variance Extracted (AVE)
The average variance extracted (AVE) measures the variance that is captured by a construct in relation to the variance due to measurement error. An AVE of at least 0.50 is strongly advised as a general rule and for adequate convergence. A smaller than 0.50 AVE indicates that items account for more mistakes than the variance in constructs (Peterson and Kim, 2013). According to the results of the analysis, Table 3 shows that all the constructs have adequate convergence since all the Average Variance Extracted (AVE) are higher than 0.50.

Table 02: Composite Reliability

| Variable | Composite Reliability (CR) |
|---|---|
| FQ | 0.973 |
| FSA | 0.933 |
| FSK | 0.951 |
| FSP | 0.964 |

Table 03: Average Variance Extracted

| Variable | Average Variance Extracted (AVE) |
|---|---|
| FQ | 0.784 |
| FSA | 0.668 |
| FSK | 0.736 |
| FSP | 0.75 |

The average variance extracted (AVE) measures the variance that is captured by a construct in relation to the variance due to measurement error. An AVE of at least 0.50 is strongly advised as a general rule and for adequate convergence. A smaller than 0.50 AVE indicates that items account for more mistakes than the variance in constructs (Peterson and Kim, 2013). According to the results of the analysis, Table 3 shows that all the constructs have adequate convergence since all the Average Variance Extracted (AVE) are higher than 0.50.

### D. Descriptive Statistics

Descriptive statistical analysis is shown in the Table 04. The mean value was interpreted as $1 \leq X < 1.79$ - Strongly agree, $1.80 \leq X < 2.59$- Agree,

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2.60 ≤ X < 3.39 - Moderate, 3.40 ≤ X < 4.19 - Disagree, 4.20 ≤ X < 5 - Strongly disagree (Alonazi, White and Beloff, 2019). All the constructs of FSK is in between 1 and 1.79 except FSK6 showing that the respondents have strongly agreed with the constructs and all the constructs except FSA3 of FSA is also in between 1 and 1.79.

The mean values of all the constructs of FSP are in between 1.80 and 2.59 showing that respondents have agreed with the constructs.

Table 04: Descriptive Statistics

| | | Indicator | N | Mean | Std. Dev | Skewness | Kurtosis |
|---|---|---|---|---|---|---|---|
| Food Safety Knowledge | FSK1 | I know that stay clean is essential when handling food to ensure food safety. | 200 | 1.47 | .641 | 1.268 | 1.487 |
| | FSK2 | I know that wearing gloves is very important while handling food. | 200 | 1.67 | .967 | 1.478 | 1.140 |
| | FSK3 | I know that physical objects like jewelry, hair and stones contaminate foods. | 200 | 1.41 | .659 | 1.881 | 4.140 |
| | FSK4 | I know that Bacteria, viruses and mold contaminate foods. | 200 | 1.65 | .966 | 1.541 | 1.304 |
| | FSK5 | I always remove jewelry when I am handling food. | 200 | 1.54 | .934 | 1.801 | 2.122 |
| | FSK6 | I always keep the environment around the stall clean. | 200 | 2.06 | .875 | .983 | .572 |
| | FSK7 | I always clean food preparation areas using sanitizer. | 200 | 1.77 | .946 | 1.315 | .913 |
| Food Safety Attitude | FSA1 | Reading books increase my knowledge on food safety. | 200 | 1.84 | 1.006 | 1.233 | .596 |
| | FSA2 | Attending food safety seminars and training programs improve my food safety knowledge and practices. | 200 | 1.97 | .999 | .955 | .048 |
| | FSA3 | I believe that the safety of food is more important than taste. | 200 | 2.07 | .951 | .965 | .151 |
| | FSA4 | Maintaining good hygiene practices is a good way to ensure food safety. | 200 | 1.94 | 1.003 | .946 | -.134 |
| | FSA5 | I am a responsible person to prevent food poisoning. | 200 | 1.96 | 1.095 | .855 | -.625 |
| | FSA6 | Checking food for freshness and nutritional value is important. | 200 | 1.62 | .995 | 1.564 | 1.180 |
| | FSA7 | Expired foods should be disposed. | 200 | 1.87 | 1.083 | 1.375 | 1.071 |
| Food Safety Practice | FSP1 | I always keep raw foods and cooked foods separately. | 200 | 2.30 | .695 | 1.791 | 1.821 |
| | FSP2 | I am avoiding from reheating foods. | 200 | 2.31 | .690 | 1.728 | 1.674 |
| | FSP3 | I wash my hands in clean water each time before handle foods. | 200 | 1.93 | .646 | .857 | 2.260 |
| | FSP4 | I always use gloves when handling food. | 200 | 2.46 | .788 | 1.052 | -.169 |
| | FSP5 | I always remove jewelry when I am handling food. | 200 | 2.37 | .752 | 1.346 | .976 |
| | FSP6 | I always keep the environment around the stall clean. | 200 | 2.11 | .663 | 1.440 | 3.028 |
| | FSP7 | I always clean food preparation areas using sanitizer. | 200 | 2.24 | .731 | 1.693 | 2.439 |
| | FSP8 | I daily clean the containers I use for storage. | 200 | 2.07 | .811 | 1.125 | 1.243 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | FSP9 | I always check the temperature of food before storing it. | 200 | 2.36 | .729 | 1.616 | 1.437 |
| | FQ1 | Customers praise me for being concerned about the taste of food. | 200 | 1.76 | .804 | 1.226 | 1.566 |
| | FQ2 | Satisfied with the taste of my food, customers buy the food again. | 200 | 1.69 | .841 | 1.355 | 1.528 |
| | FQ3 | Customers praise me for being concerned about the attractive appearance of food. | 200 | 2.01 | .830 | 1.164 | 1.307 |
| | FQ4 | Satisfied with the appearance of my food, customers buy the food again. | 200 | 2.19 | .746 | 1.362 | 1.717 |
| | FQ5 | Customers praise me for being concerned about the nutritional value of food. | 200 | 2.31 | .811 | 1.490 | 1.688 |
| Food Quality | FQ6 | Satisfied with the nutritional value of my food, customers buy the food again. | 200 | 2.29 | .799 | 1.515 | 1.944 |
| | FQ7 | Customers compliment me on trying to serve food at the right temperature. | 200 | 2.17 | .827 | 1.233 | 1.073 |
| | FQ8 | Satisfied with the temperature of my food, customers buy the food again. | 200 | 2.32 | .747 | 1.528 | 1.145 |
| | FQ9 | Customers praise me for being concerned about the freshness of the food, such as softness, crispiness and aroma. | 200 | 2.05 | .898 | 1.087 | .669 |
| | FQ10 | Satisfied with the fresh condition of my food, customers buy the food again. | 200 | 2.03 | .910 | 1.081 | .608 |

***FSK= Food Safety Knowledge, FSA= Food Safety Attitude, FSP = Food Safety Practice, FQ=Food Quality

All constructs relate to the food quality variable are also in between 1.80 and 2.59 except FQ1 and FQ2 showing that respondents have agreed with constructs. The mean values of all the indicators are less than 2.59 in all four variables. Hence, all the constructs were accepted by the respondents showing that there is high quality in street food in Sri Lanka, and street food handlers' knowledge, attitude and practice at a high level.

*E. $R^2$ Value*

The research model implies a 0.811 percent variance of change in Food Quality and a 0.834 percent variance of change in Food Safety Practice according to $R^2$ Value. Hence, the suggested model explains the percentage of the total variance of FQ and FSP are substantial.

*F. Hypotheses Testing*

All the hypotheses are accepted according to specific indirect effect since all the P values are below 0.05 and T values are above 1.96. Hence, direct impacts are positive in this study.

Table 05: $R^2$ Value

| Variable | R-square |
|---|---|
| Food Quality | 0.811 |
| Food Safety Practice | 0.834 |

Table 06: Results Analyzed with Direct Path Coefficient

| Hypothesis | Hypothesized Relationship | Path Coefficient (PC) | T statistics | p values | Status |
|---|---|---|---|---|---|
| $H_1$ | FSK positively impact on FSP. | 0.563 | 6.995 | 0.000 | Accepted |
| $H_2$ | FSA positively impact on FSP. | 0.377 | 4.376 | 0.000 | Accepted |
| $H_3$ | FSK positively impact on FQ. | 0.194 | 2.048 | 0.041 | Accepted |
| $H_4$ | FSA positively impact on FQ. | 0.233 | 2.238 | 0.025 | Accepted |
| $H_5$ | FSP positively impact on FQ. | 0.506 | 5.736 | 0.000 | Accepted |

*** PC = Path Coefficient (Significant value $P < 0.05$), T = T-Statistics (significant value $1.96 < T$)

Table 07: Results Analyzed with Specific Indirect Effect

| Hypothesis | Hypothesized Relationship | Path Coefficient (PC) | T statistics | p values | Status |
|---|---|---|---|---|---|
| $H_6$ | FSP mediate the association between FSK and FQ | 0.285 | 4.884 | 0.000 | Accepted |
| $H_7$ | FSP mediate the association between FSA and FQ. | 0.191 | 3.244 | 0.001 | Accepted |

*** PC = Path Coefficient (Significant value $P < 0.05$), T = T-Statistics (significant value $1.96 < T$)

*G. Mediating Impact*

Table 08: Mediation Impact Analysis of FSK on FQ through FSP

| Direct Effect (FSK -> FSP) | | | Mediator Influence | Specific Indirect Effect (FSK -> FSP -> FQ) | | |
|---|---|---|---|---|---|---|
| Coefficient | T-value | p-value | | Coefficient | T-value | p-value |
| 0.194 | 2.048 | 0.041 | $H_6$ | 0.285 | 4.884 | 0.000 |

*** PC = Path Coefficient (Significant value $P < 0.05$), T = T-Statistics (significant value $1.96 < T$)

Table 09: Mediation Impact Analysis of FSA on FQ through FSP

| Direct Effect (FSA -> FSP) | | | Mediator Influence | Specific Indirect Effect (FSA -> FSP -> FQ) | | |
|---|---|---|---|---|---|---|
| Coefficient | T-value | p-value | | Coefficient | T-value | p-value |
| 0.233 | 2.238 | 0.025 | $H_7$ | 0.191 | 3.244 | 0.001 |

*** PC = Path Coefficient (Significant value $P < 0.05$), T = T-Statistics (significant value $1.96 < T$)

Table 08 revealed that both the direct path ($\beta = 0.194$, T-value = 2.048, p-value = 0.041) and the indirect path ($\beta = 0.285$, T-value = 4.884, p-value = 0.000) were significant. FSP has made the relationship more strong between FSK and FQ since the significance level has increased in the indirect effect. Table 09 revealed that both the direct path ($\beta =0.233$, T-value =2.238, p-value = 0.025) and the indirect path ($\beta = 0.191$, T-value = 3.244, p-value = 0.001) were significant. FSP has made the relationship more strong between FSA and FQ since the significance level has increased in the indirect effect.

The present study is scientifically proven that the current level of food safety knowledge, attitude, practice and food quality of street food handlers in the Colombo district of Sri Lanka is at a satisfactory level from the perspective of street food handlers, in contrast to previous baseline studies, in which was stated that street food handlers knowledge and practices were not at a satisfactory level (Karunapema, 2021; Wickrematilake, 2022). The Basers' (2016) statements of "There is no relationship between food safety knowledge and food safety practice" can be rejected and "There is a positive relationship between food safety attitude and food

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safety practices among hotel food handlers" can be proved in context of street food handler too. As Dharmarathne and Abeysundara (2022), street food quality of Sri Lanka can be improved by increasing food safety knowledge and practices since findings proved that food safety knowledge, attitude and practices were impact on food quality and food safety practice act as a threshold in the association.

## IV. CONCLUSION

This study proved that even the negative comments made by the society about the quality of street food in developing countries, the current level of street food quality is at a satisfactory level in Sri Lanka. The knowledge, attitude and practices on food safety of street food handlers also proven to be positive. Also, knowledge, attitude and practices on food safety are positively impact on street food quality and food safety practices mediate the association. Mass media and

social media should be used in an effective manner to promote quality street foods in Sri Lanka. Moreover, People involved in Sri Lankan tourism industry should take further efforts to promote tourism niches through street food considering the good quality of street food as an asset in the country. However, taking actions for further improvements of the quality of street food are very effective since the street food industry is one of the trending industries in the world which can generate the number of economic and socio-cultural benefits for a country. Government and non-government organizations can work collaboratively to increase street food handlers' knowledge, attitude and practices of food safety in order to increase the street food quality through training programs, seminars, workshops and regular monitoring system. It is vital to introducing a new standardized procedure for licensing street food handlers.
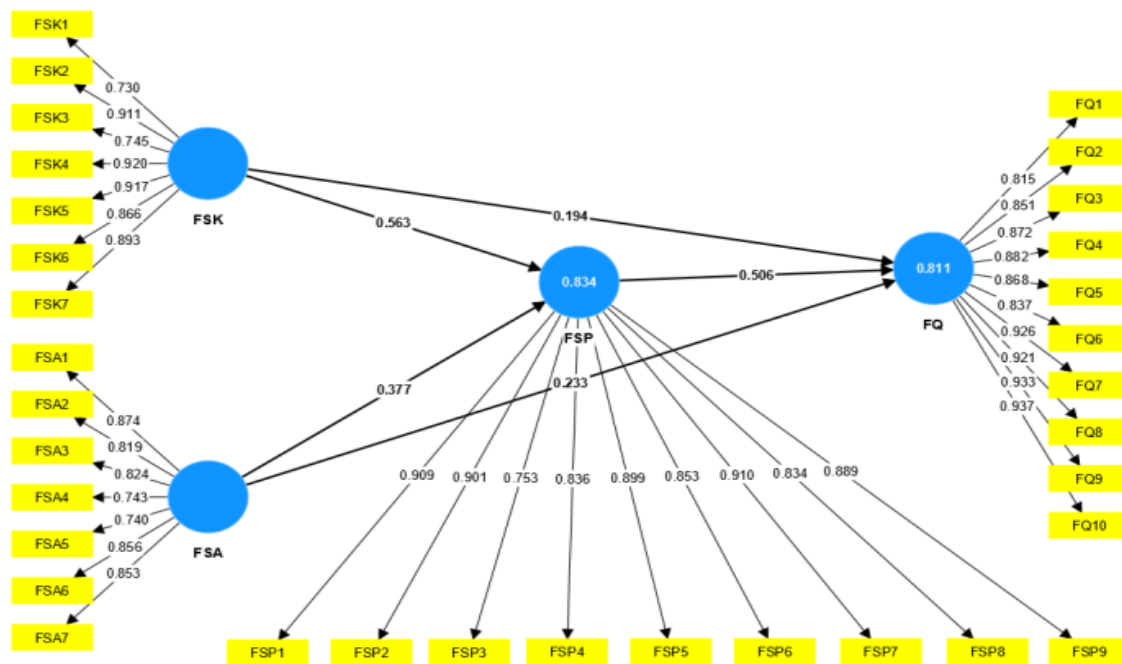


Figure 02: Smart PLS Algorithm Output

REFERENCES

Dharmarathne, G.G.N.T. and Abeysundara, P.D.A. (2022) "*Assessment of microbial quality of street foods sold in Nuegoda, Sri Lanka*", 1(1), pp.12-18.

Iriguler, F. and Ozturk, B. (2016) "Street food as a gastronomic tool in Turkey", Researchgate.net, 12(1), pp. 49–64.

Ismail, F.H., Chik, C.T., Muhammad, R. and Yusoff, N.M. (2016) "Food safety knowledge and personal hygiene practices amongst mobile food handlers in Shah Alam, Selangor", Procedia-Social and Behavioral Sciences, 222(12), pp. 290-298.

Karunapema, R.P.P. (2021) "Educational Intervention Aimed at Street Food Vendors to Improve Knowledge and Practices on Food Safety and Hygiene" 1(2), pp.1-8.

Ko, W.-H. (2013) "The relationship among food safety knowledge, attitudes and self-reported HACCP practices in restaurant employees", Food Control, 29(1), pp. 192–197.

Mudunkotuwa, M.A.D.M. and Arachchi, R.S.S.W. (2020) "The Impact of Tourists' Perceived Risk on Attitude and Behavioral Intention towards Street Food : A Casse Study of Central Colombo", Journal

of Tourism Economics and Applied Research, 4(2), pp.12-19.

Namkung, Y. and Jang, S. (2007) "Does food quality really matter in restaurant? Its impact on customer satisfaction and behavioral intentions", SAGE, 8(5), pp. 12-20.

Omemu, A.M. and Aderoju, S.T. (2008) "Food safety knowledge and practices of street food vendors in the city of Abeokuta,Nigeria", Food control, 19(4), pp. 1-18.

Oraedu, E.N. (2016) "Assessment of food safety knowledge and practices among food handlers in restaurants in Nnewi Urban", University of Nigeria, 12(5), pp. 11-24.

Perera, M., Nawarathne, A. and Kulathunga, K. (2018) "Determinants of street food consumption in Colombo city, Sri Lanka", Perspective of foreign tourists, 2(4), pp. 13-26.

Pokhrel, B., Pokhrel, K.P., Chhetri, M.R., Awate, R.V. and Sah, N.K. (2016) "Knowledge, Attitude and Practice regarding food hygiene among food handlers: A cross sectional study.A Cross - sectional study",Janaki Medical College, 3(1), pp. 9–14.

Riet, H.V.T. (2002) "The role of street foods in the diet of low - income urban residents, the case of Nairobi", Wageningen University, 12(1), pp. 45-53.

Taha, S., Osaili, T.M., Vij, A. and Albloush. A. (2020) "Structural modelling of relationships between food safety knowledge, attitude, commitment and behavior of food handlers in restaurants in Jebel Ali Free Zone Dubai, UAE", Food Control, 7(5), pp. 41-52.

Tuglo, L.S., Agordoh, P.D., Tekpor, D., Pan, Z., Agbanyo, G. and Chu, M. (2021) "Food safety knowledge, attitude, and hygiene practices of street-cooked food handlers in North Dayi District, Ghana", Environmental health and preventive medicine, 26(1), pp.1-13.

# Shelf-life Evaluation Using Accelerated Stability Testing (AST) and Transit Trial Testing in Selected Confectionery Products

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## Abstract

*The shelf life of confectionery products can be changed commonly during storage and transportation. In this study, accelerated shelf life estimation (AST) and transit trial (TT) in selected confectionery products (hard candy, center filled chewing gum and jelly) were focused and the properties of confectionery samples were compared with the commercial products. Test sample and control sample were stored in climate chamber at 35/40ºC and 50/80% RH and test reference sample and control reference samples stored at finished good ware house <30 ºC. The samples were evaluated once a week along 21 days period. For TT, the samples were transported to the distance and returned back (850Km). Product's physical and packaging properties were evaluated by visual methods and moreover, organoleptic parameters were checked according to 5-point hedonic scale. The data were analyzed using analysis of variances (ANOVA) followed by Friedman Test at 0.05 significance level. Comparative test was done by test sample comparing with the other three of samples. According to the results, all of the quality properties were decreased with the storage period. Hard candy and center filled chewing gum specifically showed the textural changes but jelly samples had no changes in AST. Moreover, hard candy and jelly samples showed no significant differences in TT but chewing gum samples were showed somewhat differences. The overall qualities of the sample showed the more or less exact quality properties with the commercial products.*

*Keywords: Keywords: Accelerated Stability Test (AST), Transit Trial Test (TT), Center Filled Chewing Gum, Hard Candy, Jelly, Sugar confectionery*

## I. INTRODUCTION

The confectionery industry can be categorized into three main classes: chocolate, flour, and sugar confectioneries. Chocolate and flour confectioneries made from chocolate and flour and their shelf life can be short or long period (Edwards, 2018). Another confectionery industry can be identified as sugar confectioneries. Sugar is a generic term used to refer to any form of carbohydrate suitable for use as a sweetener, including sucrose, a chemical term for sugar extracted from sugar cane or beet (Lees, 2012). A broad range of sweet varieties of soft candy, hard candy and chewing gum are being marketed in the country (SLSI, 2017). This study aimed to predict the shelf life of selected confectionary products using Accelerated Stability Testing (AST) and the Transit trial method and to compare the properties of confectionery samples with commercial confectionery products.

## II. LITERATURE REVIEW

### A. Quality Properties of Sugar Confectioneries

The texture of candy is impacted by the concentration of sugar and boiling temperature, wherein lower temperatures yield softer candies, while higher temperatures result in harder ones. Texture analysis, conducted with a Texture Analyzer, quantifies firmness, fracturability, and fracture quantity. Color intensity contributes to the appetizing value and consumer acceptance of candies (Dilrukshi et al., 2019). Proper packaging and storage conditions prevent undesirable sugar crystallization, influencing food taste perception.

Chemical properties: Maillard reactions, caramelization and lipid peroxidation, create brown compounds in confectionery items. These reactions occur at higher temperatures, oxidize unsaturated fatty acids, and degrade ascorbic acid (Cheung and Mehta, 2015).

Organoleptic parameters: Flavor enhances food taste, with sweetness determined by sugars' chemical formula and tongue interaction. Storage changes flavor, texture, moisture content, and water activity, affecting product freshness (Arturo

and Paredes, 2000; Hartel, von Elbe and Hofberger, 2018).

### B. Ingredients

Sugar substitutes are compounds used for sweetening without insulin, such as sugar alcohols, sorbitol, xylitol, and mannitol. Dairy ingredients like condensed milk, milk powder, whey, and butter fat are used in the confectionery industry. Emulsifiers help form or stabilize emulsions, altering droplet size and texture. Flavors improve product appearance or are essential. Colors enhance product appearance or add flavor, with synthetic colors being more stable and pure (Schieberle and Grosch, 1988).

### C. Preparation Methods and Techniques

In the preparation of confectionery, techniques such as vacuum cooking, steam injection cooking, and continuous plant utilization are employed. Within continuous vacuum conditions, sugar undergoes cooking and can be discharged at reduced temperatures, facilitated by a vacuum of 10 inches (25 cm) of mercury, thereby decreasing the boiling temperature by 20°C. The incorporation of a first stage cooker enhances production capacity, and evaporated syrup moisture is eliminated through a designated pipe. The cooking chamber is equipped with a sight glass outlet for real-time monitoring of the sugar stream, allowing the continuous addition of buffered lactic and citric acid, colors, and flavors. Furthermore, a discharge pump facilitates the extraction of the cooked sugar.

### D. Common Types of Sugar Confectioneries

Hard candies are liquid mixtures of sucrose and corn syrup, maintained by high-temperature cooking (Spanemberg, 2019). They can be plain, modified, or lozenges. Chewing gum is a gum base with nutrients and flavorings, released through chewing. Soft candies include chewy products with sugar syrup, fats, coloring, and flavorings, and jelly-based candies like jelly beans and fruit paste (SLSI, 2017). Soft candies include plain toffee, milk toffee, modified toffee, and center filled toffee. They are made from sugar, edible vegetable fat, and may contain coloring, flavorings, fruits, nuts, modified toffee, and optional ingredients. These candies are similar to milk toffee or modified toffee but have distinct coatings (SLSI, 2017). Gelatin jellies have a soft, rubbery texture, often enhanced with gelling agents like thin boiling starch. Agar jellies are low-boiled, soft, and short-eating, while pectin jellies are excellent fruit-flavored bases, with acidic pH (E.B.Jackson, 1992).

### E. Packaging of Sugar Confectioneries

Polypropylene film, oriented films, Polyvinyl Chloride (PVC), Polyvinylidene Chloride (PVDC), metalized films, shrink, and stretch films are suitable for confectionery packaging in humid conditions (Board, 2013).

### F. Shelf Life of Sugar Confectioneries

Product characteristics, packaging, and transportation and storage factors include composition, raw material quality, structure, moisture content, water activity, fat content, pH, and oxygen susceptibility (Subramaniam, 2009). External conditions like temperature, humidity, oxygen, and light also affect shelf life. Estimation of shelf life involves real-time stability tests and accelerated stability tests (Calligaris et al., 2019).

## III. METHODOLOGY

The confectionery samples were manufactured in the same way as commercial products. Hard Candies and gum/jelly were manufactured according to the company recipe. Liquid glucose, water, sugar, acid, flavor mixed together and cooking under vacuum pressure. Then kneaded, cooled and rope sized and finally foamed candy. Sugar, gum base, liquid glucose, flavors and colors mixed together and pre extruded the batch and then rope sized and foaming gums. Jellies were prepared using sugar, liquid glucose, and water, and acid, fruit pulp with pectin, flavors and colors. All together added to collecting chambers and then passed through the depositors. For the depositor used depth increased depositing plates. The final product was packaged in a sealed package and collected from commercial samples and trial samples. The samples run in a temperature and humidity climate chamber with temperatures of
35/40°C and 50/80% relative humidity for 12 cycles.

Accelerated Stability Test (AST) product is kept under conditions of increased stress (such as pH, humidity, and temperature) (Calligaris et al., 2019). AST is a test designed to increase the rate of chemical degradation or physical change of a sample by using exaggerated storage conditions. AST is relatively quick test and therefore compatible with an often-limited project timeline.

Transit Trial Test (TT) done by transportation of products may deteriorate the quality of product and/or pack. A TT is a test to evaluate the effect that transportation has on product and pack quality. Data collection was done once a week for a minimum 21 days weekly testing for AST and before and after transportation for transit trial. For the sensory evaluation follow up the 5-point Hedonic scale as low to high comparability of products with trained panel. Collected data were analyzed using SPSS software 26.0 using analysis of variances (ANOVA) followed by Friedman Test at 0.05 significance level on Tukey's test.

## IV. RESULTS AND DISCUSSION

### A. Accelerated Stability Test
#### 1) Visual Parameters of Samples
The visual property of hard candy, chewing gum and jelly was reduced with the accelerated climate conditions. There were significant differences ($p<0.05$) observed in color intensity, smoothness, wrinkle and overall appearance of hard candy (Table 01), Color intensity, smoothness, shininess, deformation, syrup leakage, and overall appearance of chewing gum (Table 02) and color intensity, deformation, overall appearance of jelly (Table 03) while AST period those parameters changed may be due to the accelerated climatic conditions. When using low temperatures and high relative humidity, the composition of sweets can alter because citric and sucrose are quickly affected by moisture content. (Netramai et al., 2018). Newly introduced hard candy had no any significant difference in shininess and deformation within 21 days but it can be change if more time stay in climate chamber like more than month. Size reduced center filled chewing gum and new consumer packaging material used jelly samples' all properties had significant differences. Size reduced gum had the changes it may be due to the graining or high moisture intake during climate conditions (Arturo and Paredes, 2000). Smoothness and shininess of jelly had no any significant difference when comparing the commercial samples.

Table 01: Visual Properties of Hard Candy

| Visual properties | Storage in days | | | |
|---|---|---|---|---|
| | Day 01 | Day 07 | Day 14 | Day 21 |
| Color Int. | 5.00±0.00[c] | 4.93±0.07[c] | 4.40±0.16[b] | 3.93±0.06[a] |
| Smooth. | 4.93±0.06[c] | 4.67±0.49[bc] | 4.33±0.82[b] | 3.67±0.13[a] |
| Shini. | 4.80±0.11[a] | 4.67±0.13[a] | 4.53±0.19[a] | 4.33±0.19[a] |
| Deform. | 5.00±0.00[a] | 5.00±0.00[a] | 4.93±0.06[a] | 4.87±0.09[a] |
| Wrink. | 4.80±0.11[b] | 4.73±0.12[b] | 4.40±0.19[ab] | 3.93±0.18[a] |
| Overall appear. | 5.00±0.00[b] | 4.73±0.12[b] | 5.00±0.00[b] | 4.06±0.21[a] |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 02: Visual Properties of Chewing Gum

| Visual properties | Storage in days | | | |
|---|---|---|---|---|
| | Day 01 | Day 07 | Day 14 | Day 21 |
| Color Intensity | 5.00±0.00[c] | 5.00±0.00[c] | 4.13±0.35[b] | 3.53±0.74[a] |
| Smoothness | 5.00±0.00[c] | 4.80±0.41[c] | 4.00±0.00[b] | 2.87±0.83[a] |
| Shininess | 5.00±0.00[c] | 4.73±0.46[c] | 3.67±0.49[b] | 1.93±0.70[a] |
| Deformation | 5.00±0.00[c] | 4.87±0.35[bc] | 4.47±0.64[b] | 3.53±0.52[a] |
| Syrup leakage | 5.00±0.00[c] | 4.87±0.35[c] | 4.00.±0.65[b] | 1.53±0.52[a] |
| Overall appearance | 5.00±0.00[c] | 5.00±0.00[c] | 3.93±0.59[b] | 1.80±0.77[a] |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 03: Visual Properties of Jelly

| Visual properties | Storage in days | | | |
| --- | --- | --- | --- | --- |
| | Day 01 | Day 07 | Day 14 | Day 21 |
| Smoothness | $5.00 \pm 0.00^a$ | $5.00 \pm 0.00^a$ | $5.00 \pm 0.00^a$ | $5.00 \pm 0.00^a$ |
| Shininess | $5.00 \pm 0.00^a$ | $5.00 \pm 0.00^a$ | $5.00 \pm 0.00^a$ | $5.00 \pm 0.00^a$ |
| Deformation | $5.00 \pm 0.00^b$ | $4.80 \pm 0.11^{ab}$ | $4.80 \pm 0.11^{ab}$ | $4.60 \pm 0.13^a$ |
| Overall appearance | $5.00 \pm 0.00^b$ | $5.00 \pm 0.00^b$ | $5.00 \pm 0.00^b$ | $4.60 \pm 0.13^a$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other $p = 0.05$ on Tukey's test under the Friedman test

## 2) Organoleptic Parameters of Samples

Organoleptic parameters including flavor, smoothness, sweetness, freshness and overall texture were evaluated. There was no any significant difference in flavor and sweetness (Figure 01) Accelerated climate condition period affect to the freshness, smoothness and overall texture of the hard candy. Moisture migration often causes the end of the shelf life for hard candies. Variations of moisture content can cause significant changes in product quality (Hartel et al., 2018b; Ergun et al., 2010). While in accelerated conditions loss or gain depends on relative humidity and water activity/ moisture content of the product. There was no any significant difference in flavor and sweetness. According to the research, confectioneries' flavor being lost in 10% over months of storage but there are no any significant differences between commercial products and testing samples (Figure 02). But bother parameters had the significant differences. The Freshness and overall texture of chewing gum showed the most difference in accelerated climate conditions within the 21-day period. In accelerated climate conditions of jelly there was no any significant difference observed according to new consumer packaging material. Permeability is impacted by the material's degree of symmetry and crystallinity. A molecule's capacity to penetrate the packaging material is decreased by a higher degree of order and structure. This may be due to that thickness does not directly correlate with permeability when comparing various packing materials, adding thickness usually reduces permeability for any given package (Ergun, Lietha and Hartel, 2010).



Figure 01: Sensory attributes in Hard Candy

The values obtained by 5 – point Hedonic scale and evaluated by Tukey's test under the Friedman test



Figure 02: Sensory attributes in chewing gum

The values obtained by 5 – point Hedonic scale and evaluated by Tukey's test under the Friedman test

*3) Packaging Visual Properties*

There was significant difference ($p<0.05$) in stickiness between product to wrapper (primary package) and stickiness between products (primary package) to secondary package. The product becomes stickier and sticks to the wrapper as the moisture content rises. Surface moisture reduces viscosity and dilutes sugar concentration, which encourages sucrose crystallization and causes graining (Arturo and Paredes, 2000). Color stability of ink had no any significant difference ($p>0.05$) among all three products (Table 04, 05 and 06). If there is a volatile compositions it can be affect to packaging material color stability of ink without these compositions no harm for the ink of package (Arturo and Paredes, 2000).



Figure 03: Sensory attributes in jelly

The values obtained by 5 – point Hedonic scale and evaluated by Tukey's test under the Friedman test

Table 04: Visual Packaging Properties of Hard Candy

| Visual properties | Storage in days | | | |
|---|---|---|---|---|
| | Day 01 | Day 07 | Day 14 | Day 21 |
| Stickiness (pro: Pack) | $5.00\pm0.00^a$ | $5.00\pm0.00^a$ | $4.87\pm0.09^a$ | $4.73\pm0.12^a$ |
| Stickiness (pro: Wrapper) | $5.00\pm0.00^b$ | $4.80\pm0.11^b$ | $4.53\pm0.17^b$ | $4.00\pm0.20^a$ |
| Color stability. Ink | $5.00\pm0.00^a$ | $5.00\pm0.00^a$ | $5.00\pm0.00^a$ | $4.87\pm0.09^a$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 05: Visual Packaging Properties of Chewing Gum

| Visual properties | Storage in days | | | |
|---|---|---|---|---|
| | Day 01 | Day 07 | Day 14 | Day 21 |
| Stickiness (pro: Pack) | $5.00\pm0.00^a$ | $5.00\pm0.00^a$ | $4.87\pm0.09^a$ | $4.70\pm0.12^a$ |
| Stickiness (pro: Wrapper) | $5.00\pm0.00^b$ | $4.80\pm0.11^b$ | $4.53\pm0.16^b$ | $4.00\pm0.19^a$ |
| Color stability of Ink | $5.00\pm0.00^a$ | $5.00\pm0.00^a$ | $5.00\pm0.00^a$ | $4.87\pm0.91^a$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 06: Visual Packaging Properties of Jelly

| Visual properties | Storage in days | | | |
|---|---|---|---|---|
| | Day 01 | Day 07 | Day 14 | Day 21 |
| Stickiness (pro: Pack) | $5.00\pm0.00^c$ | $4.80\pm0.11^{bc}$ | $4.60\pm0.13^b$ | $3.80\pm0.11^a$ |
| Stickiness (pro: Wrapper) | $5.00\pm0.00^b$ | $4.13\pm0.09^a$ | $4.33\pm0.21^a$ | $4.20\pm0.22^a$ |
| Color stability of Ink | $5.00\pm0.00^a$ | $5.00\pm0.00^a$ | $5.00\pm0.00^a$ | $4.73\pm0.18^a$ |

The mean values ± standard error. The values with the same letters are not significantly different from each other $p=0.05$ on Tukey's test under the Friedman test

Table 07: Comparative Analysis of Hard Candy

| Sample | Test Sample | Control Sample |
|---|---|---|
| Physical quality | Yes | Yes |
| Taste and Flavor | Yes | Yes |
| Texture | Yes | Yes |
| Stickiness | Yes | No |

Table 08: Comparative Analysis of Chewing Gum

| Sample | Physical quality | Taste and Flavor | Texture | Syrup Leakage | Stickiness |
|---|---|---|---|---|---|
| Test | Yes | Yes | Yes | Yes | Yes |
| T.Ref | Yes | Yes | Yes | No | No |
| Control | Yes | Yes | Yes | Yes | Yes |
| Co.Ref | Yes | Yes | Yes | No | No |

Table 09: Comparative Analysis of Jelly

| Sample | Physical quality | Taste and flavor | Texture | Stickiness |
|---|---|---|---|---|
| Test | Yes | Yes | Yes | Yes |
| Test Ref. | Yes | Yes | Yes | Yes |
| Control | Yes | Yes | Yes | Yes |
| Con.Ref. | Yes | Yes | Yes | Yes |

*B. Transit Trial*

1) Physical parameters checked by visual inspections

There was no any significant difference ($p>0.05$) in shininess, deformation, wrinkle, cracks and overall appearance. Color intensity and smoothness of the hard candy had significant deference ($p<0.05$) (Table 10). The visual properties: color intensity, smoothness, shininess, deformation, overall appearance, syrup leakage was significant difference (Table 11). There was no any significant difference in any parameter of jelly samples while comparing the commercial samples (Table 12). All visual properties of the products decrease within the transportation period. When long distance transporting products hold different situations like different climatic conditions, weather conditions, different elevations, transportation methods and time affect for the product deterioration (Arturo and Paredes, 2000).

Table 10: Visual Properties of Hard Candy

| Properties | Before transportation | After transportation |
|---|---|---|
| Color Intensity | 5.00±0.00* | 4.40±0.16* |
| Smoothness | 4.93±0.07* | 4.53±0.21* |
| Shininess | 4.80±0.11 | 4.53±0.19 |
| Deformation | 5.00±0.00 | 4.93±0.07 |
| Wrinkle | 4.80±0.11 | 4.40±0.19 |
| Cracks | 5.00±0.00 | 5.00±0.00 |
| Overall appearance | 5.00±0.00 | 5.00±0.00 |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 11: Visual Properties of Chewing Gum

| Properties | Before transportation | After transportation |
|---|---|---|
| Color Intensity | 5.00±0.00* | 3.53±0.19* |
| Smoothness | 5.00±0.00* | 2.87±0.22* |
| Shininess | 5.00±0.00* | 1.93±0.18* |
| Deformation | 5.00±0.00* | 3.53±0.13* |
| Overall appearance | 5.00±0.00* | 1.80±0.20* |
| Syrup leakage | 5.00±0.00* | 1.53±0.13* |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test

Table 12: Visual Properties of Jelly

| Properties | Before transportation | After transportation |
|---|---|---|
| Color intensity | 4.67±0.13 | 4.60±0.13 |
| Smoothness | 5.00±0.00 | 5.00±0.00 |
| Shininess | 5.00±0.00 | 5.00±0.00 |
| Deformation | 5.00±0.00 | 4.80±0.11 |
| Overall appearance | 5.00±0.00 | 5.00±0.00 |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test

2) *Organoleptic parameters*
According to 5 point hedonic scale, during the transit trial period there was significant difference in freshness and other parameters like flavor, smoothness, texture, and sweetness were no any significant difference observed (Figure 04) in hard candy. Flavor and overall texture was changed in the transit trial period because of fluctuation of storage conditions (Arturo and Paredes, 2000). There was no any significant difference in freshness and sweetness (Figure 05) when comparing the commercial samples. There was no any significant difference in new consumer package used jelly samples (Figure 06) it may be due to thickness of the packaging material not much decreased (Ergun, Lietha and Hartel, 2010).

3) *Packaging Visual Propertie* All three products had a significant difference (p<0.05) in stickiness between primary package, wrapper and stickiness, with primary package being the most significant. Color stability of ink was no significant difference (p<0.05) between the two, and all visual packaging properties were reduced during transit trial period (Table 13, Table 14 and Table 15) (Calligaris *et al.*, 2019).
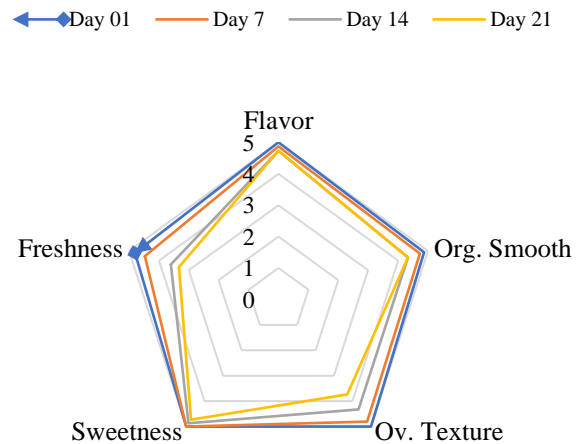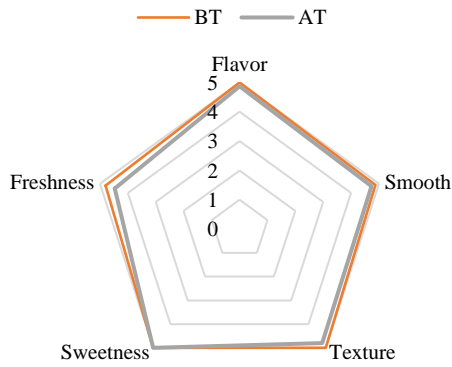
Figure 04: Sensory Attributes in Hard Candy
The values obtained by 5 – point Hedonic scale and
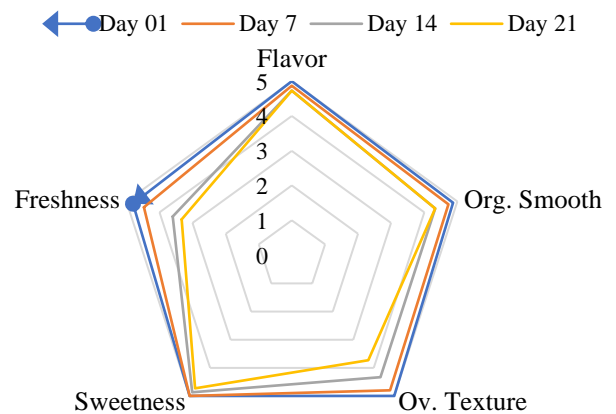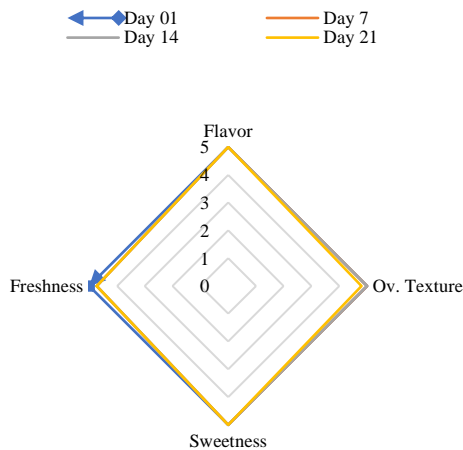evaluated by Tukey's test under the Friedman test
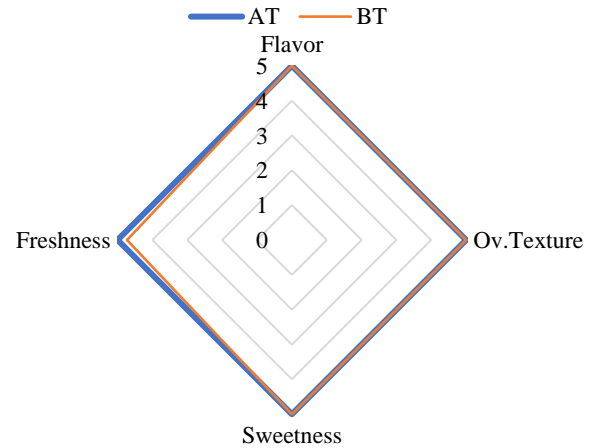


Figure 06: Sensory attributes in jelly
The values obtained by 5 – point Hedonic scale and
evaluated by Tukey's test under the Friedman test
BT – Before Transportation
AT – After Transportation
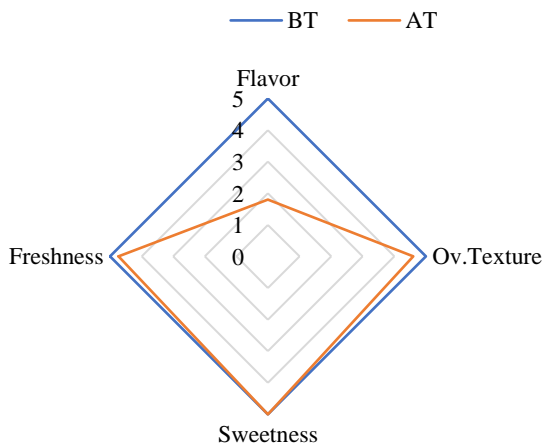


Figure 05: Sensory attributes in chewing gum
The values obtained by 5 – point Hedonic scale and
evaluated by Tukey's test under the Friedman test
BT – Before Transportation
AT – After Transportation

Table 13: Visual Packaging Properties of Hard Candy

| Properties | Before transportation | After transportation |
|---|---|---|
| Stickiness product to package | 5.00±0.00* | 4.73±0.12* |
| Stickiness product to wrapper | 5.00±0.00* | 4.00±0.90* |
| Color stability ink package ink | 5.00±0.00 | 4.87±0.90 |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05
on Tukey's test under the Friedman test

Table 14: Visual Packaging Properties of Chewing Gum

| Properties | Before transportation | After transportation |
|---|---|---|
| Stickiness product to package | 5.00±0.00* | 2.47±0.13* |
| Stickiness product to wrapper | 5.00±0.00* | 1.73±0.15* |
| Color stability of package ink | 5.00±0.00* | 4.47±0.13* |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05
on Tukey's test under the Friedman test

Table 15: Visual Packaging Properties of Jelly

| Properties | Before transportation | After transportation |
|---|---|---|
| Stickiness product to package | 5.00±0.00* | 3.80±0.11* |
| Stickiness product to wrapper | 5.00±0.00* | 4.20±0.22* |
| Color stability of package ink | 5.00±0.00 | 4.73±0.18 |

The mean values ± standard error. The values with * mark significantly different from each other p=0.05 on Tukey's test under the Friedman test

## V. CONCLUSION

The results indicated that size, texture, quality of packaging material of confectioneries was affected by storage and transportation as well as temperature, moisture migration, relative humidity. Three production processes were conducted, revealing variations in commercial products such as new hard candy, decreased chewing gum size, and reduced thickness packaging for jelly. All confectionery samples deteriorate within the period due to moisture migration, low temperature, and high relative humidity in the climate chamber (35/40ºC and50/80% RH). Overall appearance of confectioneries can be affected by sucrose and citric acid content. However commercial chewing gum samples and hard candy samples showed better quality compared to size reduced samples due to their sensitivity to humidity and temperature. Further, the overall quality of all the samples closes to commercial products.

## REFERENCES

Arturo, L. and Paredes, A. (2000) "The stability and shelf-life of foo, The stability and shelf-life of food", *Woodhead Publishing Limited and CRC Press LLC,* 6(4), pp. 97–80.

Board, N. (2013*) "Confectionery Products Handbook (Chocolate, Toffees, Chewing Gum \& Sugar Free Confectionery): Food Processing \& Agro Based Profitable Projects, Food Processing Industry in India, bread manufacturing project, candy manufacturing process", *asia pacific business press inc,* 11(4), pp. 17–29.

Calligaris, S., Manzocco, L., Anese, M. and Nicoli, M.C. (2019) "Accelerated Shelf-Life Testing. Food Quality and Shelf-Life", *Elsevier Inc,* 8(11), pp 89-92.

Cheung, P.C.K. and Mehta, B.M. eds. (2015) "Handbook of food chemistry", *Springer Berlin Heidelberg,* 11(2), pp. 19-25.

Dilrukshi, P.G.T., Munasinghe, H., Silva, A.B.G. and De Silva, P.G.S.M. (2019) "Identification of synthetic food colours in selected confectioneries and beverages in Jaffna District", *Journal of Food Quality,* 19(2), pp.1-8.

E.B.Jackson, R. L. (1992) "Sugar Confectionery and Chocolate Manufacture", *Springerlinc,* 9(2), pp.11-18.

Edwards, W. P. (2018) "The Science of Sugar Confectionery", *Royal Society of Chemistry*, 5(10), pp. 220-225.

Ergun, R., Lietha, R. and Hartel, R. W. (2010) "Moisture and shelf life in sugar confections", *Critical Reviews in Food Science and Nutrition,* 50(2), pp.162–192.

Hartel, R. W., von Elbe, J. H. and Hofberger, R. (2018) "Confectionery Science and Technology", *Confectionery Science and Technology,* 7(11), pp. 530-539.

Lees, R. (2012) "*Sugar Confectionery and Chocolate Manufacture", Springer US,* 5(1), pp. 32-39.

Netramai, S., Kijchavengkul, T., Sompoo, P. and Kungnimit, W. (2018) "The effect of intrinsic and extrinsic factors on moisture sorption characteristics of hard candy", *Journal of Food Processing and Preservation*, 42(5), pp. 135-148.

Schieberle, P. and Grosch, W. (1988) "Identification of potent flavor compounds formed in an aqueous lemon oil/citric acid emulsion", *Journal of Agricultural and Food Chemistry*, 36(4), pp. 797–800.

Spanemberg, F. E. M. (2019) "Effects of sugar composition on shelf life of hard candy Optimization study using D-optimal mixture design of experiments", *Journal of food preservation engineering,* 3(6), pp. 1–10.

Subramaniam, P. J. (2009) "Shelf-life prediction and testing, Science and Technology of Enrobed and Filled Chocolate, Confectionery and Bakery Products", *Woodhead Publishing Limited*. 3(7), pp 233-254.

# TRACK - CROP SCIENCE AND TECHNOLOGY (CST)

# Variations in the Pharmacognostic Properties of *Aegle marmelos* found across Five Geographical Locations in Sri Lanka

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## Abstract

*Aegle marmelos (Bale tree), family-Rutaceae is a very important medicinal plant used for the Ayurveda and traditional medical systems. This study is focused on pharmacognostic characteristics of the leaves, stem barks and the root barks of Aegle marmelos (A. maemelos) found in five geographical locations in Sri Lanka. A solvent system containing, Toluene, Ethyl acetate, Formic acid and Methanol was used as mobile phase for the leaves. For stem bark and root bark extracts, Toluene: Ethyl acetate: Chloroform: Hexane: Methanol solvent system was used as the mobile phase. TLC outcomes were developed by High Performance Thin Layer Chromatography (HPTLC) technique. According to this study moisture values of the selected plant parts were in the range of 7% to 12% and ash values were in the range of 5% to 10%. pH values of the selected plant parts were varied form 5-8. Microscopic view of the root bark and stem bark were observed and tracheid and xylem vessels were detected. One common compound was detected in leaves, stem bark and root bark, and two common compounds were detected in stem bark and root bark from TLC and HPTLC profiles. It was detected that the concentrations of the similar compounds vary with plant part as well with the origin of the plant. These findings can be used for the identification and authentication of A. marmelos plant parts that are used for medicinal purposes and herbal product manufacture. A comparative clinical study is needed to explore the therapeutic efficacy of these parts.*

*Keywords: Bael , HPTLC, microscopic , pH, Moisture , Ash*

## I. INTRODUCTION

Man is a creation of nature. Therefore, if a human gets an illness, there should be a cure for it through nature itself. The medicines available in the areas where we live are *sāthmya* for us. Although Sri Lanka is located in a small land area, it is rich in biodiversity due to its coastline, plains, lowlands and mountains. Since Sri Lanka is also known as a country with high biodiversity in South Asia , even though it is the same plant in Sri Lanka, diversity (Ashton *et al.*, 2004).

*Aegle marmelos* is commonly known as Bilwa or Bael which belongs to the family Rutaceae. It is an important indigenous medicinal plant in Ayurveda. The English name for Bael is stone apple, as its rather large fruit is like pale yellow to golden orange when ripe (Subedi and Bashyal, 2022). Due to urbanization and commercialized economy, nowadays we usually find the stem bark of the Bael tree is sold instead of the root bark. Therefore, when preparing Ayurvedic drugs it is vital to verify the quality of the raw materials originated from the Bael plant.

If there are similar fundamental chemical compounds found in the root bark and stem bark of the tree, the Bael tree's stem bark can be used in place of the root bark. When preparing the standard quality of Ayurveda drugs, it is needs to have a good understanding of the variation of the chemical compositions of the tree during different seasonals and in different geographical areas. This will assure a speedy recovery of a patient by a quality drug. Therefore, this study has been focused to determine variations in the pharmacognostic properties of *Aegle marmelos* found across five geographical locations in Sri Lanka.

## II. LITERATURE REVIEW

Bael can thrive well in high altitude as high as 1,200 m and withstand without any significant growth retardation at 50°C and −7°C. In the prolonged droughts, fruiting may cease, but the plant can survive with shallow soil moisture. Bael

trees generally require well-drained soil (pH:5–8)(Pathirana, Madhujith and Eeshwara, 2020). It is a subtropical, deciduous tree that grows well in various soil-climatic conditions and can also survive in alkaline soil, and is not injured by temperatures even as low as -7ºC (Shashank and Poonia, 2018). *Aegle marmelos is a* strong tree that grows 6m to 10m of height and bears aromatic trifoliate leaves (Singh, 2008).It has two varieties; *"Vanya"* is thorny and small fruited and "*Grāmya*" is less thorny large fruited (Department of Ayurveda, 1979). Bael plant contains various phytochemicals like alkaloids, tannins, essential oils, gums, resins, coumarin, polysaccharide that makes it useful in many ailments. It has numerous crucial therapeutic applications like antifungal, analgesic, anti-inflammatory, antipyretic, hypoglycemic, anti-lipidemic, and immune-modulatory, anti-proliferative, wound healing, anti-fertility and insecticidal (Mali *et al.*, 2020). Bale plant also mentioned in the specific classification systems (*Ghana vargīkarana*) in main Ayurveda texts as *Śothahara, Arśoghna, Asthāpanoga Mahakaṣāy (caraka samhitha),* Var*unādi, Ambhasthādi, Brihat pancamula gana (Susruta Samhita) and Guducyādi varga (*Bhavaprakāśa) (Agrawal and Kumar, 2015). Ayurvedic Pharmacological properties of Bale plant described in Ayurveda text (Shrma )Rasa (taste)-Kaṣāya,Tikta; Guna (properties)-Laghu, Rukṣa; Vīrya (power) -Uṣna, Vipāka Metabolism)-Katu and Karma(action)-Grāhi.

The different parts of *Aegle marmelos* are used for various therapeutic purposes such as for treatment of asthma, anemia, fractures, healing of wounds, swollen joints, high blood pressure, jaundice, diarrhea, healthy mind and brain typhoid troubles during pregnancy (Virendra, Rashmi and Pandey, 2018). Various pharmacological actions said by traditional healers are antioxidant, antibacterial, antifungal, antidiarrheal, antidiabetic, anti-proliferative, cytoprotective, hepatoprotective, antifertility, analgesic, anti-arthritis, contractile, antihyperlipidemic, cardioprotective, radioprotective, anticancer, antiviral, anti-ulcer, immunomodulatory and wound healing properties. (Bhar, Mondal and Suresh, 2019).

Chemical compounds found in various parts of *A. Marmelos* having biological influences in the body (Venthodika *et al.*, 2021). Also, the Rf of other phytocompounds of methanol extracts which are near to marmelosin range may be other

compounds under the class coumarins (Nirupama *et al.*, 2012).

The root and stem bark have more identical compounds and so they have same pharmacological activities and therefore stem bark could be substituted or used along with root in any of drug preparation where root is of important.

## III.     METHODOLOGY

### A.     Sample Collection and Preparation
Samples from the different parts of the Bael plants collected from the aforementioned geographical areas were introduced to the National Herbarium of Sri Lanka and obtained authenticated prior to the study. When collecting the plant specimens, foreign matter like sand, soil, polyethene, fungus or insect infestations were avoided and samples were cleaned, packed packages and labeled accordingly. Sample labeling was done as follows and labeling numbers are referred here on for the convenience.1 -Colombo, 2- Kegalle, 3-Matale, 4- Galle & 5 – Puttalam. All samples were cleaned well and dried under sunlight while preventing any contaminants. Then they were grounded into fine powder by a clean grinder machine (Premier Xpress 750.India), sifted and stored in clean labeled pouches separately. Sifting was done through  sieve number 125µm containing an aperture size of  0.125 mm and having a wire diameter of 0.090 mm.

### B.    Determination of Moisture Content
Moisture testing was conducted based on ISO 1573.  Initially the empty weight of the moisture dish was measured ($W_o$). Then 5g of powders specimen was put into the dish and weight was measured ($W_1$). Then it was heated for 2 hours in the electric oven at $103^0C$ temperature. Heated dish was cooled down to room temperature inside a desiccator. Final weight of the cooled dish was measured ($W_2$).

### C.    Determination of Ash
Ash value determination was conducted based on the WHO quality control methods for medicinal plants. Initially the cleaned, empty crucibles were marked and the weights were measured. Initial weights ($W_o$) of the crucibles were recorded separately and about 5 g of each sample were put in to the crucibles accordingly. Weight of the crucibles with the samples ($W_1$) were recorded separately and then the crucibles were heated in

an open flame to reduce the moisture. Then the samples were introduced to the muffle furnace (KJ-MC$_{1000}$-$_{27}$LWQ , Zhenzhou Kejia Furnace Co., Ltd, China) to be heated at 500ºC.Samples were heated for 4 hours until constant weights were gained for each sample. Then the samples were cooled down to room temperature inside the desiccator. Then then the final weights of the crucibles with the samples (W$_2$) were measured and recorded.

### D. Determination of pH

pH meter (PH400S,APERA, Columbus, Ohio, US) was calibrated with standard buffer solutions of pH 3.01 , pH 7.00 and pH 13.01.pH probe was cleaned before and after each test.10g of the powdered specimens were extracted to 100 ml of hot water at 50$^0$C temperature and allowed to cool down. Then the insoluble content was removed and the pH of the extract was tested.

### 1) Thin Layer Chromatography and High-Performance Thin Layer Chromatography

Ten grams of powdered samples were placed into Erlenmeyer flasks, and 100ml of methanol was added to each flask. The flasks were then placed on an orbital shaker and operated for 24 hours. After that, the solution was filtered using filter papers, and the filtrate was introduced to a rotary evaporator. The solvent was evaporated, and the remaining extract was taken and labeled according to the test tube it was placed in. Drops from the extract were then introduced to the starting line of a TLC plate using separate capillary tubes. The TLC plate was then immersed in the prepared mobile phase inside the TLC chamber, and the samples were allowed to run. Once the mobile phase reached the end line, the TLC plate was taken out and allowed to dry at room temperature.

### 2) Preparation of the Mobile Phase

Mobile phase was prepared with several mixtures of solvents (Toluene: Ethyl Acetate: Methanol - 16: 4: 1, Chloroform: Methanol -9:1, Toluene: Ethyl Acetate -i3: 2, Toluene: Ethyl Acetate -3: 1, Toluene: Ethyl Acetate- 5: 2, Ethyl Acetate: Toluene: Chloroform: Hexane: Methanol- 2: 2: 1: 4: 1, Ethyl Acetate: Toluene: Formic Acid: Methanol - 3: 3: 0.8: 0.2) in order to obtain the best combination for a perfect mobile phase. TLC plates with highest visibility were introduced to the HPTLC machine and separations were analyzed.

## IV. RESULTS AND DISCUSSION
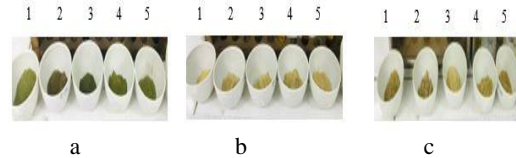


Figure 03: Powdered Samples of Bael Plant Parts
a: Leaf powder, b: Stem bark powder, c: Root bark powder

When analyzed the morphological characteristics of the dried and powdered leaves from the 05 regions shown in Figure 01, all samples exhibited a similar aromatic odor and their colors varied from dark green to light green. Since all samples were dried under similar conditions, this color variation should be due to the density of chlorophyll content and other compounds.

Dried stem bark powders were cream colour and the root bark powder was darker than the stem bark powders. Root bark powders were brownish cream in colour and both stem and root bark powders gave aromatic odour. Colour variations are mainly due to the presence of different types of chemical compounds and organelles in different concentrations.

The moisture content of Bael leaves, stem barks, and root barks were analyzed in (Figure 02) different districts, revealing distinct patterns. For Bael leaves, the moisture content ranged from 7.88% to 11.69%, with Colombo exhibiting the highest moisture content followed by Kegalle, Galle, Matale, and Puttalam. This variation is attributed to regional differences in humidity and rainfall, with areas having higher humidity areas having more moisture. In Bael stem barks, moisture content varied from 7.58% to 10.38%, with Kegalle having the highest moisture content, followed by Matale, Colombo, Galle, and Puttalam.
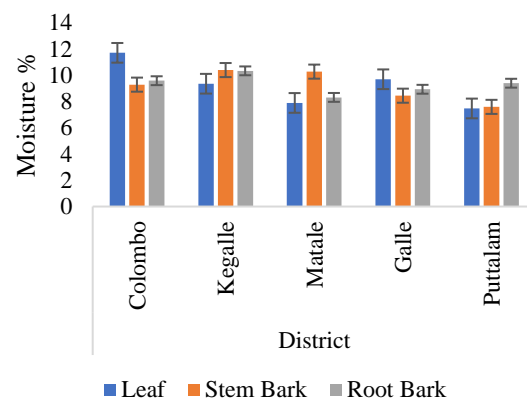


Figure 04: Moisture Variation in the Selected Districts

The moisture content of Bael root barks ranged from 8.3% to 10.32%, with Kegalle showing the highest moisture content, followed by Colombo, Puttalam, Galle, and Matale. These variations are influenced by factors such as soil moisture and altitude, highlighting the importance of understanding regional differences for standardized production in industries utilizing Bael products.

Figure 03 displays the pH variations in Bael leaves, stem barks, and root barks collected from different districts. For Bael leaves, pH ranged from 5.92 to 7.3, with Colombo having the highest pH followed by Puttalam, Kegalle, Galle, and Matale. Acidic soils in certain regions, influenced by factors like minerals and rainfall, contributed to lower pH levels in leaves. Bael stem barks showed a pH range between 6.67 and 5.87, with Galle being the most acidic followed by Kegalle, Matale, Colombo, and Puttalam. Urban and industrial activities, along with microbial processes, affected stem bark acidity. Bael root barks exhibited a pH range of 7.42 to 6.29, with Colombo being the most basic followed by Galle, Puttalam, Matale, and Kegalle. Alkaline minerals and organic matter decomposition influenced higher pH levels in root barks.

These variations stem from a complex interplay of soil composition, environmental factors, microbial activity, and organic matter content in the respective regions. Understanding these pH differences is crucial for comprehending the quality and characteristics of Bael products from different districts.
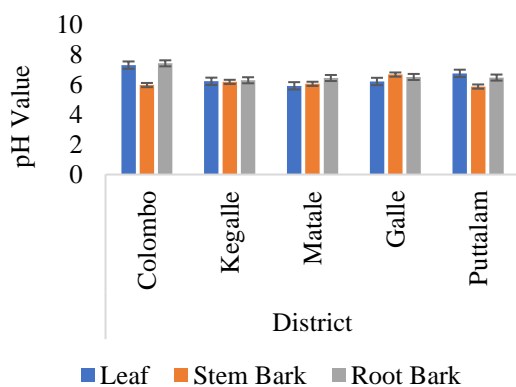


Figure 05: pH Variation in the Selected Districts among the Tested Bale Samples



Figure 06: Ash Content Variation in the Selected Districts among the Tested Bael Samples

Figure 04 demonstrates the results of the ash content in Bael leaves, stem barks, and root barks of different regions. Ash content can be indicative of the mineral content in plant samples and is commonly used to assess the quality and nutritional value of plant material. The ash content in Bael leaves ranged from 8.51% to 5.86%, with the highest content in Colombo and the lowest in Puttalam. The descending order of ash content was Colombo > Kegalle > Matale > Galle > Puttalam. The mineral content in plants often reflects the composition of the soil they grow in. Different regions have varying soil compositions, which can influence the mineral uptake by plants.

Environmental factors such as rainfall, sunlight, and temperature can affect plant metabolism and nutrient absorption, leading to differences in ash content. Older or stressed plants might have different nutrient profiles compared to younger, healthier ones. Ash Content in Bael Stem Barks varied from 6.42% to 9.36% and the descending order of ash content was Kegalle > Matale > Galle > Colombo > Puttalam Similar to leaves, environmental factors play a significant role. Adequate water supply and nutrient availability in the soil can lead to higher ash content.

Ash Content in Bael rootbarks were in the range of 7.54% - 8.75% in the following descending order .Kegalle > Colombo > Puttalam > Galle > Matale. Plants absorb minerals not only from the surface but also from deeper layers of the soil. Variations in root depth across regions can lead to differences in mineral content. The pH of the soil can influence the availability of certain minerals. Plants in regions with more acidic or alkaline soils might have different ash content.

## A) Analysis of TLC & HPTLC Observations



| TLC Plate at 200 nm | TLC Plate at 254 nm | TLC Plate at 366 nm |
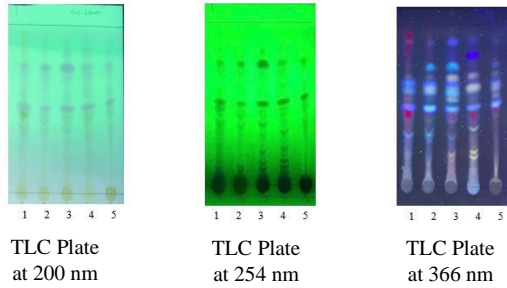
Figure 07: TLC profiles of Leaf Extracts under Different Wave Lengths

(Left to right Spots :1-Colombo,2-Kegalle,3 - Matale,4-Galle and 5-Puttalam)

Figure 05 depicts the TLC profiles of leaf extracts under different wave lengths. The Solvent system used for the Bael leaves was different form the solvent system used for the stem and root barks due to the different compositions of the parts.



| TLC Plate at 200 nm | TLC Plate at 254 nm | TLC Plate at 366 nm |
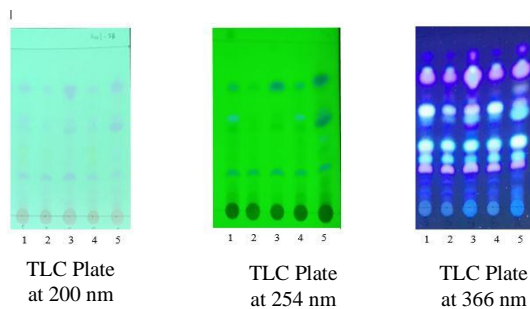
Figure 08: TLC Profiles of Stem Bark Extracts under Different Wave Lengths

(Left to right Spots: 1-Colombo,2-Kegalle,3-Matale, 4-Galle and 5 -Puttalam )

Developed TLC profiles of stem bark extracts under different wave lengths described in Figure 6. Most clear visualization of the sperated spots of stem bark extracts were observed under 366nm wave length.



| TLC Plate at 200 nm | TLC Plate at 254 nm | TLC Plate at 366 nm |
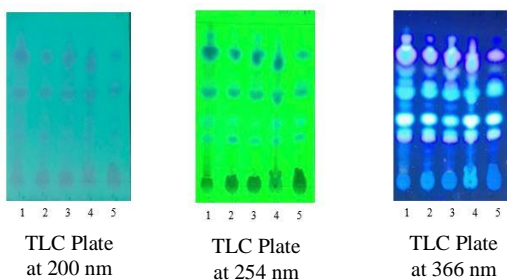
Figure 09: TLC Plated of Root Barks under Different Wave Lengths

(Left to right Spots :1-Colombo, 2-Kegalle, 3-Matale, 4- Galle and 5- Puttalam)

Figure 07 described the TLC profiles of root bark Extracts at different wave lengths. The clearest visualization of the sperated spots of root bark extracts were observed under 366nm wave lenth.

The data provided on Table 03 indicate the presence of certain compounds in the samples, as represented by their Retention Factor (Rf) values and the corresponding areas under the peaks (which indicate the quantity of the compounds).

Table 01: Comparison of Rf Values and Peak Areas in HPTLC Readings on Rf Values and Peak Areas for Bael Leaves

| Sample | Leaves of *Bale* plants from different geographical locations | | | | | |
| | Rf 01 | | Rf 02 | | Rf 03 | |
| | Max Rf | Area % | Max Rf | Area % | Max Rf | Area % |
|---|---|---|---|---|---|---|
| 1 | 0.4 | 23.85 | 0.11 | 3.9 | 0.23 | 0.51 |
| 2 | 0.4 | 11.12 | 0.12 | 2.69 | - | - |
| 3 | 0.39 | 3.78 | - | - | - | - |
| 4 | 0.39 | 4.02 | 0.11 | 3.29 | 0.23 | 0.43 |
| 5 | 0.42 | 1.87 | 0.12 | 6.69 | 0.24 | 0.49 |

(Sample Origin: 1-Colombo,2-Kegalle,3-Matale,4-Galle and 5-Puttalam)

Rf values indicate the presence of specific compounds in the samples. Each Rf value corresponds to a different compound or a group of compounds in the Bael leaves. The presence and quantity of compounds vary across regions. For instance, all 5 samples share some compounds (Rf around 0.4), but the quantities differ significantly. Additionally, certain compounds found in Colombo and Galle samples (Rf: 0.11, 0.23) are present in lower /higher quantities or absent in other regions. The differences in compound presence and quantity suggest that the chemical composition of Bael leaves varies based on the geographical location where the plants are grown. These differences could be due to soil composition, climate, or other environmental factors.

Best Solvent system for the TLC for Bael leaves is the mixture of Ethyl Acetate: Toluene: Formic Acid: Methanol in 3 :3 : 0.8 : 0.2 ratio and the Best solvent system for the TLC for Bael root bark

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and stem bark is Ethyl Acetate: Toluene: Chloroform: Hexane: Methanol mixture in 2: 2: 1: 4: 1 ratio. The best Wavelength to visualize the separations using the selected mobile phase is 366nm.

Table 04: TLC profiles of Root Bark and Stem Bark with Rf Values

| Sample | Stem bark | | | | Root bark | | | |
|---|---|---|---|---|---|---|---|---|
| | Rf 01 | | Rf 02 | | Rf 01 | | Rf 02 | |
| | Max Rf | Area % | Max Rf | Area % | Max Rf | Area % | Max Rf | Area % |
| 1 | 0.22 | 8.59 | 0.57 | 43.02 | 0.24 | 6.3 | 0.53 | 27.85 |
| 2 | 0.21 | 8.76 | 0.57 | 14.34 | 0.23 | 10.04 | 0.57 | 7.94 |
| 3 | 0.19 | 9.62 | 0.55 | 13.4 | 0.22 | 13.76 | 0.56 | 7.12 |
| 4 | 0.21 | 8.81 | 0.56 | 14.57 | 0.23 | 10.75 | 0.56 | 4.74 |
| 5 | 0.21 | 7.98 | 0.56 | 14.57 | 0.23 | 13.94 | 0.57 | 8.6 |

(Sample Origin:1-Colombo,2-Kegalle,3-Matale, 4-Galle and 5-Puttalam)

According to Table 04, root bark and the stem bark had 02 similar Rf values with higher peak areas. That implies, both stem bark and root bark have two similar chemical compounds in large concentrations. The highest area of common Rf 01 of the stem bark Sample was found in Colombo (8.59%) & Kegalle (8.76%) .Highest Area %: of common Rf 02 was also found in Colombo (43.02%), Kegalle (14.34%) samples. For Root Bark Samples the highest area was found in Puttalam (27.85%) and Colombo (6.3%) for common Rf 01 and for common Rf 02, highest area was found in Colombo (27.85%) and Puttalam (8.6%).

Colombo exhibits significant presence and high area percentages for both Common Rf 01 and Common Rf 02 in both stem bark and root bark samples. It stands out as having considerable quantities of the compounds represented by these Rf values. Kegalle shows notable presence for both Common Rf 01 and Common Rf 02 in stem bark samples, although the area percentages are comparatively lower than Colombo. In root bark samples, Kegalle's presence is moderate. These regions exhibit moderate presence and area percentages in both stem bark and root bark samples. They do not have the highest values but still have considerable quantities of the compounds represented by the given Rf values. Matale samples generally show lower presence and area percentages compared to the other regions. It has moderate presence in stem bark samples and relatively low presence in root bark samples.

Industries utilizing Bael bark for medicinal or herbal products should consider the regional differences in chemical composition for quality control and standardization purposes. It's crucial to ensure consistent quality and efficacy of the products derived from Bael bark across different regions. These variations highlight the importance of understanding regional differences in herbal products. The presence and concentration of specific compounds can influence the medicinal properties and overall quality of Bael leaves in different regions.

### B. Microscopic View of the Different Parts of the Bael plant

Starch granules were not found in the root bark microscopic view but single and compound starch granules were found in Bael leaves. Tracheids and xylem vessels were found in the Bael root bark and Stem bark also showed xylem vessels in the microscopic view.
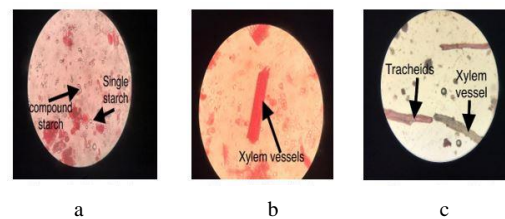


Figure 010: Microscopic view of a: Bael leaves, b: stem bark and c: root bark

### VII. CONCLUSION

These results revealed that sustainable medicinal usage from the *Aegle marmelos* plant, there is a possibility to use stem bark of the plant as a substitute for root bark because both parts presented with many similar compounds. This replacement prevents the damage done to the root of the Bael plant by people when they search root barks for commercial purposes. This would be validated with clinical studies in therapeutic practice and their potential medicinal significance, additional analysis, such as mass spectrometry or chemical profiling.

Moreover, the results of this study would be used for further research to understand the specific compounds responsible for the medicinal properties of Bael leaves in each region. Such knowledge is crucial for both traditional medicine and the pharmaceutical industry to harness the full potential of this plant for medicinal purposes.

REFERNCES

Agrawal, N., and Kumar, A. (2015) "Dravyaguna Vigyan with Pharmacology", *Varanasi Chaukamba Publishers*, 12(2), pp. 185-194.

Ashton, M., Gunathilake, S., Zoysa, N., Dassanayake, M. D., Gunathilake, S., and Wijesundara, S. (2004) "Sri Lanka Gaskolan Athpotha", *Sri Lanka Wildlife Conservation*, 7(1), pp. 374-379.

Mali, S.S., Dhumal, R.L., Havaldar, V.D., Shinde, S.S., Jadhav, N.Y. and Gaikwad, B.S. (2020) "A systematic review on Aegle marmelos (Bael)", *Research Journal of Pharmacognosy and Phytochemistry*, 12(1), pp.31-36.

Nirupama, G.S., Padmasri, G., Ramesh, R.V. and Vasanthi, M. (2012) "Comparative analysis of phytochemical constituents present in various parts of Aegle marmelos", *Asian Pacific Journal of Tropical Disease*, 12(3), pp.774-777.

Pathirana, C.K., Madhujith, T. and Eeswara, J., (2020) "Bael (*Aegle marmelos* L. *Corrêa*), a medicinal tree with immense economic potentials", *Advances in Agriculture*, 8(2), pp.1-13.

Singh, J., (2008) "*Atlas of Āyurvedic Medicinal Plants*", Chaukhambha Sanskrit Bhawan. 4(1), pp.1-20.

Subedi, A. and Bashyal, B. (2022) "Medicinal properties and uses of Aegle marmelos (Bel) plant: a review", *Asian J Pharm*, 6(1), pp.10-20.

Venthodika, A., Chhikara, N., Mann, S., Garg, M.K., Sofi, S.A. and Panghal, A. (2021) "Bioactive compounds of Aegle marmelos L., medicinal values and its food applications: A critical review", *Phytotherapy Research*, 35(4), pp.1887-1907.

# Field Performance of F2 Generation Progenies of a Locally Developed Hybrid Chili (*Capsicum annuum* L.) Variety

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## *Abstract*

*Researchers and plant breeders have been consistently working to create improved chilli cultivars through hybridization. Because of the ability to thrive in specific niches and environmental conditions, locally produced hybrid chilli types have become well known. Hence, this study was conducted at the Field Crops Research and Development Institute (FCRDI) Mahailupallama, Sri Lanka to assess the field performances of F2 generation progenies obtained from a locally developed hybrid chilli variety MICH HY1. F1 Generation of MICH Hy 1 Chilli seeds (T1), F2 Generation of self-pollinated MICH Hy 1 Chili seeds (T2) and F2 Generation of open-pollinated MICH Hy 1 Chilli seeds (T3) were used as planting materials and the treatments were arranged in Randomized Complete Block Design having 20 replicates. Different vegetative and reproductive characteristics and yield parameters were recorded. The results showed that the F1 generation performed well compared to the F2 generations from both self-pollination and open-pollination in terms of plant height and canopy width, suggesting a genetic advantage defined by taller plants and broader canopies. Chilli plants in T3 took higher days for 1st flowering (65.3 days) while the T1 and T2 took 62.3 and 61.8 days respectively. Moreover, when compared to the F2 generation, the F1 generation produced more pods, higher total weights, and higher overall crop yields. These findings provide chilli farmers and breeders with practical assistance, allowing them to make informed decisions to increase chilli crop yield and success. Future study into the underlying genetic pathways promises more efficient and sustainable chilli cultivation approaches.*

***Keywords: Chilli, F2 Generation, Hybridization, MICH Hy 1, Open-Pollination, Self-Pollination***

## I. INTRODUCTION

Chilli (*Capsicum annuum* L.) is one of the world's most important vegetable crops, valued for its strong taste and widespread use in culinary traditions around the world (Hernández-Pérez *et al*., 2020). Chili is an essential condiment in most of the cuisines of Sri Lanka and people consume large quantities of chillies annually (Weerasekara *et al*., 2018). The cultivation extent of chilli in Sri Lanka is around 15,000 ha and production is about 75,000 Mt on a green chilli basis. However, due to insufficient production Sri Lanka imports large quantities of dry chili annually spending huge amounts of foreign exchange. Demand for chilli has increased in recent years, not only for culinary purposes but also for its pharmaceutical and therapeutic capabilities, making it a crop of major agricultural and commercial importance. To address this rising demand, high-yielding and disease-resistant chilli varieties must be developed (Hewage, Bandara and Rathnayake, 2022).

Plant breeders and researchers have been constantly engaged with producing superior chilli cultivars through hybridization. Locally created hybrids have received prominence among the numerous hybrid chilli types due to their suitability to unique ecological niches and tolerance to local diseases and pests (Rasco Jr, 2008). Sri Lanka has a diverse chilli collection, including Open Pollinated Varieties (OPVs) and newly released local hybrid chilli varieties (LHCVs). Despite the fact that LHCVs have only been on the market for around 5 - 6 years, they have quickly gained appeal among farmers due to increased production. However, only MICH HY1, released in 2015, is widely cultivated in various parts of the country, whereas MICH HY2 (issued in 2017) has not been as popular due to a lack of readily available seeds (Hewage, Bandara, and Rathnayake, 2022). MICH HY1 is a more

appealing variety for chilli growers due to higher yields recorded by farmer fields, longer crop duration, less sensitivity to leaf curl complex, and significantly taller plants that make it easier for farmers to carry out specific agronomic procedures (Hewage, Bandara, and Rathnayake, 2022).

Further, the F2 generation, which is the self-pollination of F1 hybrids, is an important stage in the hybrid breeding process. It provides a unique chance to analyze the segregation of desirable features and identify the possibility for further development in future generations (Couto *et al.*, 2019). Hence, the purpose of this research was to assess the field performances of F2 generation progenies obtained from a locally developed hybrid chilli variety MICH HY1. The findings of this study have the potential to contribute to the development of more resilient and high-yielding chilli cultivars for cultivation.

## II. MATERIALS AND METHODS

### A. Experimental Site
The study was conducted at the Field Crops Research and Development Institute (FCRDI) Mahailupallama, Department of Agriculture, Sri Lanka from May to October (one cropping cycle) during *Yala* season of 2022. The location represents $DL_{lb}$ agroecological region of Sri Lanka. The average annual rainfall is 900 to 1100 mm and the temperature is around $27 - 29\ ^{o}C$. The soil type is Reddish Brown Earth with a moderate well-drained sandy clay loam texture (Panabokke, 1996).

### B. Planting Materials
F1 and F2 generations of MICH Hy 1 Chilli seeds were used as planting materials in this study (Table 01). The F1 generation of MICH Hy 1 chilli plants was covered with isolation cages made of nylon fabric to obtain the F2 generation of self-pollinated seeds (T2) and other plants were allowed for open pollination to obtain the F2 generation of open-pollinated seeds (T3). Accordingly, seeds were extracted from 20 plants in each treatment separately by hand, and allowed to air-dry.

### C. Nursery Preparation And Management
The extracted chilli seeds were treated with Captan fungicide and planted in black-coloured polythene bags (4" X 4") with unsealed bottom.

Bags were filled with a well-prepared potting mixture of Top soil: Organic matter: Sand at the ratio of 2:1:1 by volume leaving 2-3 cm from the top. Four seeds were planted in each bag and covered with soil. 2-3cm thickness straw mulch was placed to cover the pots and fungicide was applied after mixing with water. Bags were placed ensuring sufficient sunlight and drainage and the seedlings were maintained in a net house (50 % shade) and carefully protected from pests and diseases. Watering was done daily for good moisture conditions during the dry period. Seedlings were exposed to light sunlight gradually for hardening.

Table 01: Planting Materials Used in this Study

| Treatment | Treatments |
|---|---|
| T1 | F1 Generation of MICH Hy 1 Chili seeds |
| T2 | F2 Generation of self-pollinated MICH Hy 1 Chili seeds |
| T3 | F2 Generation of open-pollinated MICH Hy 1 Chili seeds |

### D. Land Preparation and Transplanting
Properly ventilated and well drained open field was selected for transplanting the chilli seedlings. The field was ploughed about 30 cm – 45 cm depth and the roots and stones were removed to make the soil finer. Thirty raised beds of 7.2 m² (1.2 m x 6 m) were prepared with 20 planting holes in each bed after getting the fine tilth. Four weeks old (28 days) healthy seedlings were selected for transplanting. Seedlings were transplanted with the spacing of 60 cm x 60 cm and two plants per hole. Weeding and watering were done as per the requirement during the experiment period.

### E. Data Collection
All vegetative and reproductive characteristics and yield parameters were recorded according to the descriptor for chilli. Plant height (cm) and canopy width (cm) at 100 % flowering and at the 5th pick stages were collected from randomly selected 10 plants from each treatment using a meter scale. Flower Initiation – Days to first flowering and 50 % flowering were counted from the planting date. The average pod length (cm) and pod width (cm) of five green chillies from a single plant were recorded from 1st to 5th harvest using a cm scale. Pod thickness (mm) and pod breadth (mm) were measured using a vernier calliper and pod weight was measured using a weighing balance. In addition to these, number of

pods per plot, total pod weight in each plot and total yield (t/ha) in each plot were recorded.

### F. Statistical Analysis

The data were analysed using Analysis of Variance techniques and performed t-tests with 95% confidendce level using SPSS (SPSS 25.0, IBM, New York, USA) software.

## III. RESULTS AND DISCUSSION

### A. Plant Height and Canopy Width

Plant height was significantly ($p<0.05$) varied among different treatments at 100 % flowering and at 5th harvest. The highest plant height was observed in T1 compared to other treatments during both stages (47.8 cm and 59.1 cm respectively). Meanwhile, T1 also had a significantly higher canopy width (48.8 cm) at 5th harvest and no significant ($p>0.05$) differences were observed in the canopy width of chilli plants at 100 % flowering (Table 02). This observation shows that the F1 generation may have a genetic advantage, resulting in higher plant height.

### B. Days to 1st Flowering and Days To 50% Flowering

In order to optimize planting times and crop management techniques, it is essential to comprehend the flowering patterns of various generations of chilli plants. Different treatments had significant ($p<0.05$) variation in the number of days taken to 1st flowering while no significant ($p>0.05$) variation was observed in the number of days taken to 50 % flowering. Chilli plants in T3 took higher days for 1st flowering (65.3 days) while the T1 and T2 took 62.3 and 61.8 days respectively (Table 03). When comparing T3 (F2 Generation of open-pollinated MICH Hy 1 Chili seeds) to T1 (F1 Generation of MICH Hy 1 Chili seeds) and T2 (F2 Generation of self-pollinated MICH Hy 1 Chili seeds), it is clear that T3 took the longest time to reach the first flowering. This finding shows that controlled breeding may cause the MICH Hy 01 Chili plants to flower earlier than they would by open-pollination.

### C. Yield Parameters

There were no significant (p>0.05) differences observed in most of the pod characteristics of chilli plants (Table 04). However, the total number of pods per plot, total weight of pods per plot and total yield were significantly (p<0.05) varied among different treatments. Treatment T1 had the highest total number of pods per plot (272.5), the total weight of pods per plot (2725 g) and the total yield (17027 kg/ha) (Table 05). Further, no significant difference was observed in the yield parameters of T2 and T3. With its initial hybrid vigour, the F1 generation produces significantly more pods and yield overall than the F2 generation from both self-pollination (T2) and open-pollination (T3). Theses yield variations have important effects on chilli farming since better yields can boost farmers' profitability.

These yield performance differences between generations could be caused by both additive and dominant genes as well as their interaction effects, the most of which could be altered by recombination and selection (Perera *et al.* 2001). In a previous study, Marame *et al.* (2009) concluded that progeny generations (F1 and F2) outperformed their parents (P1 and P2) in terms of fruit characteristics in chilli plants. Furthermore, they stated that the superior performance of the segregating generations (F2) could indicate a higher frequency of their transgressive segregants while the improved performance of F1 could result from an accumulation of favourable dominant alleles. Kabilan *et al.* (2021) evaluated the performances of the F2 generation of Mundu Chili and recorded a range of 57.7 cm – 62.2 for plant height, 40 to 61 days for 50 % flowering, 57.4 – 70.5 for number of fruits per plant, 4.1 g – 4.5 g for individual fresh fruit weight and 236.7 g – 324.5 g for ripe fruit yield per plant.

## IV. CONCLUSION

The results of this study offer important new understandings of the development, flowering, and yield parameters of MICH Hy 01 Chili plants of various generations. It is clear that the selection of seed generation and breeding procedures has a considerable impact on a number of chilli plant performance factors. In conclusion, the F1 generation's initial hybrid vigour is a crucial feature for producing exceptional growth and yields. These findings provide chilli farmers and breeders with practical assistance, allowing them to make informed decisions to increase the productivity and success of their chilli crop production initiatives. Further investigation into the genetic factors underlying these differences may lead to more effective and sustainable chilli growing strategies in the future.

Table 02: Plant Height and Canopy Width of Chili Genotypes at Two Growth Stages

| Treatments | At 100 % flowering | | At 5th Harvest | |
|---|---|---|---|---|
| | Plant height (cm) | Canopy width (cm) | Height of plant (cm) | Canopy width (cm) |
| T1 | $47.6 \pm 0.8^a$ | $36.4 \pm 0.6^a$ | $59.1 \pm 1.7^a$ | $48.8 \pm 1.6^a$ |
| T2 | $40.9 \pm 1.0^b$ | $36.2 \pm 1.0^a$ | $52.6 \pm 1.3^b$ | $43.0 \pm 1.6^b$ |
| T3 | $40.0 \pm 0.8^b$ | $33.5 \pm 1.1^a$ | $53.5 \pm 1.9^b$ | $45.4 \pm 1.4^b$ |
| *P value* | 0.01 | 0.06 | 0.01 | 0.03 |

Mean values followed by the same letters within a column are not significantly different at *p< 0.05.*

Table 03: Days Taken to 1st and 50% Flowering

| Treatments | Day to 1st flowering | Days to 50% flowering |
|---|---|---|
| T1 | $62.3 \pm 0.6^b$ | $69.0 \pm 0.6^a$ |
| T2 | $61.8 \pm 0.5^b$ | $70.5 \pm 0.6^a$ |
| T3 | $65.3 \pm 0.3^a$ | $71.3 \pm 1.0^a$ |
| *P value* | 0.01 | 0.17 |

Mean values followed by the same letters within a column are not significantly different at p< 0.05.

Table 04: Pod Characteristics among Chilli Genotypes

| Treatment | Average pod weight (g/pod) | Average pod length (cm) | Average pod breadth (mm) | Average pod thickness (mm) |
|---|---|---|---|---|
| T1 | $5.60 \pm 0.26^a$ | $10.9 \pm 0.2^a$ | $11.3 \pm 0.1^a$ | $1.3 \pm 0.02^a$ |
| T2 | $5.04 \pm 0.28^a$ | $10.5 \pm 0.2^a$ | $10.7 \pm 0.5^a$ | $1.3 \pm 0.02^a$ |
| T3 | $5.51 \pm 0.14^a$ | $10.2 \pm 0.1^a$ | $10.7 \pm 0.2^a$ | $1.3 \pm 0.03^a$ |
| *p value* | 0.22 | 0.10 | 0.29 | 0.118 |

Mean values followed by the same letters within a column are not significantly different at *p<0.05.*

Table 05: Yield Characteristics among Chilli Genotypes

| Treatment | Total no of pods/plot | Total weight of pods /plot(g) | Total yield (kg/ha) |
|---|---|---|---|
| T1 | $272.5 \pm 10.48^a$ | $2725.50 \pm 190.42^a$ | $17.27 \pm 1.31^a$ |
| T2 | $151.2 \pm 7.22^b$ | $1421.50 \pm 77.30^b$ | $7.97 \pm 0.60^b$ |
| T3 | $171.6 \pm 9.18^b$ | $1873.75 \pm 162.15^b$ | $9.16 \pm 1.03^b$ |
| *p value* | 0.01 | 0.01 | 0.01 |

Mean values followed by the same letters within a column are not significantly different at *p<0.05.*

REFERENCES

Couto, E.G.D.O., Cury, M.N., Bandeira e Souza, M., Granato, Í.S.C., Vidotti, M.S., Domingos Garbuglio, D., Crossa, J., Burgueño, J. and Fritsche-Neto, R., (2019). Effect of F1 and F2 generations on genetic variability and working steps of doubled haploid production in maize. *Plos One*, *14*(11), p.e0224631.

Hernández-Pérez, T., Gómez-García, M.D.R., Valverde, M.E. and Paredes-López, O., (2020). Capsicum annuum (hot pepper): An ancient Latin-American crop with outstanding bioactive compounds and nutraceutical potential. A review. Comprehensive Reviews in Food Science and Food Safety, 19(6), pp.2972-2993.

Hewage, S., Bandara, S. and Rathnayake, D., (2022). Local hybrid chili cultivation and dry chili production. Occasional publication No 48, Hector Kobbekaduwa Agrarian Research and Training Institute.

Kabilan, M., Balakumbahan, R., Nageswari, K. and Santha, S., (2021). Evaluation of F2 generation of Mundu chilli (Capsicum annuum L.) for yield and quality. The Pharma Innovation Journal, 10(10), pp.1215-1219.

Marame, F., Desalegne, L., Fininsa, C. and Sigvald, R., (2009). Genetic analysis for some plant and fruit traits, and its implication for a breeding program of hot pepper (Capsicum annuum var. annuum L.). Hereditas, 146(4), pp.131-140.

Panabokke, C.R., (1996). Soils and agro-ecological environments of Sri Lanka. Natural Resources, pp.35-101.

Perera, A.M., Pooni, H.S. and Saxena, K.B., (2001). Components of genetic variation in short-duration pigeonpea crosses under waterlogged conditions. Journal of genetics & breeding, 55(1), pp.21-38.

Rasco Jr, E.T., (2008), February. Contributions and prospects of plant breeding research for improving vegetable production in tropical Asia. In International Symposium on the Socio-Economic Impact of Modern Vegetable Production Technology in Tropical Asia 809, pp. 35-54.

Weerasekara, P.C., Withanachchi, C.R., Ginigaddara, G.A.S. and Ploeger, A., (2018). Nutrition transition and traditional food cultural changes in Sri Lanka during colonization and post-colonization. Foods, 7(7), p.111-120.

# Assessment of Soil Fertility and Nutrient Management in Betel (*Piper betle*) Cultivations in the Kurunagala District

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## *Abstract*

*Betel plant (Piper betle) leaves, harvested at frequent intervals, result in the permanent depletion of soil nutrients. Farmers often complain that the amount of fertilizer recommended by the Department of Export Agriculture (DEA) is insufficient and there is a tendency to overuse fertilizers. The study aimed to assess the variability of soil fertility in betel cultivations in the Kurunagala district. It investigated the relationship between fertilizer amounts and betel yield, along with relationship of farm scale on soil fertility characteristics. Thirty farmer fields were surveyed, measuring soil fertility traits such as Nitrogen, Phosphorus, Potassium, and soil pH. Of the selected fields, 84% betel poles were cultivated between 2 to 3 years, while 16% were less than 2 years old. The survey found that 61% of farmers used cow dung and 39% used green manure as organic fertilizer. Harvesting was done every three weeks by 68% of farmers and every two weeks by 32%. Chemical fertilizers applied, biweekly by 72%, while the remaining 28% did so every three weeks. All farmers surveyed the used bed method and the same chemical fertilizers mixture. The soil analysis revealed that Wariyapola had the higher nitrogen (2.48±0.8 mg/g), Phosphorus (0.13±0.01 mg/g), Potassium (0.06±0.01 mg/g) and soil pH (5.63) values than Panduwasnuwara and Bingiriya areas. There is a negative relationship between amount of fertilizer applied and yield, but the ratio of leaf length to leaf width had a positive relationship. However, none of these differences or relationship between farm scale and soil fertility traits were statistically significant. The results indicate that over-dosing with fertilizer has no significant impact on betel yield improvement, besides excessive use of chemical fertilizers may increase cost and leads to nutrient loss by leaching, runoff, and evaporation.*

***Keywords: Betel, Fertilizer, Inorganic, Organic, Soil Fertility***

## I. INTRODUCTION

Betel (*Piper betel* L.), a member of the Piperaceae family, holds significant economic, social, medicinal, religious, and cultural value in Sri Lanka. This crop is one of the country's important Export Agriculture Crop (EAC) with Sri Lanka being a major producer, consumer, and exporter of betel. The primary utilization of betel is for chewing, although it also finds extensive applications in traditional medicine. Safrole is the predominant chemical compound found in Sri Lankan betel (Anon, 2016).

In Sri Lanka, approximately 8,000 to 10,000 farmers are engaged in the commercial cultivation of betel. The total cultivated land spans an estimated 2,860 hectares, with the majority of cultivation concentrated in the districts of Kurunagala, Gampaha, Kegalle, and Kalutara. In 2022, the annual production reached 13 466 metric tons, with an export volume of 3908.1 metric tons valued at Rs 5034.5 million. (DEA, 2022).

The economic value of betel lies in its leaves, which are harvested at regular intervals of two to three weeks. However, this harvesting process results in the permanent removal of a substantial quantity of nutrients from the fields. Consequently, an abundant supply of both micro and macronutrients is essential for optimal betel growth. For instance, from a one-hectare betel field, approximately 7,200 kilograms of organic materials, along with 288 kilograms of nitrogen, 33 kilograms of phosphorus, and 302 kilograms of potassium are removed annually. Thus, farmers employ a combination of organic and inorganic fertilizers in betel cultivation (Anon, 2016). Given these nutrient demands, the application of chemical fertilizers becomes indispensable for achieving higher yields and promoting better growth. The Department of Export Agriculture recommends a fertilizer mixture, including Urea (195 grams), Triple Super Phosphate (TSP) (65

grams), Muriate of Potash (MOP) (100 grams), and Kieserite (60 grams), totalling 420 grams, for every 100 betel vines, applied every three weeks. Initially, organic manure should be applied to the beds, which can be repeated at intervals of several months. Alternatives such as cow dung, compost, well-composed poultry manure, or goat manure can also be applied in betel cultivation. Additionally, the application of Gliricidia leaves has been shown to be highly beneficial for betel growth, yield, and overall quality. However, a common concern among farmers is that the recommended fertilizer rates are insufficient for betel cultivation. Consequently, some farmers resort to applying higher doses of fertilizer than what is advised by the Department of Export Agriculture (DEA). This practice may incur higher fertilizer costs and results in wastage through leaching, washing, and evaporation, among other issues.To address these challenges and assess the variation in soil fertility within betel fields in the Kurunagala district, as well as to investigate the relationship between soil fertility characteristics and betel yield, the Intercropping and Betel Research Station of the Department of Export Agriculture conducted this investigation.

## II. METHODOLOGY

Survey questionnaires and Soil samples were collected from Low country Intermediate Zone of Kurunegala district. Soil samples were analysed under room temperature at soil science lab of the Cinnamon Research Institute, Thihagoda, Matara. Thirty farmer fields were randomly selected from three extension officer's regions (EO Regions) namely, Bingiriya, Wariyapola and Panduwasnuwara (Table 02) of Low Country Intermediate Zone of Kurunegala district. Betel leaf and soil samples were collected from betel farmer's fields. Number of leaf and soil samples were collected depend on extent of betel cultivation in each location. All soil and leaf samples consisted of 3 replicates.

Soil samples were collected from randomly selected locations within the betel field using auger. Collected soil samples were air dried, ground and passed through a 2 mm sieved to get a homogeneous sample prior to soil chemical analysis. Soil pH was measured using a pH meter (ORION 550A model USA) in 1: 2.5 Soil: water solution. Total Nitrogen recorded by Kjeldahl method (Bremner, 1982). Soil available

Phosphorous was extracted by Borax solution and Phosphorous was determined by Vanadomolybdate blue method. Available potassium was measured using flame photometer method. Further, ten fresh betel leaf samples of harvesting stage were collected from randomly selected vines. Leaf length and leaf width were measured by a ruler and average length and width in cm were recorded. In addition, a survey was carried out through individual discussion with selected farmers to investigate about fertilizer usage for betel cultivation. Data were analysed using Mini tab 18 software, Microsoft Excel 2016 and SAS 9.0 version software package.

## III. RESULTS AND DISCUSSION

### A. Overview of the Betel Farming in the Selected Regions

Betel cultivation in Sri Lanka primarily employs two methods, namely the bed method and the single support method. Both methods require some form of vertical support for the betel vines to climb. In the surveyed area, it was evident that all farmers (100%) exclusively used the bed method, which involved preparing beds of approximately 1.2 m by 7.5 m in size. Betel cultivations in the region were of varying ages, spanning from 1 to 3 years. These were categorized into two groups, with the majority (84%) falling into the 2–3 year old group, while remaining 16% were less than 2 years old.

Different types of fertilizers were observed in the surveyed areas, and it became apparent that farmers consistently applied excessive doses compared to the recommended fertilizer quantity. The Department of Export Agriculture recommends a three-week interval for fertilizer applications. However, farmers were observed using chemical fertilizers at both two-week and three-week intervals, with a majority (72%) favouring the two weeks.

Apart from inorganic fertilizers, 86% of farmers used cow dung. While there was a growing trend towards the use of goat and poultry manure in the Kurunegala district, 46.6% of farmers applied leaf manure, such as Keppetiya and Giricidia. Notably, these betel farmers refrained from using cow dung sourced from stockyards in the Kurunegala area due to concerns about the presence of coconut oil coming with poonac feed, which they believe transmits the bacterial blight to betel vines. Instead, they procure cow dung from dry zone areas like Anuradhapua, Polonnaruwa, and

Vavniya, despite its higher cost (Herath and Rathnasoma, 2010).

The survey revealed that almost all farmers opted for organic fertilizer in betel cultivation, with cow dung (61%) and green manure (39%) being the most prevalent organic choices.

In terms of irrigation, all farmers' ensured betel was irrigated during the dry season, with a frequency of every other day at minimum. Harvesting mature betel leaves followed a consistent pattern, with a 2-week interval for the local market and a 3-week interval for export. According to the survey results, a majority of farmers (68%) adopted a 2-week harvesting interval, while the remaining 32% favoured a 3-week cycle. Regarding market supply, the majority (76%) primarily catered to the local market, while a smaller proportion (24%) mainly engaged in export market supply. Though commercial cultivation lasted up to 6 years, the most favourable yields were obtained from 2-year-old betel plants. A typical yield per 100 poles ranged from 6,000 to 8,000 leaves in a single harvest (Anon, 2016).

B. *Soil Fertility Status in Different Betel Growing Regions*

Table 01. Soil Fertility Status in Three EO Regions

|  | Bingiriya | Wariyapola | Paduwasnuwara |
|---|---|---|---|
| N (mg/g) | 1.59 ± 0.30 | 2.48 ± 0.80 | 1.55 ± 0.90 |
| P (mg/g) | 0.10 ± 0.07 | 0.13 ± 0.01 | 0.12 ± 0.01 |
| K (mg/g) | 0.04 ± 0.01 | 0.06 ± 0.01 | 0.05 ± 0.01 |
| pH | 5.63 ± 0.90 | 5.65 ± 080 | 5.47 ± 0.10 |

Soil analysis results revealed that the Wariyapola region had the highest values for nitrogen (2.48 ± 0.8 mg/g), Phosphorus (0.13 ± 0.01mg/g), Potassium (0.06 ± 0.01 mg/g), and soil pH (5.63) among selected areas.

C. *Correlation Between Chemical Fertilizer Application with Yield of Betel*

There was a weak negative relationship between applied fertilzer amounts and yield. However, the total yield of betel do not significantly differ ($p \geq 0.05$) with the application of chemical fertilizer amounts. The recommended fertilizer mixture had the highest number of large Peedunu

Kola (betel leaf) productions compared to the application of double the quantity of the recommendation, indicating a waste of fertilizer at higher doses.
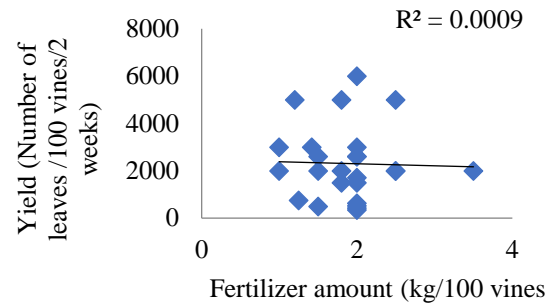


Figure 01. Relationship of Application of Chemical Fertilizer Amount with Yield of Betel

D. *Relationship Between Chemical Fertilizer Application and the Average Leaf Length/Width Ratio of Betel Plants*

There was a weak positive relationship between applied fertilizer amounts with average leaf length/width ratio.
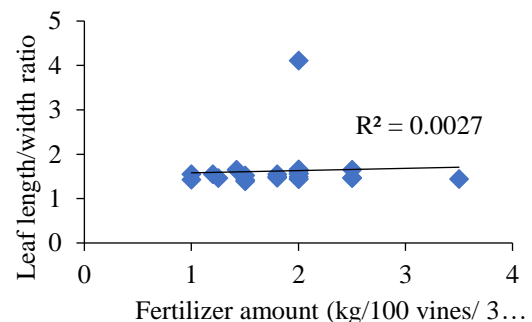


Figure 02. Relationship of Application of Chemical Fertilizer Amount with Average Leaf Length/Width Ratio of Betel

Also, the average leaf length/width ratio was not significantly different ($p > 0.05$) with the application of chemical fertilizer amounts. Farmers commonly believe that increasing fertiliser amounts can boost yields. Nevertheless, experimental results consistently demonstrate that such practises are wasteful. Moreover, achieving optimal betel leaf yields and quality relies on environmental factors such as rainfall, temperature, shading, and sound agronomic practises.

E. *Analysis of Soil pH Values Across Various Farm Size Group*

The mean soil pH value was not significantly different ($p \geq 0.05$) among different farmer

groups. While the 200–400 pole farm size group showed the lowest soil pH value (5.3 ± 0.47), the highest pH value (5.82 ± 0.28) was shown by the 800-1000 pole farm size group. Small farm size groups have low pH values, probably due to the higher dosage of urea, the most commonly used nitrogen fertilizer in Sri Lanka.
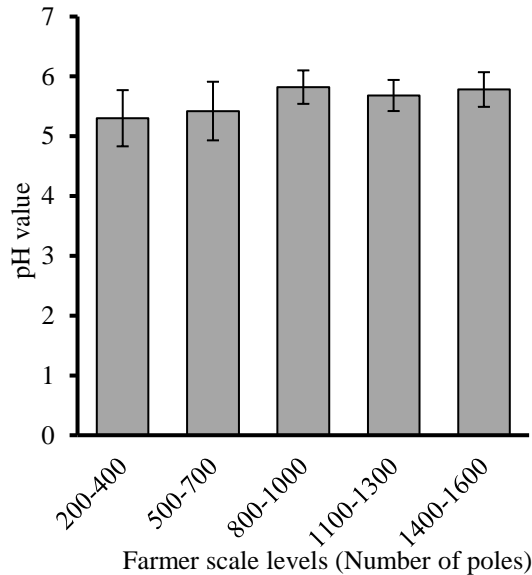


Figure 03. Mean pH Value in Different Farmer Scale Levels

According to the results of the study, Small farmer scale level had lowest pH value due to small farmer scale level were applied higher dosage of Nitrogen fertilizer (N).

### F. Assessment of Chemical Fertilizer Application and Soil Fertility Across Diverse Farmer Scale Levels

The mean application of chemical fertilizer was not significantly different (p > 0.05) among different farm size groups, according to the current study. The lowest mean application of chemical fertilizer amount (1.48 ± 0.21) was observed in the 1400–1600 pole group, and the highest mean application of chemical fertilizer amount (2.1 ± 0.18) was observed in the 200–400 pole group.

### G. Assessing the Influence of Fertilizer Application Levels on Various Farmer Scales

According to the results of the study, a high amount of fertilizer is applied by small-scale farmers, and large-scale farmers apply low amounts of fertilizer.

### H. Assessment of Soil Phosphorus (P) Content across Various Farmer Scale Levels

The mean soil Nitrogen (N) content was not significantly different (p > 0.05) between different farmer scale levels in the current study. The lowest Nitrogen (N) content in the soil (1.48 mg/g ± 0.13) was recorded from the 800–1000 pole group, and the highest soil N content (2.34 mg/g ± 0.41) was reported from the 200–400 pole group.
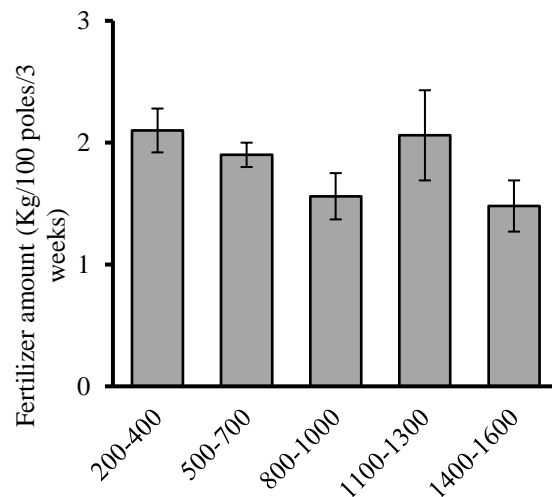


Figure 04. Mean Chemical Fertilizer Application Across Various Farmer Scale Levels

The mean soil Nitrogen (N) content was not significantly different (p > 0.05) between different farmer scale levels in the current study. The lowest Nitrogen (N) content in the soil (1.48 mg/g ± 0.13) was recorded from the 800–1000 pole group, and the highest soil N content (2.34 mg/g ± 0.41) was reported from the 200–400 pole group.
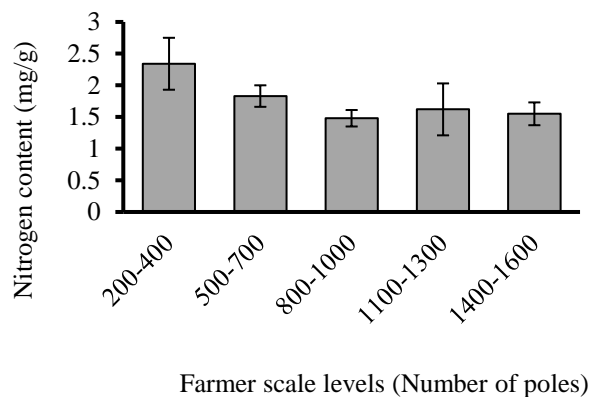


Figure 05. Mean Soil Nitrogen Content in Different Farmer Scale Levels

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## I. Assessment of the soil Phosphorus (P) content across Various Farmer Scale Levels

The mean phosphorus (P) content in the soil was not significantly different (p ≥ 0.05) between different farm size groups. The lowest soil P content (0.09 mg/g ± 0.02) was recorded from 500–700 pole groups, and the highest P content (0.15 mg/g ± 0.03) was found in 1100–1300 pole groups.
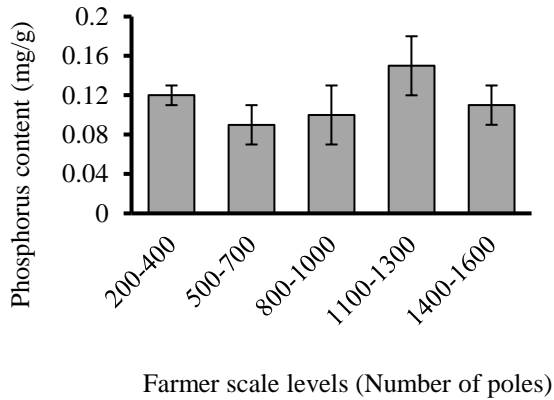
Figure 06. Soil Phosphorus Content in Different Farmer Scale Levels, The Bars Indicate The Mean P Content

## J. Assessment of the soil potassium (K) content across Various Farmer Scale Levels
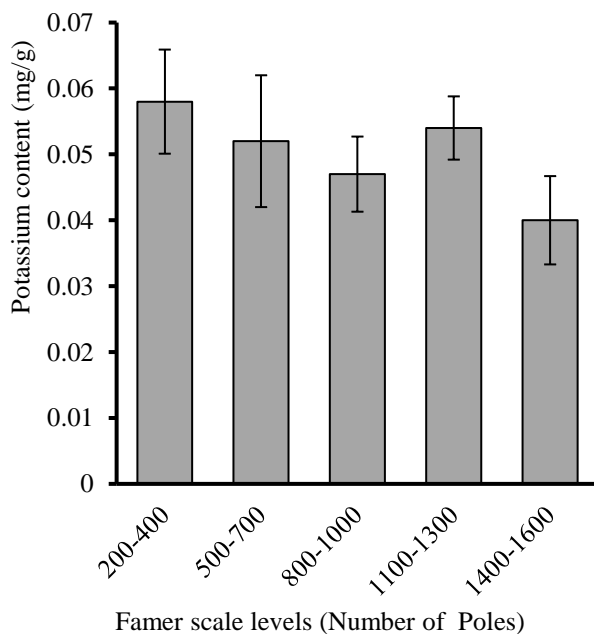
Figure 07. Soil Potassium Content in Different Farmer Scale Levels

The mean soil Potassium (K) content was not significantly different (p ≥ 0.05) among different farm size groups. The lowest soil K content (0.04 mg/g ± 0.0067) had been recorded in the 1400–1600 group, and the highest soil K content (0.058 mg/g ± 0.0079) was observed in the 200–400 pole group.

## IV. CONCLUSION

This study highlights the challenges in betel cultivation, particularly the loss of nutrients due to overuse of chemical fertilizer. The need for balanced nutrient application, with organic, and inorganic fertilizers, is emphasized. Despite farmer concerns about DEA-recommended fertilizer quantities, the study identifies no statistically significant relationships between yield, fertilizer amounts, and soil fertility traits. Moreover, negative correlation between fertilizer application and betel yield indicates the detrimental effects of over-dosing on betel productivity. Although regional soil analysis did not reveal statistically significant findings, Wariyapola exhibited higher nutrient levels. In summary, the study advises against undue reliance on chemical fertilizers, as it may incur additional costs with the risk of environmental issues related to nutrient loss through leaching, runoff, and evaporation. Promoting awareness among farmers about sustainable nutrient management practices is essential for optimizing betel cultivation outcomes.

REFERENCES

Anon, (2016) "Technical Bulleting of betel cultivation number 11", *Department of Export Agriculture, 1095, Peradeniya, Sri Lanka,* 2(1), pp. 02-48.

DEA, (2022) Export Agriculture Crops, Statistical Pocket Book 2021/2022. *Department of Export Agriculture, 1095, Peradeniya, Sri Lanka,* 1(1), pp. 49-50.

Herath, H.M.I.U.K. and Rathnasoma, H.A., (2010). "Evaluation of Alternative Types of Supporting Materials for Betel (*Piper betel* L.) Cultivation". *Journal of Food and Agriculture,* 1(1), pp. 1-10.

# Identification of the Best Seed Sowing Rates for Optimizing Grain Yield of At-362 Rice Variety

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## Abstract

*Rice (Oryza sativa L.) is a staple food for a substantial portion of the global population and it is cultivation all over the world. Seed rate has a significant impact on plant population, crop quality and overall yield in paddy cultivation. Hence, this study was conducted to identify the best seed sowing rates for optimized growth and yield potentials of the At362 rice variety in Ampara District, Sri Lanka. Six different seed rates viz; 2 Bu/ac, 2.5 Bu/ac (Control), 3 Bu/ac, 3.5 Bu/ac, 4 Bu/ac and 4.5 Bu/ac were selected for this experiment. The treatments were arranged in Randomized Complete Block Design (RCBD) with three replications. Data on growth and yield related parameters were collected at different time periods and analyzed using SPSS software. The results revealed that most of the tested parameters were significantly (p<0.05) affected by different seed rates. Lower seeds rate (2 Bu/ac, 2.5 Bu/ac and 3 Bu/ac) resulted in increased mean values for growth parameters including plant height, number of leaves produced in the main culm, flag leaf length and width, culm length and root length compared to higher seed rates. Similarly, panicle length and number of filled per panicle were higher at 2.0 and 2.5 Bu/ac respectively. However, the number of panicles/m$^2$ was significantly higher in 4 Bu/ac and 4.5 Bu/ac while the filled panicle and the grain weight were increased in the lower seed rates suggesting that the increasing seed rates marginally increased the panicle production in cv. At362 rice variety.*

**Keywords:** *At362, flag leaf, Oryza sativa L., Panicle, Seed rates*

## I.   INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple crops in the world, providing a foundational source of nutrition for many different civilizations around the world while sustaining the livelihoods of billions (Sandeep *et al*., 2018). With Asia in the forefront of rice cultivation, countries like China, India, Indonesia, and Bangladesh emerge as key contributors to global rice production (Singh *et al*., 2021). In the Sri Lankan context, rice is incredibly significant both culturally and economically. The various agro-climatic conditions of Sri Lanka enable the cultivation of a wide range of rice varieties, from high-yielding modern varieties to traditional selections with significant cultural and historical significance (Irangani and Prasanna, 2017).

The goal of sustainable and effective crop production has taken center stage in contemporary agricultural practices to solve the problem of global food security. In this regard, the appropriate seed sowing rate is one of the most important variables affecting the yield of crops (Tadesse and Tadesse, 2019). The choice of an ideal seed sowing rate may considerably impact the final grain yield of a specific crop variety (Abuzar *et al*., 2011). Higher plant densities increase the yield up to a limit and thereafter a decline in yield is observed (Dongarwar *et al*., 2018). Increased competition for nutrition, air and light among the plants are the causes for the yield reduction (Tadesse and Tadesse, 2019). Moreover, high seeding rates result in unproductive tillers, increased disease pressure, and lodging susceptibility (Garba *et al*, 2013). In contrast, weeds can take advantage of gaps in the field created by sparse plant populations caused by a reduced seed rate (Nie and Peng, 2017). Low plant density may also lead to insufficient use of the available resources, which could restrict production potential (Ali and Talukder, 2008). A controlled reduced seed rate, however, can occasionally be advantageous, especially in regions with scarce water supplies or with certain

rice types that have active tillering traits (Pathak *et al*., 2011).

The ideal seed rate achieves a delicate balance between increasing potential production and guaranteeing that each plant has sufficient access to vital elements (Mohaddesi *et al.,* 2011). This method encourages strong growth, healthy tillering, and effective nutrient usage. It lowers the likelihood of disease outbreaks and improves the crop's ability to endure environmental shocks. The ideal seed rate varies depending on the type of soil, climatic conditions, and variety of rice (Tadesse *et al*., 2019). Precision in selecting this rate can result in uniform plant stands, improved grain filling, and ultimately, enhanced yield and grain quality. Hence, this study evaluated the impact of different seed rates on the crop performance of the At362 rice variety. Ampara district is a prominent rice growing region in Sri Lanka, and a total of 136,036 hectares of paddy was planted largely using the At-362 and Bg-94-1 owing to its superior agronomic and yield features (Mubarak *et al*., 2022; Sewwandi *et al*., 2023). The results of this study can help farmers in Ampara district of Sri Lanka to make well-informed decisions about seed allocation that increase agricultural productivity while avoiding resource waste.

## II. MATERIALS AND METHODS

### A. *Description of the Study Area*
A field experiment was carried out at Rice Research Station, Sammanthurai which is located in Ampara District (7°21'18.4"N; 81°46'38.2"E) from May to August during the *Yala* season of 2022. The mean annual temperature of this area is 27 °C to 30 °C and annual precipitation is between 1500 mm to 2225 mm. The soil type is non-calcic brown which contains sand with slightly acidic soil.

### B. *Planting Materials*
The rice variety At362 was selected to conduct the trial since it is the most popular and high yielding rice variety in Ampara district. Initially, the land was prepared and paddy seeds were sown in six different seed sowing rates (2.0 Bu/ac, 2.5 Bu/ac (Control), 3.0 Bu/ac, 3.5 Bu/ac, 4.0 Bu/ac and 4.5 Bu/ac). The experiment was arranged in a Randomized Complete Block Design (RCBD) with 3 replicates and the plot size was 2 m x 3 m. fertilizing and irrigation were done at regular recommended intervals. Weeds were removed

manually at regular intervals. Pest and disease management were performed with cultural techniques whenever required.

### C. *Data Collection*
Plant height (cm) was obtained by measuring the main stem length from ground level to the tip of leaves using (Sivaneson and Vijayakumari, 2019) during the $4^{th}$, $6^{th}$, $8^{th}$ and $10^{th}$ weeks after seed sowing (WAS). The number of plants/$m^2$ and tillers/$m^2$ were taken by placing a quadrate of 0.5 × 0.5 m size on the field at 6 WAS. The number of leaves produced on the main culm per plant was counted during 6, 8 and 10 WAS. Flag leaf length (cm) and width (cm), root length (cm) and culm height (cm) were taken at 10 WAS. At harvest, panicle length (cm) was measured from the base to the tip of the panicle (Himasha *et al*., 2022). The number of panicles, total number of spikelets, and filled and unfilled grains per panicle were also counted separately. Dry weights were determined by placing the plant samples inside an oven at 80°C for 72 hours until a constant weight was observed. All the above data were collected from 10 randomly selected plants in each plot.

### D. *Data Analysis*
Statistical analysis of the collected data was performed using SPSS software (version 25). The statistical evaluation of the treatments was conducted using the analysis of variance (ANOVA). To determine whether there was a significant difference between the treatment means at 0.05 probability levels, Tukey's post-hoc test was used.

## III. RESULTS AND DISCUSSION

### A. *Effect of Different Seed Rates on Plant Height*
Plant height is an important parameter that helps determine the growth attained during a period of time (Pachuri *et al*., 2017). Our results indicated that different seeding rates had significant ($p<0.05$) effects on the rice plant height at 6, 8 and 10 WAS while no significant ($p>0.05$) effect was observed during 4 WAS. The seed rates 2 Bu/ac, 2.5 Bu/ac and 3 Bu/ac resulted in significantly higher plant heights compared to other treatments while the plants grown at 4.5 Bu/ac had the lowest plant heights (Table 01).

Table 01: Mean Plant Height (cm) of cv. At362 Rice Variety

| Treatment | 4WAS | 6WAS | 8WAS | 10WAS |
|---|---|---|---|---|
| 2.0 Bu/ac | $38.66\pm1.16^a$ | $49.0\pm1.08^b$ | $72.08\pm0.73^{bc}$ | $79.5\pm1.43^b$ |
| 3.0 Bu/ac | $38.88\pm0.87^a$ | $51.83\pm0.75^b$ | $73.10\pm1.38^c$ | $80.26\pm1.04^b$ |
| 3.5 Bu/ac | $36.66\pm0.66^a$ | $45.16\pm1.08^a$ | $72.26\pm0.95^{bc}$ | $76.70\pm1.07^{ab}$ |
| 4.0 Bu/ac | $37.88\pm1.18^a$ | $43.36\pm0.85^a$ | $68.13\pm1.41^{ab}$ | $77.43\pm1.07^{ab}$ |
| 4.5 Bu/ac | $38.33\pm1.20^a$ | $43.86\pm0.68^a$ | $65.7\pm0.87^a$ | $73.80\pm1.16^a$ |
| 2.5 Bu/ac (Control) | $37.77\pm0.75^a$ | $50.33\pm0.59^b$ | $73.06\pm1.00^c$ | $80.16\pm1.13^b$ |
| CV | 7.73% | 11.95% | 9.23% | 8.58% |
| $P$ | 0.636 | 0.001 | 0.001 | 0.001 |

Values shown are mean ± S.E.  Means with different letters represent significant differences at Tukey's p<0.05.

*B.  Effect of Seed Rates on Number of Tillers*
Number of tillers/m$^2$ were not significantly (p>0.05) affected by different seed rates (Table 02).

*C.  Effect of Seed Rates on Number of Leaves*
A significant difference (p<0.05) in the number of leaves produced on the main culm per plant was observed in different seed treatments during 6, 8 and 10 WAS. The highest number of leaves were produced by 2.5 Bu/ac (6.03) and 2 Bu/ac (6.43) during 6 WAS and 8 WAS respectively. During 10 WAS, both 2.0 Bu/ac and 2.5 Bu/ac resulted in the highest number of leaves (7.3 and 7.26 respectively). The lower number of leaves was recorded by 4.0 Bu/ac (Table 03).

Table 02:  Mean Number of Tillers/m$^2$ of cv. At-362 Rice Variety at 6WAS

| Treatment | No. of tillers/m$^2$ |
|---|---|
| 2.0 Bu/ac | $360.89\pm65.15^a$ |
| 3.0 Bu/ac | $442.22\pm55.11^a$ |
| 3.5 Bu/ac | $513.77\pm55.68^a$ |
| 4.0 Bu/ac | $477.78\pm37.00^a$ |
| 4.5 Bu/ac | $507.11\pm51.06^a$ |
| 2.5 Bu/ac (control) | $446.66\pm21.31^a$ |
| C.V | 35% |
| $P$ | 0.077 |

Values shown are mean ± S.E.  Means with different letters represent significant differences at Tukey's p<0.05.

Table 03:  Number of leaves produced on the main culm of cv. AT362 rice plants

| Treatment | 6WAS | 8WAS | 10WAS |
|---|---|---|---|
| 2.0 Bu/ac | $5.60\pm0.12^{ab}$ | $6.43\pm0.10^b$ | $7.30\pm0.17^b$ |
| 3.0 Bu/ac | $5.60\pm0.16^{ab}$ | $6.36\pm0.10^{ab}$ | $7.10\pm0.15^{ab}$ |
| 3.5 Bu/ac | $5.66\pm0.13^{ab}$ | $6.13\pm0.11^{ab}$ | $7.03\pm0.17^{ab}$ |
| 4.0 Bu/ac | $5.26\pm0.09^a$ | $5.93\pm0.10^a$ | $6.46\pm0.16^a$ |
| 4.5 Bu/ac | $5.56\pm0.12^{ab}$ | $6.03\pm0.14^{ab}$ | $6.43\pm0.16^a$ |
| 2.5 Bu/ac (Control) | $6.03\pm0.19^b$ | $6.10\pm0.14^{ab}$ | $7.26\pm0.20^b$ |
| CV | 14.49% | 11.03% | 14.43% |
| $P$ | 0.05 | 0.03 | 0.01 |

Values shown are mean ± S.E.  Means with different letters represent significant differences at Tukey's p<0.05.

### D. Effect of Seed Rates on Flag Leaf Length and Width and Culm Length

Different seed rates significantly (p<0.05) affected the flag leaf length and width and culm length. The highest flag leaf length (29.9 cm) at 10 WAS recorded at 3.0 Bu/ac while the lowest was at 4.5 Bu/ac (24.50±0.62[a]). Meanwhile, the highest flag leaf width (0.9 cm) was recorded in three treatments including the control (2.0 Bu/ac, 3.0 Bu/ac and 2.5 Bu/ac) conversely, the rest of the treatment had lower values. The control treatment (2.5 Bu/ac) resulted in the highest culm length (65.3 cm) while the 4.0 Bu/ac (60.3 cm) and 3.5 Bu/ac (58.5 cm) treatments had the lowest (Table 04).

### E. Effect of Seed Rates on Root Length

Figure 01 shows the root length of the At362 rice variety at 6, 8 and 10 WAS which was significantly (p<0.05) affected by different seed rates. A lengthier root system contributes to the rice plant in obtaining water and nutrients from deeper soil layers (Himasha *et al.*, 2021). At 6 WAS, the highest root length was recorded in 2 Bu/ac (12.4 cm) and 3 Bu/ac (11.7 cm) compared to the control. However, at 8 (14.6 cm) and 10 (16.1 cm) WAS, 4 Bu/ac resulted in the highest root length (Figure 01).

Table 04: Mean Culm Height, Flag Leaf Length and Width (cm) at Flowering Stage of cv. AT362 Rice Plants

| Treatment | Flag Leaf length(cm) | Flag Leaf width(cm) | Culm height (cm) |
|---|---|---|---|
| 2.0 Bu/ac | 28.17±0.78[ab] | 0.87±0.03[b] | 63.11±1.07[ab] |
| 3.0 Bu/ac | 29.86±0.50[b] | 0.87±0.03[b] | 63.11±0.77[ab] |
| 3.5 Bu/ac | 26.16±1.03[ab] | 0.71±0.04[a] | 58.55±1.47[a] |
| 4.0 Bu/ac | 29.10±2.68[ab] | 0.69±0.04[a] | 60.33±0.57[a] |
| 4.5 Bu/ac | 24.50±0.62[a] | 0.71±0.03[a] | 62.77±1.68[ab] |
| 2.5 Bu/ac (Control) | 27.93±0.70[ab] | 0.87±0.02[b] | 65.33±1.15[b] |
| CV | 26.06% | 26.92% | 6.42% |
| *P* | 0.044 | 0.001 | 0.004 |

Values shown are mean ± S.E.  Means with different letters represent significant differences at Tukey's p<0.05.
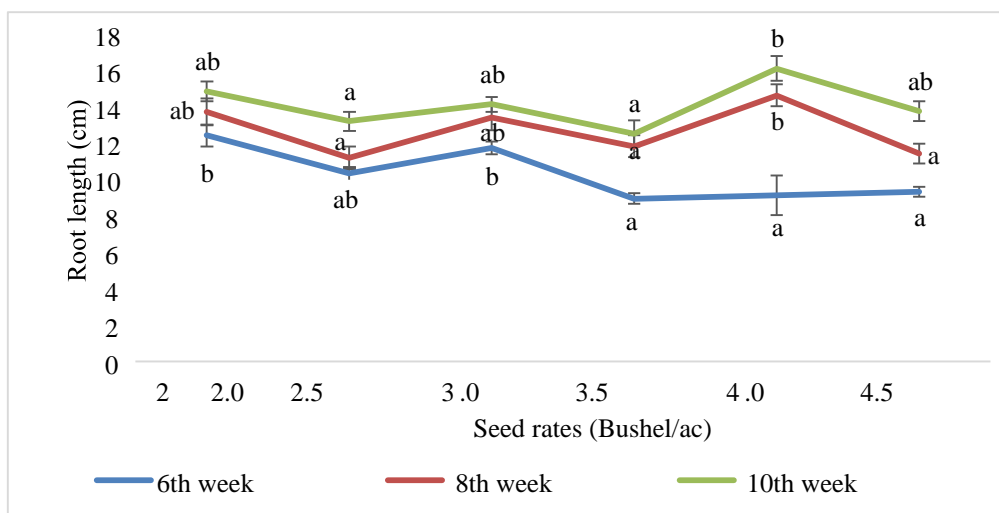


Figure 01. Effects of Seed Sowing Rates on the Root Length of cv.At-362 Rice Variety

## F. Effect of Different Seed Rates on Panicle Characteristics

According to the findings, panicle characteristics showed significantly differences (p<0.05) in our study. Seed rates 4 Bu/ac (386.2) and 4.5 Bu/ac (380.9) gave the highest number of panicles/m$^2$, while 2.0 Bu/ac had the lowest count (272.9). However, the highest panicle length (23.3 cm), number of grains per panicle (120.6), and number of filled grains per panicle (89.6) were recorded in 2.0 Bu/ac followed by 2.5 Bu/ac (70.0) and 4.0 Bu/ac (65.5) while the lowest values were recorded in 3.5 Bu/ac (Table 05).

## G. Effects of seed rates on biomass characteristics and yield

Grain yield is a complex character which depends on several factors (Begum et al., 2018). According to our findings, the control treatment (2.5 bushel/ac) produced the highest grain yield (2.74 kg/12m$^2$) compared to the other treatments. A declining trend in grain yield was seen with the increasing seed rates. Treatment 4.5 bushel/ac has the lowest grain yield (1.95 kg/12m$^2$) of the other treatments (Table 06).

Table 05: Panicle Characteristics of cv.At-362 Rice Variety at Harvesting Stage

| Treatment | Number of panicles /m$^2$ | Panicle length (cm) | Number of spikelets /panicle | Number of filled grains /panicle | Number of unfilled grains / panicle |
|---|---|---|---|---|---|
| 2.0 Bu/ac | 272.88±10.45[a] | 23.26±0.3[d] | 120.63±4.73[c] | 89.63±4.08[c] | 30.60±2.23[c] |
| 3.0 Bu/ac | 327.11±15.48[ab] | 21.43±0.39[bc] | 86.90±4.93[b] | 59.73±3.94[ab] | 27.40±1.98[bc] |
| 3.5 Bu/ac | 340.00±15.57[ab] | 19.61±0.31[a] | 66.30±4.04[a] | 46.20±3.00[a] | 20.23±1.41[ab] |
| 4.0 Bu/ac | 386.22±19.59[b] | 20.88±0.34[ab] | 91.43±5.63[ab] | 65.56±4.73[b] | 25.93±1.82[abc] |
| 4.5 Bu/ac | 380.88±39.94[b] | 21.10±0.38[bc] | 83.46±4.5[b] | 62.90±4.00[ab] | 19.90±1.14[a] |
| 2.5 Bu/ac | 310.66±27.59[ab] | 22.35±0.36[cd] | 96.46±5.31[b] | 70.46±4.61[b] | 26.83±1.84[abc] |
| CV | 22.6% | 10.4% | 34.16% | 31.13% | 41.15% |
| P | 0.01 | 0.01 | 0.001 | 0.001 | 0.001 |

Values shown are mean ± S.E. Means with different letters represent significant differences at Tukey's p<0.05.

Table 06: Mean Dry Weight of cv. AT362 Rice Plants

| Treatment | Panicle weight (g/10panicle) | Straw weight(g/10 culms) | Above ground weight (g/10 culms) | Total grain yield/12m$^2$ (kg) |
|---|---|---|---|---|
| 2.0 Bu/ac | 17.81±1.29[a] | 6.73±0.98[a] | 24.54±1.85[a] | 2.45±0.43[a] |
| 3.0 Bu/ac | 12.68±2.04[a] | 5.81±0.84[a] | 18.48±2.82[a] | 2.38±011[a] |
| 3.5 Bu/ac | 10.02±1.35[a] | 5.52±1.17[a] | 15.55±2.5[a] | 1.87±0.23[ab] |
| 4.0 Bu/ac | 13.67±1.59[a] | 5.50±0.17[a] | 19.17±1.76[a] | 2.22±0.23[a] |
| 4.5 Bu/ac | 14.17±2.2[a] | 5.58±0.64[a] | 19.783±2.4[a] | 1.95±0.16[ab] |
| 2.5 Bu/ac (Control) | 15.51±2.77[a] | 6.61±0.40[a] | 22.12±3.03[a] | 2.74±0.27[a] |
| CV | 26.84% | 20.97% | 23.01% | 20.79% |
| P | 0.19 | 0.78 | 0.23 | 0.751 |

Values shown are mean ± S.E. Means with different letters represent significant differences at Tukey's p<0.05.

Gunawardana et al. (2013) conducted a field experiment in rice var. Bg300, under aerobic circumstances examined with three seed paddy rates (100, 150, and 200 kg/ha). According to their findings, larger seed paddy rates (150 and 200 kg/ha) resulted in lower grain production (0.49 and 0.33 t/ha, respectively) than the acceptable seed rate (100 kg/ha) (150kg/ha). Furthermore, the rate of seed paddy used had no effect on the number of seeds per panicle of rice plants (p>0.05). Field experiments sown with 100 kg/ha and 200 kg/ha produced statistically identical

results, however plots sown with 150 kg/ha produced considerably lower full grain% than the other seed rates.

These findings are aligned with the current findings as the lower seed rates (2.0, 2.5 & and 3.0 bu/ac) produced an increased number of leaves, and larger flag leaves (length & and width). This may result in increase in leaf area index (LAI) and enable rice plants to synthesis large amounts of photosynthates during the day times (Mubarak *et al*., 2022). On the contrary, the increased seed rates tend to decline the plant leaf area in the rice canopy, as such the amount of photosynthates translocated into rice panicles is lower, causes large depletion in the rice grain yield. According to Anwar *et al*. (2011), the maximum number of panicles/m2 was associated with the lowest number of filled grains/panicle and 1000 grain weight, resulting in a low grain yield. However, according to Baloch *et al*. (2002), greater plant density causes intra-specific competition for light and nutrients, resulting in a decrease in grain output.

## IV.   CONCLUSION

According to the results of the present study, there were significant variations in plant height, flag leaf, root, and panicle and grain characteristics of the At362 rice variety. Notably, lower seed rates outperformed than the higher seed rates in terms of plant growth indices such as plant height, leaf traits, flag leaf features and panicle characteristic, as such the number of grains and fill percentages were positively influenced by decreasing seed rates. The lower seed rates (2.5 bushel/ac) produced the increased grain yield among the treatments. Hence, the present seed rates practiced by the DOA seem sufficient to maintain the rice production. However, additional field trials with economic analysis needed to confirm the financial benefits to the farmer who wanted to increase their rice yield as well as profit margins generated through their paddy cultivation.

REFERENCES

Abuzar M.R., Sadozai G.U., Baloch M.S., Shah A.A., Javaid T., and N. Hussain N. (2011) "Effect of plant population densities on yield of maize", *The Journal of Animal and Plant Science*, 21(4), pp. 692-695.

Ali, M.H. and Talukder, M.S.U. (2008) "Increasing water productivity in crop production—A synthesis", *Agricultural water management*, 95(11), pp. 1201-1213.

Anwar, P., Juraimi, A.S., Puteh, A., Selamat, A., Man, A. and Hakim, A. (2011) "Seeding method and rate influence on weed suppression in aerobic rice", *African Journal of Biotechnology*, 10(68), pp.15259-15271.

Baloch, A.W., Soomro, A.M., Javed, M.A., Ahmed, M., Bughio, H.R., Bughio, M.S. and Mastoi, N.N. (2002) "Optimum plant density for high yield in rice (*Oryza sativa* L.)", *Asian Journal of Plant Science*, 1(1), pp.25-27

Begum, S.L.R., Pavithira, E. and Mubarak, A.N.M., (2018) "Contribution of growth and physiological characteristics in yield of field grown rice varieties in low country dry zone", *Proceedings of 8th International Symposium, SEUSL*, 1(5), pp.197-204.

Dongarwar, U.R., Patke, N., Dongarwar, L.N. and Kashiwar, S.R. (2018) "Impact of different seed rates on yield and economics of direct seeded rice in eastern Vidharbha zone of Maharashtra, India*", Int. J. Curr. Microbiol. App. Science*, 7(3), pp. 32-42.

Garba, A.A., Mahmoud, B.A., Adamu, Y. and Ibrahim, U. (2013) "Effect of variety, seed rate and row spacing on the growth and yield of rice in Bauchi, Nigeria. African Journal of Food, Agriculture", *Nutrition and Development*, 13(4), pp. 8155-8166.

Gunawardana, W.G.N., Ariyaratne, M., Bandaranayake, P. and Marambe, B., (2013) "Control of Echinochloa colona in aerobic rice: effect of different rates of seed paddy and post-plant herbicides in the dry zone of Sri Lanka", *In Weed Science Society Conference October 22-25, 2013, Bandung Indonesia*, 12(5), pp.431-437.

Himasha, P.S.S., Millawithanachchi, M.C., Nashath, M.N.F. and Mubarak, A.N.M. (2022) March. "Screening of rice germplasms for superior root, shoot morphologies and dry matter productivity under anaerobic conditions in Sri Lanka", *In 10th YSF Symposium*, 15(8), pp. 311-318.

Himasha, P.S.S., Millawithanachchi, M.C., Nashath, M.N.F. and Mubarak, A.N.M., (2021) "Evaluation of root morphology of selected rice varieties under anaerobic and aerobic conditions in Sri Lanka", *10th Annual Science Research Sessions 2021 (ASRS-2021*, 71(5), pp.7-9.

Irangani, M.K.L. and Prasanna, R.P.I.R., (2017). "The Fallacy of Underlying Assumptions of Green Revolution Technology in Sri Lanka: A Historical Comparative Analysis." Current Politics and Economics of South, Southeastern, and Central Asia, 26(4), pp.357-383.

Mohaddesi, A., Abbasian, A., Bakhshipour, S. and Aminpanah, H. (2011) "Effect of different levels of nitrogen and plant spacing on yield, yield components and physiological indices in high-yield rice (number 843)", *American-Eurasian Journal of Agricultural & Environmental Sciences,* 10(5), pp. 893-900.

Mubarak, A.N.M., Musthapha, M., Roshana, M.R. and Kumara, A.D.N.T. (2022) "Influence of canopy architecture on the light interception, photosynthetic and biomass productivity in irrigated elite Sri Lankan rice varieties" *The Journal of Agricultural Sciences-Sri Lanka,* 17(1), pp. 148-160

Nie, L. and Peng, S. (2017) "Rice production in China", *Rice production worldwide,* 45(5), pp. 33-52.

Pathak, H., Tewari, A.N., Sankhyan, S., Dubey, D.S., Mina, U., Singh, V.K. and Jain, N. (2011) "Direct-seeded rice: potential, performance and problems-Areview", *Current Advances in Agricultural Sciences (An International Journal),* 3(2), pp.77-88.

Sandeep, S., Sujatha, M., Subbarao, L.V. and Neeraja, C.N. (2018) "Genetic variability, heritability andgenetic advance studies in rice (*Oryza sativa* L.)", *International Journal of Current Microbiology and Applied Science,* 7(12), pp. 3719-3727.

Sewwandi, M.C., Somarathna, W. G. R. S., Mubarak, A. N. M., Nashath, M. N. F. and Kumara, A. D. N. T. (2023) "Evaluating the growth and yield performances of selected rice (*Oryza sativa* L.) Varieties grown in organic fertilizer", *AGRIEAST,* 17(1), pp. 54-67.

Singh, G., Gupta, M.K., Chaurasiya, S., Sharma, V.S. and Pimenov, D.Y. (2021) "Rice straw burning: a review on its global prevalence and the sustainable alternatives for its effective mitigation", *Environmental Science and Pollution Research,* 28(25), pp. 32125-32155.

Sivaneson, S. and Vijayakumari, V. (2019) "Impact of different depths of transplanting by machine transplanter on growth and yield performance of rice variety (Bw 361)", *Journal of Dry Zone Agriculture,* 2(1), pp. 417-424.

Tadesse, T. and Tadesse, Z. (2019) "Review of rice response to fertilizer rates and time of nitrogen application in Ethiopia" *International Journal of Applied Agricultural Sciences,* 5(6), pp. 129-137.

# Aloe Vera (*Aloe barbadensis* miller) Extract as Media Supplement in Orchid Tissue Culture

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*Abstract*

*The use of natural substances as media supplements to promote the growth and development of orchid has received a lot of interest. Aloe vera extract which is well-known for its nutritional characteristics, has the potential to influence the in vitro growth of orchid plants. Hence, the present study was conducted in the Floriculture Research and Development Unit at the Royal Botanical Gardens, Peradeniya to evaluate the potential of usage Aloe vera extract as nutrient additive for Orchid tissue culture. The experiment was arranged in Complete Randomized Design having four treatments with 15 replicates for each experiment. The number of leaves, shoots and roots per plantlet and explant height were measured. The results showed that various treatments had a substantial impact on the growth characteristics of Orchid explants. During the third week of incubation, 900ml of KNC+100ml of Aloe vera extract and 700ml of KNC+300ml of Aloe vera extract, consistently promoted higher numbers of leaves and shoots and plantlet height compared to the control (KNC media), highlighting the potential benefits of Aloe vera extract supplementation, particularly in the early growth stages. These benefits continue throughout the fifth week of incubation, with all treatments except the control. Notably, 800ml of KNC+200ml of Aloe vera extract produced the most shoots per explant. As a result, these findings emphasize the potential benefits of including Aloe vera extract in orchid tissue culture media, particularly during the early phases of growth.*

*Keywords: Aloe Vera Extract, In Vitro Growth, Media Supplements, Orchid*

## I. INTRODUCTION

Because of their astonishing beauty and diversity, orchids are among the most valuable ornamental plants in the world (Chugh et al., 2009). However, numerous obstacles stand in the way of their cultivation and propagation due to their slow growth rates and susceptibility to diseases. Orchids reproduce naturally through seeds, but in the absence of suitable hosts, the seeds do not germinate in sufficient numbers. These challenges can be overcome by using tissue culture techniques. The micro propagation technique, the most often utilized biotechnological tool for producing ornamental plants commercially is very fast and effective compared to the conventional methods.

All the nutrients necessary for a plant's regular growth and development are present in plant tissue culture media, such as macronutrients, micronutrients, vitamins, amino acids, sugar, other nitrogen and organic supplements, growth regulators, and solidifying agents (Hussain et al., 2012). In general, orchid tissue culture media contains water, vitamins, and mineral salts and as organic additives in orchid growth medium, coconut water, tomato juice, peptone, potato, banana, and beef extracts are commonly employed. A number of recent research have found that medium additives aid in the germination, micropropagation, and growth of many orchid varieties (Rathnayaka et al., 2023b; Tawaro et al., 2008) and other ornamental crops (Rathnayaka et al., 2023a; Maitra et al., 2012).

In this regards, *Aloe vera* gel has been employed in a prior study as an organic nutritional supplement to enhance the growth of plants *in vitro* (Hamdeni et al., 2022). Aloe vera gel is the part of the plant that is employed the most frequently due to its biological efficacy and chemical composition (carbohydrates, organic acids, proteins, phenolic compounds, vitamins, minerals, and amino acids). Furthermore, the plant's enormous potential for therapeutic, pharmacological, and aesthetic uses is revealed by the secondary metabolites and antioxydant profile of Aloe vera gel (Cardarelli et al., 2017). Hence, the objective of this study is to evaluate the

impacts of Aloe vera extract as a media supplement in orchid tissue culture. Understanding the complicated interactions between Aloe vera extract and orchid tissue culture media will pave the way for more effective and sustainable orchid production, helping to conserve these extraordinary plants and the thriving ornamental sector.

## II. MATERIALS AND METHODS

### A. Study Area
The experiment was carried out in the tissue culture laboratory facilities of Floriculture Research and Development Unit at the Royal Botanical Gardens, Peradeniya ($7^o$ 16' N, $80^o$ 35' E), which is located in the $WM_{3a}$ agro ecological zone of Sri Lanka.

### B. Planting Materials
The young *Dendrobium* orchid plantlets (each 1 cm height) were taken from the existing collection of explants from Royal Botanical Gardens. The explants were immersed in a 10 % Sodium Hypochlorite solution for 5 – 10 minutes and washed thrice using autoclaved distilled water for surface sterilization before incubation (Ranthnayaka et al., 2023b). Aloe vera leaves were cleaned using 70 % alcohol and then washed by "Teepol". The thorns in the both side of Aloe vera leaves were removed and the leaves were ground using a blender without water.

### C. Media Preparation and Culture Conditions
Different strengths of KnC (Knudson) media were prepared for Orchid cultures separately as shown in Table 01. After that 4 % (W/V) of sugar and 1.27 % (W/V) of agar were added and the pH of the media was adjusted to 5.60 - 5.63. The media were then autoclaved at 120 $^o$C for 15 minutes and 40 ml of each medium was poured into sterilized culture bottles (100 ml). Then the surface sterilized Orchid explants were established into culture bottles inside a laminar flow with one culture vial held four small plantlets. Cellophane layers were used to seal the culture bottles, which were then kept in a growth room at 25 °C and 16 hours of photoperiod under fluorescent lighting (40 μmol photons $m^{-2}s^{-1}$).

### D. Data Collection
The following data were recorded in Orchid cultures at 3, 5 and 7 weeks after explant inoculation. The number of leaves, shoots and roots per plantlet were counted. Shoot length was measured using 1 mm graph paper.

Table 01: Different Media for Orchid Cultures using Aloe Vera Extract

| Treatment | Media combination |
| --- | --- |
| T1 (Control) | 1litre of KNC media |
| T2 | 900ml of KNC + 100ml of Aloe vera extract |
| T3 | 800 ml of KNC+ 200 ml of Aloe vera extract |
| T4 | 700 ml of KNC + 300ml of Aloe vera extract |

### E. Data Analysis
The treatments were arranged in a CRD (Completely Randomized block Design) method having 15 replicates where each replicate consisted of 4 plantlets. The data obtained were distributed normally and evaluated using the SPSS software. Additionally analysis of variance (ANOVA) was performed to check whether there were treatments having differed significantly at Tukey's 5 % level of probability.

## III. RESULTS AND DISCUSSION

### A. Effect of Aloe Vera Extract on Number of Leaves of Orchid Plantlets
The number of leaves per Orchid explant was significantly affected ($p<0.05$) by different treatments during $3^{rd}$ and $5^{th}$ week after incubation. During $3^{rd}$ week after incubation, T2 (900ml of KNC + 100ml of Aloevera extract) (4.8) and T4 (900ml of KNC + 100ml of Aloe vera extract) (4.6) produced significantly higher number of leaves per explant while the control T1 (KNC media) produced the lowest (2.8). During $5^{th}$ week, all the treatments except T1 (4.2) had higher number of leaves (5 – 5.2). However, during $7^{th}$ week after incubation, no significant differences were observed the number of leaves of Orchid explant ($p>0.05$) (Figure 01).

### B. Effect of Aloe vera Extract on Number of Shoots of Orchid Plantlets
Different treatments had significant effect ($p<0.05$) on the number of shoots per Orchid explant during $3^{rd}$ and $5^{th}$ week after incubation. During $3^{rd}$ week after incubation, all the treatments except control (T1 = 1) produced higher number of shoots per explant (T2 = 1.8, T3 = 2.2 and T4 = 2.1). The treatment T3 resulted the highest number of shoots per explant (2.9) during

5th week after incubation while T1 resulted the lowest (1.7) (Figure 02).
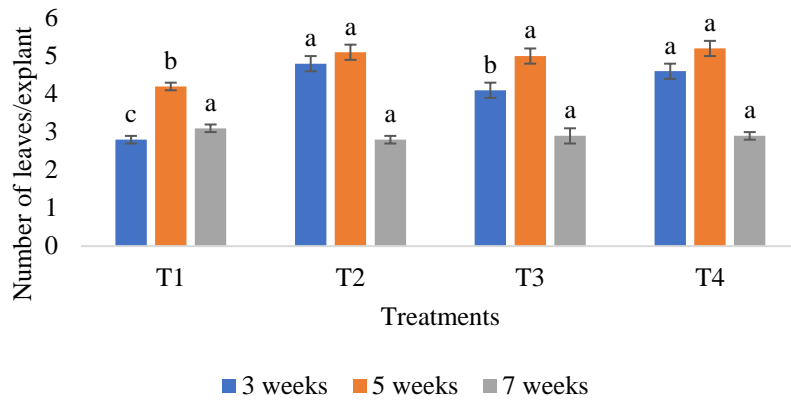


Figure 01: Variations in the Number of Leaves of Orchid Plantlets Grown with Aloe Vera Extracts. Bars with different letters represent significant differences at Tukey's $p<0.05$. CV – Coefficient of Variance, n=15
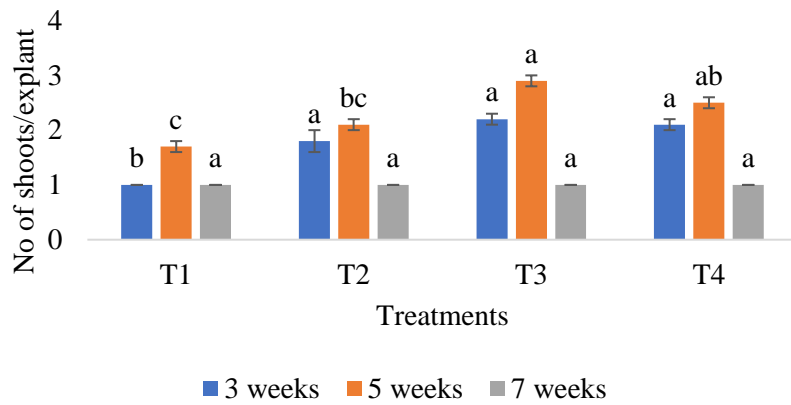


Figure 02: Variations in the Number of Shoots of Orchid Plantlets Grown with Aloe Vera Extracts. Bars with different letters represent significant differences at Tukey's $p<0.05$. CV – Coefficient of Variance. N=15
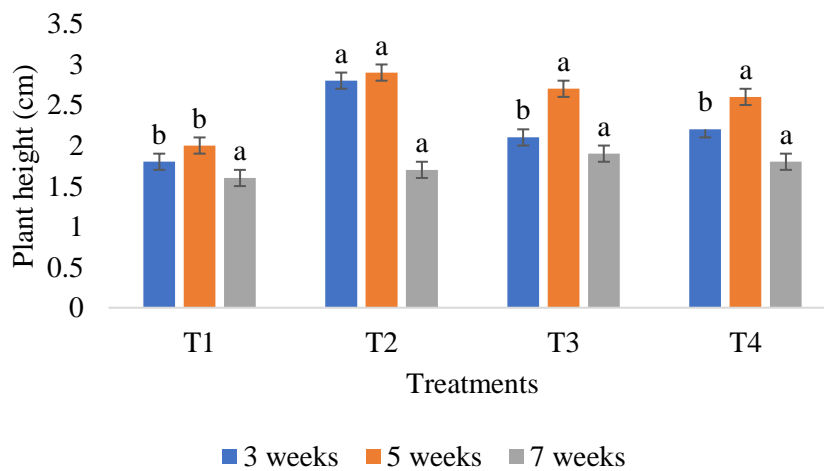


Figure 03: Variations in the Plant Height (cm) of Orchid Plantlets Grown with *Aloe vera* Extracts. Bars with different letters represent significant differences at Tukey's $p<0.05$. CV – Coefficient of Variance. N=15
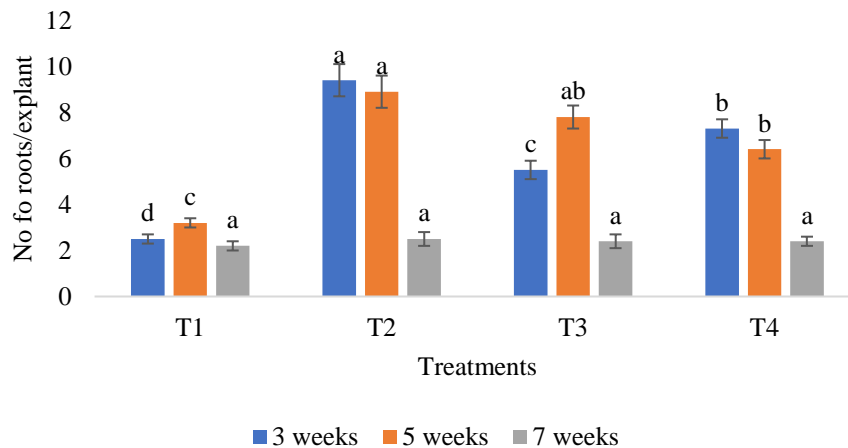
Figure 04: The number of roots of Orchid plantlets grown with Aloe vera extracts. *Bars with different letters represent significant differences at Tukey's p<0.05.* CV – Coefficient of Variance. N=15

## C. Effect of Aloe vera Extract on Plant Height of Orchid Plantlets

The plant height of Orchid explant was significantly affected ($p<0.05$) by different treatments during 3rd and 5th week after incubation. During 3rd week after incubation, the highest plantlet height (2.8 cm) was observed in T2 (900ml of KNC + 100ml of Aloe vera extract) compared with other treatments. During 5th week, higher plantlet heights were observed in all the treatments except T1 (Figure 03).

## D. Effect of Aloe Vera Extract on Number of Roots of Orchid Plantlets

Different treatments had significant effect ($p<0.05$) on the number of roots per Orchid explant during 3rd and 5th week after incubation. The highest number of roots were in T2 during 3rd (9.4) and 5th (8.9) week after incubation respectively. The T1 treatment resulted the lowest number of roots (2.5 and 3.2 respectively) (Figure 04).

The findings of this study show that different treatments have a substantial impact on the growth characteristics of Orchid explants at various phases of incubation. Treatments containing a combination of KNC media and Aloe vera extract, such as T2 and T4, consistently promoted the maximum number of leaves, shoots, and plantlet height during the third week after incubation as compared to the control treatment (T1). These findings highlight the potential benefits of supplementing Orchid tissue culture media with Aloe vera extract, particularly during the early phases of growth. The favourable influence of the

treatments was maintained as the experiment advanced to the fifth week following incubation. Except for the control, all treatments continued to produce more leaves and shoots, with T3 producing the most shoots per explant. Furthermore, during this time span, treatment T2 consistently produced the tallest plantlets, confirming the beneficial effect of Aloe vera extract on the Orchid.

## IV. CONCLUSION

Several previous studies have proven the success of incorporating organic additives in tissue culture media of Orchid. Rathnayaka et al. (2023b) evaluated the potential usage of Moringa and neem additives in Orchid tissue culture. Based on their results, Moringa and neem leaf extracts both performed better than moringa powder. 14 KnC+15g/l moringa leaf extract produced an increased number of leaves and roots per plantlet, whereas full KnC+5g/l moringa leaf extract produced the maximum number of shoots per plantlet (3.5). On the contrary, neem leaf extracts (5g/l, 10g/l, and 15g/l) boosted orchid explant shoot length and produced a much higher number of roots per plantlet. As a result, moringa and neem leaf extracts can be employed to create a simple and low-cost culture media for supporting orchid tissue culture. According to Aktar et al. (2008), in laboratory circumstances, the interaction of various media and organic additives had a substantial effect on the growth and development of protocorm like bodies and subsequent plantlets regeneration of *Dendrobium* orchid. Except for shoot and leaf length, the

interaction of ½ MS medium with Sabri banana pulp yielded the highest values for all metrics. The longest shoots, however, were discovered in KNC medium with Sabri banana pulp, and the longest leaves were discovered in both KNC and 1/2MS media with Sabri banana pulp.

## REFERENCES

Abdalla, N., El-Ramady, H., Seliem, M.K., El-Mahrouk, M.E., Taha, N., Bayoumi, Y., Shalaby, T.A. and Dobránszki, J. (2022) "An academic and technical overview on plant micropropagation challenges", *Horticulturae*, 8(8), pp.677-683.

Aktar, S., Nasiruddin, K.M. and Hossain, K., (2008) "Effects of different media and organic additives interaction on in vitro regeneration of Dendrobium orchid", *Journal of Agriculture & Rural Development*, 6(1), pp.69-74.

Cardarelli, M., Rouphael, Y., Pellizzoni, M., Colla, G. and Lucini, L. (2017) "Profile of bioactive secondary metabolites and antioxidant capacity of leaf exudates from eighteen Aloe species", *Industrial Crops and Products*, 108(3), pp. 44-51.

Chugh, S., Guha, S. and Rao, I.U. (2009) "Micropropagation of orchids: a review on the potential of different explants", *Scientia Horticulturae*, 122(4), pp. 507-520.

Flores-López, M.L., Romaní, A., Cerqueira, M.A., Rodríguez-García, R., de Rodríguez, D.J. and Vicente, A.A. (2016) "Compositional features and bioactive properties of whole fraction from Aloe vera processing", *Industrial Crops and Products*, 91(6), pp. 179-185.

Hamdeni, I., Yangui, I., Sanaa, A., Slim, S., Louhaichi, M., Messaoud, C., Boulila, A. and Bettaieb, T. (2022) "Aloe vera L.(Asphodelaceae): Supplementation of in-vitro culture medium with Aloe vera gel for production of genetically stable plants", *South African Journal of Botany*, 147(12), pp. 1206-1213.

Hussain, A., Qarshi, I.A., Nazir, H. and Ullah, I. (2012) "Plant tissue culture: current status and opportunities", *Recent advances in plant in vitro culture*, 6(10), pp. 1-28.

Loyola-Vargas, V.M. and Ochoa-Alejo, N. (2018) "An introduction to plant tissue culture: advances and perspectives" *Plant cell culture protocols*, 70(2), pp. 3-13.

Maitra, S., Ghosh, P.D., Roychowdhury, N. and Satya, P. (2012) "Effect of Culture Media on In-vitro Regeneration of Anthurium (Anthurium andraeanum Lind.) from Axillary Bud Explants", *International journal of Bio-resource and Stress Management*, 3(1), pp. 35-39.

Mccormick, M.K., Lee Taylor, D., Juhaszova, K., Burnett Jr, R.K., Whigham, D.F. and O'NEILL, J.P. (2012) "Limitations on orchid recruitment: not a simple picture", *Molecular Ecology*, 21(6), pp. 1511-1523.

Murdad, R., Latip, M.A., Aziz, Z.A. and Ripin, R., (2007) June. "Effects of carbon source and potato homogenate on in vitro growth and develop-ment of Sabah's Endangered orchid: Phalaenopsis gigantean", *In Proceedings Asia Pacific Conference on Plant Tissue and Agribiotechnology (APaCPA)*, 17(6), pp. 21-31.

Rathnayaka, R.M.C.U., Herath, H.M.I., Mubarak, A.N.M. and Nashath, M.N.F. (2023) "Exploring the potential use of Moringa olifera Lam and Azadirachta indica additives in Orchid tissue culture", *Sri Lankan Journal of Technology*, 4(1), pp. 1-5.

Rathnayaka, R.M.C.U., Herath, H.M.I., Mubarak, A.N.M. and Nashath, M.N.F. (2023) "Potential use of Moringa olifera Lam. and Azadiracta indica L. leaf powder on the growth and development of Anthurium in vitro cultures", *International Symposium on Agriculture and Environment*, 10(3), pp. 116-118.

Tawaro, S., Suraninpong, P. and Chanprame, S. (2008) "Germination and regeneration of Cymbidium findlaysonianum Lindl. on a medium supplemented with some organic sources", *Walailak Journal of Science and Technology (WJST)*, 5(2), pp. 125-135.

# Effect of Organic Potting Media on Growth Performance of Rose Stem Cuttings

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## Abstract

*The pot experiment was carried out to study the effect of different organic potting media on the growth parameters of rose stem cuttings. It was carried out with five treatments with four replications comprised of different organic potting media, T1 (no organic manure), T2 (cow dung), T3 (sawdust), T4 (poultry manure), T5 (goat manure). in a Completely Randomized Design. The results confirmed that the different organic potting media had significant differences in the number of leaves, number of sprouts, length of internodes, length a diameter of the main root, root area and root volume, fresh and dry weights of shoot and fresh and dry weights of the root. According to the statistically analyzed results, T4 (Poultry manure) gave a higher growth in the tested growth parameters of rose cutting which could be used as potting media for vegetative plant propagation. Poultry manure is environmentally friendly organic manure and it contains high nutrients, thereby it could be used for enhancing the growth of rose stem cuttings.*

*Kewwords: Cow Dung, Poultry Manure, Sawdust, Goat Manure, Stem Cuttings*

## I. INTRODUCTION

Rose (*Rosa hybrida* L) belongs to the family Rosaceae and it is the most diverse flowering ornamental shrubs in the world. It occupies a special position in the floriculture industry. Many roses are grown for their beautiful flowers and most have a delightful fragrance, which differs according to the variety and climatic conditions (Britannica, 2023). Roses use for commercial perfume, bouquet industry and in herbal and folk medicines (Savita, 2016). Organic manures are used as various potting medium in plant propagation. Organic materials such as crop residues, animal manures, green manures to soils supply organic matters, soil fertility, soil physical characteristics, and increase microbial activities, in the soil (Suthamathy and Seran, 2011; Roy and Kashem, 2014). Microbes in the soil decide the plant nutrient availability (Viharnaa *et al.*, 2013). Cow manure is not only an agricultural waste, but also an organic fertilizer resource and it. Mainly consist of lignin, cellulose, hemicellulose, and 24 various minerals like N, K and P along with low amount of S, Fe, Mg, Cu, Co and Mn (Guptha *et al.* (2016). In addition to providing of plant supplements, organic manures generally improve soil tilth, air circulation, and water holding capacity of the soil and advances development of beneficial soil life forms (Fulhage, 2000). Sawdust, a bulky waste generated by wood processing industries, has very few profitable and ecofriendly uses and poses a problem of proper disposal (Maboko et al., 2013). Sawdust revealed beneficial attributes to various types of soils to make them suitable for agricultural purposes. Positive physical properties such as biodegradability at an acceptable rate, low superficial specific gravity, high porosity, high water retention, moderate drainage and high bacterial tolerance elevated the usage of sawdust as a plant growth medium in manufacturing industries (Maharani et al., 2010).

Goat manure improves the effectiveness of fertilizer, and its co-application increases the growth. Organic manures from dairy goats contained adequate amounts of nutrients, especially higher contents of N and P for optimal growth of plants (Gichangi *et al.*, 2010). Poultry manure is the feces of chickens used as an organic fertilizer, especially for soil containing low nitrogen. All animal manures, it has the highest amount of nitrogen, phosphorus, and potassium. Composted poultry manure provides a slow-release source of macro and micronutrients and acts as a soil amendment. Compared to other manures, poultry manure and the associated litter are higher in nitrogen, potassium, phosphorus and

calcium, and are also rich in organic matter (Zublena, 1993). The organic matter in poultry manure has another benefit and it gives food to soil microbes allowing organic nutrients to break down faster, which in turn makes them available to plants more quickly (Place *et al.*, 2002). Organic farming provides several benefits to the growers (Viharnaa *et al.*, 2013) and incorporation of animal manure with EM solution gave the healthy seeds as planting materials (Seran and Shahardeen, 2013). It reduces production cost and it is an environmentally friendly method of cultivation (Green, 2015). In all parts of Sri Lanka, poultry manure, cowdung, goat manure and sawdust are available and those can be used as an organic fertilizer. The present study shows influence of organic manure on growth of rose stem cuttings and select the suitable organic manure for better plant performance of rose stem cutting.

## II. MATERIALS AND METHODS

### A. Experimental Location

This study was carried out as a pot experiment of August to November in 2022 to study the influence of organic manure on growth of rose stem cuttings and to select the suitable organic manure for better plant performance of rose stem cutting. The experiment was done at home garden Mathale, Central province of Sri Lanka which is located in the latitude of 7.4675°N and the Longitude of 80.6234° E and it is part of the Sri Lankan mid-country wet zone. The average annual temperature at the experimental site is 24.1°C and annual mean rainfall is 1868 mm during the year. Soil type of the experiment site is sandy clay loam in texture and dark brown to reddish brown in color.

### B. Agronomic Practices

Rose variety, Grand gala was used in this experiment which is not very sprawling, up to 80 cm wide, but rather tall, reaching up to 1.2 m with proper care. Shoots are straight, strong, abundantly covered with dark green foliage with a glossy surface. The variety Grand Gala itself belongs to the re-flowering. Flowers appear singly on the stem. The inflorescence consists of 40-60 rounded double petals, which slowly unfold and, when fully expanded, elegantly bend outward. For the experiment, black polybags (12 inches diameter, 12 inches height and 8 inches width) were used. Three holes were made at the bottom of each polybag to facilitate the drainage of water. The polybags were filled with treatments (organic

manures): garden soil in the ratio of 1:2 and a distance of 3 cm was left unfilled from the top of the soil to facilitate irrigation. Organic manures were collected from farm household. The stem cuttings were planted in the center of the pots at the depth of 2-3 cm which were collected from home garden and pots were kept at the under shade. Watering was practiced by using watering can.

### C. Measurements

Number of sprouts and number of newly formed leaves per plant in each replication of all treatments was counted at regular intervals. Length of internode (cm) in each replication of all treatments were measured at 9th week. Length and diameter (cm) of main root, root area ($cm^2$) and root volume ($cm^3$) of each plant of each replication of all treatments was measured after destructing the plant after 9th week. Fresh weights of shoot and root (g) were taken using an electronic balance after cutting into small pieces. Dry weights of shoot and root (g) were taken by using electronic balance after drying at $105^0C$ in oven until a constant weight is obtained. Fresh weight of shoot and root and dry weight of shoot and root were taken after destruction of plant.

### D. Experiment Design

The pot experiment was laid out in a completely randomized design (CRD) with five treatments and four replications each having two plants. The treatments used in this experiment are no fertilizer (T1), cow manure (T2), saw dust (T3), poultry manure (T4) and goat manure (T5).

### E. Statistical Analysis

The data were analyzed by using statistical software, SAS 9.1 version. Duncan's Multiple Range Test was used to compare the treatment means at a 5% significant level.

## III. RESULTS AND DISCUSSION

### A. Number of Leaves

Effect of different organic potting media on number of leaves per stem cutting of rose is shown in Table 01 from 3rd week after planting (WAP) to 9th WAP. The results showed that different organic manures significantly influenced the number of leaves per stem cutting at 3rd (p=0.001), 6th (p=0.001) and 9th WAP (p<0.0001). The highest number of leaves was observed in T4 (3.3±0.7) and lowest number of leaves was observed in T1 and T3 (1.3±0.2) in 3rd WAP. From

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6th WAP to 9th WAP, highest numbers of leaves were noted in T4 (5.8±0.6 and 7.5±0.8) and lowest numbers of leaves were observed in T1 (2±0.7 and poultry manure showed significant differences on number of leaves than other treatments from 3rd nutrient status of the soil and boost crop productivity. Compared to other manures, poultry manure and the associated litter are higher in nitrogen, potassium, phosphorus and calcium, and are also rich in organic matter (Zublena, 1993) and Place et al. (2002) reported that organic matter in poultry manure help to soil microbes to breakdown organic nutrients faster which in turn makes them available to plants more quickly.

### B. Length of Newly Developed Shoot

The data presented in Table 02 clearly indicates that there was significant effect on the average length of the newly developed shoot at the 9th WAP (P<0.0001). The maximum length of the newly developed shoot was recorded in T4 (21.25±1.89 cm) followed by T5 (13.50±0.65 cm) and the minimum length of the newly developed shoot was recorded in T1 (4.50±0.65 cm). Mean values in a column having a similar letter indicate that there is no considerable variation between the treatments. Therefore, there are no substantial differences in the length of newly developed shoots between T2 and T3 which significantly varied from T1. Dauda et al. (2008) found that organic manures promote vigorous growth, and

3±0.4). The results prove that stem cuttings which were treated with

WAP to 9th WAP. Ndubuaku *et al.* (2014) observed that poultry manure increased the increase meristematic and physiological activities in the plant due to the supply of plant essential nutrients and enhancing the soil properties. Thereby, resulting in the synthesis of more photo assimilates and also N play a vital role in cell proliferation and cell elongation during the vegetative stage of plant (Marchner, 1995).

### C. Number Sprouts per Cutting

There was a significant difference in number of sprouts per cutting at 9th WAP (p = 0.0017) (Table 02). Maximum number of sprouts per cutting were recorded in T4 (3.5±0.3) followed by T2 and T3 (2.3±0.5 and 2.3±0.2) and the minimum was recorded in T3 (1.3±0.2). There were no any significant differences between T1, T2, T3, and T5 among treatments. The nutrients in the substrate can be activated by organic fertilizer, which can also enhance the soil's physical and chemical properties, encourage plant nutrient absorption, increase nutrient content (Xiao *et al.*, 2018), supply the nutrients required for dry matter accumulation, and encourage both vegetative and reproductive growth (Zhou *et al.,*2020 and Yuan *et al.*, 2021).

Table 01: Effect of Different Organic Potting Media on Number of Leaves of Stem Cutting of Rose Leaves

| Treatments | Number of leaves at different weeks | | |
|---|---|---|---|
| | 3 WAP | 6 WAP | 9 WAP |
| T1 | 1.3±0.2c | 2.0±0.7c | 3.0±0.4d |
| T2 | 2.3±0.5b | 3.8±0.8b | 5.3±0.8b |
| T3 | 1.3±0.2c | 2.8±0.5bc | 3.5±0.5c |
| T4 | 3.3±0.7a | 5.8±0.6a | 7.5±0.8a |
| T5 | 2.0±0.4bc | 2.3±0.5bc | 4.5±0.6bc |
| P value (df = 4) | 0.001 | 0.001 | <0.0001 |

Value represents mean ± standard error of five replicates. Means followed by the same letter in each column are not significantly different according to Dunca's multiple range test 5% significant level.

Table 02: Effect of Different Organic Potting Media on Length of Newly Developed Shoot in Stem Cutting of Rose, Number of Sprouts per Cutting and Internode Length of Rose Cutting at 9th WAP.

| Treatments | Length of newly developed shoot (cm) | Number of sprouts per cutting | Internode length (cm) |
|---|---|---|---|
| T1 | 4.50±0.65d | 1.5±0.3b | 4.03±0.22 |
| T2 | 10.25±0.48c | 2.3±0.5b | 3.15±0.30 |
| T3 | 9.75±0.86c | 1.3±0.2b | 3.70±0.34 |
| T4 | 21.25±1.89a | 3.5±0.3a | 3.87±0.43 |
| T5 | 13.5±0.65b | 2.3±0.2b | 3.35±0.44 |
| P value (df=4) | P<0.0001 | P=0.0017 | P=0.4117 |

Value represents mean ± standard error of five replicates. Means followed by the same letter in each column are not significantly different according to Duncan's multiple range test 5% significant level.

*D. Internode Length*

Effects of different organic manure on internodes length of newly developed shoot in rose cutting at 9th WAP shows in Table 02. The statistical analysis showed that there were significantly differences (p=0.4117) in internode length between treatments. Maximum Internode length was recorded in T1 (4.03±0.22 cm) followed by T4 (3.87±0.43 cm) and T3 (3.70±0.34) and the minimum was recorded in T2 (3.15±0.30 cm). Stem length is determined both by number of internodes and internode lengths (Pearson *et al*, 1995).

*E. Root Diameter*

Effects of different organic manure on root diameter of rose cutting at 9th WAP shows in Table 03. According to the statistical analysis data, there was a significant difference (p<0.0001) on average root diameter. There were no any Significant differences between T1 and T4. Maximum root diameter was recorded in T5 (1.54±0.08 mm) followed by T2 (1.22±0.06 mm) and the minimum root diameter was recorded in T1(1.01±0.07 mm). Poultry manure enhances the soil's physical properties and conditions, as well as nutrient uptake and crop productivity (Mbah and Nnej 2011; Ojeniyi *et al*., 2013).

*F. Root Length*

The data presented in Table 03 shows that the different organic manure has significant effect on root length of rose cuttings at 9th WAP (p < 0.0001). Maximum root length was recorded in T4 (10.92±0.41 cm) followed by T2 (8.91±0.44 cm), and the minimum was recorded in T1 (6.35±0.29 cm). Desuki (2005) reported that average root length of radish increased with increase N due to higher availability of N in root zone area. Ali *et al*, (2010) reported P present in organic manure increase the root development of rose.

*G. Root Area*

Effects of different organic manure on area of root of rose cutting at 9th WAP shows in Table 04. There was significantly difference (P < 0.0001) in root area per plant at 9th WAP. Maximum tap root area was recorded in T4 (63.20±2.58 cm$^2$) followed by T5 (47.31±4.297248 cm$^2$), T2 (46.60±4.11 cm$^2$), T3 (26.44±3.14 cm$^2$), and the minimum was recorded in T1 (23.02±2.12 cm$^2$). The plant treated with poultry manure (T4) root area was increased compared to control treatment (T1) at 9th WAP.

*H. Root volume*

The data presented in Table 04 shows that the different organic manures have significant effect on root volume at 9th WAP (P=0.0018). There were no any significant differences between T1 and T3 as well as T2 and T5. Maximum root volume was recorded in T4 (0.325±0.03 cm$^3$) followed by T2 (0.320 ±0.03 cm$^3$) and the minimum was recorded in T1 (0.170±0.02 cm$^3$).

Table 03: Effect of Different Organic Potting Media on Root Length (cm) and Diameter (mm) in Shoot Newly Developed in Stem Cutting of Rose at 9th WAP

| Treatments | Root diameter (mm) | Root length (cm) |
|---|---|---|
| T1 | 1.01±0.07c | 6.35±0.29d |
| T2 | 1.22±0.06b | 8.91±0.44b |
| T3 | 1.05±0.03bc | 7.65±0.28c |
| T4 | 1.02±0.02c | 10.92±0.41a |
| T5 | 1.54±0.08a | 7.07±0.37cd |
| p value (df=4) | $p < 0.0001$ | $p < 0.0001$ |

Value represents mean ± standard error of five replicates. Means followed by the same letter in each column are not significantly different according to Duncan's multiple range test 5% significant level.

## I. Fresh and Dry Weight of Shoot

Effects of different organic manure on fresh and dry weights of shoot of stem cutting of rose shown in Table 05. The results showed that there was significant difference (p = 0.0428) in fresh weights of shoot but remarkable variation was not noted in dry weight of shoot. Maximum fresh and dry weights of the shoot were recorded in T2 (2.175±0.519 g and 1.01±0.314 g) and the minimum fresh and dry weights of the shoot (0.795±0.2331 g and 0.462±0.049 g) were recorded in T1. The addition of cow dung to damaged soil improves the organic carbon content, which may lead to increased activity of beneficial soil microorganisms as well as improved soil fertility by improving the availability of nutrients for plants. Cow manure improved plant growth and yield substantially (Mehedi *et al*., 2011; Gudugi, 2013).

## J. Fresh and Dry Weights of Roots

Effects of different organic manure on fresh and dry weight of roots of stem cutting of rose shown in Table 06. The results showed that there were significant differences (P<0.0001) in the fresh and dry weights of roots of rose cutting. Maximum fresh and dry weights of roots were recorded in T4 (2.52±0.219 g and 1.335±0.131 g) and the minimum fresh and dry weights of roots were recorded in T1 (0.987±0.046 g and 0.357±0.014 g). It was believed that the mineralization process slowly released the nutrients in the chicken waste, maintaining their availability for plant growth.

This raised the number of leaves and plant height, which in turn increased the plant's fresh weight (Joseph *et al.,* 2017. Lawal and Girei (2013) stated organic manure has the ability to increase the nutrient content of soil, soil moisture holding capacity, reduction in soil pH physico-chemical properties of soil. This finding was in conformity with Kaplan *et al*. (2019) who stated that the addition of organic manure improves the soil's physical and biological condition. Also, by creating more favorable environments for root growth and nutrient availability, increased plant growth and dry matter (Trevisn *et al*., 2010).

Table 04: Effect of Different Organic Potting Media on Root Area and Volume of Stem Cutting of Rose at 9th WAP.

| Treatments | Root area (cm$^2$) | Root volume (cm$^3$) |
|---|---|---|
| T1 | 23.02±2.12c | 0.170±0.02b |
| T2 | 46.60±4.11b | 0.320±0.03a |
| T3 | 26.44±3.14c | 0.195±0.01b |
| T4 | 63.20±2.58a | 0.325±0.03a |
| T5 | 47.31±4.297248b | 0.227±0.034b |
| p value (df=4) | $p < 0.0001$ | $p = 0.0018$ |

Value represents mean ± standard error of five replicates. Means followed by the same letter in each column are not significantly different according to Duncan's multiple range test 5% significant level.

Table 05: Effect of Different Organic Potting Media on Fresh and Dry Shoot Weights of Stem Cutting of Rose Shoot Weight at 9th WAP.

| Treatments | Shoot weight (g) at 9th WAP | |
|---|---|---|
| | Fresh weight (g) | Dry weight (g) |
| T1 | 0.795±0.2331b | 0.462±0.049 |
| T2 | 2.175±0.519a | 1.01±0.314 |
| T3 | 1.343±0.320ab | 0.662±0.152 |
| T4 | 1.965±0.336a | 0.965±0.362 |
| T5 | 1.550±0.1728ab | 0.785±0.081 |
| p value (df=4) | p=0.0428 | p=0.4568 |

Value represents mean ± standard error of five replicates. Means followed by the same letter in each column are not significantly different according to Duncan's multiple range test 5% significant level.

Table 06: Effect of Different Organic Potting Media on Growth Parameter of Stem Cutting of Rose Root Weight

| Treatments | Root weight (g) at 9th WAP | |
|---|---|---|
| | Fresh weight (g) | Dry weight (g) |
| T1 | 0.987±0.046c | 0.357±0.014b |
| T2 | 1.743±0.1049b | 1.050±0.057a |
| T3 | 1.295±0.148bc | 0.462±0.0217b |
| T4 | 2.520±0.219a | 1.335±0.131a |
| T5 | 1.512±0.185b | 0.527±0.205b |
| p value (df=4) | p<0.0001 | p<0.0001 |

The value represents mean ± standard error of five replicates. Means followed by the same letter in each column are not significantly different according to Duncan's multiple range test 5% significant level.

## IV. CONCLUSION

This investigation was conducted to find out the effects of different organic manure on the growth stem cutting of roses (Grand Gala). The potting media of 2:1 ratio is two parts soil and one part organic manure increased the growth of stem cutting rose. Treatments of different organic potting media had a significant effect on all tested growth parameters on stem cuttings of rose. The results confirmed that the poultry manure was given the best results than the other treatments. In the parameters such as number of leaves, number of sprouts, lengths of internodes (cm), length and diameter (cm) of main root, root area (cm$^2$) and root volume (cm$^3$), fresh and dry weight of root (g) were significantly higher in poultry manure treatment than other treatment. Accordingly, Poultry manure is the best treatment for best growth of the rose stem cuttings. Poultry manure could be recommended for the cultivation of stem cutting of rose in order to achieve ecologically sound and better growth in roses.

## REFERENCES

Dauda, S. N., Ajayi, F. A., Ndor, E. (2008) "Growth and yield of water melon (*Citrullus lanatus*) as affected by poultry manure application", *Journal of Agriculture and Social Science*, 4(3), pp.121-124.

Fulhage, C.D. (2000) "Reduce environmental problems with proper land application of animal manure", *University of Missouri Extension,* 7(1), pp. 1-10.

Gichangi, M., Pearson N.S., Minkeni, N.S., Brookes, C. (2010) "Goat manure application improves phosphate fertilizer effectiveness through enhanced biological cycling of phosphorus", *Soil science and plant nutrition,*. 56(6), pp. 853-860.

Green, B.W. (2015) "Fertilizers in aquaculture. In: Davis, D. A., editor. Feed and Feeding Practices in Aquaculture. Sawston, Cambridge", *Woodhead Publishing Ltd*, 23(1), pp. 27-52.

Gudugi, I.A.S. (2013) "Effect of cowdung and variety on the growth and yield of okra (*Abelmoschus esculentus* L.)", *Europian Journal of Experimenatal Biology,* 3(2), pp. 495–498.

Gupta, K., Aneja, K., Rana, D. (2016) "Current status of cow dung as a bioresource for sustainable development", *Bioresources and Bioprocessing,* 3(2), pp. 28-36.

Joseph, P. O., Ojomah, F. O., Joseph, P. O. (2017) "Effect of poultry manure and NPK fertilizer on growth and yield of eggplant (*Solanum melongena*)", *Journal of Agriculture and Rural Research,* 10(2), pp. 112–117.

Kaplan, H., Ratering, S., Felix-Henningsen, P., Schnell, S. (2019) "Stability of in situ immobilization of trace metals with different amendments revealed by microbial 13C-labelled wheat root decomposition and efflux-mediated metal resistance of soil bacteria", *Science Total Environment,* 659(12), pp. 1082-1089.

Lawal, H. and Girei, H. (2013) "Infiltration and organic carbon pools under the long term use of farm yard manure and mineral fertilizer" *International Journal of Advanced Agricultural Researach*, 12(5), pp. 92–101.

Maboko, M.M. and Du-Plooy, C.P. (2013) "High density planting of tomato cultivar's with early decapitation of growing point increased yield in a closed hydroponic system", *Acta Agriculturae Scandinavica, Section B-Soil & Plant Science,* 63(8), pp. 676-682.

Maharani, R., Tamai, Y., Takashi, Y., Terazawa, M. (2010) "Scrutiny of Physical Properties of Sawdust from Tropical Countries Wood Species: Effect of Different Mills and Sawdust Particle Size", *Journal of Forestry Research,* 7(1) pp. 20-32.

Marschner, H. (1995) "Mineral Nuttition of Higher Plants", *Academic Press Limited,* 12(88), pp. 864-869.

Mbah, C.N., Nnej, I.R. (2011) "Effect of different crop residue management technique on selected soil properties and grain production of maize", *African Journal of Agricultural Research,* 6(7), pp. 4149–4152.

Mehedi, T.A., Siddique, M.A. and Shahid, S.B. (2012) "Effect of urea and cow dung on growth and yield of carrot", *Journal of the Bangladesh Agricultural University,* 10(5), pp. 9–13.

Ndubuaku, U.M., Nwankwo, V.U., Baiyeri, K.P. (2014) "Influence of poultry manure application on the leaf amino acid profile, growth and yield of moringa (*Moringa oleifera* Lam)", *Albanian Journal of Agricultural Science Albania* , 13(1) pp. 42-47.

Ojeniyi, S.O., Amusan, O.A., Adekiya, A.O. (2013) "Effect of poultry manure on soil physical properties, nutrient uptake and yield of cocoyam (*Xanthosoma saggitifolium*) in southwest Nigeria", *American-*

*Eurasian Journal of Agriculture and Environmental Sciences,* 13(1), pp. 121–125.

Pearson, S., Hadley, P., Wheldon, A.E. (1995) "A model of the effect of day and night temperatures on the height of chrysanthemums", *Acta Horticulturae,* 378(15), pp. 71–79.

Place, F., Swallow, B.M., Wangila, J.W., Barrett, C.B. (2002) "Lessons for natural resource management technology adoption and research. In Barrett (Eds.). Natural Resources Management in African Agriculture: Understanding and Improving Current Practices", *Oxon and New York: CABI publishing,* 45(4), pp. 275-285.

Roy, S. and Kashem, M. D. (2014) "Effects of Organic Manures in Changes of Some Soil Properties at Different Incubation Periods", *Open Journal of Soil Science,* 04(03), pp. 81-86.

Savita, C. (2016) "Rose Ornamental As Well As Medicinal Plant", *Journal of Research in Agriculture and Animal Science,* 4(1), pp. 08-10.

Seran, T.H. and Shahardeen, R.N.M. (2013) "Effect of EM-Bokashi on vigorous seed production in vegetable cowpea (*Vigna Unguiculata* L.)", *Proceedings of 3rd International Symposium, Section: Biology, Agricultural Sciences and Environmental Sciences, South Eastern University, Sri Lanka,* 1(1), pp. 13-18.

Suthamathy, N. and Seran, T. H. (2011) "Influence of different rates of cattle manure application on the weed occurrence in groundnut (*Arachis hopogae* L.). Proceedings of the 10th Annual Research Session", Eastern University, Sri Lanka, 18(2), pp. 132-139.

Trevisan, S., Francioso, O., Quaggiotti, S., Nardi, S. (2010) "Humic substances biological activity at the plant-soil interface from environmental aspects to molecular factors", *Plant signal behavior,* 5(6), pp. 635-643.

Viharnaa, S., Seran T.H. and Hassaan, A.M. (2013) "Dry matter content of groundnut (*Arachis hypogaea* L.) fertilized with liquid organic fertilizer", *In Proceedings of 3rd International Symposium, Section: Chemistry, Physics and Earth Science, South Eastern University, Sri Lanka,* 1(1), pp. 5-10.

Xiao, Q., Wang, Q.Q., Wu, L., Cai, A.D., Wang, C.J., Zhang, W.J., Xu, M.G. (2018) "Fertilization impacts on soil microbial communities and enzyme activities across China's croplands: A meta-analysis", *Plant Nutrition and Fertilizer. Science,* 24(5), pp. 1598-1609.

Yuan, Q., Feng, B., Zhong, Y.H., Wang, J., Xu, X.J. and Ma, H.B. (2021) "Partial replacement of chemical

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fertilizer with organic fertilizer: Effects on eggplant yield, quality and soil fertility", *Chinese Agricultural Science Bulletin,* 37(12), pp. 59-63.

Zhou, Y., Li, Y.M., Fan, M.P., Wang, Z.L., Xu, Z., Zhang, D. and Zhao, J.X. (2020) "Effects of different base fertilizer treatments on mountain red earth soil nutrition, enzyme activity, and crop yield", *Chinese Journal of Applied and Environmental Biology*, 26(2), pp. 603-611.

Zublena J. P., Barker J. C., Carter T. A. (1993) "Poultry manure as a fertilizer source", *Publication AG-439-5. North Carolina Cooperative Extension Service*, 45(1), pp. 45-96.

# Interaction between Seed Rates, Weed Population and Yield Performance of Field Grown Irrigated Rice Variety *Cv. At362*

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## Abstract

*Rice (Oryza sativa L.) is an important economic food crop in Sri Lanka. Weeds are a major constraint to the success of rice production. Crop-weed competition has a profound effect on the grain yield of rice. However, using herbicides alone may not be considered sustainable in the long term. Hence, a field experiment was conducted at Rice Research Station, Sammanthurai to study the interaction between seed rates - weed population and yield performance of field-grown At362 rice variety. The treatment (T) consisted of six seed rates viz; 2 bushel/ac, 2.5 bushel/ac (as control), 3 bushel/ac, 3.5 bushel/ac, 4 bushel/ac and 4.5 bushel/ac. The field experiment was laid out in Randomized Complete Block Design (RCBD) with 6 treatments having 3 replications. Field data were collected on weed populations, rice crop growth and yield parameters throughout the cultivation season under field conditions. According to the results, plant height, the number of leaves per plant, root length, panicle length and number of panicles were significantly ($p<0.05$) affected by different seed rates. Lower seed rates resulted in increased values for the above-tested parameters in the At362 rice plant. Sedges were the most dominant weeds in this field plot compared to grasses and broad leaves. However, no significant differences were observed in the yield and weed population ($p>0.05$). Further research in various seasons and regions can offer a more thorough comprehension of the relationship among rice seed rates, weed dynamics, and yield.*

*Keywords: At362, Grasses, Oryza sativa L., Panicle, Sedges, Seed rates*

## I. INTRODUCTION

The rice (*Oryza sativa* L.) is one of the most important food crops in the world with 40 % of the world population depending on it. In Sri Lanka, rice is a staple diet food where 1.8 million farm families are engaged in paddy Cultivation Island-wide (Senanayaka and Premaratna, 2016). On average 560,000 hectare (ha) are cultivated during the *Maha* season and 310,000 ha during the *Yala* season making the annual extent sown with rice to about 870,000 ha (Department of census and statistics, 2022). Ampara district is a prominent rice-growing region in Sri Lanka, and a total of 136,036 hectares of paddy was planted largely using the At-362 and Bg-94-1 owing to its superior agronomic and yield features (Mubarak *et al*., 2022).

There are various obstacles to rice production, including limited soil, nutritional shortages, insect and diseases problems and water availability. One of the major biological constraints is weeds which leads to considerable amount of yield losses (Savary *et al*., 2000). Depending on the type of weeds, infestation level, establishment methods and weed management approaches, typical yield losses due to weed infestation in rice can range from 40 to 60 percent, with certain cases reaching 94-96 percent (Monira *et al*., 2022). *Echinochloa* spp. (barnyard grass), *Cyperus* spp. (nutgrass), *Leptochloa chinensis* (red spangletop), and *Ludwigia* spp. (water primrose) are some of the primary weeds in rice production in the country (Rajapakse *et al*., 2011). Herbicides for weeds are now widely used by farmers, harming the Environment and people's health as well as having the potential to breed resistant populations (Liebman *et al*., 2016). Therefore, it is important and encouraged to manage the weeds using environmentally friendly, sustainable methods.

The seed rate is considered one of the most agronomic factor for uniform growth of the rice production (Kassam *et al*., 2011). The interaction between seed rate and weed growth is complex and is affected by a number of factors, including the type of rice grown, local environmental

circumstances, and weed species composition (Mahajan, Singh and Chauhan 2012). Higher rates, in general, result in increased plant density and faster canopy closure, which may restrict weed growth by lowering the available space and light for weeds to establish and thrive (Chauhan and Singh Mahajan 2012). A densely populated rice canopy can shade away developing weeds, restricting their growth and reproductive capacity. Excessive seed rates, on the other hand, can cause overcrowding and resource competition among rice plants, resulting in poor tillering, diminished panicle development, and ultimately, lower grain yield (Akilu, 2020). Furthermore, if the rice canopy does not shut rapidly due to poor early development, weeds may be able to sprout and grow, even in high-density plantings. Therefore, this study was aimed to evaluate the interaction between seed rates, weed population and growth and yield performances of field grown *cv*. At362 rice variety in Ampara district of Sri Lanka.

## II. MATERIALS AND METHODOLOGY

### A. Study Area
The field experiment was conducted at the Rice Research Station in Sammanthurai located at Ampara district (7°21'18.4"N; 81°46'38.2"E) during the *Yala* season (April to August) in 2022. The mean annual temperature of this area is 27 °C to 30 °C and annual precipitation is between 1500 mm to 2225 mm. Soil type is non-calcic brown which contains sand with slightly acidic soil.

### B. Planting Materials and Field Conditions
The rice variety *cv*. At362 was selected to conduct the trial since it is the most popular and high yielding rice variety in Ampara district (Sewwandi *et al*., 2023). At-362 was sown (Broad casting method) at different seed rates on April 2022. Before sowing the plot was kept weed-free conditions by hand weeding. Land was ploughed before sowing and then harrowed. Each treatments were prepared 6 m x 3 m field plots and replicated three-times. Paddy seeds were soaked in water at 24 hours for germination after that soaked seeds were removed from water and were sown in six different seed sowing rates (2.0 Bu/ac (T1), 2.5 Bu/ac (T6 Control), 3.0 Bu/ac (T2), 3.5 Bu/ac (T3), 4.0 Bu/ac (T4) and 4.5 Bu/ac (T5)). Field management practices such as irrigation, fertilizer application were done according to the Depatment

of Agriculture (DOA) recommendations. Basal application of fertilizer rate of 1782 g /18 m$^2$ comprised Urea, Muriate of Potash (MOP), Triple super phosphate (TSP) were broadcast uniformly and incorporated into soil plots. Except urea, all other fertilizers were applied before rice sowing, and Urea was top dressed in three installments at 15, 30 and 45 days after sowing. The field plots were maintained under weed condition.

### C. Data Collection
#### 1) Growth and Yield Parameters of Rice Plant
Plant height (cm), root length (cm), and number of leaves/plant were recorded at 6 (vegetative stage), 8 (reproductive stage) and at 10 WAS (ripening stage). Plant height was obtained by measuring the main stem length from ground level to the tip of leaves using meter scale (Sivaneson and Vijayakumari, 2019). For root length measurement, the length of the longest root was measured from the base of the culm to the tip of the longest root using a scaled ruler (Himasha *et al*., 2022). At harvest, the panicle length (cm) was measured using scale ruler and grains per panicle (filled and unfilled grain) was counted and thousands grains weight was measured using electronic balance. All the above data were collected from 10 randomly selected plants in each plot. Finally, grain yield was determined from harvested area in each plot by avoiding the edge-effect of the field. Dry weights were determined by placing the plant samples inside an oven at 80 °C for 72 hours until a constant weight was observed.

#### 2) Growth Measurements of Weeds
The weed density (weeds/m$^2$) was counted 6 and 10 was using 50 cm x 50 cm quadrate by randomly placing it in three places of each plot. The dry weight (g) of weeds samples were determined at 80 °C for 72 hours until a constant weight was observed.

### D. Data Analysis
Statistical analysis for the collected data was performed using SPSS software (version 25) using the analysis of variance (ANOVA). To determine whether there was a significant difference between the treatment means at 0.05 probability levels, the Tukey's post-hoc test was used.

## III. RESULTS AND DISCUSSION
### A. Effects of Seed Rates on Plant Height
Rice plant height was significantly varied among treatments at 6, 8 and 10 WAS ($p < 0.05$). The

tallest plants were observed in T 2 (44.7 cm) at 6 WAS, while, the T4 reached (71.5 cm) at 8 WAS. Meanwhile, at 10 WAS, treatments T2 (73.6 cm), T5 (73.9 cm) and T6 (73.1 cm) resulted the highest plant heights. Conversely, T 3 had the shortest plants. Accordingly, the lower seed rate increased the plant height during early stages, conversely, 10 WAS, taller plants were observed in higher seed rates (Table 01).

### B. Effect of Seed Rate on Number of Leaves/Plant

The number of leaves produced on the main culm of the rice plant was significantly differed among treatments ($p<0.05$). Highest number of leaves were produced by T 1 and T 6 (control) compared to other treatments during all three times (Table 02).

### C. Effect of Seed Rate on Rice Plant Root Length

Lengthier root system contributes to the rice plant in obtaining water and nutrients from deeper soil layers (Himasha *et al*., 2021). Root length of plant was significantly affected ($p<0.05$) by different seed rates at 6 and 10 WAS. The root length progressively increased from 6 th, 8 th and 10th WAS. At 10 WAS, all the treatments except the control resulted significantly increased root length. Among those treatments, T2 (9.4 cm) and T3 (9.5 cm) had the highest root lengths (Table 03).

### D. Effect of Seed Rate on Number of Weeds /m²

Three types of weeds were identified in the experimental field including the grasses: (Barnyard grass, *Isachne globosa*, *Echinochloa galabrescenns*, *Ischaemum rugosum*), broad leaves: Water cloves, *Commelina diffusa* and sedges: *Cyperus irrialinn*, *Cyperus rotundus*, *Fimbristylis miliacea, Cyperus difformisli*.

The most prominent type was *Cyprus sedges* in this field. There was no significant variation (p>0.05) in weed levels between treatment combination. However, the weed population was higher in the early stages of crop establishment (6 th WAS), than in the subsequent rice growth stages (10 th WAS). Similar trends were observed for sedges and grasses. Moreover, sedges were particularly prominent in the experimental field, and even in the 10 th WAS the sedge population was higher (Table 04).

Table 01: Plant Height at 6th, 8th and 10th Weeks after Field Sowing of Rice Variety *cv*. At-362

| Treatment | Plant height (cm) | | |
|---|---|---|---|
| | 6 WAS | 8 WAS | 10 WAS |
| T1 | 40.63±1.0[b] | 69.40±1.1[ab] | 70.60±1.6[ab] |
| T2 | 44.73±0.8[c] | 71.26±1.9[b] | 73.63±1.9[b] |
| T3 | 35.86±0.6[a] | 62.13±2.4[a] | 66.33±1.5[a] |
| T4 | 40.10±0.1[b] | 71.56±1.9[b] | 72.20±1.9[ab] |
| T5 | 40.40±0.9[b] | 67.56±1.4[ab] | 73.96±1.0[b] |
| T6 (control) | 41.20±0.8[bc] | 66.43±1.8[ab] | 73.16±2.0[b] |
| CV | 13.70% | 15.40% | 13.30% |
| *P* | 0.001 | 0.001 | 0.001 |

Values shown are mean ± S.E. Means with different letters across the column represent significant differences at Tukey's p <0.05.n=30

Table 04: Effect of Seed Rate on Weed Population (Number of Weeds/m$^2$)

| Treatment | Broad leaves/m$^2$ | | Sedges/m$^2$ | | Grasses/m$^2$ | |
|---|---|---|---|---|---|---|
| | 6 WAS | 10 WAS | 6 WAS | 10 WAS | 6 WAS | 10 WAS |
| T1 | 17.3±4.8[a] | 8.6±6.1[a] | 158.6±32.8[a] | 149.0±52.2[a] | 36.0±2.3[a] | 10.0±2.0[a] |
| T2 | 28.0±6.1[a] | 1.0±0.5[a] | 240.0±32.8[a] | 140.3±38.5[a] | 30.6±4.8[a] | 9.6±2.0[a] |
| T3 | 32.0±8.3[a] | 2.6±1.1[a] | 149.3±35.9[a] | 137.3±74.8[a] | 26.3±1.6[a] | 11.3±2.9[a] |
| T4 | 12.0±0.0[a] | 7.3±4.0[a] | 132.3±7.2[a] | 114.6±17.4[a] | 33.3±10.9[a] | 13.0±5.0[a] |
| T5 | 28.0±18.0[a] | 14.6±13.6[a] | 118.6±24.9[a] | 99.0±34.0[a] | 34.6±18.6[a] | 17.3±0.6[a] |
| T6 (Control) | 13.3±1.3[a] | 7.3±5.4[a] | 120.0±16.6[a] | 102.0±21.0[a] | 24.0±8.3[a] | 27.3±9.5[a] |
| CV | 69% | 84% | 37.80% | 66% | 46.70% | 14.80% |
| *P* | 0.475 | 0.762 | 0.072 | 0.941 | 0.936 | 0.141 |

Values shown are mean ± S.E.  Means with different letters across the column represent significant differences at Tukey's $p < 0.05$. n=30

Table 05: Panicle and Yield Characteristics of Paddy under Different Seed Rate

| Treatment | Panicle length (cm) | Total grains / panicle | No of filled grains/ panicle | No of unfilled grains /panicle |
|---|---|---|---|---|
| T1 | 19.58±0.42[a] | 85.96±5.06[a] | 62.70±4.14[a] | 23.33±2.01[a] |
| T2 | 18.31±0.54[bc] | 67.36±5.67[ab] | 50.13±4.50[abc] | 17.23±1.66[ab] |
| T3 | 17.18±0.39[ab] | 52.90±3.25[c] | 36.0±2.88[c] | 16.90±0.94[ab] |
| T4 | 16.31±0.57[b] | 53.80±4.75[c] | 58.33±3.49[ab] | 15.46±1.85[c] |
| T5 | 18.30±0.35[bc] | 68.23±4.49[ab] | 51.20±3.14[bc] | 17.03±1.8[ab] |
| T6 (control) | 19.78±0.38[a] | 82.26±4.57[b] | 63.01±3.47[a] | 19.26±1.3[ab] |
| CV | 14.90% | 41.30% | 44.50% | 51.30% |
| *P* | 0.01 | 0.01 | 0.01 | 0.02 |

Values shown are mean ± S.E.  Means with different letters across the column represent significant differences at Tukey's $p < 0.05$. n=30

Table 06: Mean Yield and Biomass Features of Rice Plant Biomass Production

| Treatment | 1000 grain weight (g) | Straw weight (g/10 stem) | Grain yield (kg/12m$^2$) |
|---|---|---|---|
| T1 | 21.98±1.47[a] | 4.93±0.32[a] | 3.74±0.34[a] |
| T2 | 27.48±6.50[a] | 5.66±0.31[a] | 3.83±0.06[a] |
| T3 | 20.58±0.76[a] | 5.06±0.92[a] | 3.56±0.58[a] |
| T4 | 21.78±0.81[a] | 5.23±0.31[a] | 3.21±0.45[a] |
| T5 | 23.15±1.97[a] | 5.0±0.75[a] | 4.43±0.42[a] |
| T6 (Control) | 18.63±5.16[a] | 4.83±0.37[a] | 3.66±0.10[a] |
| CV | 24.60% | 14.20% | 17.64% |
| *P* | 0.55 | 0.83 | 0.4 |

Values shown are mean ± S.E.  Means with different letters across the column represent significant Differences at Tukey's $p < 0.05$. n=30.

*E. Effect of Seed Rate on Rice Grain Characteristics*
All the tested panicle characteristics were significantly affected by seed rates ($p < 0.05$).

Higher panicle length and number of filled grains per panicle were recorded in T 1 (19.5 cm and 62.7 respectively) and control (19.7 cm and 63.0 respectively). Meanwhile, T 1 resulted the highest total number of grains per panicle (86) and unfilled grains per panicle (23.3) compared to other treatments. In contrast, T 3 and T 4 recorded the lowest values for the panicle parameters (Table

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05). The result indicates that increased seed rates reduced the panicle length and grain numbers.

Grain yield is a complex character which depends on several factors (Begum Pavithra and Mubarak 2018). There was no significant effect on the biomass and yield of rice plants in the present study. Phuong *et al.* in 2005 demonstrated that raising the seed rate strengthens the crop's ability to suppress weeds and increases crop yields by reducing weed densities in low-land rice. In a previous study, Gunawardana *et al.* (2013) conducted a field experiment with rice variety Bg300, under aerobic conditions with three seed rates (100, 150, and 200 kg/ha) and reported that larger seed paddy rates (150 and 200 kg/ha) resulted in lower grain yield (0.49 and 0.33 t/ha, respectively) than the recommended seed rate (100 kg/ha). Furthermore, the rate of seed paddy used had no effect on the number of seeds per panicle of rice plants ($p>0.05$). Field experiments sown with 100 kg/ha and 200 kg/ha produced statistically identical results, however plots sown with 150 kg/ha produced considerably lower full grain% than the other seed rates. Among the treatments utilized, application of 3,4 dichloropropionanilide or bispyribac sodium at the recommended dosage at the weed's 2/3 leaf stage, paired with the recommended rate of seed paddy at 100 kg/ha, is an effective integrated weed management approach for *E. colona* control in aerobic rice.

## IV. CONCLUSION

The current study found substantial differences in the plant height, number of leaves, root length, panicle, and grain properties of the At362 rice variety. Notably, lower seed rates including the recommended rate performed better in terms of plant growth indices and panicle characteristics; as a result, decreasing seed rates positively influenced the number of grains and filled grain percentages. However, no significant differences were observed in weed populations and rice plant yield among different seed rate treatments.

## REFERENCES

Begum, S.L.R., Pavithira, E. and Mubarak, A.N.M. (2018) " Contribution of growth and physiological characteristics in yield of field grown rice varieties in low country dry zone", Proceedings of 8th International Symposium, SEUSL, pp.197-204.

Chauhan, B.S., Singh, R.G. and Mahajan, G. (2012) " Ecology and management of weeds under conservation agriculture: a review", Crop Protection, 38, pp.57-65.

Department of census and statistics Sri Lanka, (2022), http://www.statistics.gov.lk/ Accessed on 17.07.2023.

Gunawardana, W.G.N., Ariyaratne, M., Bandaranayake, P. and Marambe, B. (2013) " Control of Echinochloa colona in aerobic rice: effect of different rates of seed paddy and post-plant herbicides in the dry zone of Sri Lanka", In Weed Science Society Conference October 22-25, 2013, Bandung Indonesia. pp. 431-437.

Himasha, P.S.S., Millawithanachchi, M.C., Nashath, M.N.F. and Mubarak, A.N.M. ( 2022) "Screening of rice germplasms for superior root, shoot morphologies and dry matter productivity under anaerobic conditions in Sri Lanka", In 10TH YSF SYMPOSIUM, pp. 311.

Himasha, P.S.S., Millawithanachchi, M.C., Nashath, M.N.F. and Mubarak, A.N.M. (2021) " Evaluation of root morphology of selected rice varieties under anaerobic and aerobic conditions in Sri Lanka" 10th Annual Science Research Sessions 2021 (ASRS-2021). pp. 7-9

Kassam, A., Stoop, W. and Uphoff, N. (2011)" Review of SRI modifications in rice crop and water management and research issues for making further improvements in agricultural and water productivity", Paddy and Water Environment, 9, pp.163-180.

Liebman, M., Baraibar, B., Buckley, Y., Childs, D., Christensen, S., Cousens, R., Eizenberg, H., Heijting, S., Loddo, D., Merotto Jr, A. and Renton, M. (2016) " ecologically sustainable weed management: how do we get from proof-of-concept to adoption?" Ecological applications, 26(5), pp.1352-1369.

Mahajan, G., Singh, S. and Chauhan, B.S. (2012) " Impact of climate change on weeds in the rice-wheat cropping system", Current science, 102(9), pp.1254-1255.

Monira, S., Ali, M.I., Sarker, U.K., Begum, M. and Uddin, M.R. (2022) " Floristic divergence of weeds in rice fields under subtropical condition", Archives of Agriculture and Environmental Science, 7(3), pp.450-462.

Mubarak, A.N.M., Musthapha, M., Roshana, M.R. and Kumara, A.D.N.T. (2022) " Influence of canopy architecture on the light interception, photosynthetic and biomass productivity in irrigated elite Sri Lankan

rice varieties", The Journal of Agricultural Sciences-Sri Lanka, 17(1), pp.148-160.

Phuong, L.T., Denich, M., Vlek, P.L.G. and Balasubramanian, V. (2005) "Suppressing weeds in direct-seeded lowland rice: Effects of methods and rates of seeding", Journal of Agronomy and Crop Science, 191(3), pp.185-194.

Rajapakse, R., Chandrasena, N., Marambe, B. and Amarasinghe, L. (2011) " Planning for effective weed management: lessons from Sri Lanka", In 23rd Asian-Pacific Weed Science Society Conference. Volume 2: weed management in a changing world, Cairns, Queensland, Australia, 26-29 September 2011 pp. 116-126.

Savary, S., Willocquet, L., Elazegui, F.A., Castilla N.P. and Teng, P.S. (2000) "Rice pest constraints in tropical Asia: quantification of yield losses due to rice pests in a range of production situations", Plant disease, 84(3), pp.357-369.

Sewwandi, M.C., Somarathna, W. G. R. S., Mubarak, A. N. M., Nashath, M. N. F. and Kumara, A. D. N. T. (2023) " Evaluating the growth and yield performances of selected rice (Oryza sativa L.) varieties grown in organic fertilizer", AGRIEAST, 17(1), pp. 54-67.

Sivaneson, S. and Vijayakumari, V. (2019) " Impact of different depths of transplanting by machine transplanter on growth and yield performance of rice variety (Bw 361)", *Journal of Dry Zone Agriculture*, 2(1), pp.417-424.

# Development of a Tool to Apply Chemical Fertilizer for Pineapple (*Ananas comosus*) Cultivation

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## *Abstract*

*Pineapple (Ananas comosus) is a heavy feeder and needs more nutrients to get an optimum yield. Fertilizer application is problematic in all Pineapple cultivations mainly due to two reasons. On the one hand, there are spiny and pointed leaves and on the other hand, the place where fertilization needs to be applied. The fertilizer should be applied to the base of the leaves and is a laborious and annoying practice, especially when done manually in commercial cultivation. Therefore, there is a necessity to develop a convenient technique to facilitate the fertilizer application. Hence, an experiment was conducted at the University of Colombo Institute for Agro-Technology and Rural Sciences, Hambantota, Sri Lanka to develop a simple tool to apply chemical fertilizer at the base of Pineapple leaves. The tool was developed using PVC pipes, nuts, bolts, rubber bands, a spring and glue. All these items were assembled in an orderly manner to develop a smart and a simple tool to achieve the purpose. The height of the tool can be adjusted by changing the fertilizer loading component. A questionnaire survey was conducted among the pineapple cultivators to evaluate the usefulness of the tool. The weight, height, safety, efficiency, cost and overall acceptability were evaluated using a five-point Likert scale. Further, the developed tool was compared with manual fertilizer application to monitor the time taken to apply fertilizers and the labour cost using 20 pineapple plants at the same age. The independent sample T-test was used to test the significance at 5% level. The tool placed the recommended amount of fertilizer/plant in two pushes (5.1 ± 0.19g) and covered 20 plants with an efficiency of 326.84 ± 2.46%. And efficiency of the cost involvement of the tool was 305.84 ± 3.58%. The farmer responses indicated that the tool was a simple, portable, smart and user-friendly tool with more advantages.*

*Keywords: Applicator, Efficiency, Fertilizer, Pineapple, Tool*

## I. INTRODUCTION

One of the main commercial fruit crops grown in Sri Lanka is pineapple (*Ananas comosus*), which has a significant export market potential due to the country's ability to produce some of the best pineapples in the world. Due to a shortage of supplies and exportable quality, Sri Lanka, which ranks 34th among countries that produce pineapple, is unable to meet the rising demand for the fruit on domestic and international markets (Rupasinghe et al., 2016). Both in the lowlands and at higher altitude of up to 1,000 m above sea level, pineapples thrive in a temperature range of 18–32$^0$C. Despite being a drought-tolerant crop, pineapples will still bear fruit in years with annual rainfall between 650 and 3,800 mm. The growth environment, cultivation methods, and variety all affect pineapple quality (Hossain, 2016). Costa Rica, the Philippines, Netherland, USA, and Belgium were the top five pineapple exporters in the world in 2020. Total export quantity of 3.1 million tons in 2020, representing a 7.9 percent fall compared to 2019 (FAO, 2021). For pineapple, Sri Lanka's rank among global exporters was 36 and its market share in world pineapple market was 0.09 (Silva et al., 2023).

Nitrogen and potassium fertilization greatly impact pineapple fruit yield, organoleptic, and sanitary quality (Spironello et al., 2004). Nitrogen is essential to maintain high growth rates, and pineapple response to N fertilization is strong, making it possible to produce high yields with short growing cycles. Potassium vital role in fruit quality (Hepton and Bartholomew, 2003), and plants and fruits require large quantities of K. The K/N ratio is also essential to yielding and organoleptic quality build-up. Although recommended fertilizer quantities vary according to the cultivar. As recommended by DOA Sri Lanka, fertilizers for pineapple plants should be applied on initially one month after planting and thereafter every 3-4 months after planting at the rate of urea – 10g/ plant, TSP – 5g to 7g/plant and

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MOP – 15g/plant. Chemical fertilization thus represents a large part of total production costs.

Large-scale pineapple cultivation faces a challenge in fertilizer application. In Sri Lanka, manual application is the primary method of fertilizer application due to the difficulty of applying it to the leaf base. However, this method often causes hand injuries to farmers, which discourages them from using it. Therefore, there is a need to develop a simple tool to facilitate fertilizer application for pineapple farmers. An experiment was conducted with the aim of developing such a tool that could apply chemical fertilizers to the base of pineapple leaves and designing an efficient instrument for the precise application of fertilizer to pineapple plants, while ensuring the safety of farmers.

## II. MATERIALS AND METHODS

### A. Design Concept

The instrument we have developed allows for the targeted application of fertilizer to the base of pineapple plant leaves. The key components of this instrument include a 1.5-inch PVC fertilizer container, 1-inch PVC pipe, 0.75-inch PVC pipe, rubber band, fertilizer exhaust hole, spring, reducer, 45-degree barrier, and a fertilizer output PVC pipe. To use the instrument, fertilizer is loaded into the fertilizer container, which is then pushed into place and released. Subsequently, the fertilizer output hole opens, allowing the fertilizer to flow through the exhaust PVC pipe fixed at a 45-degree angle. This precise delivery method ensures that the fertilizer reaches the base of the pineapple leaves effectively. Once the fertilizer has been dispensed, the spring and rubber mechanism automatically return the fertilizer container to its original position, closing the fertilizer output hole securely. This instrument not only increases the efficiency of fertilizer application but also minimizes the risk of damage to farmers during the process.

An initial framework of the instrument (Figure 01) was designed using photoshop software (Coreldraw, 2019) to finalize the materials needed to develop the instrument.

### B. Development of the Instrument

PVC pipes were selected with diameters of 1.5 inches and 0.75 inches, each measuring 80cm and 20cm in length, respectively (Figure 02). A hole with a diameter of 0.5 cm was drilled at the top end of the 1.5-inch PVC pipe, positioned 8cm from the top. A round wooden piece with a 6cm diameter was inserted into this hole until it reached the end of the pipe. To join the 1.5-inch and 0.75-inch PVC pipes, a reducer was used, securely fixing them together (Figure 02a).
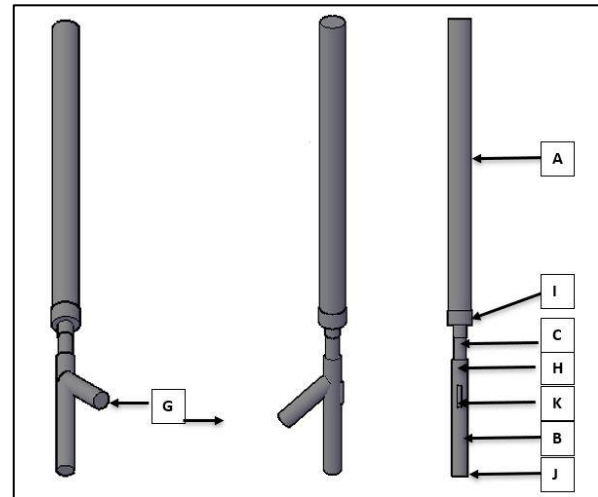


Figure 01: Initial framework of Developed Tool

A. Fertilizer container (1.5 inch PVC pipe)
B. 1 inch PVC pipe
C. 0.75 inch PVC pipe
D. Fertilizer exhaust hole (inside of the instrument)
E. Spring (inside of the instrument)
F. 45 degree barrier (inside of the instrument)
G. Fertilizer output PVC pipe
H. Rubber band
I. Reducer
J. Base
K. Screw

Another component involved a single piece of 30cm-long PVC pipe with a 1-inch diameter. An end cap with a 1-inch diameter was affixed to the bottom end of this pipe. Additionally, a hole with a 0.5cm diameter was drilled 8cm from the top end of this PVC pipe. In close proximity to this hole, another hole measuring 0.5cm in width and 5cm in length was created, also positioned 8cm from the top. This pipe was then inserted into the 0.75-inch diameter PVC pipe. A screw was fastened to the round wooden piece inserted into the 1.5-inch PVC pipe, and a rubber band was attached to the top end of the instrument. Lastly, a 1-inch PVC pipe, measuring 20cm in length, was selected and cut at a 45-degree angle. This cut piece was then attached to a hole in the instrument. The final assembled tool is indicated in Figure 02b.

## C. Working Principle

The rubber band is tightly fastened to the fixed piece, while the screw is connected to the movable piece. When the movable piece is pressed downward, it moves easily, but it returns to its original position with the aid of the rubber band. The open ends of both pieces meet together when the movable piece is pushed down. This action triggers the release of fertilizer, a process that occurs within seconds. The released fertilizer flows through the outlet end of the instrument, targeting the base of the pineapple crop. To utilize this tool effectively, fertilizer must be loaded into the fixed piece, which has a narrower PVC structure, creating the necessary pressure for the fertilizer to descend. By pushing the fertilizer container, minor pressure is applied to the long PVC pipes, facilitating the controlled release of the fertilizer.



Figure 02: a) Parts of developed tool; b) Final view of developed tool; c) Field evaluation of developed tool; d) applying fertilizer at the leaf base of pineapple plants

## D. Operation of the Tool

About 500 grams of fertilizer was filled through the top opening of the tool. The tool is equipped with a handle that allows for easy movement from one location to another. The tool was placed at a distance of 20 cm from the base of the pineapple crop. The end of the tool with the fertilizer was precisely positioned on the base leaf of the pineapple crop. The handle of the tool was pressed and did it for a second. During this brief period, the required amount of fertilizer was effectively applied to the base leaf of the pineapple crop (Figure 02d). This straightforward process facilitated the efficient and precise application of fertilizer to the base of the pineapple crop, ensuring optimal nourishment for healthy growth.

## E. Evaluation of the Developed Tool

The weight and length of the tool were measured using scales. Acceptability of the developed tool for its weight, height, safety, handling ability, fertilizer efficiency, cost incurred for the tool and overall acceptability were evaluated five-point Likert scale (1 – Highly acceptable, 2 – Acceptable, 3 – Neutral, 4 – Not acceptable and 5 – Highly not acceptable). The collected data were statistically analyzed using SPSS version 25 and descriptive statistics were explained graphically.

Further, a field experiment was conducted to evaluate the time taken to apply fertilizers and the cost incurred for operation (Figure 02c). The land (1 acre) was divided into 4 parts (4 replicates) and the developed instrument was tested 20 times and average values were taken for comparison and substituted in equation 1. The above variables were measured separately the for manual method and using the tool. The collected data were statistically analyzed using an independent sample T-test at 5% significance level.

Then, time efficiency and cost efficiency were calculated for the tool as follows;
Time efficiency was calculated by comparing time taken for fertilizer application using manual method and by using developed tool (E 1).

$$Time\ efficiency = \frac{Time\ taken\ for\ fertilizer\ application\ using\ manual\ method}{Time\ taken\ for\ fertilizer\ application\ using\ developed\ tool} \times 100\ \%\ ------E1$$

Cost for labour was used to calculate the efficiency and it was calculated by comparing cost incurred for fertilizer application using manual method and by using developed tool (E 2).

$$Cost\ efficiency = \frac{Cost\ incurred\ for\ fertilizer\ application\ using\ manual\ method}{Cost\ incurred\ for\ fertilizer\ application\ using\ developed\ tool} \times 100\ \%\ ---E2$$

## III. RESULTS AND DISCUSSION

### A. Characteristics of the Developed Tool

The developed tool has been designed with specific attributes that make it particularly user-friendly for farmers. It weighs about 328 grams, which is remarkably light. This lightweight feature ensures that it can be carried and manipulated with ease by farmers regardless of their physical strength. Additionally, the tool's height is 1 meter, which falls within a practical range for ease of handling. This height is

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conducive to comfortable usage, allowing farmers to work with the tool without straining themselves or adopting uncomfortable postures. Height of the tool is adjustable by replacing the upper part (fertilizer loading component). The combination of its light weight and manageable height renders this tool highly convenient and accessible for all farmers, facilitating their agricultural tasks with efficiency and comfort.

## B. Acceptability of the Developed Tool

Figure 03 indicates the user response for the developed tool. It was observed that the highest percentage (65%) of the respondents highly accepted the weight of the tool and the comparatively lowest percentage (35%) of the respondents accepted the weight of the tool. Further 55% of the respondents indicated that the height of the tool was highly acceptable and 35%. The lowest percentage (10%) of the respondents were neutral in tool height. Most of the respondents (75%) mentioned the safety of the tool is highly acceptable and 25% of the respondents were acceptable with the safety of the tool while handling.

Approximately 60% of the respondents expressed a high level of satisfaction with the instrument's handling ability, while the remaining respondents found the handling ability of the equipment satisfactory. Approximately 70% of the participants indicated a strong acceptance of the fertilizer efficiency of the recently created instrument in comparison to manual application. 30% of the responders acknowledged the fertilizer efficiency of the instrument. 65% of respondents expressed a high level of satisfaction with the cost of the instrument, whereas 35% agreed with its pricing. Ultimately, 60% of participants expressed a high level of satisfaction with the overall acceptance, while the remaining 40% indicated agreement (Table 01).

## C. The Efficiency of Developed Tool

It was found that there were significant differences between the manual fertilizer application method and application using tool in terms of time required to apply fertilizers for 20 plants and labour cost (Table 2). It was found that approximately less time was consumed (39.3 seconds) to apply fertilizers for 20 plants using newly developed tool and 128.4 seconds consumed for the manual application. Furthermore, comparatively higher cost (1389.7) incurred for manual fertilizer application and

lower cost (454.4 Rs.) was observed to apply fertilizers using tool.

Table 01: Descriptive Statistics for Performances of the Tool

| Description | Mean | SD |
|---|---|---|
| Acceptability for the weight of the tool | 1.35 | 0.49 |
| Acceptability for the height of the tool | 1.55 | 0.69 |
| Acceptability for safety to the farmer when applying | 1.25 | 0.44 |
| Acceptability for handling ability of the tool | 1.40 | 0.50 |
| Acceptability for fertilizer efficiency of the tool | 1.30 | 0.47 |
| Acceptability for the cost of the tool | 1.35 | 0.49 |
| Overall acceptability | 1.40 | 0.50 |

Values represent the mean ± standard deviation of a 5 point Likert scale (1 – Highly acceptable; 5 – Highly not acceptable).
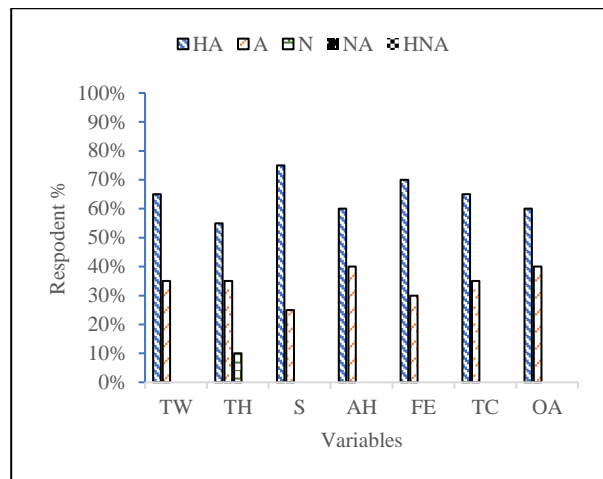


Figure 03 : Acceptability for the Developed Tool by the Respondents
*(TW – Tool Weight; TH – Tool Height; S – Safety; AH – Ability for Handling; FE – Fertilizer Efficiency; TC – Tool Cost; OA – Overall Acceptability; HA – Highly Acceptable; A – Acceptable; N – Neutral; NA – Not Acceptable; HNA – Highly Not Acceptable)*

Further, it was revealed that, an average of 5.1 g was released from the developed tool in a single push. There was 326.84 % of time efficiency and 305.84 % cost efficiency on the fertilizer application using tool compared to the manual.

When it comes to the safety of agronomic practices, the use of machinery is essential, especially when chemicals are used. With manual fertilizer application, the farmer has to bend down to apply the fertilizer every time it is applied, which is laborious. Therefore, the better ergonomics is also a decisive advantage of the instrument. When using the fertilizer spreader

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created, difficult bending positions are avoided. The operator, on the other hand, does not need to wear safety boots or overalls to avoid excessive contact with the fertilizer.

Table 02: Time and Labour Cost Efficiency

| Parameter | Manual method | Using Tool | P value | Efficiency (%) |
|---|---|---|---|---|
| Time taken to for 20 plants (Sec) | 128.44 ± 4.83 | 39.30 ± 1.18 | 0.000 | 326.84 ± 2.46 |
| Labour cost (0.25 ac) | 1389.74 ± 55.8 | 454.4 ± 13.6 | 0.000 | 305.84 ± 3.58 |

Values represent Mean ± Standard error of 4 replicates. Each replications contained 20 plants. P<0.05 is significant at 0.05 level.

Some regions still prefer manual application because they feel mechanical applicators waste fertilizer since they lack a speed feedback system to change the rate at which they apply the fertilizer. To satisfy crop nutrient needs, manual fertilizer application is frequently not tailed but rather maintained constant throughout time or over vast areas (Xu et al., 2017). This contributes to fertilizer misuse, which runs counter to ecologically friendly agriculture and results in imbalanced, ineffective fertilization and low economic returns. In addition, excessive and improper fertilization results in low nutrient use efficiency (Qin et al., 2013), which has an adverse effect on the environment by contributing to greenhouse gas emissions (Feng et al., 2013), land degradation, and freshwater pollution (Guo et al., 2010; Reidsma et al., 2013).

There should be consistency between doses administered at different times of fertilizer application. The goal of fertilizer application is to accelerate plant growth. Once the harvest schedule is established, there may still be plants that are not ready for harvest as uneven fertilization results in different harvest schedules for each tree (Moreno et al., 2017). The problem of fertilization is one that many researchers in the agricultural industry are working to solve. Making a fertilizer spreader automation tool is a way to distribute fertilizer quickly, correctly and precisely. However, in actual application, this device is still ineffective due to its non-adjustable dosage, operational clogging, and inaccurate fertilizer dispensing dose. According to Jinfeng et al. (2018), Yinyan et al. (2017), and Zhu et al. (2018), the main disadvantage of using an applicator is that it has very little flexibility,

stability, and dose, which has poor in uniformity and discharge rate.

IV. CONCLUSION

An innovative tool has been developed to address the challenges associated with fertilizer application in pineapple cultivation. The device was designed to be simple but effective and received positive feedback from farmers following a field evaluation that compared its performance to manual application methods.This validation highlights the tool's potential for improved efficiency in the field. However, further testing is required in different regions of the country before the tool can be successfully rolled out to pineapple farmers across the island.

REFERENCES

Diacono, M., Rubino, P. and Montemurro, F. (2013) "Precision nitrogen management of wheat. A review", *Agronomy for Sustainable Development,* 33(3), pp. 219-241.

Feng, J.F., Chen, C.Q., Zhang, Y., Song, Z.W., Deng, A.X., Zheng, C.Y. and Zhang, W.J. (2013) "Impacts of cropping practices on yield-scaled greenhouse gas emissions from rice field in China: a meta-analysis", *Agriculture. Ecosystem. Environment,* 164 (4), 220–228.

FAO, (2021) "Major Tropical Fruits Market Review" Rome.

Guo, J.H., Liu, X.J., Zhang, Y., Shen, J.L., Han, W.X., Zhang, W.F., Christie, P., Goulding, K.W.T., Vitousek, P.M. and Zhang, F.S. (2010) "Significant acidification in major Chinese croplands", Science, 327(596), pp. 10-39.

Hepton, A. and Bartholomew, D.P. (2003) "Cultural system. In The pineapple: Botany", *Production and Uses,* 27(3), pp. 109–142.

Hossain. M.F. (2016) "World Pineapple Production: An Overview", *African Journal of Food, Agriculture, Nutrition and Development,* 16(6), pp. 47-56.

Jinfeng, W.A.N.G., Guanbao, G.A.O., Wuxiong, W.E.N.G., Jinwu, W.A.N.G., Dongwei, Y.A.N. and Bowen, C.H.E.N. (2018) "Design and experiment of key components of side deep fertilization device for paddy field", *Nongye Jixie Xuebao/Transactions of the Chinese Society of Agricultural Machinery,* 49(6), pp. 75-89.

Lang, C., Wang, J., Wang, J., He, J., and Xi, X. (2013)

**112**

"Variable fertilizer control system for deep-fertilization liquid fertilizer applicator", *Nongye Jixie Xuebao Transactions of the Chinese Society for Agricultural Machinery,* 44 (2), pp. 43-62.

Moreno, J.L., Bastida, F., Ondono, S., Garcia, C., Andres-Abellan, M. and Lopez-Serrano, F.R. (2017) "Agro-forestry management of Paulownia plantations and their impact on soil biological quality: The effects of fertilization and irrigation treatments", *Applied Soil Ecology*, 117(3), pp. 46-56

Owusu-Bennoah, E., Ahenkorah, Y. and Nutsukpo, D. X. (1997) "Effect of different levels of N: K2O ratios on the yield and quality of pineapple in the forest-savanna ecotone of Ghan",. In *Second International Pineapple Symposium - Proceedings,* 1(3), pp. 393–402.

Qin, J.Q., Impa, S.M., Tang, Q.Y., Yang, S.H., Yang, J., Tao, Y.S. and Jagadish, K.S.V. (2013) "Integrated nutrient: water and other agronomic options to enhance rice grain yield and N use efficiency in double-season rice crop", Field *Crops Research,* 148(5), pp. 15–23.

Reidsma, P., Feng, S., Loon, M.V., Luo, X., Kang, C., and Lubbers, M. (2012) "Integrated assessment of agricultural land use policies on nutrient pollution and sustainable development in taihu basin", *China. Environmental science & policy,* 18(6), pp. 66-76.

Rupasinghe, R.A.D.S., Jayasinghe, H.A.S.L., Rathnayake, R.M.P.S., and Silva, T.A.P. (2016). Determinants for Contribution of Pineapple Growers for Export Volume in Gampaha District in Sri Lanka. Current Agriculture Research Journal, 4(1), 69-73.

Silva, R., Sitisekera, H., Ranathunga, T., Perera, T., Hunter, D. and Borelli, T. (2023) "Consumption and dietary intake of fruits and vegetables in Sri Lanka with a focus on traditional and indigenous fruits and vegetables" *Sri Lanka Journal of Agrarian Studies,* 20(1), pp. 12-19.

Spironello, A., Quaggio, J.A., Teixeira, L.A.J., Furlani, P.R., Sigrist, J.M.M. (2004) "Pineapple yield and fruit quality effected by NPK fertilization in a tropical soil", Rev. *Bras. Frutic., Jaboticabal,* 2(1), pp. 155-159.

Van Loon, J., Speratti, A.B., Gabarra, L. and Govaerts, B. (2018) "Precision for Smallholder Farmers: A Small-Scale-Tailored Variable Rate Fertilizer Application Kit", *Agriculture,* 8(5), pp. 1–14

Vidanapathirana, R., Rambukwella, R., Somarathne, T. G. and Hathurusinghe, C. P. (2012) "A Study on value chain of Pineapple and Banana in Sri Lanka", *Hector Kobbekaduwa Agrarian Research and Training Institute,* 5(1), pp. 55-59.

Xu, X.P., He, P., Yang, F.Q. and Ma, J.C., Pampolino, M.F., Johnston, A.M., Wei, Z., (2017) "Methodology of fertilizer recommendation based on yield response and agronomic efficiency for rice in China", Field *Crops Research,* 206(2), pp. 33–42.

Yinyan, S., Chen, M. and Wang, X. (2017) "Analysis and experiment of fertilizing performance for precision fertilizer applicator in rice and wheat fields", *Nongye Jixie Xuebao/Transactions of the Chinese Society of Agricultural Machinery*, *48*(7), pp. 78-96.

Zhu, Q., Wu, G. and Chen L. (2018) "Influences of structure parameters of straight flute wheel on fertilizing performance of fertilizer apparatus", *Transactions of the CSAE*, 34(18), pp. 12-20.

# Evaluation of Mung Bean (*Vigna Radiate* L.) Germplasm for Mung Bean Yellow Mosaic Virus Disease

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## *Abstract*

*Mung bean yellow mosaic virus (MYMV) is one of the most important diseases affecting mung beans, transmitted by the whitefly (Bemisia tabaci). MYMV poses a significant threat to mung bean production, emphasizing the need to identify resistant genotypes for the development of effective disease control strategies. In this study, we screened 60 mung bean germplasm under field conditions during the Yala season of 2022 to identify stable MYMV-resistant lines. Infector rows were planted alongside the test entries, and disease incidence and severity were observed under natural conditions. The genotypes studied were categorized as highly resistant to highly susceptible, with none of the test entries appearing to be highly resistant. We identified MIMB 909, MIMB 913, MIMB 916, MIMB 918, MI 7, MIMB 907, MIMB 908, MIMB 911, MIMB 912, MIMB 914, MIMB 923, MIMB 926, MIMB 933, MIMB 937, MIMB 938, MIMB 941, MIMB 945, MIMB 982, and MIMB 983 as resistant and moderately resistant genotypes, respectively. These genotypes could serve as parental lines in a mung bean breeding program focused on developing more MYMV-resistant varieties. Further studies are needed to evaluate the stability of resistance in these genotypes across multiple growing seasons and locations. The research contributes Valuable insight into the dynamics of MYMV infection in mung bean providing a foundation for developing disease-resistant varieties and sustainable crop management strategies. Consequently, in the near future, the improved varieties may surfeit the sustainable agriculture production in the biotic stress prone areas.*

*Keywords: Germplasm, Mung bean, Mung bean Yellow Mosaic Virus, Resistance, Screen*

## I. INTRODUCTION

The mung bean (*Vigna radiata* L.) is one of the most important edible legume crops, grown on more than 6 million ha worldwide (about 8.5% of the global pulse area) and consumed by most households in Asia. Due to its characteristics of relatively drought-tolerant, low-input crop, and short growth cycle (70 days or so), the mung bean is widely cultivated in many Asian countries (concentrated mainly in China, India, Bangladesh, Pakistan, and some Southeast Asian countries) as well as in dry regions of southern Europe and warmer parts of Canada and the United States (Dahiya et al., 2015). In the predominantly cereal-based diets of China and India, the mung bean has been consumed as a common food for centuries. The mung bean contains balanced nutrients, including protein, dietary fiber, minerals, vitamins, and significant amounts of bioactive compounds (Gan et al., 2017)

In mung bean, yellow mosaic disease (YMD) caused by yellow mosaic viruses (YMVs) is of key importance especially in South and Southeast Asia. Besides mung bean, YMD also affect various leguminous crops including black gram (*Vigna mungo*), moth bean (*Vigna aconitifolia*), Lima bean (*P. lunatus*), pigeon pea (*Cajanus cajan*), French bean (*Phaseolus vulgaris*), cowpea (*Vigna unguiculata*), Dolichos (*Lablab purpureus*), horse gram (*Macrotyloma uniflorum*), and soybean (*Glycine max*) (Ramesh, Chouhan and Ramteke, 2017; Dikshit et al., 2020).

In India, MYMV was first reported from the mung bean fields of Indian Agricultural Research Institute (IARI), New Delhi during 1950s (Nariani, 1960). In general, MYMV is the major isolate infecting mung bean crop in western and

southern India, Thailand, and Indonesia; whereas, MYMIV isolate in central, eastern and northern India, Pakistan, Bangladesh, Nepal, and Vietnam (Malathi and John, 2009). With this background, this review systematically deals with the scientific developments about YMVs infecting mung bean, its vector and also various YMD management challenges including the prospective use of recent tools like omics approaches and translational genomics, across the world.

One of the main reasons for insufficient production is low productivity due to the high incidence of diseases, the unavailability of suitable mung bean varieties for rain-fed conditions for third-season cultivation, and the unavailability of quality seeds.

Aphids, whiteflies, leafhoppers, trips, stem flies, pod bugs, and pod borer complexes are the most significant pests that attack mung beans. Among these, whiteflies act as vectors of mung bean yellow mosaic virus (MYMV) (Sekar and Nalini, 2017). It is found to spread the Begomo viruses, the major hazard to the flourishing production of mung bean in India, Sri Lanka, Pakistan, Bangladesh, Papua New Guinea, Philippines, and Thailand (Haq et al., 2011).

II. METHODOLOGY

A.    *Study Area*
This experiment was conducted at Field Crop Research and Development Institute (FCRDI), Mahailippallama (8.1152° N and 80.47199° E) during *Yala* season of 2022(May to September). It is in the DL1b agro ecological region, at elevation of 138 m above mean sea level in the North Central Province of Sri Lanka. The average annual rainfall of this area is less than 1750 mm and the temperature range is 25 °C to 35 °C.

B.  *Planting Materials*
Exotic and local mung bean germplasms (including recommended variety MIMB 07) available in Field Crops Research and Development Centre, were evaluated under field condition.

C.    *Land Preparation and Mung Bean Planting*
The mung bean germplasms were planted with the spacing of 30 cm X 10 cm on the plots having the size of 3 m X 3 m in Randomized Complete Block Design (RCBD) with two replications.

One row of the most MYMV susceptible species called "*Lathoroid*" was planted in every other row of tested entries as infester rows. Plants of the trial were not treated with chemicals to obtain the maximum chance of primary infection. To estimate the yield reduction due to viral infestation, infested as well as non-infested plants of the same genotype should be available.

All the genotypes were established in a nearby field with no viral infestation achieved by chemical control of whitefly only in the central region as estimation in yield reduction in all three regions becomes tedious. The genotypes in the non-infested field was established as similar to the infested field but without the susceptible check in every other row.

D.  *Crop Management Practices*
All management practices including fertilizer application were performed as per the Department of Agriculture (DOA) recommendations. Urea, Muriate of potash (MOP) and Triple superphosphate (TSP) were applied as basal dressing before seed planting at the rate of 30 kg/h, 75 kg/h and 100 kg/h respectively. Top dressing was done 5 weeks after planting using urea at the rate of 35 kg/ h, and weeding was done manually at two weeks interval after planting.

E.  *Data Collection*
1) *Weather data:*
Daily weather data of rain fall, maximum and minimum temperature relative humidity and wind velocity were collected.

2) *Disease incidence:*
Disease reaction of germplasms were recorded using 1 – 9 scale (Singh *et al*, 2004) at two weeks interval after first symptom observed. To offer a comprehensive overview of disease incidence across all genotypes, it was calculated the mean Disease Incidence (DI) and mean Disease severity index (DSI) values. DI reflects the percentage of plants exhibiting disease symptoms out of the total number of plants evaluated. Meanwhile, the mean DSI value furnishes an average measure of disease symptom severity encompassing all genotypes. DSI and percentage disease incidence (PDI) were recorded using the following formulas.

$$PDI = \frac{Total\ number\ of\ infected\ plants\ of\ genotype}{Total\ number\ of\ plants\ of\ genotype} \times 100$$

$$DSI = \frac{Sum\ of\ the\ numarical\ rating}{total\ no.\ of\ leaves\ observed\ X\ maxi.\ grade} \times 100$$

*F. Data Analysis*

Rank or/and scale data were pre-transformed before analysis using a pre-transformed scale. When interactions were significant, they were further evaluated using response curves or further analysis using variance component methods. DMRT was used to separate means wherever necessary and other relevant statistical tools such as Microsoft Excel were used.

## III. RESULTS AND DISCUSSION

According to the analysis results in the Table 01 there has been significant ($p \leq 0.05$) differences between the genotypes. Variety MIMB 913 (7.10) was very effective in mung bean yellow mosaic virus and it showed the lowest Disease Severity Index Percentage (7.10). Variety NIMB 910 showed the highest Disease Severity Index Percentage (52.24) and it was highly susceptible in mung bean yellow mosaic virus under field conditions. The genotypes classified into six categories based on the severity of disease infection recorded. Out of the 60 genotypes studied, none were classified as highly resistant to disease, while four were classified as resistant and fifteen as moderately resistant.

Meanwhile, twenty-one genotypes were moderately susceptible to disease, eighteen were susceptible, and two were highly susceptible. The severity of disease infection varied among the genotypes, with some showing high disease severity and others showing low disease severity. The genotypes with the highest disease severity were identified as MIMB 909, MIMB 913, MIMB 916, and MIMB 918, as shown in Table 01.

Conversely, the genotypes with the lowest disease severity were identified as MIMB 919 and MIMB 910. Overall, the study provides insights into the disease resistance of different mung bean genotypes and can help guide future efforts to develop more disease-resistant varieties of mung bean. Screened a set of 60 genotypes and observed the absence of disease symptoms in these genotypes until the crops reached five weeks of age under field conditions during the Yala season in 2022. Subsequently, symptoms of MYMV

disease began to manifest on the leaves of young plants of susceptible varieties, and these symptoms progressively intensified over time. By the fifth week of planting, a few genotypes exhibited initial signs of MYMV symptoms, which escalated in prevalence up to the eighth week, at which juncture, all genotypes displayed symptomatic features. The study assessed the Disease Severity Index (DSI) values across the genotypes, ranging from 0 to 9, signifying the extent of MYMV disease symptom severity. DSI values were ascertained by evaluating the disease symptom levels on each genotype, utilizing a scale from 0 (indicating no symptoms) to 9 (indicating severe symptoms).

The mean DI and mean DSI values, have been visually depicted in Figure 01. Altogether, this study provides valuable insights into the resistance of mung bean genotypes to MYMV disease under field conditions. These insights can offer guidance for the development of mung bean varieties that are more resistant to this disease.

In Figure 02, the illustration portrays the impact of variations in climate parameters on disease incidence (DI) and disease severity index (DSI). The results reveal that minimum temperature, maximum temperature, and wind velocity exerted no significant influence on DI and DSI. Conversely, both rainfall and relative humidity exhibited a highly significant effect on both DI and DSI.

The study discerned that whiteflies thrived and were most prevalent during periods of elevated rainfall and reduced humidity, potentially contributing to an escalated disease spread rate.

In a similar study conducted by S. Mohan, A. Sheeba, E. Murugan, and S. M. Ibrahim in India, several mung bean genotypes were identified as displaying resistance to MYMV. These genotypes, which encompass TM-11-07, TM-11-34, PDM-139, IPM-02-03, IPM-02-14, Pusa-0672, Pusa-0871, CO-7, and MH-521, hold promise as potential donors for the development of MYMV-resistant lines. This discovery bears significant implications, as it offers valuable insights for the advancement of mung bean varieties with enhanced disease resistance.

## IV. CONCLUSION

This study has successfully pinpointed various mung bean genotypes showcasing diverse levels of resistance to MYMV. Among the genotypes analyzed, MIMB 909, MIMB 913, MIMB 916, and MIMB 918 have demonstrated high resistance, while MI 7, MIMB 907, MIMB 908, MIMB 911, MIMB 912, MIMB 914, MIMB 923, MIMB 926, MIMB 933, MIMB 937, MIMB 938, MIMB 941, MIMB 945, MIMB 982, and MIMB 983 have been categorized as moderately resistant genotypes. These identified genotypes hold significant promise as potential parental lines within a mung bean breeding program aimed at cultivating more MYMV-resistant varieties.

Such an endeavor has the potential to substantially mitigate the occurrence and severity of the disease, ultimately resulting in improved crop yields and enhanced food security. Nevertheless, it is imperative to conduct further research to assess the stability of resistance in these genotypes across various growing seasons and geographical locations.

Table 01: Reaction of Mung Bean Lines to Mung Bean Yellow Mosaic Virus

| Lines name | DSI % | Reaction | Lines name | DSI % | Reaction |
|---|---|---|---|---|---|
| MIMB 913 | 7.10 | R | MIMB 939 | 26.03 | MS |
| MIMB 918 | 9.50 | R | MIMB 974 | 26.52 | MS |
| MIMB 909 | 9.69 | R | MIMB 924 | 26.74 | MS |
| MIMB 916 | 9.89 | R | MIMB 903 | 27.81 | MS |
| MIMB 914 | 11.51 | MR | MIMB 927 | 28.34 | MS |
| MIMB 908 | 14.66 | MR | MIMB 940 | 28.48 | MS |
| MIMB 937 | 15.32 | MR | MIMB 972 | 28.80 | MS |
| MIMB 945 | 16.60 | MR | MIMB 986 | 28.96 | MS |
| MIMB 923 | 17.81 | MR | MIMB 978 | 30.03 | MS |
| MIMB 926 | 17.83 | MR | MIMB 905 | 30.70 | MS |
| MIMB 911 | 17.90 | MR | MIMB 988 | 32.12 | S |
| MIMB 941 | 17.92 | MR | MIMB 981 | 33.18 | S |
| MIMB 982 | 18.15 | MR | MIMB 944 | 33.68 | S |
| MIMB 938 | 19.00 | MR | MIMB 936 | 33.72 | S |
| MIMB 912 | 19.61 | MR | MIMB 930 | 33.96 | S |
| MI 07 | 19.76 | MR | MIMB 920 | 35.21 | S |
| MIMB 933 | 20.15 | MR | MIMB 979 | 36.23 | S |
| MIMB 983 | 20.17 | MR | MIMB 917 | 36.24 | S |
| MIMB 907 | 20.28 | MR | MIMB 942 | 36.61 | S |
| MIMB 922 | 21.33 | MS | MIMB 931 | 37.21 | S |
| MIMB 943 | 21.88 | MS | MIMB 921 | 37.45 | S |
| MIMB 932 | 22.18 | MS | MIMB 985 | 39.03 | S |
| MIMB 991 | 22.72 | MS | MIMB 901 | 39.81 | S |
| MIMB 973 | 23.27 | MS | MIMB 906 | 40.48 | S |
| MIMB 952 | 23.57 | MS | MIMB 902 | 41.83 | S |
| MIMB 929 | 24.45 | MS | MIMB 980 | 43.08 | S |
| MIMB 934 | 25.31 | MS | MIMB 915 | 44.30 | S |
| MIMB 935 | 25.50 | MS | MIMB 987 | 47.91 | S |
| MIMB 904 | 25.75 | MS | MIMB 919 | 51.84 | HS |
| MIMB 990 | 25.99 | MS | MIMB 910 | 52.24 | HS |

R= Resistant, MR= Moderate resistant, MS= moderate susceptible, S= Susceptible, HS= Highly susceptible
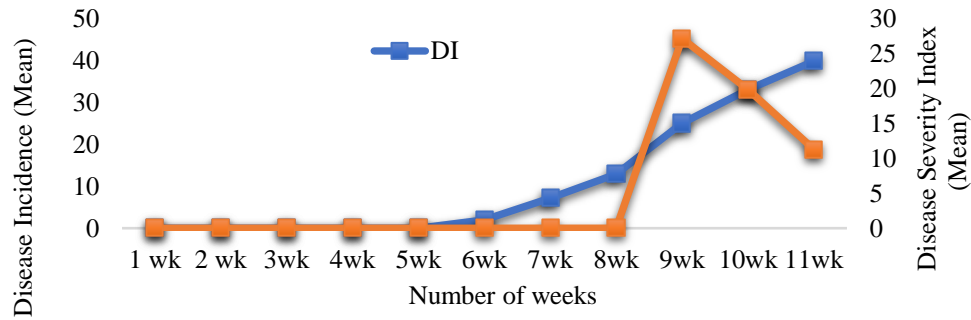
Figure 01: Weekly progress of mean percentage disease incidence (PDI) and mean Disease severity index (DSI) of MYMV in mung bean genotype
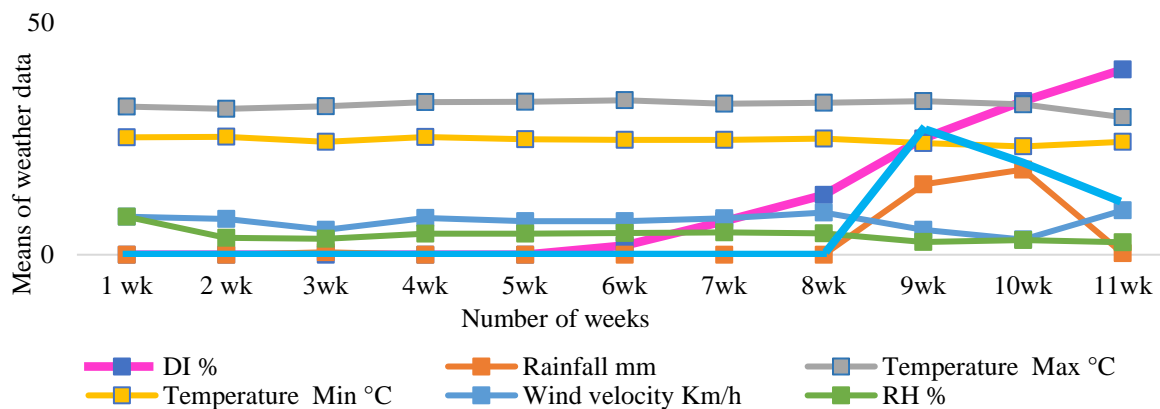


Figure 02: Effect of the climate parameters on Disease incident (DI) and Disease Severity index (DSI) during field evaluation

REFERENCES

Bhanu, A.N., Singh M.N. and Srivastava, K. (2017). Mungbean [Vigna radiata (L.) Wilczek] Genotypes for Mungbean Yellow Mosaic Virus Resistance under Natural Condition", *Advances in Plants & Agriculture Research*, 7(6), 2015–2018. <https://doi.org/10.15406/apar.2017.07.00276>

Dahiya, P.K., Linnemann, A.R., Van Boekel, M.A.J.S., Khetarpaul, N.,Grewal, R.B. and Nout, M.J.R., (2015) "Mung Bean: Technological and nutritional potential", *Critical reviews in food science and nutrition*, 55 (5), pp.670-688

Dikshit, H. K., Mishra, G. P., Somta, P., Shwe, T., Alam, A. K. M. M., Bains, T. S. and Nair, R.M. (2020) CClassical genetics and traditional breeding in mungbean," *in The Mungbean Genome, Compendium of Plant Genomes. (Switzerland AG: © Springer Nature)*, 43–54. doi: 10.1007/978-3-030-20008-4_4

Gan, R.Y., Lui, W.Y., Wu, K., Chan, C.L., Dai, S.H., Sui, Z.Q. and Corke, H. (2017) "Bioactive compounds and bioactivities of germinated edible seeds and sprouts: An updated review", *Trends Food Sci. Technol*, 59, 1–14.

Haq, Q. M. I., Jyothsna P., Arif A. and Malathi, V.G. (2011) " Coat protein deletion mutation of mungbean yellow mosaic India virus (MYMIV) ", *J. Plant Biochem. Biotechnol*. 20 (2), 182–189. 10.1007/s13562-011-0044-7

Kanatt, S.R., Arjun, K. and Sharma, A. (2011) " Antioxidant and antimicrobial activity of legume hulls", *Food Res Int*, 44,3182–3187.

Maiti S., Basak J., Kundagrami S., Kundu A. and Pal A. (2011) "Molecular marker-assisted genotyping of Mungbean Yellow Mosaic India Virus resistant germplasms of mungbean and urdbean", Mol. Biotechnol. 47, 95–104. 10.1007/s12033-010-9314-1 Malathi V.C. and John P. (2009)"Mungbean yellow mosaic viruses", *in Desk encyclopedia of plant and*

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*fungal virology. Eds. Van Regenmortal M., Mahy B.* (London: Academic press; ), 217–226.

Nariani T. K. (1960)"Yellow mosaic of mung (Phaseolus aureus L.)", Indian Phytopathol. 13, 24–29.

Ramesh, S.V., Chouhan, B. S. and Ramteke, R. (2017) "Molecular detection of Begomovirus (family: Geminiviridae) infecting Glycine max (L.) Merr. and associated weed Vigna trilobat", *J. Crop Weed* 13 (2), 64–67.

Sekar, S. and Nalini, R. (2017) "Varietal Screening of Mungbean Genotypes against Whitefly (Bemisia tabaci Genn.), Mungbean Yellow Mosaic Virus (MYMV) and Cercospora Leaf Spot", *Int. J. Curr. Microbial.* App. Sci., 6(3): 1278-

Singh, G., Sharma, Y.R., Shanmugasundaram, S., Shih, S.L. and Green, S.K., (2004)"Status of mung bben yellow mosaic virus resistance breeding", *in proceeding of the final workshop and planning meeting on Mung bean. Punjab Agricultural University.*p. 204A213.

# Evaluating the Effectiveness of Organic and Inorganic Liquid Fertilizers on Growth and Development of Pepper (*Piper nigrum* L.) Nursery Plants

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## Abstract

*This study aimed to identify the effectiveness of different liquid fertilizers and suitable application intervals for black pepper nursery growth as an alternative to cow dung. The study used three different fertilizers with two different factors variety of fertilizer and fertilizer application rate combined to create nine treatments (F1A1, F2A1, F3A1, F1A2, F2A2, F3A2, F1A3, F2A3, and F3A3) and two control groups. The results showed that the majority of growth parameters were highest in the Bio Green Beper which is an inorganic fertilizer enriched with seaweed extraction and fish emulsion. Specifically, treatments F3A1 and F3A3, which used a potting mix of top soil, sand, and coir dust in a ratio of 2:1:1 and were applied with Bio Green Beper once or three times, showed the highest survival rates among all the treatments. The cost-benefit analysis showed that Bio-Green Beper was the most cost-effective, followed by Albert Solution. Because the usage amount of fertilizer was lower than others. In conclusion, the study demonstrated the effectiveness of using liquid fertilizers as an alternative to cow dung.*

*Keywords: Black Pepper, Organic Liquid Fertilizer, Nursery*

## I. INTRODUCTION

*Piper nigrum* L. (Pepper) is a highly valuable spice crop and it is often referred as the "King of Spices" or "Black Gold". The spikes are derived from a perennial climbing vine in the Piperaceae family. (DEA, 2015). Black pepper was believed to have originated in the tropical evergreen forests of the Western Ghats in South India, but also considered native to Sri Lanka due to its genetic diversity and wild pepper relatives. Nowadays, black pepper is widely cultivated in the humid tropical regions of 26 countries around the world. The cultivation of pepper in Sri Lanka is concentrated in low- and mid-country, wet, and intermediate agro-climate zones, with the major districts being Matale, Kandy, Kegalle, Badulla, Rathnapura, Monaragala, and Kurunegala. The export volume of black pepper in Sri Lanka has increased in recent years, and the local pepper varieties are mostly cultivated due to their high yields and resistance to diseases (DEA, 2015).

Black pepper requires friable soil with good drainage and sufficient nutrients, particularly N, P, K, S, Ca, Mg, and micronutrients. Cow dung is a valuable source of these nutrients and commonly used in black pepper nursery and field. Foliar liquid fertilizer application can also supplement the plant's nutrient needs and slow senescence processes (Srinivasan, 2007). Nursery management practices are crucial for field establishment and yield, with stem cuttings which is commonly used for planting. The nursery stage is crucial for black pepper cultivation, with cow dung being an important fertilizer used in the potting mixture. However, cow dung is becoming increasingly difficult to find due to high demand and transportation issues, leading to a need for alternative fertilizers. This study focused on identifying suitable liquid fertilizers that can replace cow dung in the nursery stage. Therefore, the current study was conducted to evaluate the effectiveness of organic fertilizers, including only seaweed extraction, seaweed and fish emulsion liquid fertilizer, and inorganic fertilizers, on the growth and development of Pepper (*Piper nigrum* L.) nursery plants.

## II. MATERIALS AND METHODS

The research was carried out at the Central Research Station, Department of Export Agriculture, Matale which belongs to Mid-Country Intermediate Zone (WM $_{3b}$ Agro-ecological Region). It is located in $7^0$ 27' N, $80^0$ 38 E, at an altitude of 375 m above sea level.

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Average annual rainfall is 1400–3300 mm from two main monsoonal rains, and the maximum average temperature is 25–30 °C. The daytime relative humidity range is 55%–80%. The soil type is Reddish Brown Latesolic Soil (Typic Rhodusalfs) belonging to the Matale series.

A local black pepper hybrid, Digirala, was selected for the study. Ground runners with two nodes were selected for pepper cutting, and they were obtained from the multiplication technique. The selected ground runners were cut into two nodal cuttings. Leaves were clipped off, leaving a small portion of the petiole on the stem. Media were prepared according to treatments (Table 01). Pepper cuttings were treated with a Capatan fungicide slurry by dipping their ends for 20 minutes. Cuttings were then planted one node below ground level and watered in a closed chamber propagator with 40–50% sunlight and 85–95% humidity.After 21 days, the nursery plants were acclimatised to the environment by removing the polythene cover of the propagator.

This research was carried out in a randomized complete block design (RCBD) with two factors. The first factor was application of different fertilizer including inorganic fertilizer (Albert Solution®) and organic fertilizers (Maxi Crop®, Bio Green Beper®). The second factor was fertilizer application intervals Maxi Crop® was with only seaweed extraction, and Bio Green Beper® has seaweed extraction with fish emulsion. Data were analyzed by following ANOVA and post hoc (Turkey's pairwise) comparison using SPSS version 25. The significant level was set at p≤0.05.

## III. RESULTS AND DISCUSSION

### A. Leaf Growth Characteristics

Control 1 (C1) produced the highest average leaf area and number of leaves and was significantly different from the treatments (Table 02). The use of foliar fertilizers can improve the growth conditions of plants by supplying minerals to the leaves. It is particularly effective in the early stages of growth when the root system is not fully developed, as the leaves can absorb nutrients. Netty (2021), research found that the same foliar spray of liquid fertilizer increased the number of leaves. Macro- and micro-nutrients are needed to increase photosynthetic assimilatory surface area. Statistically, the treatments and controls gave insignificant results on the fresh and dry weight of leaves. The treatment F1A3 showed the highest value.

Table 02: Potting Mixtures and Treatments Schedule

| Treatment number | Composition of treatments | |
|---|---|---|
| C1 | without any liquid fertilizer - DEA recommended potting media (Top soil: coir dust: sand: cow dung 1:1:1:1) (Agriculture, 2015) | |
| C2 | Without any fertilizer | |
| F1A1 | Albert solution® – one time apply | |
| F2A1 | Maxi Crop® – one time apply | |
| F3A1 | Bio Green Beper®– one time apply | |
| F1A2 | Albert Solution® – two time apply | |
| F2A2 | Maxi Crop® – two time apply | Top soil: sand: coir dust (2:1:1) |
| F3A2 | Bio Green Beper® – two time apply | |
| F1A3 | Albert solution – three time apply | |
| F2A3 | Maxi Crop® – three time apply | |
| F3A3 | Bio Green Beper ® – three time apply | |

Table 02: Interaction between Control and Treatments on leaf growth Characteristics of Nursery Pepper Plants

| Treatment | Number of leaves | Fresh weight of leaves (g) | Dry weight leaves (g) | Leaf area (cm$^2$) |
|---|---|---|---|---|
| C1 | 4.53±O.58[a] | 2.93±0.41 | 0.45±0.02[ab] | 106.67±3.28[a] |
| C2 | 1.73±0.27[b] | 1.60±0.25 | 0.34±0.08[ab] | 34.51±16.71[b] |
| F1A1 | 2.80±0.53[ab] | 1.87±0.38 | 0.42±0.04[ab] | 28.09±7.28[b] |
| F2A1 | 2.07±0.57[ab] | 2.15±0.52 | 0.41±0.09[ab] | 56.61±20.09[ab] |
| F3A1 | 2.67±0.07[ab] | 2.21±0.10 | 0.51±0.04[ab] | 54.16±12.76[ab] |
| F1A2 | 2.60±0.58[ab] | 1.73±0.20 | 0.37±0.05[ab] | 35.73±14.26[b] |
| F2A2 | 2.40±0.20[ab] | 1.66±0.39 | 0.30±0.05[b] | 47.09±11.08[ab] |
| F3A2 | 2.07±0.41[ab] | 1.83±0.35 | 0.37±0.07[ab] | 37.21±3.46[b] |
| F1A3 | 2.60±0.50[ab] | 3.13±0.61 | 0.62±0.10[a] | 79.55±9.10[ab] |
| F2A3 | 2.33±0.77[b] | 1.88±0.14 | 0.38±0.07[ab] | 57.00±3.84[ab] |
| F3A3 | 2.80±0.31[ab] | 2.49±0.28 | 0.47±0.02[ab] | 59.66±20.99[ab] |
| P value | 0.0400 | 0.0820 | 0.0840 | 0.0110 |
| Grand mean | 2.6 | 2.13 | 0.42 | 54.21 |
| CV% | 27.73 | 33.76 | 29.22 | 52.86 |

Table 03: Interaction between Control and Treatments on Root Growth Characteristics

| Treatment | Fresh weight of root (g) | Dry weight of root (g) |
|---|---|---|
| C1 | 0.88±0.44 | 0.15±0.02 |
| C2 | 1.26±0.46 | 0.20±0.07 |
| F1A1 | 1.01±0.21 | 0.16±0.04 |
| F2A1 | 1.57±0.30 | 0.22±0.05 |
| F3A1 | 1.51±0.16 | 0.35±0.06 |
| F1A2 | 1.39±0.22 | 0.23±0.03 |
| F2A2 | 1.12±0.24 | 0.19±0.02 |
| F3A2 | 0.95±0.21 | 0.16±0.06 |
| F1A3 | 1.84±0.44 | 0.29±0.08 |
| F2A3 | 1.06±0.17 | 0.18±0.02 |
| F3A3 | 1.42±0.21 | 0.25±0.04 |
| P value | 0.4730 | 0.1850 |
| Grand mean | 1.27 | 0.22 |
| CV% | 40.79 | 42.27 |

## B. Root Characteristics

The results of the analysis of variance showed that there was no significant differences between the control and treatments on the fresh and dry weight of roots. However, the highest fresh weight was observed in F1A3, and the highest dry weight was observed in F3A1. Similar findings were recorded and found that chemical fertilizers led to better growth and root development in common crops compared to using organic manure from livestock.

## C. Shoot Characteristics

The analysis of variance showed that controls and treatments had a significant effect on the number of newly formed nodes, but other shoot characteristics had no significant effects (Table 03). C1 produced the highest average number of nodes. Table 04 shows that the treatment F2A1 resulted the highest values for fresh and dry weights of vines, while the lowest value was from C1. The growth of vines could be affected by different organic substitutions of nitrogen. High plant dry matter in pepper vines is due to the

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optimal uptake of nutrients through soil and foliar-based fertilizers.

The F3A3 treatment had the highest number of shoots. According to Netty (2021), the level of fertilizer application was highly significant in determining the emergence of shoots, the leaf numbers, and the shoot length of pepper seedlings. The highest internode distance was recorded in the F1A1 treatment, and the lowest value was recorded in control 2. The organic fertilizer treatment resulted in an average increase in plant height, number of leaves, number of internodes, and leaf green levels that were not significantly different.

Table 03: Interaction between Control and Treatments on Root Growth Characteristics

| Treatment | Fresh weight of root (g) | Dry weight of root (g) |
|---|---|---|
| C1 | 0.88±0.44 | 0.15±0.02 |
| C2 | 1.26±0.46 | 0.20±0.07 |
| F1A1 | 1.01±0.21 | 0.16±0.04 |
| F2A1 | 1.57±0.30 | 0.22±0.05 |
| F3A1 | 1.51±0.16 | 0.35±0.06 |
| F1A2 | 1.39±0.22 | 0.23±0.03 |
| F2A2 | 1.12±0.24 | 0.19±0.02 |
| F3A2 | 0.95±0.21 | 0.16±0.06 |
| F1A3 | 1.84±0.44 | 0.29±0.08 |
| F2A3 | 1.06±0.17 | 0.18±0.02 |
| F3A3 | 1.42±0.21 | 0.25±0.04 |
| P value | 0.4730 | 0.1850 |
| Grand mean | 1.27 | 0.22 |
| CV% | 40.79 | 42.27 |

Table 04:

Interaction Between Control and Treatment on Shoot Characteristics of Nursery Pepper Plant

| Treatment | Number of shoots | Fresh weight of vine (g) | Dry weight of vine (g) | Inter node distance (cm) | Number of newly form node |
|---|---|---|---|---|---|
| C1 | 9.33±0.88 | 3.65±0.09 | 0.76±0.02 | 2.91±0.38 | 3.47±0.44[a] |
| C2 | 7.00±1.00 | 4.89±0.71 | 1.14±0.27 | 2.73±0.30 | 1.80±0.20[b] |
| F1A1 | 6.67±0.88 | 5.68±0.23 | 1.07±0.05 | 3.30±0.18 | 1.93±0.07[b] |
| F2A1 | 7.67±1.33 | 6.32±0.64 | 1.43±0.15 | 3.21±0.03 | 2.00±0.12[b] |
| F3A1 | 8.00±1.15 | 5.88±0.82 | 1.37±0.16 | 2.79±0.12 | 1.80±0.20[b] |
| F1A2 | 9.00±1.73 | 5.15±0.79 | 1.12±0.23 | 2.97±0.30 | 1.73±0.24[b] |
| F2A2 | 8.67±1.20 | 4.02±0.30 | 0.85±0.05 | 3.22±0.34 | 1.67±0.13[b] |
| F3A2 | 6.00±1.52 | 4.23±0.82 | 0.92±0.21 | 2.94±0.19 | 2.20±0.23[b] |
| F1A3 | 8.00±0.58 | 6.18±0.23 | 1.32±0.02 | 3.05±0.25 | 2.27±0.18[b] |
| F2A3 | 8.00±1.54 | 4.79±0.43 | 1.02±0.11 | 3.13±0.40 | 1.67±0.07[b] |
| F3A3 | 10.33±2.85 | 5.64±1.02 | 1.20±0.27 | 3.05±0.21 | 2.07±0.07[b] |
| P value | 0.6570 | 0.0770 | 0.1630 | 0.9050 | 0.0000 |
| Grand mean | 8.06 | 5.13 | 1.11 | 3.03 | 2.05 |

*D. Survival Rate*

Liquid fertilizer-applied treatments significantly increased the survival rate compared to the control treatments. Results appearing in Figure 01 showed that the survivability percentage was high for F3A1 and F3A3. The lowest value was recorded from control 2, which was without any fertilizer supplement.

*E. Fertilizer Cost for Different Treatments*

Table 05 showed that cow dung was the most expensive organic fertilizer. Bio Green Beper®

(F3A1, F3A2, and F3A3), which par at Albert Solution® (F1A1, F1A2, F1A3) and Maxi Crop® (F2A1, F2A2, F2A3), were found to have the most economical cost-benefit analysis. Because the usage amount of fertilizer was lower than others. Cow manure is required in higher quantities per plant and also has a high transportation cost. Liquid fertilizers, on the other hand, could be added directly to the plants at a lower concentration.



Figure 01: Survival Rate of Nursery Plants among the Treatments

Table 03: Fertilizer Requirement for 10000 plants

| Treatment | Fertilizer for 10000 plants |
|-----------|------------------------------|
| C1 | 1.5 m$^3$ |
| C2 | - |
| F1A1 | 73 mL |
| F1A2 | 147 mL |
| F1A3 | 219 mL |
| F2A1 | 67 mL |
| F2A2 | 134 mL |
| F2A3 | 201 mL |
| F3A1 | 333 mL |
| F3A2 | 666 mL |
| F3A3 | 999 mL |

## REFERENCES

DEA. (2015) *Pepper Cultivation and Postharvest.* Kandy: Department of Goverment Printing unit.

DEA. (2015) *Pepper technical bulleting - 4.* Department of goverment printing.

Lijo Thomas and Rajeev P. (2015) "*Black Pepper. Kerala, India*", *ICAR- Indian Institute of Spices Research,* 48(6), pp. 56-89.

Masood Sadiq Butt, I. P. (2012) January. "Black pepper and health claims: a comprehenive treatise", *Critical Reviews in Food Science and Nutrition*, 12(8), pp. 1 - 42.

Netty Syam, H. S. (2021) "Effects of Trichoderma and Foliar Fertilizer on the Vegetative Growth of Black Pepper (*Piper nigrum* L.) Seedlings. (D. Clay, Ed.)", *International Journal of Agronomy,* 41(1), pp. 1-9.

Srinivasan, K. (2009) May. "Black Pepper *( Piper nigrum )* and Its Bioactive Compound, piperine", *Central Food Technological Research Institute*,12(6), pp. 2 - 40.

# Evaluating the Efficacy of Various Fungicidal Agents and Phytohormone to Manage Rough Bark Disease of Cinnamon (*Cinnamomum zeylanicum* B.)

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## Abstract

*Cinnamon, a vital spice crop exported from Sri Lanka, faces the economic threat of Rough Bark Disease (RBD), a major biotic factor affecting cinnamon production. In response to the environmental and health concerns associated with chemical pesticides, environmentally friendly alternatives to control RBD are becoming increasingly popular. This study compares the effectiveness of multiple fungicide treatments and a phytohormone in controlling RBD under field conditions. The field experiment was based on a factorial design and included six treatments with ten replicates each. Both in vitro and in vivo evaluations of the treatments were carried out, which included tebuconazole at a concentration of 0.05% (T1), tebuconazole at a concentration of 0.1% (T2), aqueous neem extract (T3), 5 ml salicylic acid (T4) and 1% Bordeaux mixture included (T5) and a control group (T6). The results showed that the most effective inhibition of mycelial growth (100%) occurred with 1% Bordeaux mixture treatments in in vitro evaluations. Tebuconazole also significantly inhibited mycelial growth at concentrations of 0.05% and 0.1%. In the field trial, which included two application periods, no differences were evident between the treatments with 1% Bordeaux mixture and 0.05% or 0.1% tebuconazole in the occurrence and severity of RBD. However, combined in vitro and in vivo studies highlight the superiority of the 1% Bordeaux mixture as the most effective antifungal agent for controlling RBD in cinnamon compared to other treatments.*

*Keywords: Cinnamomum zeylanicum B., Rough bark disease, Fugicidal agents, Phytohormones*

## I. INTRODUCTION

Cinnamon (*Cinnamomum zeylanicum* B.) is the most valuable spice crop exported from Sri Lanka (Suriyagoda et al., 2021). In Sri Lanka, cinnamon is grown in the Sinharaja and Knuckles forest reserves and the central highland regions. According to EDB (2020), there will be 33,000 ha of cinnamon cultivation in Sri Lanka in 2021, and according to Jayasinghe et al. (2016), 60,000 farming families, or around 300,000 people, are involved in the industry. Cinnamon exports totaled 18,722.8 metric tonnes, in 2020resulting a foreign exchange earnings of Rs. 38.2 billion.

The presence of pests and diseases, some of which have attracted significant attention in Southeast Asian countries, poses a significant threat to cinnamon production (Khan et al., 2020). Among these challenges, Rough Bark Disease (RBD), caused by *Phomopsis* spp., stands out as the most widespread, damaging and economically important fungal disease in Sri Lanka's cinnamon (Ashan et al., 2020; Jayasinghe et al., 2017). Treatment for this condition typically involves a combination of cultural practices and chemical treatments.

Although chemical fungicides are known for their effectiveness, there is growing recognition that organic fungicides offer a more cost-effective and environmentally friendly approach to crop protection, providing effective disease control without negative environmental impacts. In addition, the application of plant hormones has been shown to significantly increase a plant's resistance to disease and infection (Burketova et al., 2015). Despite their potential benefits, there is limited research exploring alternative fungicidal agents to replace traditional commercial fungicides for the treatment of plant diseases. This study aims to fill this knowledge gap by

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comparing different fungicidal treatments and phytohormones related to the treatment of bark disease in cinnamon and assessing their overall effectiveness. In this way, it aims to provide valuable insights into sustainable and environmentally friendly approaches to disease control in cinnamon cultivation.

## II.    MATERIALS AND METHODOLOGY

### A.    Study Area
The study was carried out from February to August 2022 at the National Cinnamon Research and Training Centre (NCR & TC), Palolpitiya, Matara (latitude 6°01'42.1"N and longitude 80°33'34.2"E; 38 m amsl). The main type of soil in the field study area is red-yellow podsolic, and it is located in agro ecological zone IL10. The annual precipitation is 2261 mm.

### B.    In vitro Experiment
First, samples of the rough bark disease were collected, and then, using the hyphal tip transfer technique, the isolated fungus was cultivated in petri plates (Heath, 2011). Tebuconazole (EW 250 g/l), a chemical fungicide, was employed in two quantities to prepare the testing reagent. 1 ml and 0.5 ml per 1 liter of water. 5 ml of a salicylic acid solution were used as a plant hormone. Freshly made Neem extraction (a strained solution generated from 100g of Neem leaves cooked in 1 l of water) and a 1% Bordeaux mixture were used as homemade reagents. 10g of $CuSO_4$ was dissolved in 100 ml of hot water to create a 1% Bordeaux mixture. 900 ml of tap water was used to dissolve 10 g of lime. Then, two solutions were properly combined.

The poison food technique was used to assess the fungicidal impact of testing regents. Using a micropipette, precisely 1 ml of filter-sterilized testing solution (Whatman Slinger filters, 0.45 cm diameter) was applied to a 9 cm diameter sterilised petri plate. Next, 15 ml of potato dextrose agar (PDA) was added to the plate. With 15 ml of PDA and 1 ml of sterilised distilled water, control plates were run. The centre of each PDA plate was then implanted with a 0.5 cm diameter mycelial plug that was taken from the pathogen culture that had been growing for 7 days. Each testing regent underwent five duplicates of these steps. The PDA plates were appropriately identified and parafilm-sealed. At 25°C, plates were kept in an incubator. Following a 48-hour

observation period, the colony diameters (measured in cm) of each plate were assessed, and the percentage inhibition of diameter growth (PIDG) was determined using the equation shown below (Khan et al., 2021).

$$PIDG = \frac{(Diameter\ of\ control - Diameter\ of\ sample)}{Diameter\ of\ control} *100\%$$

Field Experiment Two months following the harvesting, a field trial was established on the grounds of NCR and TC. After 3–4 weeks following harvest, the beginning of new shoots can be observed. Then, for the experiment, bushes with at least two new shoots were chosen. The two-factor factorial design was used for the study (Figure 01). The application of the treatment was done once in every two weeks and once a month.
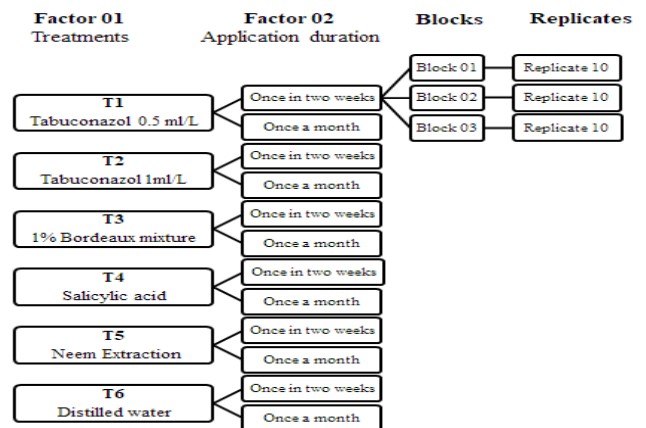


Figure 01: Design of the study

The number of typical Rough Bark Disease spots that appeared on new shoots was recorded once a month separately, and disease incidences (number of initial spots) and severity (area of initial spots) were calculated.

## III.    RESULTS AND DISCUSSION

The upper and lower surfaces of the colony that was isolated on the diseased cinnamon plants are shown in Figure 02. After seven days, fast-growing off-white, pale yellow-coloured mycelia were visible in the PDA medium.  Table 01 shows the percentage inhibition of *Phomopsis* spp by different treatments. Diameter growth inhibited by the poison food technique. The results showed that the 1% Bordeaux mixture performed at its highest level by completely preventing mycelial growth over the 6 day observation period. The

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media supplemented with 5 mL of salicylic acid showed the lowest PIDG values, indicating no fungicidal activity. The three treatments, for example 0.05% tebuconazole, 0.1% tebuconazole and 1% Bordeaux combination, do not differ significantly when considering the PIDG values obtained for the fourth, fifth and sixth days. However, considering the aqueous neem extract over the entire observation period, the concentration tested was not sufficient to inhibit the RBD-causing active ingredient by 50%, nor was there any noticeable difference between the two treatments (5 ml salicylic acid and aqueous neem extraction) during the entire observation period.

Table 02 shows the effects of application to six different treatments to reduce RBD under field conditions over a five-month period. According to the table, after 5 months of use, the treatment effect for the two observed parameters (number of spots and area of spots) became significant (p 0.05), while the duration of use and the interaction of treatment and duration remained non-significant. This is further supported by Figure 03, which shows the average number RBD spots appearing in fresh cinnamon shoots at the end of the five-month treatment period. Over a period of five months, T1, T2 and T5 caused the least RBD spot development, while T3 and T4 also prevented RBD spot development compared to the control, once applied every two weeks, but no significant difference between T3 when used once monthly, T4 and control. Regarding the number of RBD spots that have developed, there is no discernible difference between T3 and T4, similar to how there is no discernible difference between T1, T2, and T5. (Figure 04).

Figure 04 shows the average number of spots in new shoots in six different treatments over the period of two applications. The figure shows that there is no difference between the two application periods T1, T2, T5 and T6 (p > 0.05). The results showed that using treatments T1, T2 and T5 once a month rather than every two weeks is sufficient. Compared to once-monthly dosing, T3 and T4 applications once every two weeks demonstrated significant disease suppression. The control group discovered the most stains for both durations of use. The average spot area on new shoots treated with six different substances in two applications also shows the same treatment.



Figure 02: Upper and lower surface of *phomopsis spp*

Table 01: Percentage Inhibition of Diameter Growth of Isolated *Phomopsis spp.* under the Five Treatments in the Culture

| Treatment | PIDG* value | | | | |
|---|---|---|---|---|---|
| | Day 02 | Day 03 | Day 04 | Day 05 | Day 06 |
| Tebuconazole 0.05% (T1) | $36.11^b \pm 5.01$ | $60.83^b \pm 2.20$ | $75.00^a \pm 1.80$ | $80.00^a \pm 2.22$ | $79.29^a \pm 1.71$ |
| Tebuconazole 0.1% (T2) | $100.00^a \pm 0.00$ | $90.00^{ab} \pm 10.00$ | $88.02^a \pm 6.14$ | $91.11^a \pm 4.63$ | $91.91^a \pm 4.13$ |
| Neem aqueous extraction (T3) | $18.06^b \pm 5.01$ | $31.67^d \pm 8.33$ | $39.06^b \pm 10.97$ | $41.85^b \pm 8.07$ | $44.01^b \pm 7.85$ |
| 5 ml Salicylic acid (T4) | $18.06^b \pm 12.34$ | $21.67^d \pm 11.67$ | $10.52^b \pm 9.00$ | $12.22^b \pm 3.57$ | $17.15^b \pm 13.32$ |
| 1% Bordeaux mixture (T5) | $100.00^a \pm 0.00$ | $100.00^a \pm 0.00$ | $100.00^a \pm 0.00$ | $100.00^a \pm 0.00$ | $100.00^a \pm 0.00$ |

Table 02: Effect of Application on Six Different Treatments for Controlling RBD under Field Conditions in 5 Months Period

| Data set | Factor | P - values generated in ANOVA | |
|---|---|---|---|
| | | For no. of spots | For area of spots |
| After 2 months of application | Treatments (A) | 0.520 | _ |
| | Application duration (B) | 0.269 | _ |
| | (A) X (B) | 0.246 | _ |
| After 3 months of application | Treatments (A) | 0.270 | 0.183 |
| | Application duration (B) | 0.086 | 0.215 |
| | (A) X (B) | 0.587 | 0.702 |
| After 4 months of application | Treatments (A) | 0.470 | 0.164 |
| | Application duration (B) | 0.133 | 0.210 |
| | (A) X (B) | 0.906 | 0.837 |
| After 5 months of application | Treatments (A) | 0.000 | 0.004 |
| | Application duration (B) | 0.374 | 0.332 |
| | (A) X (B) | 0.155 | 0.472 |
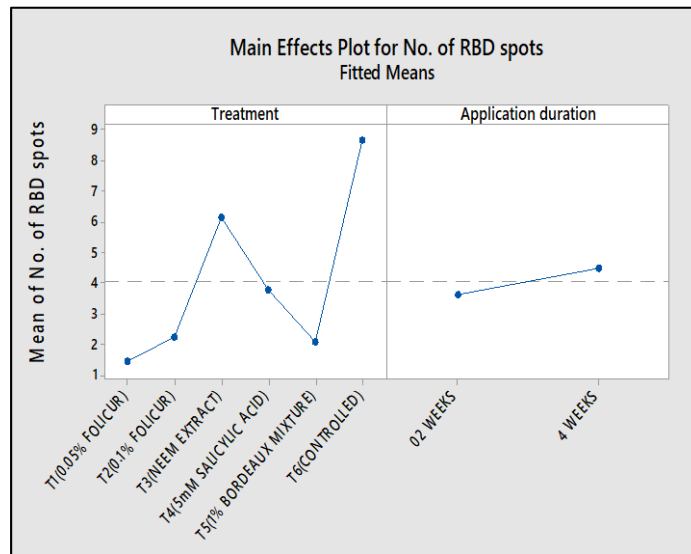
Figure 03: Mean Number of RBD Spots Appeared in New Shoots of Cinnamon after the Treatment
Application at the End of the Five Months

In vitro studies have shown that various fungicidal solutions have a suppressive effect on the growth of *Phomopsis* sp. The phytohormone and other fungicidal compounds have varying degrees of inhibitory effect. In this study, a 1% Bordeaux mixture was found to be most effective in suppressing mycelial growth, consistent with the findings of Park et al. matches. (2016) that 1% Bordeaux mixture was the best treatment for both *in vivo* and *in vitro* assays, Bordeaux mixture was the best treatment for reducing the incidence of *Phomopsis* sp. caused gummosis diseases (Farias et al., 2021). With increasing concentrations of tabuconazole at two concentrations of 0.05% and 0.1%, respectively, there was a progressive increase in PIDG for *Phomopsis* sp. was seen. The PIDG values on the sixth day for these two concentrations were 79.29% and 91.91% respectively. This is consistent with the findings of Najoi et al. (2018) to control a wide range of pathogenic fungi, tabuconazole has been widely used on a variety of crops in several countries. In the current study, aqueous neem extraction achieved a PIDG value of 44.01% on the sixth day. In the in vitro study there was only minimal inhibition of diameter growth. The absence of *Phomopsis* spp. the inhibition in cinnamon RBD may be due to the low concentration. Aqueous neem extraction reduces mycelial growth of both pathogenic fungi and the degree of suppression progressively increases with concentration (Kumar et al., 2016; Nandini et al., 2018). Furthermore, it was observed that all symptom parameters were recorded less in other treatments than in the control treatment as plant hormones have immense value in disease control by managing plant biotic stress (Ali and Baloch, 2020).

IV. CONCLUSION

In comparison to the two positive controls examined, 0.05% and 0.1% Tebuconazole, the 1% Bordeaux combination emerged as the most effective fungicidal treatment for managing Rough Bark Disease (RBD) in cinnamon. However, our findings suggest that applying 0.05% Tebuconazole once a month is sufficient for successful RBD management. Interestingly, the phytohormone salicylic acid did not exhibit any significant suppression of diameter growth in the in vitro study. Nevertheless, it positively impacted the outcomes of the field trial by reducing the frequency and severity of the disease. These results indicate that salicylic acid may possess biotic stress-supporting capabilities rather than fungicidal ones, enabling the plant to better withstand against biotic stress caused by pathogen.
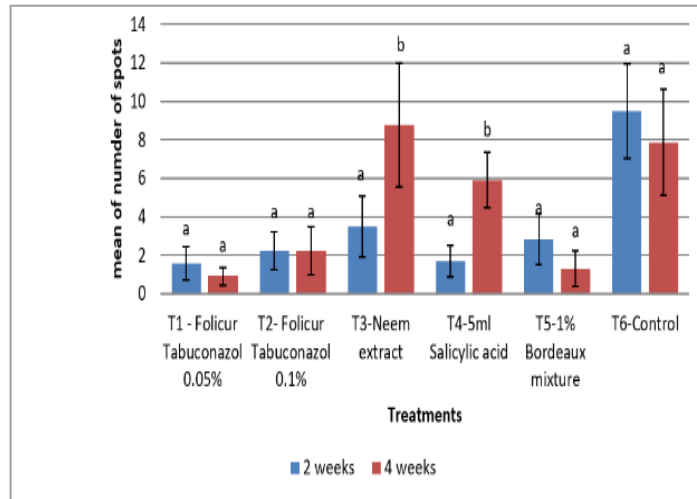
Figure 04: Mean Number of Spots in New Shoots with Six Different Treatments with Two Application
Means sharing a common letter(s) are not significantly different by Tukey's multiple comparison test.
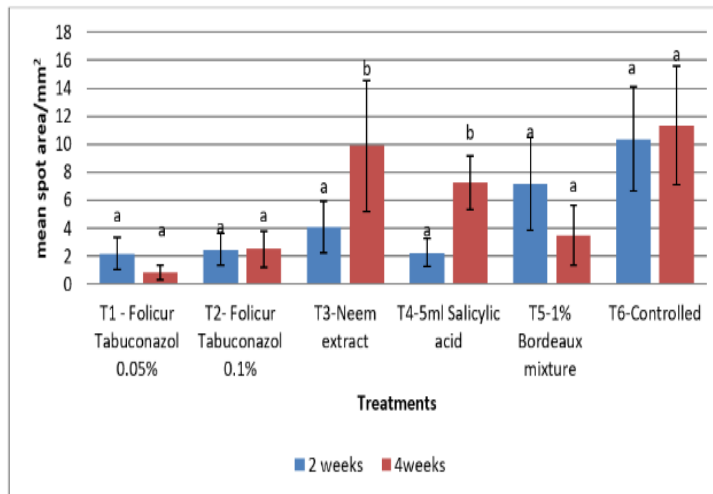


Figure 05: Mean of Spot are in New Shoots with Six Different Treatments with Two Application
Duration at the End of Five Month.
Means sharing a common letter(s) are not significantly different by Tukey's multiple comparison test.

REFERENCES

Ali, S. and Baloch, A. M. (2020) "Overview of sustainable plant growth and differentiation and the role of hormones in controlling growth and development of plants under various stresses", *Recent patents on food nutrition & agriculture,* 11(2), pp.105-114.

Burketova, L., Trda, L., Ott, P. G. and Valentova, O. (2015) "Bio-based resistance inducers for sustainable plant protection against pathogens", *Biotechnology Advances,* 33(6), pp. 994-1004,

Farias, E. S., Santos, A. A., Carmo, D. G., Melo, J. B. and Picanco, M. C. (2021) "Lethal and antifeedant effects of Bordeaux mixture on the marsh slug (Deroceras leave*", Journal of Environmental Science and Health - Part B Pesticides*, Food Contaminants, and Agricultural Wastes, 56(2), pp. 117–121.

Heath, I. (2011) "Integration and regulation of hyphal tip growth", *Canadian Journal of Botany,* 73(2), pp. 131-139.

Jayasinghe, G. G., Ketakumbura, K. H. M. P. K., Wijesinghe, K. G. G., Hemachandra, K. S. and Weligamage, S. (2016) "Relationship between pest and disease incidences and agronomic operations implemented by farmers in cinnamon (Cinnamomum

zeylanicum Blume) fields in southern Sri Lanka", *Sri Lanka Journal of Food and Agriculture,* 2(1), pp. 35-37.

Jayasinghe, G. G., Kumara, K. L. W., Wijayawardana, M. W. G. C., Wijesinghe, K. G. G., Samaraweera, D. N. and Priyangika, K. M. M. (2017) "Rough bark disease on cinnamon (*Cinnamomum zeylanicum*): Disease symptoms development and the causal agent with special reference to its morphology", *Proceedings of the Symposium on Minor Export Crops,* 18(3), pp. 63–72.

Khan, A. U., Choudhury, M. A. R., Maleque, M. A., Dash, C. K., Talucder, M. S. A., Maukeeb, A. R. M., Ema, I. J. and Adnan, M. (2021) "Management of insect pests and diseases of jackfruit (Artocarpus heterophyllus L.) in agroforestry system: A review", *Acta Entomology and Zoology,* 2(1), pp. 37–46.

Khan, A. U., Khan, A. U., Khanal, S. and Gyawali, S. (2020) 'Insect pests and diseases of cinnamon (Cinnamomum verum Presi.) and their management in agroforestry system: A review", *Acta Entomology and Zoology,* 1(2), pp. 51–59.

Kumar, D., Rahal, A. and Malik, J. K. (2016) "Neem Extract', Nutraceuticals: Efficacy, Safety and Toxicity", pp. 585–597.

Najoi, E. A., Eftychia, D., Romain, B., Veronika, S., Maria, T., Jeremie, B., Panagiotis, K., Luigi, L., Nadine, R., Lucio, B., Federico, F., Marco, T., Dimitrios, K. and Fabrice, M. L. (2018) "The dissipation and microbial ecotoxicity of tebuconazole and its transformation products in soil under standard laboratory and simulated winter conditions", *The Science of the total environment,* pp. 637-638.

Nandini, M. L. N., Naik, S. M. R., Ruth, C. H. and Gopal, K. (2018) "Compatibility of biocontrol agents with fungicides used in turmeric cultivation under in vitro conditions", *Journal of Pharmacognosy and Phytochemistry,* 7(6), pp. 1271–1276.

Park, S.J., Lee, S.M., Gwon, H.W., Lee, H. and Kim, H. T. (2014) "Control efficacy of Bordeaux mixture against Pepper Anthracnos", *The Korean Journal of Pesticide Science,* 18(3), pp. 168–174.

Suriyagoda, L., Mohotti, A. J., Vidanarachchi, J. K., Kodithuwakku, S. P., Chathurika, M., Bandaranayake, P. C. G., Hetherington, A. M. and Beneragama, C. K. (2021) "Ceylon cinnamon: Much more than just a spice', Plants People Planet", 3(4), pp. 319–336.

# TRACK – ANIMAL AND AQUATIC SCIENCE AND TECHNOLOGY (AAT)

# A Survey on the Management Practices and Production Performances of Broiler Chickens in Kurunegala District, Sri Lanka

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## Abstract

*Remarkable improvements in broiler management made its meat available at low cost. To what extent management practices are adopted by local farmers and their effects on broiler production performance are not well documented in the Sri Lankan context. Hence, the present study investigated the effects of management factors on broiler production. One hundred broiler farmers, selected randomly from the areas in Kurunegala district, filled the structured questionnaire with face-to-face interviews. The data was analyzed with Excel and SPSS. The results showed that 74% of the farmers reared 1000 – 3000 birds, 88% of them fed pre-starter feed to birds below 10 days old, 94% fed starter feed from 10 – 20 days and 94% fed finisher to the birds above 20 days. Further, 77% of the farmers did not change the litter throughout the rearing cycle, 76% of them provided vaccine to birds, 96% were able to diagnose diseases, 96% used Baycox to treat disease and 40% provided supplements to their birds. 98% of the farmers sold live birds at 2kg and above 2kg body weight at the maximum of 42 days. The linear regression analysis showed that vaccination, experience of farmers, number of birds, not changing the litter, amount of starter feed, feeding days of pre-starter, feeding days of finisher, disease diagnosis and supplement can affect the body weight of the broiler and these factors together explain 68.1% of the variation in slaughter body weight. The study concludes that the slaughter weight of broiler chickens are affected by several rearing practices, thus, it is suggested the farmers may focus on feeding, vaccination, disease diagnosis, flock size, supplementation and litter management to increase the final slaughter weight of broiler chickens and production performance.*

*Keywords: Feeding, Vaccination, Litter management, Disease management, Slaughter weight*

## I.   INTRODUCTION

Poultry is the most developed livestock sub sector in Sri Lanka, and has shown a phenomenal growth over the past three decades (Prakash et al., 2017). Poultry sector in Sri Lanka has recently placed in a higher position due to higher contribution to national GDP. It developed as countries most disciplined and well-organized livestock subsector which generates the billions of tax revenue compared to the other livestock and fisheries (Manjula et al., 2018). The poultry industry in Sri Lanka plays a prominent role in the protein supply to the nation, important to safeguard children from malnutrition. Hence, it is necessary to ensure the sustainability of the poultry production which can be fulfilled by identifying the factors that are found to be the hindrance for its performance and sustainability. Prakash et al. (2017), identified the poor support services from government as affecting the poultry production in the Kurunegala district. Factors influencing poultry production is not only based on physical inputs such as land area, labour, quantity of feed used, quantity of vaccine applied and quantity of energy used, but also socio-economic, demographic, institutional and non-physical factors. According to Gharib, El-Menawey and Hamouda (2023), experience, gender, education, labor type, extension, training, veterinary, credit, flock size, management interventions, marketing information, and the market price of live chickens positively influenced the profitability of broiler while farmer age, feed cost, home consumption, and mortality rate negatively influence the broiler profitability.

Adebayo and Adeola (2005), found that the limited finance; high cost of input and labour coupled with unfriendly government policy had adversely affected the overall performance of poultry farmers. Overall, broiler chicken production performance are be influenced by

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management factors which are under the control of the farmers and socioeconomic characteristics, and climatic factors which can be totally or partially manipulated by farmers and support services which include supplies to farms and government services. However, in open house intensive broiler production system, management practices play a pivotal role therefore, management practices should be understood and well-maintained to ensure the better production and optimum level of yield (Biesek et al., 2022).

According to Prakash et al. (2017), the highest number of the poultry farms were located in the Kurunegala district, however, 74% of layer farms and 62% of broiler farms operated at small scale rearing less than 1000 chickens in open house intensive production system. The management practices carried out by poultry farmers will play important role in the performance of poultry farms. Remarkable improvements were already achieved in poultry performances. This improved management practices led to the price reduction of poultry and made the poultry meat available to everyone at low cost. Even though advanced management practices are available, to what extent those practices are adopted by farmers and how those adopted practices affect the broiler production performance are poorly studied in Kurunegala district where the poultry farms are concentrated in Sri Lanka. Therefore, the present study is an attempt to identify the management factors affecting the production performance of broiler chicken in selected areas of Kurunegala district.

## II. METHODOLOGY

### A. Study Area
The study was conducted in Kurunegala district (7.4871° N, 80.3649° E) in North Western province of Sri Lanka. Kurunegala features a tropical and hot throughout the year. During the month of April, the temperature can rise up to about 35 degree Celsius. The only major change in Kurunegala weather occurs during the monsoons from May to August and October to January. Moreover, Kurunegala has good road and rail connections with the rest of Sri Lanka. This area was chosen because of its popularity for broiler farming and large number of broiler farms are situated in this area.

Local broiler farmers (n=100) were selected using random sampling method from Aariyamam,

Yagamwela, Dvirumpola, Dummalasooriya, (Udubaddawa DS division), Maningala (Nattandiya DS division), Hettipola (Panduwasnuwera west DS division), Pannava (Kobeigana DS division), Gallegama, Kureekotuwa, Horambawa, Siyambalagaskotuwa (Kuliyapitiya east DS division), Kinniyama (Bingiriya DS division), Anukkana (Panduwasnuwera east DS division), and Panagamuwa (Rideegama DS division) areas. Structured questionnaire with field visits and observations was filled with face-to-face interview. The questionnaire included information such as personal details, breeds adopted, housing conditions, feeding and watering, poultry health, marketing, mortality, and slaughtering. All the data from filled questionnaires were coded and entered into Microsoft Excel and analyzed with Excel (2016) and SPSS (25.0). The Ethical Review Committee approval (ERC/FT/2022/06) was obtained for the study from the ERC of Faculty of Technology, South Eastern University of Sri Lanka.

## III. RESULTS AND DISCUSSION

### A. Socioeconomic Characteristics of Broiler Farmers
The data on socioeconomic characteristics from the questionnaires were analyzed using Microsoft excel and the results are presented in Table 01.

According to the results (Table 01), most of the farmers (77%) were below the age of 56 and above 25 years old indicating that they are in their productive age. The results showed that 50% of the farmers had 4 – 6 members in their family, however, 31% of the farmers had 7 – 9 members in their family. All most all of the farmers (96%) were educated up to secondary level. With regard to the ownership, 79% of the farmers had their own farm while 20% of farmers practiced buyback method and another 1% operated the farm on partnership basis. With regard to the engagement of the farmers in farming activities, it was found that 77% of them engaged full time farming while 23% of them involved part time in farming. Both the full-time engagement in farming and ownership together indicates the importance of broiler farming in contributing for employments and livelihoods of the people in the study area. The results also showed that 91% of the farmers started the farming without prior experience while only 9% of them started with experience. Further, 91% of the farmers indicated

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that they did not have training on broiler farming whereas another 9% had training. The results may indicate that farmers are with the attitude that both formal experience and formal training are not necessary to undertake broiler farming operations. From our discussion with farmers, we found that farmers usually follow the instructions provided by the chick suppliers and other input suppliers in managing their farms.

Table 01: Socioeconomic Characteristics of Poultry Farmers

| Characteristics | Percentage |
|---|---|
| *Age* | |
| 25 -35 | 20% |
| 35- 45 | 27% |
| 45-55 | 30% |
| 55-65 | 20% |
| 65-75 | 03% |
| *Family size (number of heads)* | |
| 0-3 | 19% |
| 3-6 | 50% |
| 6-9 | 31% |
| *Educational status* | |
| Primary level | 1% |
| Secondary level | 96% |
| Degree level | 03% |
| *Status of farm* | |
| Own | 79% |
| Partnership | 1% |
| Buyback | 20% |
| *Engagement of farmer* | |
| Full time | 77% |
| Part time | 23% |
| *Experience level of farmer* | |
| With experience | 09% |
| Without experience | 91% |
| *Undertaken a course* | |
| Yes | 09% |
| No | 91% |

### B. Management Practices

The study found that there were three chick supply sources i.e., 1. private hatcheries, 2. companies that supply chicks to farmers who involve in buyback method, and 3. chick sellers (Table 02). Farmers mainly purchased chicks from private hatcheries (46%), and also from companies (19%) and chick sellers (35%). All of the chick suppliers supplied Cobb 500 breed. We could not collect the data on the quality of chicks and prices. Therefore, it is not possible to comment on the quality of chicks. The results showed that most of the farmers (74%) reared 1000 – 3000 broiler chickens. According to the existing literature, the characterization of poultry farms based on the

number of birds varies. For example, flock size with 50 – 1000, 1001 – 10000 and above 10000 are categorized as small scale, medium scale and large scale commercial farm respectively. Whereas Uchendu et al. (2015), categorized poultry farms having the flock size with 250-1900 birds, 2000-5000 birds and above 5000 birds as small scale, medium scale and large scale respectively. In the present study, we categorize poultry farms in the study area with the flock size of below 1000 birds, 1001 to 5000 and above 5000 as small scale, medium scale and large scale respectively. Accordingly, 91% of the broiler farms were categorized as medium scale farms. Further, majority of the farmers (55%) operated more than five production cycles per year which is in agreement with previous findings wherein it was found that broiler farmers operated 1 – 6 cycles per year in Nigeria (Adeyonu and Odozi, 2022) and about eight cycles in Indonesia (Setiadi et al., 2022). According to the results, most of the farmers (77%) did not change the litter. Three common practices are adopted for litter management in broiler units, those are single use litter, partial re-use and multi-use litter (Bernhart et al., 2010). The single-use litter involves the total clean-out of the house after each flock and replacement of the bedding material. Partial re-use involves the removal of litter from the brooding section for spreading on the grower section of the house. With the multi-use of litter, only caked material is removed (Sistani et al., 2003) and the house is disinfected (Bolan et al., 2010). According to Abougabal (2019), recycling litter had no adverse effect on broiler performance, survival %, carcass traits, economic consideration and broiler welfare.

The results (Table 03) showed that most of the broiler farmers (88%) fed pre-starter feed (booster feed) to the birds with the age of below 10 days. Broiler booster is a complete supplement with a formulation consisting of vitamins, probiotics, amino acids, and minerals. Boosters for broilers are commercial feed additives. The booster products/feed produced by the feed mill has a diverse composition. Likewise, 94% of the farmers fed starter feed from 10 - 20 days. The broiler starter feed contains 21 - 22% of crude protein and 12.45MJ/kg of metabolizable energy. Similarly, 94% of the farmers fed finisher feed to the birds with the age of above 20 days.

Table 02: General Management Characteristics

| Characteristics | Percentage of farmers |
|---|---|
| *Sources of chicks* | |
| Directly from private hatcheries (private companies) | 46% |
| Provided by the company (under buyback method) | 19% |
| Chick sellers | 35% |
| *Number of birds* | |
| Below 1000 | 5% |
| 1001 - 3000 | 74% |
| 3001 - 5000 | 17% |
| Above 5000 | 4% |
| *Number of production cycles per year* | |
| 1 - 3 | 1% |
| 4 – 5 | 44% |
| 6 and above | 55% |
| *Housing and management system* | |
| Intensive management system | 100% |
| *Changing of litter materials* | |
| Below 3 times during a cycle | 9% |
| Above 3 times during a cycle | 5% |
| Spreading new husk on wetted husk | 9% |
| No changing of litter materials | 77% |

The finisher feed contains 18 – 19% of crude protein and 12.97MJ/kg of metabolizable energy. Muharlien et al. (2020) in their study used pre-starter, starter and finisher diets from 1 – 7days, 8 – 21 days and more than 21 days respectively. Accordingly, most of the broiler farmers' feeding practice in the present study was acceptable. However, according to the results, feeding practice carried out by certain farmers was not as per the recommendations. For example, 5% of the farmers fed starter feed to the birds with the age of below 10 days. Likewise, 5% of the farmers fed finisher feed to the broiler chicken with the age of below 20days. These types of feeding practices may affect the feed intake and the performance of the birds.

Table 04 shows that only 40% of the broiler farmers provided supplements to their birds and 60% of the farmers did not provide supplements. Out of the supplements used, it was found that chick tonic (31%) was the widely used supplement by farmers.

According to the results (Table 05), 76% of the farmers provided vaccine to their broiler chickens and another 24% did not provide vaccines. Most of the farmers (89.3%) provided Gamboru vaccine to their birds.

Table 03: Feeding Practices Carried out by Farmers

| Feeding practices | Percentage of farmers |
|---|---|
| Feeding at morning and evening | 100% |
| *Feeding pre-starter feed (booster feed)* | |
| Below 10 days | 88% |
| From 10 – 20 days | 10% |
| Above 20 days | 2% |
| *Feeding starter feed* | |
| Below 10 days | 5% |
| From 10 - 20 days | 94% |
| Not using starter feed | 1% |
| *Feeding finisher feed* | |
| Below 20 days | 5% |
| Above 20 days | 94% |
| Not using finisher feed | 1% |

Table 04: Feed Supplements Given to Broiler Chickens by Farmers

| Supplementation details | Yes | No |
|---|---|---|
| Providing supplements | 40% | 60% |
| Chick tonic | 31% | 69% |
| Vitamin B and C | 19% | 81% |
| Anasone | 2% | 98% |
| Biovit | 12% | 88% |
| Aminovit | 8% | 92% |
| Ganadexil | 5% | 95% |
| Selvit E | 2% | 98% |

Note: Supplements details were given in % by taking yes (40%) as 100%.

Table 05: Vaccination Practices Undertaken by Farmers

| Vaccination details | Yes | No |
|---|---|---|
| Providing vaccine | 76% | 24% |
| Gamboru | 89.3% | 10.7% |
| Endovict | 1.2% | 98.8% |
| Ranikhet | 8.3% | 91.7% |
| IBH | 1.2% | 98.8% |

Note: Vaccination details were given in % by taking yes (89.3%) as 100%.

Most of the farmers (96%) were able to diagnose Gamboru disease, only 4% of them said they did not diagnose Gamboru disease. Further, 84% of the farmers diagnosed chick cough and 16% said they did not. Whereas 24% of the farmers diagnosed coccidiosis and 76% of them did not diagnose coccidiosis. With regard to the treatments, 96%, 27%, 76% and 62% of the farmers used Baycox, Amoxicillin, Salpharin and Panadol and Paracetamol respectively to treat diseases. The diseases diagnosed and the treatments used by farmers indicated that the farmers were not able to correctly apply treatments against the diseases diagnosed. For example, Baycox is used against coccidiosis in

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poultry (Vertommen Peek and van der Laan, 1990). In the present study, 96% of the farmers used Baycox to treat disease, however, only 24% of the farmers said they diagnosed coccidiosis. The contradictory results may suggest the immediate need of training to farmers on disease diagnosis and treatments that will help them to apply correct treatments.

The study found that the mortality was highest (80%) in broiler chickens during the age of 21 – 30 days whereas it was 28% above 30 days of age and 2% below 20 days of age. According to Yerpes, Llonch and Manteca (2020), the first week mortality on average was 1.8%. According to Heier et al. (2002), the mortality increases 0.48% per week during the rest of the growth period. The present study further showed that heat stress (54%) was the main cause for the mortality compared to weak chicks (32%) and disease (14%). These results were unexpected because previous studies found diseases as the major cause of mortality in broiler chickens (Dalal et al., 2020). Therefore, it is recommended to carry out further studies on the causes of mortality in broiler chickens.

The results (Table 08) showed that 83% of the farmers performed culling in the broiler production and 17% of them did not carry out culling. The culling at farm level is performed since the birds are considered economically worthless. Most of the farmers (77%) carried out culling at the age of 10 – 20 days. Another 19% of the farmers carried out culling whenever they identify the birds to be culled. Further, 80% of the farmers stated that broken legs as the main reason for culling whereas 20% of them stated that broken legs is not the reason for culling. The findings in the present study is in agreement with previous finding where Knowles et al. (2008) reported the leg disorder as the main reason for culling in broiler birds. The disease was identified as the reason for culling by 69% of the farmers however, 31% said it was not the reason for culling. The study also found that poor growth was not the reason for culling which was mentioned by 98% of the farmers.

Table 06: Disease Diagnosis and Treatment Activities Carried out by Farmers

| Diseases and treatment | Yes | No |
|---|---|---|
| Diseases are diagnosed | 96% | 4% |
| *Diseases diagnosed* | | |
| Gamboru disease | 96% | 4% |
| Coccidiosis | 24% | 76% |
| Diarrhea | 7% | 93% |
| Chick cough | 84% | 16% |
| *Treatments used* | | |
| Baycox | 96% | 4% |
| Amoxicillin | 27% | 73% |
| Salpharin | 76% | 24% |
| Panadol and paracetamol | 62% | 38% |
| ESB3 (Sulfaclozine) | 1% | 99% |
| Dinatrin | 1% | 99% |
| Ganadexil | 1% | 99% |

Note: Disease diagnosis and treatments details were given in % by taking yes (96%) as 100%.

Table 07: Mortality Status at Farms

| Mortality status | Percentage |
|---|---|
| *Age of mortality* | |
| Below 20 days | 2% |
| 21 – 30 days | 80% |
| Above 30 days | 28% |
| *Reasons for mortality* | |
| Heat stress | 54% |
| Weak chicks | 32% |
| Disease | 14% |

Table 08: Culling Practices Performed by Farmers

| | Yes | No |
|---|---|---|
| Culling is done | 83% | 17% |
| *Age of culling* (out of 83%) | | |
| Below 10 days | 1% | |
| 10 – 20 days | 77% | |
| Above 20 days | 3% | |
| Whenever identified | 19% | |
| *Reasons for culling* (out of 83%) | | |
| Broken legs | 80% | 20% |
| Disease | 69% | 31% |
| Poor growth | 2% | 98% |

Table 09: Body Weight at Selling and Slaughtering

| | Body weight | Percentage of farmers |
|---|---|---|
| Selling live birds | 2 – 2.2kg | 97% |
| Selling slaughtered birds | 1 – 2kg | 2% |
| Selling slaughtered birds | Above 2kg | 1% |

The study found that 97% of the farmers sold live birds at the body weight of 2kg at the maximum age of 42 days. Or above and only 3% of the

farmers sold slaughtered birds. The live weight at selling is in agreement with previous findings where in survey on status of broiler production found that live weight at selling was 2kg.

## C. Factors Affecting Selling Weight of Broiler Chickens

We employed a linear regression model to analyze the effects of some factors on the selling/slaughtering weight of broiler chickens.

According to the model obtained through the linear regression analysis, variables such as vaccination, experience level of farmers, number of birds, not changing the litter, amount of starter feed, feeding days of pre-starter feeds, feeding days of finisher, disease diagnosis and supplement can affect body weight of the broiler. Further, aforementioned mentioned variables explained 68.1% of the variation of the broiler production performance and slaughter weight.

Table 10 shows the significant factors affecting the broiler production in the study area. Accordingly, farmers by focusing on poultry management related factors such as size of the flock, litter management, amount of feeding of starter feed, feeding days of pre-starter feed, feeding days of finisher feed, disease diagnosis and feed supplements can improve the slaughter weight of broiler chickens.

The model is stated as follows:

$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8$

Where,

$\beta_0 = 1.620$

$\beta_1 X_1 = -.480$ experience level of farmer

$\beta_2 X_2 = .311$ number of birds

$\beta_3 X_3 = .296$ no change litter

$\beta_4 X_4 = .221$ amount of starter feed

$\beta_5 X_5 = .277$ feeding days of pre-starter feed

$\beta_6 X_6 = .346$ feeding days of finisher

$\beta_7 X_7 = .456$ disease diagnosis

$\beta_8 X_8 = .246$ supplement provided

Table 10:  Significant Factors Affecting Broiler Production

| Factors | Co efficient | t value | p value/ sign |
|---|---|---|---|
| Constant) vaccination | - | 19.517 | .000 |
| Experience level of farmers | -.480 | -5.575 | .000 |
| No of birds | .311 | 4.249 | .000 |
| No changing litter | .296 | 3.950 | .000 |
| Amount of starter feed | .221 | 3.181 | .000 |
| Feeding days of pre-starter | .277 | 3.396 | .000 |
| Feeding days of finisher | .346 | 2.558 | .000 |
| Disease diagnosis | .456 | 6.540 | .000 |
| Supplements provided | .246 | 2.837 | .000 |

## IV.    CONCLUSION

The study found that the broiler production performance is affected by several rearing practices carried out by farmers. The slaughter or selling weight of broiler chickens can be affected feeding, vaccination, disease diagnosis, size of the flock, and feed supplements. Having the findings of the study, it is suggested that farmers may focus on proportionately maintaining feeding, vaccination, disease diagnosis, number of birds, feed supplement and litter management to increase final slaughter weight of broilers and production performance.

## REFERENCES

Abougabal, M. S. (2019) 'Possibility of broiler Production on reused litter', *Egyptian Poultry Science Journal*, 39(2), pp. 405-421.

Adebayo, O.O. and Adeola, R.G. (2005) 'Socio-economics factors affecting poultry farmers in ejigbo local government area of Osun State', *Journal of Human Ecology,* 18(1), pp. 39-41.

Adeyonu, A.G. and Odozi, J.C. (2022) 'What are the Drivers of Profitability of Broiler Farms in the North-central and South-west Geo-political Zones of Nigeria', *SAGE Open,* 12(1), pp. 21-24.

Bernhart, M. Fasina, O. O. Fulton, J. and Wood, C. W. (2010) 'Compaction of poultry litter'. *Bioresource technology,* 101(1), pp. 234-238.

Biesek, J. Banaszak, M. Wlaźlak, S. and Adamski, M. (2022) 'The effect of partial replacement of milled finisher feed with wheat grains on the production efficiency and meat quality in broiler chickens', *Poultry Science,* 101(5), 101-108.

Bolan, N. S. Szogi, A. A. Chuasavathi, T. Seshadri, B. Rothrock, M. J. and Panneerselvam, P. (2010) 'Uses and management of poultry litter', *World's Poultry Science Journal,* 66(4), pp. 673-698.

Chibanda, C. Wieck, C. and Sall, M. (2023) 'An analysis of the broiler value chain and economics of broiler production in Senegal: status quo after two decades of import restrictions', *Journal of Agribusiness in Developing and Emerging Economies*, 6(4), pp. 67-69.

Dalal, D.S. Malik, B.S. Poonam, R. and Patil C.S. (2020) 'Mortality pattern evaluation in layer and broiler chickens at an organized farm of Northern India', *Indian Journal of Poultry Science,* 55(1), pp. 63-67.

Diktaş, M. Şekeroğlu, A. Duman, M. and Yildirim, A. (2015) 'Effect of different housing systems on production and blood profile of slow-growing broilers', *Kafkas Üniversitesi Veteriner Fakültesi Dergisi,* 21(4), pp. 19-27.

Gharib, H. B. El-Menawey, M. A. and Hamouda, R. E. (2023) 'Factors Affecting Small-Scale Broiler Chicken Farm Profitability and Challenges Faced by Farmers in Egyptian Rural', *Tropical Animal Science Journal,* 46(2), pp. 261-268.

Heier, B. T. Høgåsen, H. R. and Jarp, J. (2002) 'Factors associated with mortality in Norwegian broiler flocks', *Preventive Veterinary Medicine,* 53(1-2), pp. 147-158.

Kalio, G. A. and Okafor, B. B. (2012) 'Response of broilers to two management systems of housing in Etche local government area of Rivers State, Nigeria', *Asian Journal of Agriculture and Rural Development,* 2(393), pp. 184-188.

Knowles, T. G. Kestin, S. C. Haslam, S. M. Brown, S. N. Green, L. E. Butterworth, A. and Nicol, C. J. (2008) 'Leg disorders in broiler chickens: prevalence, risk factors and prevention', *PloS one,* 3(2), pp.15-45.

Vertommen, M.H. Peek, H.W. and van der Laan, A. (1990) 'Efficacy oftoltrazuril in broilers and development of a laboratory model for sensitivity testing of Eimeria field isolates', *Veterinary Quarterly,* 12(3), pp.183-192.

Manjula, P. Wijayananda, H. I. Gajaweera, C. Lakmalie, D. Lee, S. H. and Heon, J. (2018) 'A Brief Review on Poultry Sector and Genetic Resources in Sri Lanka', *Journal of Animal Breeding and Genomics,* 2(3), pp. 52-67.

McCoy, R. A. Behnke, K. C. Hancock, J. D. and McEllhiney, R. R. (1994) 'Effect of mixing uniformity on broiler chick performance', *Poultry Science,* 73(3), pp. 443-451.

Muharlien, M. Sudjarwo, E. Yulianti, D. L. Hamiyanti, A. A. and Prayogi, H. S. (2020) 'Comparative production performance of broiler under opened house and closed house system', *Journal of Animal Science,* 30(1), pp. 86-91.

Prakash, N. Roy, S. S. Ansari, M. A. Sharma, S. K. Punitha, P. Sailo, B. and Singh, I. M. (2017) 'Jhum improvement for sustaining farm livelihood and natural resource conservation in North Eastern Hill Region: vistas and frontiers', *ICAR Research Complex for NEH Region,* 3(7), pp. 26-41.

Setiadi, A. Santoso, S. I. Mukson, M. and Roessali, W. (2022) 'Contract broiler farming as an effective pathway to improve rural prosperity in Indonesia', *International Social Science Journal,* 72(244), pp. 461-473.

Sistani, K. R. Brink, G. E. McGowen, S. L. Rowe, D. E. and Oldham, J. L. (2003) 'Characterization of broiler cake and broiler litter, the by-products of two management practices', *Bioresource Technology,* 90(1), pp. 27-32.

Uchendu, G.C. Ihedioha, J.I. Ogbu, C. and Onyeaka, E.C., (2015) 'Distribution and characteristics of poultry farms in Enugu State, Nigeria after the 2007 outbreak of highly pathogenic avian influenza', *International Journal of Livestock Production,* 6(3), pp.41-46.

Vernooij, A. G. Cornelissen, J. M. R. Claassen, I. J. T. M. Beitler, E. Rees, H. L. Giani, A. and Cloezeman, S. (2012) 'Poultry in Ethiopia: a survey of production, *value chain and marketing of commercial poultry in Ethiopia. Netherlands-African Business Council*, 12(3), pp.29-46.

Yerpes, M. Llonch, P. and Manteca, X. (2020) 'Factors associated with cumulative first-week mortality in broiler chicks', *Animals,* 10(2), pp. 307-310.

# The Effect of Different Rearing Methods on Domestic Poultry Eggs Qualities in Batticaloa District

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## Abstract

*The study was carried out to determine the effect of Rearing systems on the egg qualities of Domestic Chicken. Data was collected from (n=200) Domestic Chicken Eggs under Intensive and Semi-Intensive Rearing systems. All data were collected on external egg quality characteristics i,e.,(Egg Weight, Egg Length and Width, Shape Index, Shell Weight, Shell Thickness) and internal egg quality characteristics (Weight of albumen, Weight of yolk, Height of yolk, Height of albumen, The pH of egg yolk and albumen, Haugh unit, Yolk Color) and Nutritional Egg quality characteristic i,e.,(albumen protein content, yolk protein content, albumen fat content, yolk fat content, albumen ash content, yolk ash content, albumen moisture content, yolk moisture content). Data were analyzed using SPSS version 25.0. The results of the study revealed that external egg quality parameters such as Egg Weight, Shell Thickness and Shell Weight significantly (p < 0.05) affect by rearing system. Egg Nutritional Qualities Parameters like Albumen and yolk protein, albumen and yolk fat, significantly (p < 0.05) affected by the rearing system and egg internal qualities Egg Yolk Color significantly (p < 0.05) affected by the rearing system. However, other qualities do not that much affect egg qualities but in the case of egg, yolk color will be highly affected by the rearing system. Typically, consumers tend to favor eggs from semi-intensively reared hens due to the appealing egg size and yolk color. Consequently, farmers are advised to opt for the semi-intensive rearing system, as eggs from birds raised under this method exhibit an enhanced yolk color, making them more attractive to consumers. Conversely, when it comes to raising a large number of birds, the intensive rearing system is preferable over the semi-intensive one.*

*Keywords: Egg weight, Egg external quality, Egg internal quality, Egg nutritional quality, Domestic chicken*

## I. INTRODUCTION

All domesticated birds used to produce meat and eggs for human consumption, produce other goods for sale, replenish game populations, or breed these types of birds were referred to as poultry (Wakenell, 2016). Chickens, turkeys, quail, ducks, geese, and guineas are some of the poultry species. Poultry is restricted to the conventional scavenging variety, which means that they were allowed to roam rather than being confined in any way. This allows them to walk about and scavenge for their natural diet with the least amount of human involvement. They are also known as local poultry, family poultry, or village poultry. These poultry species were raised all over the world. Since 1990, there are now more than twice as many chickens as there were. The number of chickens in the globe increased from 14.38 billion in 2000 to 25.9 billion in 2019 (Khan et al., 2021). Poultry farming starts with less capital outlay than other livestock husbandry. Low-income individuals may also launch the business on a modest basis. Bangladesh is a developing nation with an agricultural economy in Southeast Asia, and chicken production is one of the most significant sources of protein (Mamun, 2019). Due to its greater contribution to the national GDP, Sri Lanka's poultry industry has lately been given a higher ranking (Manjula et al., 2018). In 2019, the contribution of poultry to Sri Lanka's GDP was 64% of the total contribution from livestock (Premarathne and Samarasinghe, 2020). Domestic poultry is one of the most crucial tools in a rural low-input-output farming system. According to estimates, there are 1.3 million domestic chickens. 15% of the eggs produced in the nation are produced by them (Weerasinghe, 2019). According to the All-Island Egg Producers Association, Sri Lanka's egg business produces enough eggs to meet the country's daily demand of 6.5 million eggs and significantly more than 7 million eggs during the festival season. Given the growth in the human population, there were

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2586.78 million eggs produced overall, or 117.6 eggs per person. Sri Lanka's egg production increased by 18% from 18, 000 tons in 1969 to 86, 000 tons in 2018. In 2020, there will be 24,277,830 chickens in Sri Lanka (Premarathne and Samarasinghe, 2020).

According to Kingori, Wachira and Tuitoek (2010), domestic chickens are raised in an extensive system in Africa to the tune of 70% of all chickens. Domestic poultry contributes roughly 10–15% of all poultry in India. Domestic poultry does not require large initial investments. Poor people can enhance their economic endeavors to better meet their requirements and earnings. suitable for female-headed households that can manage and generate their poultry assets successfully since it involves less work, and has little to no environmental impact. The domestic chicken industry has contributed to the elimination of poverty, the safety and security of food and the economic empowerment of vulnerable groups, notably women and children (Mengesha and Tsega, 2011; Cabarles et al., 2012). Rural Domestic chicken production makes a substantial contribution to human nutrition and serves as a source of income. This is because these species of chickens have advantages over others, such as rapid reproduction, low starting costs, and low maintenance costs (Mengesha and Tsega, 2011). Another benefit is that they reproduce quickly and may be raised on small plots of land per household, but due to poor management skills, their output is still not very good. Around the world, Domestic chicken breeds are raised in a range of climatic regions, customs, religious beliefs, and lifestyles (Amare, Worku and Negussie, 2012). Due to domestic chickens' advantageous characteristics, like their disease resistance, ability to adapt to hard conditions, and capacity for using low-quality feed, this has become crucial (Abeykoon, Weerahewa, and Silva, 2013). However, it is evident that Sri Lanka's domestic livestock and poultry populations are steadily diminishing, and several varieties and species have already disappeared or are in danger of doing so. Domestic chicken plays a special role in food security (Atapattu et al., 2016). Domestic chicken eggs have a special market than commercial chicken eggs due to high-quality eggs. The egg quality traits are very important for egg consumption. The quality characteristics of an egg are those which influence the consumer's acceptance of it. As a result, in today's production-oriented industry, continuous

genetic evaluation of different egg quality traits has become necessary to maintain dominance in overall egg quality. Although there has been an increase in demand for locally produced chicken meat and eggs, smallholder farmers still supply a sizable percentage of the market. In general, 30% of all animal protein consumed worldwide comes from poultry products (egg and meat) (Magonka et al., 2018).

*A. Background of the Study*

The study of egg quality characteristics in village chickens under diverse rearing systems in Sri Lanka is crucial due to the significant socioeconomic role of poultry in the country (Thariq et al., 2022). With a diverse array of phenotypic characteristics in domestic chicken breeds and various rearing practices, understanding how different systems affects egg quality is essential for optimizing production efficiency, ensuring food safety, and conserving genetic resources. Despite the substantial contribution of village chickens to Sri Lanka's economy and food security, there exists a gap in knowledge regarding detailed egg quality assessments within specific rearing contexts. Investigating parameters such as shell strength, yolk color, and nutritional content can provide insights into optimizing production, promoting genetic diversity, and fostering environmentally sustainable practices, ultimately benefiting both farmers and consumers. In this scenario, the study of the egg quality with different rearing systems in Sri Lanka important to explore.

## II. METHODOLOGY

*A. Experimental Site*
The study was carried out in an integrated model farm in Mandur local farm in Batticaloa district. The site was located in the dry zone of the country. Batticaloa's annual rainfall was 1349 mm, the temperature was between $24 - 32\ 0C$, June is the hottest month of the year, January has the lowest temperature in the past year and the elevation was 9 m above sea level. The primary sources of income in the region were irrigated and rain-fed agriculture, followed by non-farm activities and animal rearing (Mahanama et al., 2014).

*B. Experimental Design and Eggs Collection*
The experiment was arranged in a completely randomized design (CRD) with one breed (Common village chicken - Gam kukula) with two rearing methods (intensive and semi-intensive) as

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a flock maintained 500 birds in one rearing system and age of the flock was 6.5 months. The eggs were collected from each rearing system as 100 with 3 weeks of period. Collection pattern of the eggs were 06 times per day. The collected eggs were stored 05 days of period and transferred to animal science laboratory of the South Eastern University of Sri Lanka for external, internal and nutritional analysis. 7 0C temperature (Saleh et al., 2020) maintained in all storage period and transferring time. In the laboratory external (egg weight, shell thickness, shell weight, egg length and width and shape index) and internal (Albumen weight, Albumen height, Albumen PH, Yolk weight, Yolk height, Haugh Unit, and Yolk color) parameters were analyzed by the USDA standards of measurements (Joubrane et al., 2019). The nutritional (Moisture content, protein content, Fat content, dry matter, Ash and Energy content) parameters were analyzed by AOAC-2001 methods (Hanusova et al., 2015).

### C. Data Analysis
The data analysis involved descriptive statistics, and an independent samples student t-test was conducted using SPSS version 26.0, with a significance level set at 0.05.

## III. RESULTS AND DISCUSSION

### A. Effect of Different Rearing Methods on External Egg Qualities
#### 1) Egg Weight
The Egg Weight between Intensive and Semi-Intensive management systems; there was a significant difference (t=4.17, df=126, p<0.05) (Table 1). The mean egg weight was significantly higher in an intensive rearing system (50.3±3.8 g) while it is significantly lower in a semi-intensive rearing system (47.8±2.7 g). Ramlah, (1996), also discovered that hens raised under an intensive system of management produced high egg weight than those hens raised under a semi-intensive system of management.

#### 2) Egg Length
The egg length between Intensive and semi-intensive systems; there was no significant difference (t=1.21, df=126, p>0.05) (Table 1). Hence, the Intensive rearing system had numerically better egg length than the semi-intensive rearing system. The mean egg length for the intensive rearing system and semi-intensive rearing system were 52.86±2.1 mm and 52.45±1.7 mm respectively.

#### 3) Egg Width
The Egg Width between Intensive (40.6±1.1 mm) and Semi-Intensive rearing systems (40.2±1.0 mm), there was no significant difference (t= 1.93, df=126, p>0.05) (Table 01).

#### 2) Shape Index
In the Egg Shape Index between Intensive (76.8±2.8) and Semi-Intensive (76.5±2.) systems, there was no significant difference (t= 0.52, df=126, p>0.05) (Table 01). There are several studies Champati et al., (2020) that reported the effect of different rearing systems on egg shape indices not to be statically significant. On the contrary, Bekele et al., (2022) discovered that eggs from the intensive system had a higher egg shape index than eggs from the semi-intensive. Sokołowicz, Krawczyk and Dykiel (2018), made similar findings and discovered that birds raised in the deep litter had greater egg-shape indices than those raised in free-range and organic environments.

#### 4) Shell Thickness
In the Egg shell thickness between Intensive (0.45±0.4 mm) and Semi-Intensive (0.4±0.0 mm) systems, there was a significant difference (t= 3.81, df=126, p<0.05) (Table 01). Low feeding quality insufficient calcium (Ca) and other trace mineral intake are most likely to blame for the Semi-Intensive System eggs' poorer values for shell quality features. Calcium supplementation is necessary for eggshell quality (Mosa and Al-Asadi, 2022).

#### 3) Shell Weight
The eggshell weight between Intensive (5.7±0.5 g) and Semi-Intensive (5.6±0.7 g) systems, there was a significant difference (t= 1.56, df=126, p<0.05) (Table 01). According to research by Nweke-Okorocha, Agaviezor and Chineke (2020) deep litter systems generated thicker eggshells than cage systems. However, according to Ingelmann et al. (2018) could not find differences in the shell weight of eggs from different rearing strategies. The thickness and weight of the shells of the eggs from the free-range and litter floor systems were identical (Dikmen et al., 2017).

### B. Effect of Different Rearing Methods on Internal Egg Qualities
#### 1) Albumen Weight
The Egg Albumen Weight between Intensive (29.8±3.1) and Semi-Intensive (27.8±1.9) systems there was no significant difference (t= 1.65,

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df=126, p>0.05) (Table 02). According to Tadesse et al. (2015) Bovan Brown (BB) and Potchefstroom Koekoek (PK) albumen weight did not differ between intensive and semi-intensive rearing systems on the contrary, The weight of albumin in the semi-intensive (Grass and Pasture) was higher than that of the intensive (deep litter) (Sekeroglu et al., 2014).

Table 04: Eggs' External Parameters

| External Parameters | Intensive system | Semi-intensive system | t value (p-value) |
|---|---|---|---|
| Egg Weight (g) | 50.3±3.8 | 47.8±2.7 | 4.17 (0.000) |
| Egg Length (mm) | 52.9±2.1 | 52.4±1.7 | 1.21 (0.251) |
| Egg Width (mm) | 40.6±1.1 | 40.2±1.0 | 1.93 (0.350) |
| Shape Index | 76.8±2.8 | 76.5±2.6 | 0.52 (0.253) |
| Shell Thickness (mm) | 0.4±0.0 | 0.4±0.0 | 3.81 (0.000) |
| Shell Weight (g) | 5.7±0.5 | 5.6±0.7 | 1.56 (0.000) |

(mean ± SD)

### 2) Albumen Height

The egg albumen height between Intensive (5.2±0.9) and semi-intensive (5.4±0.6) systems, there were no significant differences (t= 1.71, df=126, p>0.05) (Table 02). Tadesse et al. (2015) reported album height of exotic chickens did not differ under intensive and semi-intensive rearing systems. in regards to this albumen height, Liu et al. (2020) found no variations in rearing methods. However, improved management and feeding of the birds, which have a substantial impact on internal egg quality attributes, may be linked to the higher albumen height score for eggs from intensive farming than semi-intensive farming (Hanusova et al., 2015).

### 3) Albumen pH

The eggs' albumen pH between intensive (8.6±0.2) and semi-intensive (8.6±0.2) systems, was no significant difference (t= 0.25, df=126, p>0.05) (Table 02). Dahloum, Yakubu, and Halbouche (2018), reported that the rearing systems had an impact on various albumen quality traits of the egg, with the exception of albumen pH.

### 4) Haugh Unit

The Haugh unit (HU) is calculated using the weight of an egg and the height of the inner thick albumen, which is regarded as a typical indicator of albumen quality. It is widely acknowledged that the quality of the egg increases with the Haugh unit value. In this study, The Egg Haugh unit between intensive (74.0±7.2) and semi-intensive (77.1±4.7) systems, there was no significant difference (t= 0.68, df=126, p>0.05) (Table 02). According to Gerber et al. (2015), improved management and feeding of the birds, which have a substantial impact on internal egg quality attributes, could be linked to the higher score in the Haugh unit for eggs from intensive farming as opposed to semi-intensive farming. Furthermore, Sokołowicz, Krawczyk and Dykiel (2018), discovered a substantial rearing system effect, with deep litter system eggs outperforming free-range eggs in terms of Haugh unit value. Liu et al. (2020), did not identify any changes across rearing systems, in contrast to the current finding.

### 5) Yolk Weight

The egg yolk weight between intensive (14.8±1.3 g) and semi-intensive (14.6±1.4 g) systems, there was no significant difference (t= 0.90, df=126, p>0.05) (Table 02). However, with the highest values (14.8±1.3) recorded for birds maintained on an intensive rearing system, the current study demonstrated a substantial effect of the rearing strategy on yolk weight. A follow-up study by Dikmen et al. (2017), found that the yolk weight was higher in the free-range/semi-intensive system than in the conventional-cage and enriched-cage systems.

### 6) Yolk Height

The egg yolk height between intensive (14.6±0.9 mm) and semi-intensive (14.5±0.9 mm) systems, there was no significant difference (t= 0.64, df=126, p>0.05) (Table 02). In the study by Tadesse et al. (2015), it was observed that yolk height demonstrated an upward trend with increasing egg weight. Additionally, Khobondo et al. (2015), found similarities in egg length, egg width, and yolk height across various rearing systems.

### 7) Yolk Color

The egg yolk color between intensive (4.9±0.8) and semi-intensive (11.1±0.8) systems there was a significant difference (t= 43.80, df=126, p<0.05) (Table 02). Khobondo et al. (2015), reported the rearing systems significantly (p<0.05) affected only the yolk color while other internal and

external qualities were not significantly (p>0.05) affected. Birds on semi-intensive farms recorded a higher value for the yolk color (golden yellow), whereas deep-litter farms recorded a higher value for the (yellow color).

### 8) Yolk pH
The egg yolk pH between intensive (6.2±0.1) and semi-intensive (6.2±0.0) systems, there was no significant difference (t=1.3, df=126, p>0.05) (Table 02). These results are largely in line with earlier research. Therefore, Yolk pH and yolk/albumen ratio were not affected by the housing or rearing system (Wijnen et al., 2020).

Table 05: Eggs' Internal Parameters

| Internal Parameters | Intensive system | Semi-intensive system | T value (p-value) |
|---|---|---|---|
| Albumen Weight (g) | 29.8±3.1 | 27.8±1.9 | 1.65 (0.101) |
| Albumen Height (mm) | 5.2±0.9 | 5.4±0.6 | 1.71 (0.086) |
| Albumen pH | 8.6±0.2 | 8.6±0.2 | 0.25 (0.152) |
| Haugh Unit | 74.0±7.2 | 77.1±4.7 | 0.68 (0.250) |
| Yolk Weight (g) | 14.8±1.3 | 14.6±1.4 | 0.90 (0.502) |
| Yolk Height (mm) | 14.6±0.9 | 14.5±0.9 | 0.64 (0.388) |
| Yolk Color | 4.9±0.8 | 11.1±0.8 | 43.8 (0.000) |
| Yolk pH | 6.2±0.1 | 6.2±0.0 | 1.3 (0.246) |

(mean ± SD)

### C. Effect of Different Rearing Methods on Nutritional Egg Qualities
### 1) Albumen Protein
The egg albumen protein between intensive (12.1±0.4 %) and semi-Intensive (11.6±0.6 %) systems, there was a significant difference (t= 3.62, df=68, p<0.05) (Table 03). The albumen of eggs from intensive hens had higher protein content. It was generally known that the hen's diet has a significant impact on the protein content of the egg (Rizzi, 2021).

### 2) Yolk Protein
The egg Yolk protein between intensive (16.2±0.4 %) and semi-Intensive (15.9±0.4 %) systems, there was a significant difference (t= 2.73, df=68, p<0.05) (Table 03). Eggs from intensive reared hens had a higher protein level in the yolk. However, Kucukyılmaz et al. (2012), found no

impact of the rearing technique on the yolk protein in the egg.

### 3) Albumen Ash
The albumen ash between intensive (0.5±0.1 g) and semi-intensive (0.6±0.1 g) systems, there was no significant difference (t= 1.19, df=68, p>0.05) (Table 03). The different rearing System was not significantly (p>0.05) affected by egg Ash albumen. Bughio et al. (2021), reported that greater albumen ash levels (p>0.05) in the semi-intensive and free-range systems may be related to increased bird movement and better feed ingredient utilization, which eventually led to improved egg size and interior quality.

### 4) Yolk Ash
The yolk ash between intensive (1.7±0.2 g) and semi-intensive (1.6±0.1 g) systems, there was No significantly difference (t= 1.16, df=68, p>0.05) (Table 03). Heflin et al. (2018), reported that the ash concentration of egg yolk would differ among rearing system in summer season but different in winter season.

### 5) Albumen Fat
The egg albumen fat between intensive (0.4±0.0 %) and semi-intensive (0.3±0.0 %) systems, there was a significant different (t= 1.78, df=68, p<0.05) (Table 03). Egg albumen contain less than 0.19% of fat was reported in the study of Rehault et al. (2019).

### 6) Yolk Fat
The egg yolk fat between intensive (27.1±0.4 %) and semi-intensive (26.3±0.4 %) there was a significant difference (t= 8.43, df=68, p<0.05) (Table 03). Bughio et al. (2021), reported that the yolk fat was higher in the intensive system than in semi-intensive rearing system. Rizzi (2021), found no difference in the egg yolk fat concentration, which contrasted with the findings of Minelli et al. (2007), who found that the egg yolk fat concentration was lower in the conventional/intensive system.

### 7) Albumen Moisture
The egg albumen moisture between intensive (87.0±0.6 %) and semi-intensive (86.6±0.5 %) systems, there was no significant difference (t= 1.27, df=68, p>0.05) (Table 03). On the contrary, Bughio et al. (2021), reported that, higher albumen moisture in the free-range than in semi-intensive systems.

Table 06: Eggs' Nutritional Parameters

| Nutritional Parameters | Intensive system | Semi-intensive system | T value (p-value) |
|---|---|---|---|
| Albumen protein (%) | 12.1±0.4 | 11.6±0.6 | 3.62 (0.000) |
| Yolk protein (%) | 16.2±0.4 | 15.9±0.4 | 2.73 (0.000) |
| Albumin ash (g) | 0.5±0.1 | 0.6±0.1 | 1.19 (0.203) |
| Yolk ash (g) | 1.7±0.2 | 1.6±0.1 | 1.16 (0.150) |
| Albumen fat (%) | 0.4±0.0 | 0.3±0.0 | 0.78 (0.001) |
| Yolk fat (%) | 27.1±0.4 | 26.3±0.4 | 8.43 (0.008) |
| Moisture albumen (%) | 87.0±0.6 | 86.6±0.5 | 1.27 (0.098) |
| Yolk moisture (%) | 54.9±0.5 | 55.3±0.6 | 1.73 (0.200) |

(mean ± SD)

### 8) Yolk Moisture

The egg yolk moisture between intensive (54.9±0.5 %) and semi-intensive (55.3±0.6 %) systems there was no significant difference (t=1.73, df=68, p>0.05) (Table 03). According to Wagt et al. (2020), reported that, yolk of the intensive reared hen's egg had more moisture and fat. The same results were also reported by Minelli et al. (2007), who also noted significant moisture content in the yolk of eggs from confined (intensive) hens.

## IV. CONCLUSION

The current study's findings indicate that the rearing systems exerted a notable influence on the external, internal, and nutritional qualities of eggs. Specifically, external attributes such as egg weight, shell thickness, and shell weight exhibited significant variations based on the rearing system. Likewise, nutritional qualities, including albumen and yolk protein, as well as albumen and yolk fat, were significantly impacted by the rearing systems. Among the internal qualities assessed (weight of albumen, weight of yolk, height of yolk, height of albumen, pH of the egg yolk and albumen, haugh unit), yolk color was notably influenced by the rearing system. Notably, semi-intensive rearing systems yielded a higher yolk color value of 11.08 (golden yellow) compared to the intensive system, which recorded a value of 4.91 (yellow color). It is important to highlight that while yolk color demonstrated significant variations based on rearing systems, it did not exert a discernible influence on the nutritional composition of eggs.

## REFERENCES

Abeykoon, M., Weerahewa, J. and Silva, G. (2013) 'Determinants of market participation by indigenous poultry farmers: a case study in Anuradhapura district in Sri Lanka', Tropical Agricultural Research, 24(4), pp. 347-361.

Amare, A., Worku, W. and Negussie, H. (2012) 'Coccidiosis prevailing in parent stocks: A comparative study between growers and adult layers in Kombolcha poultry breeding and multiplication center, Ethiopia', Global Veterinaria, 8(3), pp. 285–291.

Atapattu, N., Saranga, K., Abeywickrama, L. M., Gunawardane, W. and Munasinghe, M. (2016) 'Contribution of Backyard Chicken Egg Production to Fulfill Household Nutrient Requirement: A Study in Southern Sri Lanka', International Journal of Livestock Research, 6(7), pp. 1-7.

Bekele, B., Melesse, A., Esatu, W. and Dessie, T. (2022) 'Production performance and egg quality evaluation of indigenous chickens across different agro-ecologies of Southern Ethiopia', Veterinary Integrative Sciences, 20(1), pp. 133–145.

Bughio, E., Hussain, J., Mahmud, A. and Khalique, A. (2021) 'Effects of production system and feeding regimen on carcass and meat quality traits of Naked Neck chicken', South African Journal of Animal Science, 51(2), pp. 250–261.

Cabarles, J. C., Lambio, A. L., Vega, S. A., Capitan, S. S. and Mendioro, M. S. (2012) 'Distinct morphological features of traditional chickens (Gallus gallus domesticus L.) in Western Visayas, Philippines', Animal Genetic Resources/Resources génétiques animales, 51(1), pp. 73–87.

Champati, A., Samal, L., Behura, N. C., Pati, P. K., Muduli, S. and Popalghat, H. K. (2020) 'Carcass traits and meat composition of hansli× CSML bird under Intensive and Semi-intensive rearing systems', Journal of Animal Research, 10(6), pp. 1051–1055.

Dahloum, L., Yakubu, A. and Halbouche, M. (2018) 'Effects of housing system and plumage colour on egg quality characteristics of indigenous naked-neck chickens', Livestock Research for Rural Development, 30(12), pp. 206–212.

Dikmen, B. Y., Ipek, A., Şahan, Ü., Sözcü, A. and BAYCAN, S. C. A. N. (2017) 'Impact of different housing systems and age of layers on egg quality characteristics', Turkish Journal of Veterinary & Animal Sciences, 41(1), pp. 77–84.

Gerber, P. F., Trampel, D. W., Willinghan, E. M., Billam, P., Meng, X.-J. and Opriessnig, T. (2015)

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'Subclinical avian hepatitis E virus infection in layer flocks in the United States', The Veterinary Journal, 206(3), pp. 304–311.

Hanusova, E., Hrnčár, C., Hanus, A. and Oravcová, M. (2015) 'Effect of breed on some parameters of egg quality in laying hens', Acta fytotechnica et zootechnica, 18(1), pp. 20–24.

Heflin, L. E., Malheiros, R., Anderson, K. E., Johnson, L. K. and Raatz, S. K. (2018) 'Mineral content of eggs differs with hen strain, age, and rearing environment', Poultry Science, 97(5), pp. 1605–1613.

Ingelmann, C.-J., Witzig, M., Möhring, J., Schollenberger, M., Kühn, I. and Rodehutscord, M. (2018) 'Effect of supplemental phytase and xylanase in wheat-based diets on prececal phosphorus digestibility and phytate degradation in young turkeys', Poultry science, 97(6), pp. 2011–2020.

Joubrane, K., Mnayer, D., Hamieh, T., Barbour, G., Talhouk, R. and Awad, E., (2019). Evaluation of quality parameters of white and brown eggs in Lebanon. American Journal of Analytical Chemistry, 10(10), pp.488-503.

Khan, R. U., Khan, A., Naz, S., Ullah, Q., Laudadio, V., Tufarelli, V. and Ragni, M. (2021) 'Potential applications of Moringa oleifera in poultry health and production as alternative to antibiotics: a review', Antibiotics, 10(12), pp. 1540-1549.

Khobondo, J. O., Muasya, T. K., Miyumo, S., Okeno, T. O., Wasike, C. B., Mwakubambanya, R., Kingori, A. M. and Kingori, A. K. (2015) 'Genetic and nutrition development of indigenous chicken in Africa', Livestock Research for Rural Development, 27(7), pp. 104-110.

Kingori, A. M., Wachira, A. M. and Tuitoek, J. K. (2010) 'Indigenous chicken production in Kenya: a review.', International Journal of Poultry Science, 9(4), pp. 309–316.

Liu, W.-R., Zeng, D., She, L., Su, W.-X., He, D.-C., Wu, G.-Y., Ma, X.-R., Jiang, S., Jiang, C.-H. and Ying, G.-G. (2020) 'Comparisons of pollution characteristics, emission situations, and mass loads for heavy metals in the manures of different livestock and poultry in China', Science of the Total Environment, 734, pp. 139023.

Mahanama, P., Jayasinghe, A., Jayasinghe, K.D.P.P., Bandara, R.M.P.N.S. and Chethika, C., (2014). Assesse the level of vulnerability in Sri Lankan coastal areas to climate exaggerated disasters: Application of Analytical Hierarchical Process (AHP) and Geographic Information System (GIS). International Journal of Advanced Research, 2(8), pp.523-534.

Magonka, J. M., Komwihangilo, D. M., Njau, B. G., Semuguruka, Y., Malingila, B. P. and Daniel, E. (2018)

'Growth performance of pigs fed baobab seed cake based diets', Tanzania Journal of Agricultural Sciences, 17(2), pp. 1450-1500.

Manjula, P., Park, H.-B., Seo, D., Choi, N., Jin, S., Ahn, S. J., Heo, K. N., Kang, B. S. and Lee, J.-H. (2018) 'Estimation of heritability and genetic correlation of body weight gain and growth curve parameters in Korean native chicken', Asian-Australasian Journal of Animal Sciences, 31(1), pp. 26-30.

Mengesha, M. and Tsega, W. (2011) 'Phenotypic and genotypic characteristics of indigenous chickens in Ethiopia: A review', African Journal of Agricultural Research, 6(24), pp. 5398–5404.

Minelli, G., Sirri, F., Folegatti, E., Meluzzi, A. and Franchini, A. (2007) 'Egg quality traits of laying hens reared in organic and conventional systems', Italian Journal of Animal Science, 6(1), pp. 728–730.

Mosa, Z. A. and Al-Asadi, F. S. (2022) 'Morphological development of the digestive tract at pre and post hatch period in broiler chicks (Gallus gallus domesticus)', University of Thi-Qar Journal of agricultural research, 11(2), pp. 329–342.

Nweke-Okorocha, G. O., Agaviezor, B. O. and Chineke, C. A. (2020) 'Effects of breed and sex on serum biochemical indices of local and improved Nigerian chickens raised in the south-south region of Nigeria', Journal of Bioscience and Agriculture Research, 23(02), pp. 1931–1936.

Premarathne, S. and Samarasinghe, K. (2020) 'Animal feed production in Sri Lanka: Past present and future', in Agricultural Research for Sustainable Food Systems in Sri Lanka: Volume 1: A Historical Perspective. Springer, pp. 277–301.

Ramlah, A. H. (1996) 'Performance of village fowl in Malaysia', World's Poultry Science Journal, 52(1), p. 75–79.

Rizzi, C. (2021) 'Albumen quality of fresh and stored table eggs: Hen genotype as a further chance for consumer choice', Animals, 11(1), pp. 135.

Saleh, G., El Darra, N., Kharroubi, S. and Farran, M.T., (2020). Influence of storage conditions on quality and safety of eggs collected from Lebanese farms. Food Control, 111(1), pp.107058-107065.

Sokołowicz, Z., Krawczyk, J. and Dykiel, M. (2018) 'The effect of the type of alternative housing system, genotype and age of laying hens on egg quality', Annals of Animal Science, 18(2), pp. 541–556.

Tadesse, D., Esatu, W., Girma, M. and Dessie, T. (2015) 'Comparative study on some egg quality traits of exotic chickens in different production systems in East Shewa, Ethiopia', African Journal of Agricultural Research, 10(9), pp. 1016–1021.

Thariq, M. G. M., Silva, P. M. R. and Rikasa, A. M. (2022) 'Comparative study of physical egg quality characteristics of Naked neck and Bovans chicken in diverse ages in coastal areas of Ampara district', Sri Lankan Journal of Technology, 03(02), pp. 15–20.

Wakenell, P. (2016) 'Management and medicine of backyard poultry', in Current Therapy in Avian Medicine and Surgery. Elsevier, p. 550-580.

Weerasinghe, W. (2019) 'Livestock feeds and feeding practices in Sri Lanka', Livestock feeding and feeding practices in South Asia. SAARC Agriculture Center, Dhaka, Bangladesh, pp. 181–206.

Wijnen, H. J., Van den Brand, H., Lammers, A., van Roovert-Reijrink, I. A. M., Van der Pol, C. W., Kemp, B. and Molenaar, R. (2020) 'Effects of eggshell temperature pattern during incubation on primary immune organ development and broiler immune response in later life', Poultry science, 99(12), pp. 6619–6629.

# TRACK – AGRICULTURE ECONOMICS, ENTREPRENEURSHIP & BIOSYSTEMS ENGINEERING (AEB)

# Adapting of Information on Rubber Farming by Rubber Smallholders: A Case Study in Moneragala District

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## Abstract

*The purpose of this study was to assess the utilization of information on rubber farming by Rubber Smallholders (RSs) and the sample was 389 RSs using stratified random sampling technique. The level of Utilization of Information on Rubber Farming (UIRF) was measured by developed score. The Logistic regression of analysis was employed in understanding the relationship between UIRF scores and socio-economic variables of RSs by the STATA version 19. The most prominent sources of information on rubber farming were rubber smallholders (71%), rubber extension officials (11%), social media (5%) and extension programmes (4%), while radio (0.5%) and television (0.5%) were the lowest used sources. Most of the RSs had a low utilization category (54%), while 13 % had a high utilization category. The mean UIRF score was 38 % (ranged from 05 % to 71%). The most preferred information sources by RSs were extension programmes (90%), RSs (85%), rubber traders (85%) and social media (70%). The most needed information by RSs is on rubber market prices (100%), followed by fertilizer application (92%), tapping (90 %), management of Tapping Panel Dryness (90%), disease management (85%) and sheet rubber making (80%). The perceived issues of accessing information by RSs highlighted that inadequate extension personnel (92 %), gets unreliable information (79 %), poor mechanism of distribution of Rubber Puwath (79 %) and lack of social media interventions (88%). RSs' age, level of education, rubber land extent, membership of the Thurusaviya rubber society and full-time farmer were significantly and positively correlated to UIRF. Both approaches of ICT based cyber extension and establishing para extension service are proposed strategies to improving the information accessibility of smallholder rubber sector.*

*Keywords: Information, Rubber farming, Socio economics, Social media, extension service*

## I. INTRODUCTION

Agriculture-related data that is transformed into meaningful and practical contexts for efficient decision-making in the agriculture sector is referred to as agricultural information, which is essential for boosting agricultural productivity (Aina et al., 2015: Tadesse, 2018) and a vital tool for the growth of farmers' livelihoods (Nwali et al., 2022). The governmental, non-governmental and private organizations have created and published agricultural information which is accessible in either primary or secondary form (Olaniyi, Adetumbi and Adereti, 2018). Information sources available to farmers include the internet, extension agents, mass media, contact farmers, traders, etc. (Ngathou et al., 2015; Olorunniyi et al., 2022).

Rubber Farming (RF) totally depends on the technical agricultural information which is produced and disseminated by the Rubber Research Institute of Sri Lanka (RRISL). Therefore, assessing the dissemination of information on RF into the smallholder rubber sector is a vital investment to enhance the productivity and overall performance of the industry. As, in the Sri Lankan context, the rubber smallholder sector is the most dynamic segment of the rubber sector as it represents 68 % of the total rubber extent of Sri Lanka and it contributes 69% to the national rubber production (MPI, 2022).

### A. Problem Statement and Importance of the Study

The new RF introducing areas in Moneragala district is the first intermediate zone where RF has been implemented in Sri Lanka. At present, the total extent of rubber smallholdings in Moneragala is about 4,402 ha, which involves 7,802 holdings in number (MPI, 2017).

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Gunarathne et al., 2020 reported that RSs' knowledge and adoption levels on RF is low in Moneragala. On this background, assessment of accessibility of RF information by RSs has a great impact on the decision-making tool to improve the knowledge and adoption levels of RF practices in these areas. The findings of the study also provide the necessary feedback mechanism for the media organizations, policy makers and the extension organizations for developing the strategies, ultimately improving the sustainability of RF in Moneragala district.

### B. Objectives of the Study

The main objective of this study was to assess the utilization of information on RF by RSs in Moneragala District. The specific objectives were to; i. Identification of the level of utilization of information sources, ii. Determine the information sources accessible to RSs in the study area iii. Perceived issues of accessing information by RSs, iv. Determine the information needs of RF, vi. Effect of smallholders' socioeconomic characteristics on usage of RF information, vi. To make recommendations to improve the information accessibility and usage of the smallholder rubber sector in Moneragala. The findings will assist in designing a more effective information dissemination system of RF in Moneragala, as well as have a greater impact on the economic development of the country.

## II. METHODOLOGY

### A. Study Area and Sampling

Moneragala District (6.7563° N and 81.2519° E) was selected purposely as it is a newly planted area of rubber in the country. It is located in Uva province and is the second largest district in Sri Lanka with an extent of 565,930 ha. It has Wet, Intermediate and Dry climatic conditions and many agro-ecological regions, out of which IL1c, IL2 and IM 2b are suitable for rubber cultivation, which are distributed among eight Divisional Secretariat (DS) divisions (Gunarathne et al., 2022).

Three hundred eighty-nine RHs (at a 90% confidence interval) were selected for the core study using stratified random sampling technique, based on the geographical distribution of RSs in all rubber growing DS divisions (8) in Moneragala. Adopting the Raosoft web-based sampling calculator

(http://www.raosoft.com/samplesize.html) for which stratification was applied on Twenty-three percent of the Grama Niladari (GN) divisions where the highest number of RSs could be found within each DS division were selected using the statistical sources, followed by random selection of the individual RSs according to the number in each GN division, so that the survey sample (23% of RSHs of each GN division) was randomly selected based on the number of RSs in each GN division.

### B. Measurement of Variables and Data Collection

The radio, television, newspaper, social media, *Rubber Puwath*, RSs, rubber extension officials (RDD/RRISL), input supply traders and extension programmes and rubber traders were identified as the sources of Utilization of Information on Rubber Farming (UIRF) by RSs, based on the preliminary study. The UIRF by RSs was measured using a utilization scale which comprises three different levels of utilization; Regularly (2 times/ three months), Sometimes (1 times/ three months) and Never (0 times/ three months). The level of UIRF was measured by constructing the UIRF score. The equation for UIRF scores for individual rubber smallholders is given in equation 1.

$$UIRF\ score = \frac{\sum_{i=1}^{n}(Obs_i)}{\sum_{i=1}^{n}(Maxs_i)} \ldots\ldots\ldots\ldots\ldots (1)$$

$Obs_i$ = Observed UIRF score for $i^{th}$ rubber smallholder
$Maxs_i$ = Maximum UIRF score for $i^{th}$ rubber smallholder

RSs were asked to mark their opinion on accessibility of RF information sources based on a five-point modified Likert-type scale (Strongly satisfy, satisfy, neutral, not-satisfy and strongly dis-satisfy) and asked to indicate the preferred information sources on RF which measured as most, moderate and least. In order to ascertain the information needs, an exhaustive list of possible information needs was prepared through meticulous review of literature, consultation with experts and extension personnel of RRISL. Responses of respondents were measured by not needed, needed and most needed. The respondents were asked to indicate the perceived issues of accessing information about RF. To understand how RSs' socioeconomic condition affects their

UIRF in Moneragala, the study variables and their relationships were conceptualized based on both theories of the uses and gratification and adoption-diffusion (Rogers, 2003), literature cited and views of the panel of experts of the rubber sector (Figure 01).

Studied independent variables and their description of measurements is shown in Table 01. A pre-tested questionnaire was used to collect primary data in 2022 (From March to August) by the author through personal interviews with the respondents, supplemented with secondary data from relevant sources.

### C. Data Analysis

The respondents were separated into three perception categories viz. highest, moderate and least easiness of accessibility of RF information based on perception score by using the confidence interval method and categorized the respondents as follows; Least easiness of accessibility group = Below X – 1.96.SE, Moderate easiness of accessibility group = Between X – 1.96.SE and Between X + 1.96.SE and Highest easiness of accessibility group = Between X + 1.96.SE.

Cumulative frequency distribution and percentage analysis were used to quantify groups. UIRF score ranged from 0 to 100. The Logistic regression of analysis was employed in understanding the relationship between UIRF scores and variables listed in Table 01. STATA version 19 was employed in statistical and descriptive analyses.

## IV. RESULTS AND DISCUSSION

### A. Key socio-economic Profile of the Rubber Smallholders

Male RSs (81%) were dominated. The age of RSs in the sample varied between 29 to 68 years and the majority fall to the age group of 51 to 55 years. Nobody pertained in the categories of no school or higher education qualified. Around 51% of the RSs in the sample have studied up to Ordinary Level, while 21% studied up to Advanced Level. The majority of RSs (93%) in the sample engaged in full-time farming in the study area. The majority of the sample (nearly 60 %) had 11 to 15 years of Rubber Farming (RF) experience. The majority (80%) of the holdings fall to the size of 20-35 acres. The average cultivated land size of RF in the sample was around 1.01 ac.
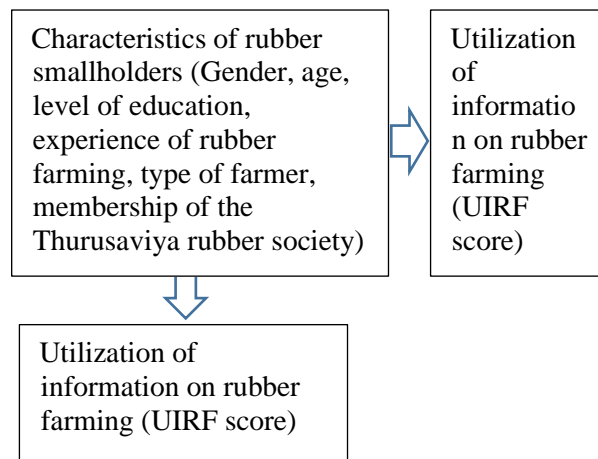


Figure 01: The conceptualization of study variables

Table 01: Independent Variables Used in the Analysis

| Variable | Description of measurement |
| --- | --- |
| Age | Years |
| Gender | Male = 1, Female = 0 |
| Level of education | Highest level of education completed |
| Experience of rubber farming | Years |
| Type of farmer | Full time farmer or not |
| Membership of the *Thurusaviya* rubber society | Yes=1, no=0 |

*B. Major Sources of Information Usage and Its' Accessibility by Rubber Smallholders*

Table 02 shows the major sources of information by RSs in the study area. The interpersonal channels have higher relative usage by RSs than mass media. Most of RSs (71%) said they get their information from RSs, 11% of respondents get information from the extension officers of Rubber Development Department (RDD) and Rubber Research Institute of Sri Lanka (RRISL). Agreeing with the results of Banmekeand Ajayi 2008; Opera, 2008 and Odoemenem and Obinne, 2010 noted that the extension agents and fellow farmers were major sources of information for farmers. Agricultural extension services play a key role in disseminating scientifically proven agricultural information to smallholders that will help them to solve their farming problems in rural farmer societies (Rehman et al., 2018). There are many ways to disseminate agricultural information, some of which include demonstrations, public gatherings, group discussions, talks, television, radio, movies, flyers, bulletins, letters, circulars (Olorunniyi et al., (2022). RSs were marked by their preference of RF information sources based on a three-point scale (high, moderate and low) in Table 04. However, 4% of RSs get information from participation in extension programmes and most of RSs (90%) preferred to participate in extension programmes (Table 03). However, in the study area, extension personnel mentioned that they were unable to conduct extension programmes during the last two years due to two major issues, namely; lack of funds and unavailability of extension personnel. Agwu and Abubakar (2009) stated that method demonstration is the most effective method of information dissemination on improved agricultural technologies among farmers. Most of the time, practical demonstrations were practiced by extension personnel. Thus, the extension agents (rubber development officer and rubber extension officer) were mentioned by the majority of them as it may be attributed to the interpersonal interaction and immediate feedback enjoyed by RSs.

Another 3% of RSs get information from input supply traders and 2% are rubber traders. The preference for getting information from rubber traders (85%) is the second most preferred information source (Table 03), while input supply traders were last (3%). So, centres of rubber traders can be developed as rubber information centers with the facilitation of ICTs. However, the utilization of radio, television and newspapers, like mass media, by organizations is at a very low level to disseminate information to the smaller-holder sector. These findings are verified by the studies of Yahaya (2002) and Tologbonse et al. (2006) which reveal that television, extension publications (bulletins, newsletters, posters and hand bills) were not considered as important sources of agricultural information among the farmers in Nigeria, while friends/neighbours/relations, extension agents and contact farmers were considered important in terms of availability and usage. The preference percentage of radio, television, newspaper and the *Rubber Puwath* are 60, 40, 15 and 55, respectively.

*Rubber Puwath* is published by RRISL in the Sinhala language with a simple form to familiarize scientific information among RSs. Although poor mechanisms are being used to distribute *Rubber Puwath* among the RSs in Moneragala, 1% of RSs are utilized as an information source. The utilization of social media is 5 % of the study sample. Most of the younger generation prefer to use social media to collect information about RF than older RSs. They created active WhatsApp groups to solve technical issues of RF. Seventy percent of RSs preferred information source is social media.

The mean UIRF score was 38 %, which ranged from 05 % to 71%. The level of UIRF is presented in Table 04. Nearly 50% of RSs in this study area consider the UIRF as the low utilization group. While, 13% of RSs consider it as a high utilization group, 33% of RSs consider it as a moderately utilized group. Based on these results, the overall UIRF presents an unsatisfactory in the study area.

As a summary, UIRF is not a satisfactory level based on evidence and more attention should be focused on developing strategies. These overall results show that more attention should be focused on developing strategies to enhance the utilization of information of RF, specially focusing on the social media which has high networking capacity, fastest and cost-effective method.

*C. Information Needs by Rubber Smallholders*

For information access to be effective, dissemination channels need to be oriented towards the user's needs and preference (Barbara

and White, 2001). The type of information needed by RSs in the study area is presented in Table 04. The result shows that the most needed information by RSs is on rubber market prices (100%), followed by fertilizer application (92%), tapping (90 %), management of Tapping Panel Dryness (90%), disease management (85%) and sheet rubber making (80%). They were least interested in information sheet rubber making (80%). The

reason could be that most of the RSs (56 %) produce latex for the market. This finding suggests that RSs made use of the information to increase rubber productivity and profit maximization. Extension personnel can provide effective transfer of technologies to their clients (RSs), if there is sufficient information on the information needs.

Table 02: Major Sources of Information usage by Rubber Smallholders

| Source of information | Usage (%) | | |
|---|---|---|---|
| | **Regularly** | **Sometimes** | **Never** |
| **Interpersonal channels** | | | |
| Rubber smallholders | 71 | 29 | 00 |
| Rubber extension officials | 11 | 68 | 21 |
| Input supply traders | 03 | 02 | 95 |
| Rubber traders | 02 | 10 | 88 |
| Participation of extension programmes | 04 | 12 | 84 |
| **Mass media** | | | |
| Radio | 0.5 | 0.5 | 99 |
| Television | 0.5 | 0.5 | 99 |
| Newspaper | 01 | 08 | 91 |
| Social media | 05 | 25 | 70 |
| *Rubber puwath* | 01 | 05 | 94 |

Table 03: The Level of Utilization of Information Sources by Rubber Smallholders

| Source of information | Perception on preference (%) | | |
|---|---|---|---|
| | **High** | **Moderate** | **Low** |
| **Interpersonal channels** | | | |
| Rubber smallholders | 85 | 05 | 10 |
| Rubber extension officials | 11 | 50 | 39 |
| Input supply traders | 03 | 07 | 90 |
| Rubber traders | 85 | 10 | 05 |
| Participation of extension programmes | 90 | 08 | 02 |
| **Mass media** | | | |
| Radio | 60 | 30 | 10 |
| Television | 40 | 50 | 10 |
| Newspaper | 15 | 60 | 25 |
| Social media | 70 | 05 | 25 |
| *Rubber puwath* | 55 | 10 | 35 |

Table 04: Type of Information Needed by Rubber Smallholders

| Areas of information needs | Smallholders (%) |
|---|---|
| Rubber market prices | 100 |
| Fertilizer application | 92 |
| Tapping | 90 |
| Management of *Tapping Panel Dryness* | 90 |
| Disease management | 85 |
| Sheet rubber making | 80 |

### D. Perceived Issues of Accessing Information by Rubber Smallholders

The perceived issues of accessing information by RSs highlighted that inadequate extension personnel (92 %), 79 % get unreliable information, poor mechanism of distribution of Rubber Puwath (79 %) and lack of social media interventions (88%). New recruits for extension staff is a crucial issue in Moneragala. This will directly affect the inadequate extension personnel, unreliable information and absence of experts. To prevent this situation, a para-extension approach can be suggested. Especially agrarian officers and contact RSs in rubber growing areas can be empowered through knowledge and skill of RF. Proper distribution channel of Rubber Puwath should be established through Thurusaviya rubber societies. Poor infrastructure for ICT continues to be a significant barrier to RSs to access and use of information, particularly those in remote areas. This study indicates that 80% of individuals are not utilizing ICT as an information source due to inadequate access and unavailability. ICT based cyber extension approaches should be implemented through Thurusaviya rubber societies.

### E. Effect of Socio-sconomic Characteristics of Rubber Smallholders on Utilization of Information

Socioeconomic characteristics are the position of an individual or group on the socioeconomic scale, which is defined by a combination of social and economic factors (Oduwole et al., 2022). The logistic regression results presented in Table 05 show the factors influencing the UIRF by RSs in Moneragala. The implication is that the dependent variables (UIRF score) included in the model (Adjusted $R^2$ = 0.67) accounted for 67% of the variations in the dependent variable. Accordingly, RF experience, level of education and rubber land extent have a positive relationship to utilization of information.

The level of education is positively and significantly related to UIRF ($> 0.05$). This result supports the claim made by Fagbohungbe and Longe (2009) that educated people have the capacity to use a variety of information sources. Education also makes it easier to access different types of information sources. More educated RSs can access and interpret the information from different sources. The extent of rubber land and experience of RF are positively related to UIRF score ($<0.05$). The majority of rubber land owners are small or medium-sized entrepreneurs and they're more interested in learning how to develop their rubber holdings further. Moneragala is a newly introduced rubber area, therefore experienced RSs find more information on RF for sustainability of RF.

The most extension professionals in developing countries are males and they frequently favour men in their extension work (Gunarathne et al., 2022). Matata et al. (2010) found that the extended message was biased against women. The most females (owners and their wives) (77%) of this study sample, participated in extension programs such as awareness programmes, workshops etc. However, the gender type of RSs does not affect ($> 0.05$) on their access to information about RF. The membership of the Thurusaviya rubber society, moreover influences RSs get to access to information, since information can be passed to a huge number of RSs at the same time through farmer groups and Thurusaviya rubber societies productively.

## IV. CONCLUSION

Extension personnel and experienced rubber smallholders were generally utilized than the other information sources, by rubber smallholders in Moneragala district. Extension programs were indicated as the most preferred information source. Television and newspapers were barely accessible and utilized by the rubber smallholders. To ensure regular availability/accessibility of extension personnel, efforts should be made to establish para-extension service technique. Proper distribution channel of *Rubber Puwath* and leaflets published by RRISL should be established on a regular basis through *Thurusaviya* rubber societies. Both approaches of ICT based cyber extension and establishing para extension service are proposed strategies to improve the information accessibility of smallholder rubber sector with the aim of developing the smallholder rubber sector.

Table 05: Logistic Regression of Analysis of the Effect of Social Economic Characteristics of Rubber Smallholders on their usage to Information

| Characteristics | Coefficient | Std. Err | z | P-value |
|---|---|---|---|---|
| Age | 0.106 | 0.0248 | 4.21 | 0.001* |
| Sex | 0.124 | 0.0658 | 1.40 | 0.300 |
| Level of education | 0.206 | 0.0246 | 4.31 | 0.000* |
| Experience of rubber farming | 0.309 | 0.0891 | 1.23 | 0.001* |
| Rubber land extent | 0.213 | 0.0567 | 1.56 | 0.001* |
| Type of farmer | 0.1052 | 0.0245 | 1.39 | 0.000* |
| Membership of the *Thurusaviya* rubber society | 0.1121 | 0.0223 | 1.51 | 0.001* |

Significant level *5%

## REFERENCES

Agwu, A. E and Abubakar. (2009) "Sources of Agricultural Information Used by Arable Crop Farmers in Isale Osun Farm Settlement, Osogbo L.G.A", *Journal of Agricultural Extension*, 13(1), pp. 7-11.

Aina, L. O., Kaniki, A.M. and Ojambo, J. B. (2015) "Agriculture Information in Africa", *Ibadan Third World Information Services,* 11(9), pp. 67-78.

Gunarathne P.K.K.S., Tennakoon T.M.S.P.K. and Edirisinghe J.C. (2020) "Strategies for Improving Rubber Productivity in Smallholder Rubber Farming: A Case Study in Moneragala District of Sri Lanka." *The Seventh International Conference on Multidisciplinary Approaches University of Sri Jayawardenapura, Gangodawila, Sri Lanka,* 9(1), pp. 53-64.

Gunarathne P.K.K.S., Tennakoon T.M.S.P.K., Edirisinghe J.C. and Jayasundara K.K.I., (2021) "Job satisfaction among public sector extension personnel in the smallholder rubber sector: Special focus on the Moneragala District of Sri Lanka", *Multidisciplinary International Research Symposium of Rajarata University of Sri Lanka,* 6(12*)*, pp. 39-41.

Gunarathne, P.K.K.S. et al. (2022) "Smallholder rubber farming based agro-tourism: Potential, attitude and challenges in Sri Lanka-A case study in Moneragala District", *Journal of Tropical Forestry and Environment,* 11(02), pp. 23-26.

Matata, P., et al. (2010) "Socio-economic factors influencing adoption of improved fallow practices among smallholder farmers in Western Tanzania", *African Journal of Agricultural Research,* 5(6), pp. 818-823.

Ministry of Plantation Industries (MPI). (2022) "Statistical Information on Plantation Crops 2017", *Ministry of Plantation Industries,* 7(6), pp. 100-120.

Ngathou, I. N., J. O. Bukenya and D. M. Chembezi. (2015) "Managing agricultural risk: examining information sources preferred by limited resource farmers", *Journal of Extension,* 44(6), pp. 10-12.

Nwali P. N., Sennuga S. O and Emeka, O. (2022) "Evaluation of Small-scale Women Farmers' Utilization of ICT in Accessing Agricultural Information in Gwagwalada Area Council, Abuja, Nigeria", *Green Reports,* 3(7), pp. 34-38.

Oduwole A. E., Sennuga S. O, Bako H. and Wilberforce, A. G. (2022) "Impact of Intensive Agricultural Training on Productivity of Smallholder Farmers: A Case Study of International Skill Acquisition Centre, Nasarawa State, Nigeria", *International Journal of Latest Research in Agriculture & Veterinary Sciences,* 04(01), pp. 18-24.

Olaniyi, O.A., Adetumbi A., and Adereti, J.G. (2018) "Information on maize production among rural

youths", *A solution for sustainable food security in Nigeria,* 7(3), pp. 10-13.

Olorunniyi A. A., Ezinne M. E., Osiboye, O. O. and Sennuga S. O. (2022) "Effect of social media in Enhancing Agricultural Extension among Farmers in Gwagwalada Area Council, Abuja", *Journal of Research in Science and Technology,* 3(4), pp. 24-32.

Rehman, F., Muhammad, I., Ashraf, I. (2018) "Effect of farmers' socioeconomic characteristics on access to agricultural information: Empirical evidence from Pakistan", *The journal of Animal and Plant sciences*, 23(1), pp. 324-329.

Rogers, E. M., (2003) "Diffusion of innovation". *An integrated approach to communication theory and research,* 5(3), pp. 432-448.

Tadesse, D. (2018) "Access and Utilization Agricultural Information by Resettler Farming Household", *The Case of MetemaWoreda, North Gender, Ethopia,* 4(2), pp. 184-187.

Tologbonse, E.B., Mesini O. and Tsado, J.H. (2006) "Farmers perception of sources of information in relation to adoption of improved technology by farmers in inland valley swamps of middle-belt zone of Nigeria", *Journal of Agriculture Extension,* 9(6), pp. 63-73.

Yahaya, M.K. (2002) "Gender and communication variables in agricultural information dissemination in two agro-ecological zones of Nigeria", *Research Monograph. Ibadan:Corporate Graphics Ltd,* 9(1), pp. 43-51.

# Spatiotemporal Variation of Pollutant Levels in the Sainthamaruthu Coastal Lagoon

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## Abstract

*Sainthamaruthu coastal lagoon is situated at the southern end of Kalmunai Municipal Council, which is one of the potential resources for waterfront development in Kalmunai and represents a typical geographical feature in the eastern part of Sri Lanka. However, due to various anthropogenic activities lagoon faces a threat of pollution. Identification of water pollutants in a lagoon is vital for conservation and sustainable utilization. The present study aimed to examine the spatiotemporal variations of surface water quality of Sainthamaruthu lagoon and to evaluate pollution levels of the lagoon concerning physicochemical water quality parameters. Data were collected biweekly in 2022 where the precise location of each location was recorded using a portable GPS unit. Samples were collected using clean high-density plastic bottles. The pH, water temperature, electric conductivity (EC), salinity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Total Solids (TS), Total Suspended Solid (TSS), turbidity, hardness, and alkalinity were tested and data were analyzed statistically to interpret the results. The results showed that the spatial variation in every location was fluctuating in all parameters with increasing and decreasing trends and temporal variation of all parameters have shown significant (p < 0.05) differences within the studied period except for turbidity, DO, TS, and alkalinity. This study concludes that the Sainthamaruthu lagoon has been polluted and measures should be taken to prevent the pollution for sustainable use of the lagoon in the future.*

*Keywords: Water Quality Parameters, Pollution, Spatiotemporal Variation*

## I. INTRODUCTION

Lagoons are shallow coastal water bodies that are isolated from the ocean by a string of barrier islands that run parallel to the beach. 13% of all coastal areas on Earth are made up of coastal lagoons, which are frequently altered by anthropogenic and natural factors (Kjerfve, 1994). The geology, geomorphology, monsoonal seasons, and other significant climatic elements are closely related to the creation, evolution, configuration, and distribution of lagoons in Sri Lanka (Silva *et al*, 2013).

Lagoons provide numerous resources for human use including goods, for example, food, water, fuel, medicine, and services like serving as natural barriers, fixing and sinking of carbon, and providing nursery and feeding grounds for important fish species. Despite all these benefits, most of the lagoons are experiencing multiple human pressures including over -exploitation of the resources, land reclamation for settlement or industrial development, urbanization, eutrophication, pollution, and hydrological modifications.

Sainthamaruthu Coastal Lagoon is situated in the south end of Kalmunai Municipal Council at the Sainthmaruthu village, and it is called Thona by the native language of the people (Jowsi, 2014). Thona is one of the potential resources for waterfront development in Kalmunai and represents a typical geographical feature in the eastern part of Sri Lanka. This water body functions as a drainage creek during the rainy season, while it is closed water in the dry season. The current scenario of the lagoon is on the verge of contamination, emits a bad smell to the surroundings, is highly polluted and deterioration of water quality due to, - the discharge of wastewater directly into the lagoon, outlets of stormwater drainage canals discharge untreated grey water into the lagoon, piles of solid waste

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dumped into the lagoon, stagnation of water and growth of aquatic plants. These causes are creating environmental pollution, mixing the contaminated water with groundwater so creating waterborne diseases, and creating a habitat for mosquito breeding, wells have adversarial impacts due to the seeping of the latrines into the water, creating foul odor so air pollution also has in the surrounding area and surrounding people are highly subjected to dengue, cholera and other infectious diseases. People who live close to the lagoon and other contaminated water sources frequently suffer from diarrhea and other infectious diseases. The main causes of disease transmission include the indiscriminate intake of groundwater that is very close to latrines, mixing contaminated water with groundwater, and connecting sewerage effluent to the groundwater. Well water, which is quite close to restrooms, is the primary cause of 70% of water-borne infections (Ameer, 2017). All these identified problems the lagoon need to remedied and treated for better human survival in the surroundings. So, to treat the lagoon the status of physico – chemical and biological parameters are needed to be known. In this view, the present study was conducted with the aims to analyzing spatial and temporal variations of pollutants in the Sainthamaruthu coastal lagoon and finding whether the water is polluted.

## II. METHODOLOGY

### A. Description of the Study Area
The study area of Sainthamaruthu lagoon is located at 7° 38' 88" latitude and 81° 84' 17" longitude in Karaithivu Divisional Secretariat (DS), Sainthamaruthu Divisional Secretariat (DS), and Kalmunai Tamil Divisional Secretariat (DS) area.

### B. Sampling
The precise location of each sampling point was determined according to the 500 m distance using a portable GPS unit (Figure 01). Five sampling points were selected and each point has three replicates. Readings were taken biweekly between July 2022 and September 2022. Samples were collected using clean high - density plastic bottles. Water samples for Biological Oxygen Demand (BOD) analysis were collected separately into aluminum foil - wrapped plastic bottles. Samples were kept in ice packs in coolers and transported to the laboratory and stored in a refrigerator at 4°C till analysis was completed. Standard procedures outlined by the Environmental Protection Agency (EPA, 1983) and American Public Health Association (APHA, 1998) were used to analyze water samples at the environmental laboratory, Department of Civil Engineering, Faculty of Engineering, South Eastern University of Sri Lanka (SEUSL) and Biosystems engineering laboratory, Faculty of Technology, SEUSL.
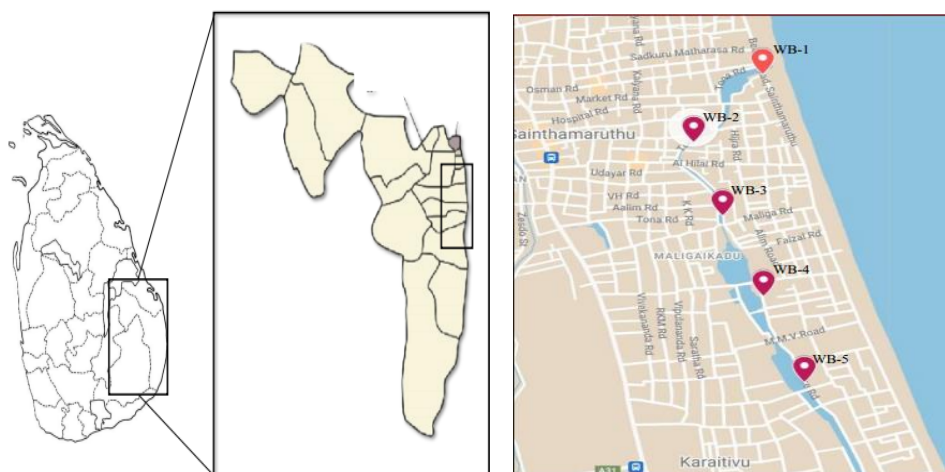


Figure 01: Sampling Locations

## C. Analysis

pH was tested using pH meter. Before testing meter was calibrated using three buffer solutions, they are pH 4.01, pH 7.00, and pH 10.01respectively. EC, Temperature, Salinity and TDS were tested using Multi- parameter analyzer (HANNA, H19829). The turbidity was measured using a turbidity meter (HACH, TL2350), which was calibrated using standard methods before taking the measurements. Total Solid (TS) and Total Suspended Solid (TSS) were analyzed by gravimetric method. DO is measured by using DO Meter (HANNA, HI 9146). A meter probe was slowly placed inside the aluminum foil wrapped bottles and reading was recorded directly. BOD was measured by using 5day incubation method. Initially dissolved oxygen content (DO1) of a particular sample was recorded. Then sample water bottles were incubated at $20^0$ C for 5 days. After 5 daysdissolved oxygen content (DO2) was measured and BOD was computed from the difference between the initial and final DO. Hardness was determined by the EDTA titrimetric method and it can be found by adding a small amount of a dye such as Erichrome Black T (EBT) is added to an aqueous solution and Ca++, Mg++ ions form chelated complexes of wine red colour with EBT. Alkalinity was determined by the titrimetric method. Descriptive analysis and one - way ANOVA were used for the statistical analyses of results obtained at a 95% confidence level using the Microsoft Excel 2013 package and SPSS (v.26).

## III. RESULTS AND DISCUSSION

### A. pH Variation

pH values in the present study were observed in the range of 6.80 to 7.42 and this values were below the standard level of 7.8 - 8.3 for aquatic water (CEA, 2001). The highest mean value was recorded in location 3 (7.32) and the lowest mean value was recorded in location 2 (6.84) in 1st and 3rd sampling time respectively (Table 02). However this variation was not significant ($p < 0.05$) among all locations. Moreover, 7.19 highest mean value was recorded in 1st week and it has a significant difference with in the weeks. As organic substances decay, carbon dioxide forms and combines with water to produce a weak acid called carbonic acid. A large amount of carbonic acid lowers the pH. This was demonstrated at sampling point 2. The values changed with time due to variations in temperature, salinity and biological activity.

Table 01: Temporal Variation of All Parameters

| Week | pH | Temperature | EC | Salinity | TDS | DO | BOD | Turbidity | TS | TSS | Hardness | Alkalinity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Week 1 | 7.19 ± 0.04[a] | 26.94 ± 0.11[b] | 676.27 ± 51.36[a] | 0.33 ± 0.03[a] | 337.47 ± 25.52[a] | 6.26 ± 0.29[a] | 6.36 ± 0.27[b] | 22.87 ± 4.74[b] | 517.67 ± 36.01[b] | 358.47 ± 14.18[b] | 357 ± 13.57[a] | 380.33 ± 17.05[a] |
| Week 2 | 6.98 ± 0.01[b] | 25.59 ± 0.05[c] | 317.13 ± 5.27[b] | 0.15 ± 0.00[b] | 158.53 ± 2.64[b] | 5.43 ± 0.18[b] | 6.89 ± 0.49[b] | 32.84 ± 5.63[ab] | 526.66 ± 39.60[b] | 461.40 ± 32.25[a] | 303 ± 9.11[b] | 347.00 ± 12.43[b] |
| Week 3 | 6.91 ± 0.02[b] | 27.45 ± 0.10a | 332.47 ± 5.46[b] | 0.16 ± 0.00[b] | 166.20 ± 2.85[b] | 5.77 ±0.25[ab] | 8.60 ± 0.46[a] | 39.83 ± 5.57[a] | 682.67 ± 67.16[a] | 384.40 ± 20.76[ab] | 312 ± 18.43[ab] | 360.67 ± 8.85[ab] |

Results are presented in the form of arithmetic mean ± standard error.

Table 02: Spatial Variation of pH

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | 7.06 ± 0.00[a] | 7.30 ± 0.06[a] | 7.32 ± 0.04[a] | 7.10 ± 0.10[a] | 7.16 ± 0.09[a] |
| 08.08.2022 | 6.97 ± 0.01[a] | 6.95 ± 0.0[a] | 7.00 ± 0.54[a] | 6.95 ± 0.05[a] | 6.99 ± 0.0[a] |
| 30.08.2022 | 6.97 ± 0.02[a] | 6.84 ± 0.0[a] | 6.92 ± 0.06[a] | 6.92 ± 0.02[a] | 6.91 ± 0.02[a] |

Results are presented in the form of arithmetic mean ± standard error.

### B. Temperature Variation

Analyzed data showed that the temperature fluctuation of the surface water of Saintamaruthu lagoon during the study period was varied with maximum and minimum temperature at 27.93°C and 25.22 °C respectively and it fell below the standard range of 28°C - 32°C (CEA, 2001). The highest mean value was recorded in location 3 (27.76°C) and the lowest mean value was recorded in location 5 (25.44°C) (Table 03). However this variation was not significant (p < 0.05) among all locations in the $1^{st}$ and $3^{rd}$ sampling time but there was a significant difference among the locations in the $3^{rd}$ sampling. In addition highest mean value 27.57 was recorded in $3^{rd}$ week and the lowest value was recorded 25.59 in $2^{nd}$ week. And it has significant with in the weeks.

### C. EC Variation

EC variation during the study period ranged from 287 – 956 µS/ cm. There was highest mean value was recorded in location 5 (906.33) and the lowest mean value was recorded in location 1 (295) in $1^{st}$ and $2^{nd}$ sampling weeks, respectively (Table 04). These variations were significant (p < 0.05) among all locations. Various industrial and urban activities with low volumes of water may have contributed to the high EC level in locations 5 and 3. Moreover highest mean value 676.27 was recorded in $1^{st}$ week and the lowest value 317.13 was recorded in $2^{nd}$ week. And it has been significant within the weeks.

### D. Salinity Variation

Results from the study indicated that salinity ranged from 0.14 to 0.47 PSU. The highest mean value (0.45) was recorded in location 5 and the lowest mean value (0.7) was recorded in location 5 at the $1^{st}$ and $3^{rd}$ sampling times, respectively (Table 05). The variation of salinity among all locations was significantly different (p < 0.05). Moreover, the highest mean value 0.33 was recorded in $1^{st}$ week and the lowest value 0.15 was recorded in $2^{nd}$ week. And it has been significant within the weeks. According to the statistical analysis salinity of the lagoon was below the acceptable range of 1-35 PSU because drainage channels were directly connected with the lagoon and stagnated. Also in the dry season there is no sea water intrusion therefore salinity was low.

### E. TDS Variation

TDS value has increased because of mud and natural materials. During the sampling period, the lagoon outfall was closed by sand, therefore the lagoon water had been stagnant so the TDS levels increased in many sample locations. Analyzed data showed that the TDS variation ranged from 143 to 478 mg/l and observed TDS values of lagoon water fell below the acceptable range of 450 -2000 mg/l for aquatic water (CEA, 2001). The highest mean value (453.33) was recorded in location 5 and the lowest mean value (147.33) was recorded in location 1 at $1^{st}$ and $2^{nd}$ sampling times, respectively (Table 06). This variation significantly differ among the locations (p < 0.05). Also highest mean value 337.47 and lowest mean value 158.53 were recorded in $1^{st}$ and $2^{nd}$ week respectively. These variations significantly differ within the weeks.

### F. DO Variation

Analyzed data indicate that DO was varied with the maximum and minimum levels at 7.64 and 3.98 mg/l respectively. The highest mean value (7.28) was recorded in location 3 and the lowest mean value (4.45) was recorded in location 4 at the $1^{st}$ and $3^{rd}$ sampling time, respectively (Table 07). There was a significant variation among all the locations (p < 0.05). In location 4, there was a low level of DO recorded, which may be the reason for the direct connection of drainage channels with the lagoon. High levels of organic content and microbial activities with a low volume of water may have been attributed to a low level of DO during the dry period. Highest mean value of 11.19 was recorded in the $3^{rd}$ week and the lowest mean value 9.38 was recorded in the $1^{st}$ week. However this variation was not significant among the weeks.

### G. BOD Variation

Unpolluted waters typically have a BOD value of 2 mg/L while those receiving wastewater may have values up to 10 mg/l or more (Chapman, 1996). The high BOD recorded in the current study is thus an indication of a large quantity of organic waste in the lagoon. BOD variation in the study period ranged from 4.48 to 11.12 mg/l. These levels exceeded the maximum acceptable limit of 5 mg/l for aquatic water (Brian, 2013). There was highest mean value was recorded in location 3 (10.14) and the lowest mean value was also recorded in location 3 (5.12) in the $3^{rd}$ and $2^{nd}$ sampling weeks, respectively (Table 08). There

was a significant variation among all the locations (p < 0.05). Moreover highest mean value of 8.60 was recorded in 3rd week and the lowest value of 6.36 was recorded in 1st week. And it has been significant within the weeks.

Table 03: Spatial Variation of Temperature

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | $26.76 \pm 0.40^a$ | $27.02 \pm 0.69^a$ | $26.53 \pm 0.11^a$ | $26.96 \pm 0.11^a$ | $27.42 \pm 0.09^a$ |
| 08.08.2022 | $25.79 \pm 0.08^a$ | $25.67 \pm 0.09^a$ | $25.60 \pm 0.12^a$ | $25.47 \pm 0.05^a$ | $25.44 \pm 0.12^a$ |
| 30.08.2022 | $26.78 \pm 0.21^b$ | $27.49 \pm 0.69^a$ | $27.76 \pm 0.98^a$ | $27.72 \pm 0.09^a$ | $27.48 \pm 0.04^a$ |

Table 04: Spatial Variation of EC

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | $603.67 \pm 34.93^b$ | $473.67 \pm 10.67^c$ | $896.00 \pm 32.15^a$ | $501.67 \pm 12.45^{bc}$ | $906.33 \pm 28.12^a$ |
| 08.08.2022 | $295 \pm 2.31^b$ | $303 \pm 2.73^b$ | $317 \pm 15.09^{ab}$ | $328.33 \pm 2.60^{ab}$ | $342 \pm 3.60^a$ |
| 30.08.2022 | $307 \pm 6.11^c$ | $324 \pm 5.51^{abc}$ | $323.33 \pm 10.48^{bc}$ | $350.67 \pm 5.78^{ab}$ | $355 \pm 3.46^a$ |

Table 05: Spatial Variation of Salinity

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | $0.29 \pm 0.01^b$ | $0.23 \pm 0.01^c$ | $0.44 \pm 0.02^a$ | $0.24 \pm 0.00^{bc}$ | $0.45 \pm 0.01^a$ |
| 08.08.2022 | $0.14 \pm 0.00^b$ | $0.14 \pm 0.00^{ab}$ | $0.15 \pm 0.01^{ab}$ | $0.16 \pm 0.00^{ab}$ | $0.16 \pm 0.00^a$ |
| 30.08.2022 | $0.14 \pm 0.00^c$ | $0.15 \pm 0.00^{abc}$ | $0.15 \pm 0.00^{bc}$ | $0.16 \pm 0.00^{ab}$ | $0.7 \pm 0.00^a$ |

Table 06: Spatial Variation of TDS

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | $302 \pm 17.56^b$ | $236.33 \pm 5.33^c$ | $444.67 \pm 16.92^a$ | $251 \pm 6.11^{bc}$ | $453.33 \pm 14.17^a$ |
| 08.08.2022 | $147.33 \pm 1.20^b$ | $152.00 \pm 1.52^b$ | $158.33 \pm 7.75^{ab}$ | $164.00 \pm 1.15^{ab}$ | $171.00 \pm 1.53^a$ |
| 30.08.2022 | $153.33 \pm 2.84^c$ | $162 \pm 3.00^{bc}$ | $161.66 \pm 5.24^{bc}$ | $175.33 \pm 3.18^{ab}$ | $178.66 \pm 2.73^a$ |

Table 07: Spatial Variation of DO

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | $6.63 \pm 0.53^{ab}$ | $5.56 \pm 0.71^{ab}$ | $7.28 \pm 0.10^a$ | $4.98 \pm 0.50^b$ | $6.83 \pm 0.36^{ab}$ |
| 08.08.2022 | $6.27 \pm 0.61^a$ | $5.51 \pm 0.05^{ab}$ | $5.68 \pm 0.09^{ab}$ | $4.73 \pm 0.10^b$ | $4.96 \pm 0.08^b$ |
| 30.08.2022 | $6.92 \pm 0.57^a$ | $5.62 \pm 0.20^{ab}$ | $5.84 \pm 0.25^{ab}$ | $4.45 \pm 0.09^b$ | $6.05 \pm 0.44^{ab}$ |

Table 08: Spatial Variation of BOD

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | $5.35 \pm 0.23^b$ | $6.24 \pm 0.38^{ab}$ | $5.84 \pm 0.25^{ab}$ | $6.61 \pm 0.69^{ab}$ | $7.76 \pm 0.36^a$ |
| 08.08.2022 | $7.75 \pm 0.24^{ab}$ | $6.25 \pm 0.20^b$ | $5.12 \pm 0.35^b$ | $5.79 \pm 0.51^b$ | $9.58 \pm 1.32^a$ |
| 30.08.2022 | $6.53 \pm 0.74^b$ | $8.36 \pm 0.69^{ab}$ | $10.14 \pm 0.51^a$ | $8.03 \pm 1.26^{ab}$ | $9.97 \pm 0.13^{ab}$ |

Table 09: Spatial Variation of Turbidity

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | $8.67 \pm 2.81^b$ | $11.28 \pm 3.01^b$ | $13.63 \pm 6.79^{ab}$ | $44.43 \pm 12.72^a$ | $36.33 \pm 5.24^{ab}$ |
| 08.08.2022 | $6.15 \pm 2.36^a$ | $39.33 \pm 16.19^a$ | $33.33 \pm 14.19^a$ | $50.55 \pm 9.37^a$ | $34.82 \pm 3.71^a$ |
| 30.08.2022 | $11.96 \pm 5.91^c$ | $25.59 \pm 4.27^{bc}$ | $36.14 \pm 3.07^b$ | $59.55 \pm 4.33^a$ | $64.93 \pm 3.45^a$ |

### H. Turbidity Variation

Analyzed data indicate that turbidity varied with maximum and minimum levels at 72.96 and 4.71mg/l respectively. The higher turbidity recorded at all locations, may be the reason for the large quantity of organic waste in the lagoon. The highest mean value was recorded in location 5 (64.93) and the lowest mean value was recorded in location 1 (6.15) in 1st and 3rd sampling weeks respectively (Table 09). However this variation was not significant ($p < 0.05$) among all locations in 2nd sampling time but there was a significant difference among the locations in 1st and 3rd sampling. In addition, the highest mean value of 39.83 was recorded in 3rd week and the lowestvalue of 22.87 was recorded in 1st week. And it has not been significant within the weeks.

### I. Total Solid Variation

Results from the study indicate TS to range from 200 to 1200 mg/l. The highest and lowest mean values were recorded in location 2 at 3rd and 1st Sampling time, respectively (Table 10). The variation of TS among all locations was not significant ($p < 0.05$) in 2nd and 3rd sampling time. However, there was a significant difference in 1st sampling time. Moreover, the highest mean value of 682.67 was recorded in 3rd week and the lowest value of 517.67 was recorded in 1st week. And it has not been significant with in the weeks.

### J. Total Suspended Solid Variation

TSS was varied with the maximum and minimum level at 683 and 245 mg/l, respectively and these values fall above the acceptable limit for aquatic water bodies of 25 mg/l (Gadhia, Surana and Ansari 2012). The highest mean value was recorded in location 3 (536.66) and the lowest mean value recorded in location 1 (294) in the 2nd and 3rd sampling weeks, respectively (Table 11). However this variation has not been significant ($p < 0.05$) among all locations. In addition highest mean value of 461.40 was recorded in 2nd week and the lowest value of 358.47 was recorded in 1st week. And it has significantly different with in the weeks.

### K. Hardness Variation

Excessive amounts of precipitation cause abundant outflow of fresh water into lakes and it decrease the hardness of water. Analyzed data indicate that hardness was varied with maximum and minimum levels at 230 and 555 mg/l,

respectively. The highest mean value was recorded in location 4 (405) and the lowest mean value was recorded in location 1 (248.33) in 1st and 2nd sampling weeks, respectively (Table 12). These variations were significant ($p < 0.05$) among all locations in 1st and 3rd sampling time. However this variation is not significant among the locations in 2nd sampling. In addition highest mean value 357 was recorded in 1st week and the lowest value was recorded 303 in 2nd week. And it has significantly different with in the weeks.

### L. Alkalinity Variation

Alkalinity is important for fish and aquatic life because it protects or buffers against pH changes. According to the analyzed data the highest mean value recorded was in location 5 (436.67) and the lowest mean value recorded was in location 1 (280) in 1st and 2nd sampling weeks respectively (Table 13). This variation was significant ($p < 0.05$) among all locations. Moreover, the highest mean value of 380.33 was recorded in 1st week and the lowest value of 347.00 was recorded in 2nd week. However this variation was not significant ($p < 0.05$) among the weeks.

### IV. CONCLUSION

The results of the study revealed that, the quality parameters tested slightly exceeded the standard levels for aquatic systems according to the spatial and temporal distribution. pH, temperature, salinity, and TDS are below the standard level and DO, BOD, turbidity, TSS, hardness and alkalinity are above the standard level. Spatial variation of every location shows that there were fluctuations in all the parameters with increasing and decreasing trends. EC, salinity, TDS, DO, BOD, hardness, and alkalinity significantly different among all the locations. Temporal variation of all parameters has significant difference within the weeks except turbidity, Dissolved Oxygen, Total Solids, and alkalinity. The variation observed for water quality parameters may be due to the influence of various factors such as, pollution from municipal, industrial, and agricultural runoff, discharge of wastewater directly into the lagoon, stagnation of water and growth of aquatic plants, climate Central Environmental Authority. Factors, lack of public awareness inadequate service of solid waste collection and so on. Since there are spatial and temporal fluctuations in quality parameters, this study suggests that regular

monitoring is essential to conserve this aquatic system.

Table 10: Spatial Variation of TS

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | 447 ± 116.54 [ab] | 375 ± 46.58[b] | 547 ± 18.48 [ab] | 533.33 ± 35.36 [ab] | 686 ± 28.51 [a] |
| 08.08.2022 | 500 ± 0.00[a] | 400 ± 57.74 [a] | 466.66 ± 120.18 [a] | 700 ± 57.73 [a] | 566.66 ± 88.19 [a] |
| 30.08.2022 | 766.66 ± 33.33 [a] | 846.66 ± 181.23 [a] | 666.66 ± 218.58 [a] | 400 ± 115.47 [a] | 733.33 ± 66.66 [a] |

Table 11: Spatial Variation of TSS

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | 323.33 ± 41.64 [a] | 407.33 ± 8.01 [a] | 365.33 ± 22.26 [a] | 378 ± 24.58 [a] | 318.33 ± 36.17 [a] |
| 08.08.2022 | 442 ±78.34 [a] | 491.66 ±104.08 [a] | 536.66 ± 60.09 [a] | 484.66 ± 56.64 [a] | 352 ±53.61 [a] |
| 30.08.2022 | 294 ± 5.29 [a] | 388.66 ± 45.04 [a] | 453.33 ± 52.68 [a] | 390.66 ± 46.41 [a] | 395.33 ± 39.28 [a] |

Table 12: Spatial Variation of Hardness

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | 325 ± 2.89 [a] | 358.33 ± 12.02 [a] | 376.67 ± 24.21 [a] | 405 ± 33.29 [a] | 320 ± 45.37 [a] |
| 08.08.2022 | 248.33 ± 1.66[b] | 296.66 ±18.33 [b] | 316.66 ± 1.66 [a] | 331.66 ±16.91 [a] | 321.66 ± 9.28 [a] |
| 30.08.2022 | 278.33 ± 1.66 [a] | 385 ± 85.78 [a] | 288.33 ± 29.20 [a] | 301.66 ± 6.01 [a] | 306.66 ± 7.26 [a] |

Table 13: Spatial Variation of Alkalinity

| Sampling date | Location 1 | Location 2 | Location 3 | Location 4 | Location 5 |
|---|---|---|---|---|---|
| 20.07.2022 | 285 ± 40.10 [b] | 371.67 ± 1.67 [ab] | 393.33 ± 8.33 [ab] | 415 ± 15.0 [a] | 436.67 ± 37.68 [a] |
| 08.08.2022 | 280 ± 2.88 [b] | 345.00 ±7.63 [b] | 353.33 ±31.79 [ab] | 383.33 ±32.45 [a] | 373.33 ± 1.66 [ab] |
| 30.08.2022 | 308.33 ± 1.66 [b] | 378.33 ± 15.89 [a] | 365 ± 24.66 [ab] | 368.33 ± 7.26 [ab] | 383.33 ± 1.67 [a] |

REFERENCS

Ameer. F.M.L. (2017) "Water-borne diseases and their challenges in the coastal of Ampara district in Sri Lanka", *World News of Natural Sciences WNOFNS,* 9(2), pp. 7-18.

Brian, O. P.G. 2013, "Partial Listing of General Surface Water Physical and Chemical Standards", *Stream Water Quality*, 5(1), pp. 3-7.

Chapman, D.V. (1996), "Water quality assessments: a guide to the use of biota, sediments and water in environmental monitoring", *Cambridge University Press*, 6(3), pp. 111-126.

Gadhia, M., Surana, R. and Ansari, E. (2012). "Seasonal Variations in Physico-Chemical Characterstics of Tapi Estuary in Hazira Industrial Area". *Our nature,* 10(1), pp. 21-27.

Jowsi. A.J.A.H. (2014) "The project proposal for the urgent environmental remediation of coastal Lagoon at Sainthamaruthu", *The Department of Coastal Conservation and Coastal Resource Management*, 2(1), pp. 1-18.

Kjerfve, B.(1994) "Coastal Lagoons. In Coastal Lagoon Processes", *Elsevier Oceanography Series*, 60(9), pp. 1-8.

Silva, E. I. L., Katupotha, J., Amarasinghe, O., Manthrithilake, H. and Ariyaratna, R. (2013) "Lagoons of Sri Lanka", from the origins to the present. Colombo, *International Water Management Institute,* 2(1), pp. 1-122.

# Morbidity Variations in Jaffna Society - A Pre-COVID Scenario Against – Regional Disparity and Socio-Economic Status

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## Abstract

*This study focuses on regional variations and socio-economic differentials of morbidity that prevailed in Jaffna society during a period prior to Covid-19 pandemic. A sample of 6388 persons of 1123 derived families of siblings of the sample of Jaffna Socio-Economic Health Study was followed. The incidence and prevalence of acute and chronic illnesses reported during 2018 were subjected to statistical analysis. In addition, various treatments, including medical and surgical admissions, by clinical and hospital episodes were recorded and analyzed to see the intensity of health issues. Correspondence analysis was applied to see relationships between "groups of diseases" and "types of treatments" to explore regional variations and socioeconomic differentials in Jaffna society. Clear pictures of groups of diseases were found for current and future research for comparative analysis in post-Covid situation that will be included with the major episodes of respiratory diseases, popularly known as Corona. The gravity and intensity of acute and chronic diseases such as infections, parasitic diseases, neoplasms, diseases of endocrine-immune mechanism-nutritional-metabolism etc. reported on the patients were analyzed and reported. Impacts on the severity, by geographical variations and socio-economic differentials, of Jaffna society required health services are clearly emphasized. Specific attention is drawn to the health professionals from this study in the Jaffna society that the people who had already been affected due to Respiratory system diseases, Circulatory system diseases and Diseases of the immune mechanism were considerably high and would be vulnerable in future Covid research.*

*Keywords: Pre-Covid Scenario, Socio-economic status, Regional disparity, Jaffna Socio-Economic Health Study (JSEHS), International Statistical Classification of Diseases (ISCD, Correspondence Analysis*

## I. INTRODUCTION

Health conditions against socioeconomic statuses of Jaffna society are being reported using statistical analysis, initially by a two-stage sample survey of 1999 and recently by a Follow-Up study conducted during 2018-2019 on the families of siblings of the original study. WHO prescribed that the well-being of a human cohort is defined by health dimensions "Physical", "Mental" and "Social" Health (Breslow, 1972). Physical disabilities of Jaffna society were followed up and outcomes were reported (Elankumaran, 2018, 2019). Mental health conditions were also followed up, and outcomes were reported (Elankumaran, 2020, 2021). The outcomes of Health by Incidence and Prevalence of Diseases with connected Hospital Episodes followed-up are reported in this paper.

Tropical diseases were given more attention during the last four decades to show the conditions of societies. In contemplating illness phenomena, invoking the concept of disease is customary. This notion and derivatives, such as the International Statistical Classification of Diseases (ISCD), consider pathological phenomena. Long prevalent traditions in thought have fostered such separation, tending to make categorical distinctions within the human world. Studies of the geographical distribution of morbidity have focused more on healthcare professionals (Jenkins, 1983). Hence, we consider our administrative DS divisions for one basis of classification. It is also our objective to see the relationship between health conditions and socio-economic status. Hence, we use the established socio-economic groups for classification and comparison (Elankumaran, 2003).

Tropical diseases are given more attention as they are directly related to socio-economic status of people. The morbidity problems arise in Jaffna mainly due to socio-cultural beliefs and behaviors. In colloquial speech, 'acute' tends to indicate

something intense, whereas 'chronic' implies severity. Thus, acute means an ending with a finite duration, which classically culminates in a crisis. On the other hand, chronic, which is derived from time, indicates long continued. The prevalence of chronic conditions may be high, but their incidence is relatively low.

ISCD is based on components of sequence being variously and severally identified. Provision for certain non-sickness related contacts has been made ever since the 6th revision of ICD, and this aspect has been tackled in the 9th and later revisions. Statistical classification encompasses the entire range of morbid conditions within a manageable category. The ICD-10 guides recording and coding morbidity, specifically the selection of a single need for presenting morbidity statistics. This leads to include two and three-digit classification of codes of diseases. Various possible solutions were envisaged, one of which is called core classification with a series of modules. This is called three-character main and four-character sub-classifications.
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## II. MORBIDITY STUDIES - A LITERATURE REVIEW

Analysis of social causes of mortality by hypertension diseases was investigated using demographic, social, and economic data in Massachusetts (Jenkins, et al., 1979), revealing that low education was the main cause of excess hypertensive mortality. The occurrence of diarrhea in children in the Republic of Congo was studied with socio-economic, environmental, demographic, and behavioral factors in a cross-sectional study. The findings underscored the potential impacts of educational intervention on the occurrence of diarrheal disease (Mock et al.,1993). The episodes of morbidity over a six-month period were recorded in a district of Dogon community with health, educational services, socioeconomic status, and hygienic conditions. It was found that the type of illness and duration of treatments were closely associated with all these factors (Coppo et al., 1992).

The relationship between social-economic-family events and hospital admissions was studied in a cohort in New Zealand. A consistent association between socioeconomic factors and morbidity rates was discussed (Fergusson et al., 1986).

Differences in health status between employed men and women were examined in Hawaii. Socio-demographic and occupational variables were considered. Employed women reported more problems than employed men, especially acute conditions and those requiring more health services (Kodama et al., 1991). Women reported a limiting long-standing illness more than men in a study carried out to see social class differences in illness (Rahkonen and Lahelma, 1992). Social class differences show a decline in CHD in New Zealand men (Kawachi et al., 1991). Dietary habits in households had more influence on mortality in relation to CHD (Morgan et al., 1989; Janice and Janet, 1990; Porrini et al., 1991). Socio-cultural factors have shown a higher association with 'Ischemic Heart Disease' (IHD) in Belgium (Lagasse et al. 1986). A study in Hong Kong with three major cardiovascular diseases (IHD, Hypertension, and Cerebrovascular) revealed that a higher risk of death by IHD is associated with a higher level of socioeconomic status (Wong and Donnan, 1992).

Malaria and diarrheal disease patterns were related to environmental and socioeconomic variables at the household level (Lenz, 1988). In the South-Asian context, it is proved in Pakistan that infectious and parasitic diseases are more prevalent in poor socioeconomic groups due to poor housing conditions, environmental sanitation, water supply, etc. (Zaidi, 1988). An integrated household survey used to study infant survival in Pakistan (Agha, 2000), revealed that access to safe water, sanitation, and socioeconomic variables influenced the infant survival. A morbidity survey in a small area within the present study area of the Jaffna peninsula by Sivarajah (1988) reveals that dysentery, diarrhea, cough and fever, passed roundworms, scabies, and measles were highly incidental and prevalent in that study area. Cancer, pulmonary tuberculosis and mental illness were selected to study the prevalence. Cross-tabulations of the selected diseases were carried out in this study. A study in New Zealand (Pearce et al., 1983) revealed that the classification of diseases against administrative divisions was useful for officers like 'Medical Officers of Health (MOOH)' to take remedial measures for prevention and control of epidemics.

## II. METHODOLOGICAL ISSUES

We used individuals as cases for collecting morbidity data. Our methodology is framed to record all morbidity details of family members from January to December 2018, that is, one year-period immediately before the Covid-19 pandemic scenario. We classify the morbidity to explore the nature of consequences after a decade of war concluded in 2008. Hence, the influences of war affect, and its atmosphere are minimized or absent.

### A. Data Used in the Present Study

The ISCD was the basis for collecting data, mainly tropical diseases of Jaffna society. We consider the history of diseases in the study sample retrospectively. The role and limitations of retrospective investigations of the diseases were well documented (Mantel and Haenszel, 1959). Statistical methods were employed for analyzing retrospective study data of diseases and the family backgrounds measured by a number of socioeconomic factors. In our original study JSEHS-1999, 23 important socioeconomic variables were used to establish four socioeconomic classes. Table 01 gives major categories of diseases. We selected the diseases relevant to Jaffna society from ICD and compiled them with a three-character core classification that included four-character sub-classifications. The diseases which required medical or surgical treatments were only collected.

We also recorded the number of admissions in clinics and hospitals that required treatments, separately for medical, surgical, and other types, and the total number of days spent on all treatments for all diseases. The list of variables in this study is as follows.

**Morbidity**: ICD codes of Diseases reported by Individuals

Hospital Episodes : Number of Medical admissions (NMeAd), Number of Surgical admissions (NSuAd), Number of Psychiatric admissions (NPsAd), Number of Other admissions (NOtAd), and Total number of days spent in the above admissions (Tot Day).

### B. Statistical Methods

Classification against socioeconomic groups serves the purpose of achieving measures related to primary health care. Geographical classification is fundamental to understanding disease etiology (Lenz, 1988). We described the demographic features of the entire sample of individuals using age and sex distributions. Our statistical method is cross-tabulation of diseases against four socio-economic groups and six DS divisions. The administrative boundaries of the six divisions are more or less the same as those of the six MOH Divisions, covering the study area.

Table 01: The Summary Codes of the International Classification of Diseases

| No | Description of the Classes of Diseases | ICD Code |
|----|----------------------------------------|----------|
| 1 | Infectious and Parasitic Diseases | A00 – B99 |
| 2 | Neoplasms | C00 – D48 |
| 3 | Diseases of Blood and Blood forming Organs and Immune Mechanism | D50 – D89 |
| 4 | Endocrine, Nutritional and Metabolic Diseases | E00 – E90 |
| 5 | Mental and Behavioral Disorders | F00 – F99 |
| 6 | Diseases of the Nervous System | G00 – G99 |
| 7 | Diseases of the Eye and Adnexa | H00 – H59 |
| 8 | Diseases of the Ear and Mastoid process | H60 – H95 |
| 9 | Diseases of the Circulatory System | I00 – I99 |
| 10 | Diseases of the Respiratory System | J00 – J99 |
| 11 | Diseases of the Digestive System | K00 – K93 |
| 12 | Diseases of the Skin and Subcutaneous System | L00 – L99 |
| 13 | Diseases of the Musculoskeletal System and Connective tissue | M00 – M99 |
| 14 | Diseases of the Genito-Urinary System | N00 – N99 |

Incidence and prevalence are two kinds of rates for measuring diseases. An '**incidence rate**' for a given event is the number of new occurrences in a specified period, as a ratio of the population at risk of experiencing the event during the same period. A '**prevalence rate**' is the ratio of total number of individuals who have an attribute or disease at a particular time or during a particular period of time to the population at risk of having the attribute or disease. Incidence rates may allow an individual to be counted more than once as a case.

Essentially, an incidence rate is an expression of the average frequency of occurrence of an event in a population.

At the second stage of analysis, we constructed a frequency table for the occurrence of groups of diseases and carried out correspondence analysis against the socio-economic groups and DS divisions. We constructed cross-tabulated frequency distributions of various hospital admissions to show the intensity of the reported diseases. Finally, we analyzed total number of days spent by individuals in hospitals to show the severity of diseases. This will also show the usage of health services. Again, correspondence analysis was suitable against socioeconomic groups and DS divisions.

## III.  RESULTS AND DISCUSSION

Our data analysis is defined with 6388 individual subjects in the sample. It is now proper to show the distributions of demographic features. Age-sex distribution of the sample of individuals is used to construct a population pyramid, given in Figure 01, which shows the basic demographic structure of the study population. This figure shows that the number of youths aged 21 to 45 years is comparatively lower than in other groups. Most youths have left their families for various purposes including educational, political and economic reasons. It also clearly shows that the life expectancy of the people varies between 61 and 80 years, on average 71.
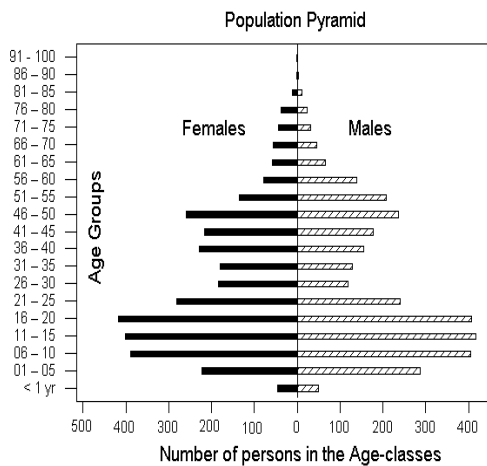


Figure 01: Age-sex Distribution of 6388 Persons in the Sample.

## A.  Incidence and Prevalence of Various Groups of Diseases

### 1)  Infectious and Parasitic Diseases

Infectious diseases are sub-grouped and named as: Intestinal infectious disease (A00-A09), Tuberculosis (A15-A19), Certain zoonotic bacterial diseases (A20-A28), Other bacterial diseases (A30-A49), Infections with a predominantly sexual mode of transmission (A50-A64), Other spirochactal diseases (A65-A69), Other diseases caused by chlamydiae (A70-A74), Rickettsioses (A75-A79), Viral infections of the central nervous system (A80-A89), and Arthropod-borne viral fevers and viral haemorrhagic fevers (A90-A99). The relevant diseases for the Jaffna society are listed in Table 02, and the occurrences of such diseases are classified against DS divisions and SE groups.

Table 02: Frequency Distributions of the Incidence of Infectious Diseases by DS Divisions and Socio-economic Groups

| Disease ICD Code | DS Divisions | | | | | | SE Groups | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAFF | NALL | VASW | VAWE | VASO | VAEA | R | UM | LM | P | UK | |
| A00 | 0 | 0 | 1 | 4 | 0 | 1 | 0 | 4 | 1 | 1 | 0 | 6 |
| A01 | 33 | 46 | 36 | 18 | 32 | 30 | 20 | 54 | 55 | 63 | 3 | 195 |
| A04/08 | 1 | 1 | 2 | 2 | 1 | 1 | 0 | 2 | 2 | 4 | 0 | 8 |
| A05/06 | 8 | 12 | 4 | 3 | 4 | 8 | 0 | 15 | 17 | 7 | 0 | 39 |
| A09 | 24 | 51 | 25 | 35 | 41 | 30 | 3 | 43 | 44 | 110 | 6 | 206 |
| A15-18 | 2 | 5 | 5 | 2 | 3 | 5 | 1 | 8 | 5 | 8 | 0 | 22 |
| A30 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| A33/34 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 3 |
| A37 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 2 | 1 | 2 | 0 | 5 |
| A41 | 3 | 2 | 0 | 3 | 0 | 0 | 2 | 1 | 4 | 1 | 0 | 8 |
| A46 | 1 | 0 | 1 | 3 | 1 | 3 | 0 | 0 | 3 | 6 | 0 | 9 |
| A48 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| A51/64 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 2 |
| A80 | 1 | 0 | 3 | 0 | 2 | 1 | 0 | 3 | 3 | 1 | 0 | 7 |
| A82 | 0 | 1 | 1 | 0 | 0 | 2 | 0 | 0 | 3 | 1 | 0 | 4 |
| A83/86 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 |
| A90 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| Total | 76 | 124 | 80 | 72 | 86 | 83 | 26 | 133 | 143 | 209 | 10 | 521 |

(R – Rich, UM – Upper Middle, LM – Lower Middle, P – Poor, UK – Unknown)

Incidence of infectious diseases in the respective DS divisions are 82.6, 100.5, 88.7, 72.9, 80.5 and 64.9 per 1000 persons. This reveals that infectious diseases are more prevalent in the Nallur DS division. The next highest rate is the Valikamam south-west division. The incidence of infectious diseases in the respective socioeconomic groups is 49.2, 77.1, 64.9, and 113.1 per 1000 persons. This reveals that infectious diseases are more prevalent in the poor SE group, which is much higher than middle SE groups and very much higher than the rich group. The overall incidence rate of the region seems to be 81.5 per 1000 persons.

If we consider specific diseases, '**typhoid**' (A01) and '**diarrhea**' (A09) are more prevalent in Jaffna society. The incidence rates of these diseases are 30.5 and 32.2 per 1000 persons. It is interesting to note that the incidence of Typhoid fever is higher in the rich SE group (37.8) than in the poor SE group (34.1). However, the incidence rate of Diarrhea is higher in the poor SE group (59.5) compared to the rich SE group which is only 5.7 per 1000 persons. The incidence of '**bacterial food-borne intoxications/amoebiasis**' (A05/A06) and '**tuberculosis**' (A15-A18) also seem to be prevalent. The incidence rates of these diseases are 6.1 and 3.4 per 1000 persons. While the former is more prevalent in middle SE groups, tuberculosis is more prevalent in poor and upper middle SE groups. The regional variations on these diseases are not significant. It is also relevant to mention here that some other infectious diseases such as '**intestinal infections**' (A04/08), '**septicaemia**' (A41), '**erysipelis**' (A46), and 'Acute **poliomyelitis**' (A80), which are slightly prevalent. The prevalence rates are 1.2, 1.2, 1.4 and 1.1 per 1000 persons.

Parasitic diseases are sub-grouped and named as: Viral infections (B00-B09), Viral hepatitis (B15-B19), Human immunodeficiency virus (HIV) disease (B20-B24), Other viral diseases (B25-B34), Mycoses (B35-B49), Protozoal diseases (B50-B64), Helminthiases (B65-B83), Pediculosis, acariasis & other infestations (B85-B89), Sequelae of infectious & parasitic diseases (B90-B94), Bacterial, viral, & other infectious agents (B95-B97), and Other infectious diseases (B99). The reported diseases in Jaffna society are listed against DS divisions and SE groups in Table 03.

Incidence rates of parasitic diseases in the respective DS divisions are 219.5, 225.3, 350.3, 358.6, 270.6 and 277.2 per 1000 persons. These results reveal that the parasitic diseases are more prevalent in the western parts, covering Valikamam's south-west and west divisions. Rural zones Valikamam south and east also seem to have higher incidence rates. However, the rates in the urban zones Jaffna and Nallur are relatively low but reasonably high. The overall incidence rate of parasitic diseases is 280.7 per 1000 persons. The incidence rates for the SE groups are 115.5, 308.4, 240.1 and 341.9 per 1000 persons. This reveals that parasitic diseases are more prevalent in poor and upper-middle groups.

Table 03: Frequency Distributions of the Incidence of Parasitic Diseases by DS Divisions and Socio-economic Groups

| Disease ICD Code | DS Divisions | | | | | | SE Groups | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAFF | NALL | VASW | VAWE | VASO | VAEA | R | UM | LM | P | UK | |
| B01 | 6 | 13 | 16 | 27 | 27 | 41 | 5 | 3 | 3 | 5 | 5 | 130 |
| B05 | 4 | 1 | 5 | 11 | 1 | 7 | 0 | 1 | 9 | 0 | 1 | 29 |
| B09 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 6 | 1 | 7 | 0 | 1 |
| B19 | 5 | 17 | 8 | 6 | 11 | 8 | 0 | 0 | 5 | 0 | 1 | 55 |
| B26 | 2 | 9 | 4 | 1 | 4 | 7 | 0 | 1 | 0 | 1 | 0 | 27 |
| B30/33 | 3 | 5 | 4 | 0 | 3 | 1 | 0 | 9 | 1 | 6 | 0 | 272 |
| B50.0 | 169 | 200 | 240 | 265 | 212 | 255 | 50 | 419 | 90 | 417 | 27 | 1613 |
| B51 | 2 | 8 | 16 | 16 | 13 | 6 | 1 | 5 | 4 | 4 | 2 | 41 |
| B54 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 3 | 5 | 0 | 61 |
| B74.0 | 23 | 25 | 53 | 24 | 13 | 23 | 0 | 15 | 92 | 27 | 0 | 2 / 14 |
| B76 | 5 | 13 | 13 | 21 | 13 | 23 | 4 | 1 | 1 | 8 | 2 | 21 / 88 |
| B77 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 3 | 7 | 0 | 1 | 33 |
| B86 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 7 | 0 | |
| B88 | | | | | | | | 24 | 3 | 17 | | |
| B99 | | | | | | | | 119 | 26 | 371 | | |
| Total | 202 | 278 | 316 | 354 | 289 | 354 | 61 | 532 | 529 | 632 | 39 | 1793 |

(R – Rich, UM – Upper Middle, LM – Lower Middle, P – Poor, UK – Un known)

Higher incidences of parasitic diseases are seen compared to infectious diseases. It is clear that infection of 'malaria-fever' (B51) is more dominant compared to other parasitic diseases.

Malaria is more prevalent in the poor and upper-middle SE groups. It is important to note that unspecified malaria (or 'chronic malaria') (B54) also reported. The overall incidence rate seems to be 9.5 per 1000 persons. It is clear that the western parts of the peninsula are affected by chronic malaria. This is also seen as more prevalent in the poor SE group, with an incidence rate of 15.1 per 1000 persons compared to other SE groups. Further, the incidence of 'cerebral malaria' (B50.0) is reported with overall rate of 2.5.

It is relevant to mention other parasitic diseases which are prevalent. The overall incidence rates of 'chickenpox' (B01), 'measles' (B05), 'viral hepatitis' (B19), and 'mumps' (B26) are 20.3, 4.5, 8.6, and 4.2 per 1000 persons. These diseases are most common in Jaffna society. However, chickenpox is more incidental compared to others. Further, the incidence rates of 'hookworm diseases' (B76), 'roundworm infection' (B77), and 'scabies' (B86) seem to be not very low. The rates are 2.2, 3.3, and 13.8 per 1000 persons. These diseases are not visible in the rich SE group but are prevalent in other groups. The incidence rate of scabies in the poor SE group 20.0 seems significant.

2) *Neoplasms, Diseases of Blood and Immune Mechanism & Endocrine, Nutritional and Metabolic Diseases*

Three types of neoplasms are malignant, in-situ and benign. Malignant neoplasms (cancer) are sub-grouped as Malignancy in the lip, oral cavity & pharynx (C00-C14), digestive organs (C15-C26), respiratory & intrathoracic organs (C30-C39), bone & articular cartilage (C40-C41), skin (C43-C44), mesotheliel & soft tissue (C45-C49), breast (C50), female genital (C51-C58), male genital (C60-C63) organs, urinary tract (C64-C68), eye, brain & central nervous system (C69-C72), thyroid & endocrine glands (C73-C75), ill-defined, secondary & unspecified sites (C76-C80) and lymphoid, haematopoietic & related tissue (C81-C96). In situ neoplasms are grouped as Carcinoma in situ and Melanoma in situ of various parts (D00-D09). Benign neoplasms are sub-grouped as: Known & certain behaviour (D10-D36), and Unknown & uncertain behavior (D37-C48).

The prevalence of malignancy is very few, as only 13 cases were reported. Regional variation is visible. Majority (77%) come from both urban divisions. The western area seems to be free of malignancy. The majority (about 46%) also come from the 'Lower Middle' class. In-situ and benign neoplasms are more prevalent in Valikamam south-west compared to other divisions. Further, middle and poor SE groups reported more cases, and rich group reported very low. Benign neoplasms in '**bone, articular cartilage**, and **skin**' (D16/D23) and in '**female genital organs**' (D26-30) are reported to be more prevalent. Overall prevalence rates of all types are 1.7 and 10.3 per 1000 persons.

Diseases of immune mechanism, endocrine, nutritional & metabolic diseases are grouped as: anaemias (D50-D64), haemorrhagic conditions (D65-D69), diseases of blood & blood forming organs (D70-D77), disorders of immune mechanism (D80-D89), thyroid glands (E00-E07), diabetes mellitus & related disorders (E10-E16), disorders of endocrine glands (E20-E35), malnutrition & nutritional deficiencies (E40-E64), and metabolic diseases (E70-E90). Reported diseases were classified by DS divisions and SE groups. Prevalence rates of these diseases for DS divisions are 63.0, 56.7, 44.3, 39.5, 42.1 and 43.1 per 1000 persons. This reveals that these are more prevalent in both urban sectors compared to rural zones. Prevalent rates for SE groups are 85.2, 48.6, 50.4, and 35.1 per 1000 persons, showing that these diseases are more prevalent in rich SE groups than low SE groups. The overall prevalence rate of Jaffna society seems is 48.1 per 1000 persons.

Diseases of blood, blood-forming organs & immune mechanisms are reported in various '**anemic conditions**'(D50, D51, D53 & D64). All types of anaemias are prevalent in DS divisions: 9.7, 8.1, 12.2, 10.1, 10.3 and 6.3 per 1000 persons. This shows that except Valikamam East all other divisions have reported higher anaemic cases. Prevalence for SE groups 1.8, 5.8, 7.3, and 17.3 per 1000 persons reveals that prevalence is very high in the poor SE group compared to the other two middle groups. The anaemias is not prevalent in rich SE group. The overall prevalence rate of the region is 9.2 per 1000 persons. Overall rates of specific anaemic cases of iron/vitamin deficiency anaemia and nutritional anaemia seem to be 3.6 and 4.8 per 1000 persons. Prevalence of '**thyroid problems**' is common in Jaffna society as reported by the overall rate of all types of thyroid problems (E02, E05 & E06) is 3.9 per 1000 persons. Prevalence is higher in both middle SE groups together, which is 3.1 per 1000 persons,

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compared to rich & poor groups. Considering regional variations, it seems there are not many variations among DS divisions.

Considering the popular disease '**diabetes mellitus**', more people reported the prevalence of '**non-insulin dependent diabetes mellitus**' (E11) with an overall prevalence rate of 27.2 per 1000 persons. The regional variations are 40.2, 29.2, 23.3, 22.3, 24.3, and 25.1 per 1000 persons. This shows that non-insulin dependent diabetes is more prevalent in metropolitan areas. Rates for SE groups 60.6, 29.5, 29.9, and 12.4 per 1000 persons show that the prevalence of diabetes in the rich SE group is very high and five times higher compared to poor SE group. **Insulin-dependent diabetes** (E10) is reported with an overall prevalence as 2.8 per 1000 persons. There are no regional or socioeconomic variations in insulin-dependent diabetes. If we include all types of diabetes (E10, E11, E12, and E14) the prevalence rate is slightly more. That is, the overall rate is 32.5 per 1000 persons. The corresponding prevalence rates for divisions are 42.4, 38.1, 27.7, 27.3, 29.0, and 30.5. This reveals that the difference compared to the rates of non-insulin dependent diabetes is higher in the Nallur division. The same rates for socioeconomic groups are 70.1, 35.4, 36.7, and 14.6. Again, the difference is higher in the rich SE group. This shows that other types of diabetes are more prevalent in the Nallur division and in the rich SE group.

### 3) Diseases of the Circulatory, Respiratory, and Digestive Systems

Circulatory diseases are grouped as Acute rheumatic fever (I00-I02), Chronic rheumatic heart disease (I05-I09), Hypertensive diseases (I10-I15), Ischaemic Heart Disease (IHD) (I20-I25), Pulmonary heart disease & pulmonary circulation (I26-I28), Other forms of heart disease (I30-I52), Cerebrovascular diseases (I60-I69), Diseases of arteries, arterioles & capillaries (I70-I79), Diseases of veins, lymphatic vessels and lymph nodes (I80-I89), and Other disorders (I95-I99). Reported diseases classified show prevalence rates in DS divisions as 98.9, 73.7, 63.2, 59.7, 63.6 and 68.1 per 1000 persons, revealing that Jaffna division has the highest rate. An overall rate of 70.9 reveals that of 1000 persons, about 71 have a circulatory disease. Rates for SE groups 85.2, 71.3, 80.7 and 54.6 per 1000 persons show that such diseases are more prevalent in rich and middle groups.

Considering specifically '**hypertensive diseases**' (I10-I15), the overall rate of 20.9 shows for every 1000 persons, about 21 persons have one of hypertensive diseases. The regional variation of this disease by 23.9, 13.7, 25.4, 17.2, 15.9 and 19.7 shows Jaffna and Valikamam south-west have reported higher prevalence. If we consider SE groups with their prevalence rates of 43.5, 24.3, 19.9, and 11.9, it is clear that rich SE group has reported more such diseases. It is relevant to note other circulatory diseases, which are prevalent in Jaffna society with overall rates as '**rheumatic fever**' (I00/I01) : 5.3, '**rheumatic heart disease**' (I05/I08/I09) : 3.9, '**angina pectoris**' (I20) : 15.3, '**myocardial infarction**' (I20/I21) : 5.3, '**ischaemic heart disease**' (I24/I25) : 6.7, '**varicose veins** of lower extremities' (I83) : 3.7, and '**haemorrhoids**' (I84) : 6.7.

Respiratory system diseases are grouped as Acute upper respiratory infections (J00-J06), Influenza & pneumonia (J10-J18), Acute lower respiratory infections (J20-J22), Diseases of the upper respiratory tract (J30-J39), Chronic lower respiratory diseases (J40-J47), Lung diseases due to external agents (J60-J70), Diseases affecting the interstitium (J80-J84), Suppurative & necrotic conditions of lower respiratory tract (J85-J86), Diseases of Pleura (J90-J94), and Other diseases (J95-J99). Classified reported diseases reveal that more respiratory diseases are prevalent than other diseases. Regional variation of such diseases; 193.4, 175.0, 78.7, 54.7, 137.6 and 142.5 reveal that these diseases are highly prevalent in Jaffna, Nallur, Vali south and Vali east DS divisions and comparatively higher than other diseases. Overall, the regional rate of 132.7 shows that for every 1000 persons, about 133 persons have one respiratory disease. Rates for SE groups 125.0, 123.4, 130.2, and 144.4 reveal that, even though these are high for all groups, the poor group has the highest among all groups. Hence, we can conclude that respiratory diseases are prevalent all over the area, comparatively higher than other diseases and have affected everyone.

Specific disease '**acute upper respiratory infections**' (J01-J06) is highly prevalent. The regional variation by incidence rates 34.7, 22.7, 8.8, 9.1, 13.1 and 12.5 show that upper respiratory infections are more prevalent in urban divisions, average in Vali south and Vali east divisions, but low in two western divisions. The overall incidence rate of 16.7 reveals that for every 1000

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persons, about 17 persons were affected by such respiratory infections. The rates 15.1, 13.3, 20.8 and 35.7 of SE groups reveal that lower middle and poor group people were infected more than other groups. Further, '**acute sinusitis**' (J01) seems to have a higher prevalence with a 5.9 per 1000 persons overall.

Specific disease '**influenza**' (J10/11), known as '**flue**' in Jaffna, the incidence rates in the divisions 52.1, 48.6, 7.7, 9.1, 56.1 and 43.1 show that flue is prevalent in all divisions but less in two western divisions. The overall rate of 37.4 reveals that for every 1000 persons, about 37 persons were affected by flu in 2019. The rates for SE groups 49.2, 33.6, 34.0 and 40.0 show that flue is more prevalent in rich group compared to others. Another specific disease in Jaffna society, '**pneumonia**' (J12/15/18), consisted 3 types due to viruses, bacteria and mixed in our classification. Incidence rates for divisions 9.7, 6.5, 7.7, 7.1, 4.7 and 1.5 show that the incidence of pneumonia is more or less absent in Vali East while very low in all other divisions. The overall incidence rate of the region is 5.9 per 1000 persons. The rates for SE groups 1.8, 8.1, 3.2 and 8.1 reveal that pneumonia is more prevalent in upper-middle and poor groups and less prevalent or absent in rich groups.

A chronic issue more prevalent in Jaffna is '**asthma**' (J45). We separately considered '**allergic asthma**' (J45.0), '**non-allergic asthma**' (J45.1) & '**mixed/unspecified asthma**' (J45.8/45.9). Prevalence rates for regional variation and SE groups are summarized in Table 04. This table reveals that for every 1000 persons in Jaffna society, about 59 persons have any type of asthma. Among them, 29 have allergic asthma, 21 have non-allergic asthma, and 9 have other types. Allergic asthma is more prevalent in urban divisions, less in western divisions, and high in upper-middle and poor groups. Non-allergic asthma is more prevalent in Jaffna, Nallur and Vali east, but very less prevalent in Vali west. Further, this is more prevalent in lower-middle and poor groups.

Table 04: The Prevalence Rates of Asthma by DS Divisions and SE Groups

| Asthma type | DS Divisions | | | | | | SE Groups | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAFF | NALL | VASW | VAWE | VASO | VAEA | R | UM | LM | P | |
| Allergic | 36.9 | 42.1 | 19.9 | 14.1 | 24.3 | 32.1 | 24.6 | 30.7 | 23.6 | 34.1 | 28.9 |
| Non-allergic | 33.7 | 26.7 | 17.7 | 7.1 | 12.1 | 26.6 | 17.0 | 19.1 | 23.6 | 21.6 | 20.9 |
| Unspecified | 8.7 | 6.4 | 11.0 | 4.0 | 14.0 | 10.9 | 9.4 | 8.1 | 8.1 | 11.9 | 9.2 |
| All types | 79.3 | 75.3 | 48.7 | 25.3 | 50.5 | 69.6 | 51.1 | 57.9 | 55.3 | 67.6 | 59.1 |

(R – Rich, UM – Upper Middle, LM – Lower Middle, P – Poor, UK – Unknown)

Mixed or unspecified asthma is more prevalent in Vali south-west and Vali south. Also, it is more prevalent in rich and poor groups but less in middle groups. All types together show higher prevalence in urban divisions and very less in Vali west. All types are more prevalent in the poor group, although these are equally high in other groups.

The prevalence of '**bronchitis**' (J20/21/42) and '**acute lower respiratory infection**' (J22) known as '**respiratory tract infection**' **(RTI)** are seen. The overall prevalence rates of these diseases are 4.5 and 2.8. The regional variation of bronchitis is given by 4.3, 7.2, 2.2, 3.0, 4.6 and 4.7, which means bronchitis is more prevalent in Nallur than others. Variations in SE groups 1.8, 2.8, 6.3, and 4.9 show this is more prevalent in lower middle and poor groups. Prevalence of RTI seems to present only in Jaffna, Nallur, and Vali East with rates of 6.5, 6.4, and 3.1, respectively and also absent in the rich group.

Diseases of the digestive system are sub-grouped as Diseases of the oral cavity, salivary glands, & jaws (K00-K14), Oesophagus, stomach & duodenum (K20-K31), Appendix (K35-K38), Hernia (K40-K46), Non-infective enteritis & colitis (K50-K52), Diseases of intestines (K55-

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K63), Peritoneum (K65-K67), Liver (K70-K77), Disorders of gallbladder, biliary tract & pancreas (K80-K87), and Other diseases (K90-K93). Reported classified diseases show prevalence rates for DS divisions as 140.2, 130.4, 119.7, 89.1, 102.1, and 80.6. This reveals that these diseases are more prevalent in urban areas than in other divisions. The overall prevalence rate of 109.2 reveals that for every 1000 persons, about 109 such diseases. The rates for SE groups are 100.3, 125.2, 100.7, and 107.1. This shows that prevalence is higher in the upper middle group compared to the other.

Regional variation on '**dental caries**' (K02) by 57.6, 65.6, 46.5, 35.4, 44.0 and 34.4 per 1000 persons show Nallur division has more dental caries. The overall rate of 47.2 reveals that about 47 persons have problems with dental caries. Rates for SE groups 54.9, 56.2, 41.7 and 43.3 show that rich and upper-middle groups have more issues. Another reported disease is '**ulcer**', including '**gastric ulcer**' (K25), '**duodenal ulcer**' (K26) & '**peptic ulcer**' (K27). Divisional rates 55.4, 36.4, 42.1, 33.4, 37.4 and 30.5 show that ulcer is more prevalent in the urban area. The overall rate of 38.5 reveals that about 38 persons have ulcer problems. Rates for SE groups 35.9, 40.5, 37.6 and 37.7 show that its prevalence is higher in upper middle group than others, which are equally high. Overall rates of 22.8, 4.7 and 10.9 for the 3 types reveal that gastric ulcer is more prevalent in Jaffna. Regional variation of '**Hernia**' (K40-K46); includes inguinal, femoral, umbilical, ventral and abdominal; given by rates 8.6, 4.0, 11.1, 9.1, 4.7 and 3.9 show it is high in Jaffna division compared to other. An overall rate of 6.5 indicates that about 6 persons have one type of hernia. Rates for SE groups 1.8, 8.6, 4.5 and 8.6 show hernia is more prevalent in the upper middle and poor groups than others.

Overall rates 1.7, 1.7, 2.0, 3.4 & 2.2 of diseases '**stomatitis**' & related lesions, and diseases of '**lips**, **oral mucosa** & **tongue**' (K12-K14), diseases of '**oesophagus**', (K20-K22), '**dyspepsia**' (chronic indigestion) & related diseases of '**stomach**' & '**duodenum**' (K30/K31), '**appendicitis**' (K35-K38), and diseases of '**intestine**' (K58/K59/K63) show that they are lee prevalent. Of 1000 persons, about 3 have appendicitis, 2 have chronic indigestion, and 2 have intestine diseases such as irritable bowel syndrome or constipation. The regional variation of '**alcoholic** and **toxic liver diseases**' (K70/K71)

by 3.2, 4.8, 5.5, 0, 4.6 and 1.5 shows this is absent in Vali West. Overall rate of 3.2 shows that for every 1000 persons, about 3 have alcoholic toxic liver disease. Rates for SE groups 1.8, 2.8, 3.1 and 4.3 show that liver diseases are more prevalent in middle and poor groups.

4) *Diseases of Skin and Subcutaneous system and of Musculoskeletal System and Connective tissue*

Diseases of Skin and subcutaneous tissue are grouped as Infections (L00-L08), Bullous disorders (L10-L14), Dermatitis & eczema (L20-L30), Papulosquamous disorders (L40-L45), Urticaria & Erythema (L50-L54), Radiation-related disorders (L55-L59), Disorders of skin appendages (L60-L75), and Other disorders (L80-L99). Reported diseases were classified for DS divisions and SE groups. Rates by divisions 46.7, 41.3, 34.3, 27.3, 36.5 and 39.9 reveal that skin disease prevalence is high in urban divisions and in Vali East and low in Vali West. The overall rate of 37.8 reveals that about 38 persons have one type of these diseases. Rates for SE groups 41.6, 36.5, 34.9 and 41.6 per 1000 persons show this is high in the rich and poor groups. The middle groups have less prevalence.

'**Infections of skin & subcutaneous tissue**' (L02/L03/L08), include cutaneous abscess, furuncle, carbuncle, cellulitis & other local infections. Regional variation 13.0, 11.3, 18.8, 13.1, 11.2 and 12.5 reveals that these are more prevalent in Vali south-west. The overall rate of 13.1 shows that about 13 persons were infected. Rates for SE groups 7.5, 9.2, 11.3 and 20.0 show that prevalence is more on lower middle and poor groups. Regional variations by rates 3.2, 11.3, 2.2, 2.0, 7.4 and 7.8 of Atopic dermatitis, including '**eczema**' (L20) show that eczema is more prevalent in Nallur, Vali south, and Vali east and very low in two western divisions. The overall rate shows that about 6 persons have eczema or other atopic dermatitis. Rates of SE groups 5.6, 5.2, 5.9 and 7.5 show that the poor SE group has more eczema. The rates of '**all other dermatitis**' (L21-L30) in the divisions 20.6, 14.5, 13.3, 10.1, 14.9 and 17.2 show that these are highly prevalent in Jaffna and Vali east. The overall rate is 15.1 per 1000 persons. Rates for SE groups 24.6, 17.9, 14.0 and 11.9 show that other types of dermatitis are more prevalent in rich group.

Diseases of the musculoskeletal system & connective tissue are grouped as Arthropathies (M00-M25), Systemic connective tissue disorders (M30-M36), Dorsopathies (M40-M54), Soft tissue disorders (M60-M79), Osteopathies & chondropathies (M80-M94), and Other disorders (M95-M99). The reported diseases classified reveal that the prevalence rates of these diseases for DS divisions are 51.1, 42.1, 32.1, 33.4, 19.6 and 17.2 per 1000 persons. This shows that these diseases are more prevalent in the urban divisions and less in Vali South and Vali East. The overall prevalence rate 31.9 reveals that about 32 persons have these diseases. The rates for SE groups 39.7, 35.3, 36.3 and 20.5 show that these types of diseases are more prevalent in rich and less prevalent in poor groups.

'**Arthritis**' (M00/M05/M06/M13), which includes pyogenic, seropositive, rheumatoid, & other types, is prevalent as seen by regional variations 13.0, 15.3, 19.9, 23.3, 7.4 and 9.3 and it is more prevalent in two western divisions. The overall rate of 14.4 reveals that about 14 persons have one type of arthritis. Rates for SE groups 15.1, 19.1, 16.3 and 7.0 show that upper middle and poor groups have more and less prevalence. Another reported disease is '**soft tissue disorders**' (M75/M79), which includes **shoulder lesions**, **rheumatism**, **myalgia**, and **pain in limbs**. Regional variations 13.0, 12.9, 5.5, 5.1, 1.8 and 4.6 show that soft tissue disorders are more prevalent in urban divisions and less in all rural zones. The overall rate is about 7 per 1000 persons. Rates for SE groups 5.6, 5.7, 9.5, and 5.9 show that lower middle group is more prevalent. Less prevalent diseases reported are '**joint disorders**' (M20-M25), '**intravertebral-disc-disorders**' & '**dorsalya**' (M51/M54), and '**disorders of muscles**' (M60-M62). Overall rates of these diseases are 2.9, 2.6 and 2.6.

### B. Overall Morbidity Variation and Relationships

We considered groups of diseases separately and described by incidence and prevalence rates for administrative divisions and socioeconomic groups. We now combine all groups of diseases together and analyze overall morbidity variation and relationships. We assign codes for disease groups as: A–Infectious diseases, B–Parasitic diseases, CD–Neoplasms, DE–Diseases of blood, blood-forming organs, immune mechanism, endocrine, nutritional, & metabolism, G–Diseases of the nervous system, H–Diseases of eye, adnexa, ear & mastoid process, I–Diseases of the circulatory system, J– Diseases of the respiratory system, K–Diseases of the digestive system, L–Diseases of skin & subcutaneous tissue, M–Diseases of musculoskeletal system & connective tissue, N–Genitourinary system. The frequency distribution for combinations of diseases is given in Table 05.

We applied correspondence analysis on frequency tables of DS divisions & SE groups separately. Two-dimensional symmetrical configuration for the correspondence between '**disease groups**' & '**DS divisions**' is shown in Figure 4.2.1. The first two components together explain 82% of total inertia. Two-dimensional symmetrical configuration for the correspondence between '**disease groups**' & '**socioeconomic groups**' is shown by the Figure 3. The first two components together explain 96% of total inertia.

Figure 02 shows that there are associations between disease groups and DS divisions. About 85% of the time, urban divisions are associated with disease groups 'Diseases of eye, adnexa, ear & mastoid process' (H). Western divisions Vali south-west and Vali west are associated with the disease group 'Parasitic diseases' (B). Other rural divisions Vali South and Vali East, have not shown any clear pattern of association. Infectious diseases (A) & diseases of the nervous system (D) have no association with any divisions. Figure 4.2.2 shows that there are associations between disease groups and socioeconomic groups. About 82% of the time poor SE group was associated with 'Infectious diseases' (A). Further, rich socioeconomic group is closely associated with 'Diseases of the blood, blood-forming organs, immune mechanism, endocrine, nutritional, and metabolism'. The figure also reveals that the upper middle socioeconomic group has very less association with all groups of diseases. The lower middle socioeconomic group seems to have a close association with 'Neoplasms' (CD) and 'Diseases of the genitourinary system' (N).

Table 05: Frequency Distribution of Groups of Diseases by DS Divisions and SE Groups

| Disease ICD Code | DS Divisions | | | | | | SE Groups | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | JAFF | NALL | VASW | VAWE | VASO | VAEA | R | UM | LM | P |
| A | 76 | 124 | 80 | 72 | 86 | 83 | 26 | 133 | 143 | 209 |
| B | 202 | 278 | 316 | 354 | 289 | 354 | 61 | 532 | 529 | 632 |
| CD | 13 | 17 | 18 | 8 | 9 | 12 | 6 | 21 | 29 | 20 |
| DE | 58 | 70 | 40 | 39 | 45 | 55 | 45 | 84 | 111 | 65 |
| F | 16 | 28 | 17 | 14 | 15 | 14 | 6 | 35 | 40 | 22 |
| G | 15 | 25 | 15 | 16 | 10 | 21 | 4 | 40 | 29 | 29 |
| H | 71 | 111 | 50 | 35 | 74 | 74 | 47 | 128 | 147 | 90 |
| I | 91 | 91 | 57 | 59 | 68 | 87 | 45 | 123 | 178 | 101 |
| J | 178 | 216 | 71 | 54 | 147 | 182 | 66 | 213 | 287 | 267 |
| K | 129 | 161 | 108 | 88 | 109 | 103 | 53 | 216 | 222 | 198 |
| L | 43 | 51 | 31 | 27 | 39 | 51 | 22 | 63 | 77 | 77 |
| M | 47 | 52 | 29 | 33 | 21 | 22 | 21 | 61 | 80 | 38 |
| N | 23 | 40 | 21 | 7 | 29 | 30 | 12 | 40 | 59 | 38 |

(R – Rich, UM – Upper Middle, LM – Lower Middle, P – Poor)

private and government hospitals of a duration of more than one day.



Figure 02: Symmetric Plot between Groups of Diseases and DS Divisions



Figure 03: Symmetric Plot Groups of Diseases and Socioeconomic Groups

## C. Hospital Episodes for Various Treatments

In the preceding sections, diseases affecting individuals are described in detail. For every individual, we recorded a particular disease only once, if that disease needed medical attention. For example, we recorded 'malaria' with code 'B51' for a person but did not record how many times 'malaria' affected him during the period. Hence, we countered all admissions of all diseases described. This included one-day clinical examinations and treatments at OPD and continuous treatments by ward admissions at

Number of admissions at clinics and hospitals were classified by types of admissions. Major categories are Medical, Surgical, Pediatric, Psychiatric, and of peripheral sub-systems. We report the percentage of people who have undergone different treatments.

### 1) Medical and Surgical Admissions

Medical admissions are related to the majority of disease groups shown above. We classified them against DS divisions and SE groups, as shown in Table 06. Surgical admissions include surgeries for treatments due to diseases, injuries, accidents,

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exposures & assaults. We classified them against DS divisions and SE groups, as shown in Table 07.

Table 06: Frequency Distribution of hospital Admissions on Medical Treatments by DS Divisions and Socio-economic Groups

| Number of Admissions | DS Divisions | | | | | | SE Groups | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAFF | NALL | VASW | VAWE | VASO | VAEA | R | UM | LM | P | UK | |
| 0 | 395 | 533 | 405 | 471 | 510 | 593 | 291 | 746 | 1075 | 763 | 32 | 2907 |
| 1-2 | 167 | 256 | 193 | 156 | 231 | 357 | 90 | 370 | | 471 | 18 | 1360 |
| 3-5 | 205 | 263 | 178 | 237 | 211 | 213 | 80 | 394 | 411 | 401 | 27 | 1307 |
| 6-10 | 91 | 109 | 76 | 76 | 57 | 46 | 38 | 1009 | 405 | 133 | 6 | 455 |
| 11-15 | 48 | 57 | 29 | 35 | 50 | 57 | 23 | 77 | 169 | 58 | 0 | 276 |
| 16-25 | 11 | 14 | 14 | 8 | 6 | 9 | 5 | 19 | 118 | 14 | 1 | 62 |
| >25 | 3 | 2 | 7 | 4 | 3 | 2 | 1 | 10 | 232 | 8 | 0 | 21 |
| Total | 920 | 1234 | 902 | 987 | 1068 | 1277 | 528 | 1725 | 2203 | 1848 | 84 | 6388 |

(R – Rich, UM – Upper Middle, LM – Lower Middle, P – Poor, UK – Unknown)

This table reveals that about 54.5% of the people have undergone at least once for medical treatments. Regional variations of people on medical treatments by 57.0, 56.8, 55.1, 52.3, 52.2, and 53.5 per cent show that more than half of the people were admitted to medical treatments at least once during 2019. Percentages for SE groups 44.8, 56.7, 51.2, and 58.7 reveal that more admissions come from the people of upper middle and poor SE groups.

Table 07: Frequency Distribution of Hospital Admissions on Surgical Treatments by DS Divisions and Socio-Economic Groups

| Number of Admissions | DS Divisions | | | | | | SE Groups | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAFF | NALL | VASW | VAWE | VASO | VAEA | R | UM | LM | P | UK | |
| 0 | 791 | 1037 | 775 | 877 | 949 | 1151 | 460 | 1500 | 1930 | 1612 | 78 | 5580 |
| 1-2 | 93 | 164 | 92 | 68 | 86 | 90 | 55 | | | | 6 | 593 |
| 3-5 | 32 | 30 | 31 | 36 | 31 | 31 | 13 | 148 | 211 | 173 | 0 | 191 |
| 6-10 | 3 | 3 | 4 | 6 | 2 | 5 | 0 | 70 | 55 | 55 | 0 | 23 |
| >10 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 61 | 90 | 80 | 0 | 1 |
| Total | 920 | 1234 | 902 | 987 | 1068 | 1277 | 528 | 1725 | 2203 | 1848 | 84 | 6388 |

(R – Rich, UM – Upper Middle, LM – Lower Middle, P – Poor, UK – Unknown)

This table reveals that about 12.6% of people have undergone at least once on surgical treatments. Regional variations of people on surgical treatments by 14.0, 15.9, 14.1, 11.1, 11.1 and 9.8 percents show that people of urban and Vali south-west have undergone to more surgical treatments compared to others. Percentages for SE groups 12.8, 13.0, 12.4 and 12.7 show no differences among SE groups regarding surgeries.

*2) Overall Pattern of Hospital Admissions*

We produced distributions of various treatments by the percentage of people who had undergone to the particular treatments for DS divisions & SE groups. Now, we consider all treatments together to see the relationships of types of treatment with divisions and groups. We counted the number of times a particular treatment was given to DS divisions and SE groups. In other words, health

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services by different treatments are countered and compiled in Table 08.

Table 08: The Frequency Distribution of Various Hospital Admissions by DS Divisions and SE Groups

| Type of Admission | DS Divisions | | | | | | SE Groups | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | JAFF | NALL | VASW | VAWE | VASO | VAEA | R | UM | LM | P |
| Medical | 2594 | 3469 | 2525 | 2491 | 2499 | 2698 | 1128 | 4837 | 5468 | 4643 |
| Surgical | 308 | 388 | 284 | 287 | 260 | 287 | 137 | 548 | 595 | 525 |
| Pediatric | 7 | 14 | 1 | 14 | 10 | 16 | 6 | 17 | 10 | 29 |
| Maternity | 48 | 85 | 72 | 93 | 102 | 107 | 20 | 99 | 101 | 285 |
| Psychiatric | 53 | 95 | 49 | 36 | 37 | 36 | 23 | 106 | 118 | 52 |
| Other | 328 | 473 | 283 | 306 | 423 | 384 | 176 | 658 | 745 | 578 |

(R – Rich, UM – Upper Middle, LM – Lower Middle, P – Poor)

We applied correspondence analysis on these two-way frequency tables for divisions and groups separately. The two-dimensional symmetrical configuration for correspondence between '**different treatments**' and '**DS divisions**' is shown in Figure 4.3.1. The first two components together explain 88% of the total inertia. The two-dimensional symmetrical configuration for correspondence between '**different treatments**' and '**SE groups**' is shown in Figure 4.3.2. The first two components together explain 99% of total inertia.

Figure 04 reveals that there are associations between types of hospital admissions and DS divisions. Medical and surgical admissions are closely associated with urban areas and Valikamam south-west. Psychiatric and pediatric admissions have independent behaviour with DS divisions. However, the miscellaneous type of admissions, 'On peripheral sub-systems' seems to have close association with Valikamam South and Valikamam East. Valikamam West has no close associations with different types of admissions. Figure 5 shows some associations. Psychiatric and paediatric admissions have no association with any of the SE groups. Both middle-class SE groups seem to be closely associated with medical, surgical, and other types of admissions. Surprisingly, poor socioeconomic group has no association with any type of hospital admissions.
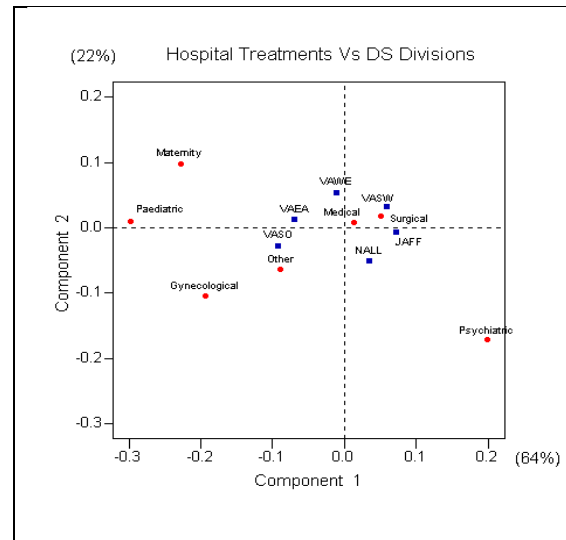


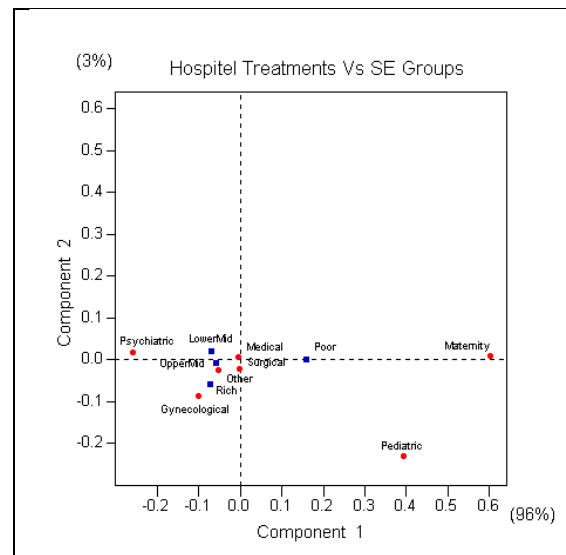Figure 04: Symmetric plot between various treatments and DS Divisions.



Figure 05: Symmetric plot between various treatments and SE groups.

3) *Hospital Usage of Individuals for Various Treatments*

The hospital usage of an individual is defined as the total number of days spent by that person during 2019 on all types of treatments. This

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includes total duration of treatments given by hospitals on all diseases. We constructed frequency distribution of persons on 'hospital usage' (total number of days spent in clinics & hospitals) by Table 09.

Table 09: Hospital Usage of Individuals by DS Divisions and Socio-economic Groups

| Number of Days | DS Divisions | | | | | | SE Groups | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | JAFF | NALL | VASW | VAWE | VASO | VAEA | R | UM | LM | P | UK | |
| 0 | 273 | 363 | 301 | 358 | 350 | 443 | 218 | 530 | 795 | 518 | 27 | 2088 |
| 1-2 | 168 | 216 | 146 | 134 | 191 | 299 | 91 | 318 | 381 | 353 | 11 | 1154 |
| 3-5 | 190 | 261 | 160 | 207 | 199 | 230 | 85 | 348 | 417 | 371 | 26 | 1247 |
| 6-10 | 141 | 177 | 130 | 141 | 152 | 134 | 69 | 245 | 274 | 273 | 14 | 875 |
| 11-15 | 79 | 102 | 74 | 63 | 84 | 89 | 38 | 124 | 171 | 157 | 1 | 491 |
| 16-25 | 33 | 64 | 41 | 41 | 52 | 50 | 12 | 73 | 94 | 100 | 2 | 281 |
| 26-50 | 24 | 39 | 33 | 31 | 27 | 25 | 12 | 63 | 48 | 55 | 1 | 179 |
| 51-100 | 9 | 10 | 13 | 9 | 9 | 4 | 2 | 18 | 17 | 15 | 2 | 54 |
| >100 | 3 | 2 | 4 | 3 | 4 | 3 | 1 | 6 | 6 | 6 | 0 | 19 |
| Total | 920 | 1234 | 902 | 987 | 1068 | 1277 | 528 | 1725 | 2203 | 1848 | 84 | 6388 |

(R – Rich, UM – Upper Middle, LM – Lower Middle, P – Poor, UK – Un known)

This table reveals that about 67.3% of the people have used the health services at least one day during the said period. About 26.7% of people have never used any health services provided by hospitals, clinics and dispensaries. Regional variations of hospital usage are given by percentages 70.3, 70.5, 66.6, 63.7, 67.2 and 65.3. Though most of the people of the divisions have used such health services, the utilization by urban divisions is higher than the other rural divisions. The percentages for SE groups 58.7, 69.2, 63.9, and 71.9 reveal that the rich SE group has low utilization and the poor SE group has high utilization. The utilization by the upper middle class seems higher than the lower middle class.

Health services is categorized by hospital usage as 'None' – (0) days, 'low' – (1-5) days, 'Medium' – (6-15) days, 'High' – (16-25) days, and 'Very high' – (>25) days. We applied correspondence analysis to see 'Hospital Usage' relationships with divisions and groups. Figure of the two-dimensional configuration of the relationships between hospital usage and DS divisions showed that the first two components together explain 90.6% of total inertia. Figure of the two-dimensional configuration of relationships between hospital usage and SE groups showed the first two components explain 97% of total inertia.

These reveal that the urban zones Jaffna and Nallur have high and medium level utilization of health services. Very high utilization of health services is not associated with particular divisions. Valikamam East has no specific association with utilization of health services. Valikamam West seems to have close association with 'none' category of hospital admissions. This means that the people of Valikamam west have very less or absent utilization of health services compared to other divisions. Also about 87% of the time, poor people are associated with high and very high utilization of health services. Upper middle SE class people seem to have medium and low utilization. The people of the Lower middle and rich SE classes have very less or no utilization.

IV. FINDINGS AND CONCLUSIONS

The age-sex distribution of 6388 individuals from 1123 sampled families constructed by population pyramid shows the demographic structure of the study population. We summarize below the general and specific findings as pin-pointed. Infectious diseases are more prevalent in the urban Nallur division and in poor SE group. The severity of these phenomena in the Jaffna peninsula is about 230% compared to the rich SE group. The overall incidence rate of the study region seems to be 81.5 per 1000 persons. We found that parasitic

diseases are more prevalent in the western parts of the peninsula. The overall incidence of parasitic diseases in the region seems 280.7 per 1000 persons. Parasitic diseases are more prevalent in poor and upper-middle SE groups.

The prevalence of malignant neoplasms is very few. Regional variation of malignancy exists as 77% come from the two urban divisions. The western area of the peninsula seems to be free of malignant neoplasms. Most of these (about 46%) also come from the 'Lower Middle' class. The prevalence of malignant neoplasms is less in Jaffna society. If we consider In-situ and benign neoplasms, Valikamam south-west has more prevalence compared to other divisions. Middle and poor SE classes have reported more cases. Overall malignancy and other neoplasms rates are 1.7 and 10.3 per 1000 persons.

Prevalence of diseases of the blood, endocrine, nutritional and metabolic diseases are high in urban sectors compared to rural zones. These diseases are more prevalent in rich SE groups than low SE groups. The overall prevalence rate for Jaffna society is 48.1 per 1000 persons. If we consider diseases of blood, blood-forming organs and immune mechanism, **'anemic conditions'**was reported in all divisions except Valikamam East. Prevalence is very high in the poor SE group compared to the two middle groups and is not prevalent in the rich SE group. The overall prevalence rate for the region is 9.2 per 1000 persons.

Jaffna division has the highest rate of circulatory diseases. Overall prevalence reveals that for every 1000 persons, about 71 persons have any one of the circulatory diseases. Further, the circulatory diseases are more prevalent in rich and middle groups. If we consider the prevalence of specific diseases, **'hypertensive diseases'** seem to be more prevalent. The overall rate shows that for every 1000 persons, about 21 persons have one of the hypertensive diseases. Jaffna and Valikamam south-west divisions have reported such higher prevalence. Further, the rich SE group has reported more hypertensive diseases.

Respiratory diseases are highly prevalent in urban, Vali South, and Vali East. Overall prevalence shows that for every 1000 persons, about 133 persons have one of respiratory disease. Even though the prevalence rates are high for all the SE groups, the poor group is the highest among all the

groups. Therefore, we can conclude that respiratory system diseases are prevalent all over the area and comparatively high compared to the other diseases. Diseases of the digestive system are more prevalent in the urban areas. The overall rate reveals that for every 1000 persons in the region, about 109 have problems due to these diseases. Further, the prevalence is higher in the upper middle group compared to the others. **'Dental caries'** and **'Úlcer'** seem more prevalent in Jaffna society.

Diseases of the genitourinary system are more prevalent in the Nallur division and less prevalent in Vali West. The overall rate reveals that for every 1000 persons, about 23 have diseases of the genitourinary system, which are equally high in all the SE groups. Another reported disease is **'urinary tract infection'**. This is less prevalent or absent in Valikamam West. The overall rate reveals that for every 1000 persons, about 3 of them have complained of urine infection, which is also high in the rich and lower middle SE groups. We combined all disease groups and analysed the overall morbidity variation and relationships against DS divisions and socioeconomic groups. We found that there are some associations between the various disease groups and DS divisions.

The number of admissions under different types of admissions was classified. Types included are medical, surgical, pediatric, psychiatric and other admissions. About 54.5% of people have undergone at least once for any type of medical treatment. More than half of people were admitted for medical treatments at least once during 2019, and more admissions come from people of upper middle and poor groups. About 12.6% of people have undergone it at least once for surgical treatments. Some associations between various types of hospital admissions and DS divisions were identified. Medical and surgical admissions are closely associated with urban regions Jaffna and, Nallur and Vali south-west. Psychiatric and paediatric admissions have independent behaviour from DS divisions. Miscellaneous type of admissions have close associations with Vali South and Vali East. Vali West has no close associations with different types of admissions.

We analyzed the hospital usage of all the people and found that about 67.3% of the people had used health services at least one day during the two years before the present study. Hence, about 26.7% of the people have never used any health

services provided by hospitals, clinics and private dispensaries. The regional variation of hospital usage shows that even though most of the people of all the divisions have used such health services, the utilization by urban divisions is higher than the other rural divisions. The variations and relationships of health services were studied by hospital usage. We found that the urban zones Jaffna and Nallur have high and medium-level utilization of health services. The very high utilization of health services seems to have no specific association with the particular DS divisions. The DS division Valikamam East seems to have no specific association with the utilization of health services. We also found that about 87% of the time, the cluster of poor people is associated with high and very high utilization of health services.

REFERENCES

Agha, S. (2000) "The determinants of Infant mortality in Pakistan", *Social Science and Medicine*. 5(1), pp. 199-208.

Breslow, L. (1972) "A quantitative approach to the World Health Organization definition of health: Physical, Mental and Social wellbeing", *International Journal of Epidemiology,* 1(1), pp347-355.

Coppo, P., Pisani, L., and Keita, A. (1992) "Perceived morbidity and health behavior in a Dogon community", *Social Science and Medicine,* 34(11), pp. 1227-1235.

Elankumaran, C. (2003) "Socio-Economic class stratification in Jaffna society - A Cluster analytic approach, Proceedings of papers presented at Research Sessions*", University of Jaffna, Sri Lanka,* 1(1), pp. 1-5.

Elankumaran, C. (2018) "Physical Disabilities in Post-War context in Jaffna society - A Statistical Review, Proceedings of the papers presented at 8th International Symposium", *South-Eastern University of Sri Lanka,* 1(1), pp. 175-176.

Elankumaran, C. (2019) "Physical Disabilities in Post-War Jaffna society, Evidences by Factor and Cluster Analysis", *Journal of Sociology and Anthropology,* 7(2), pp. 84-99.

Elankumaran, C. (2020) "Socio-economic influence on Mental Health in post-war Jaffna society - A Multivariate Statistical Review", *Proceedings of the papers presented at FARS-2020,* 1(1), pp. 1-10.

Elankumaran, C. (2021) "A Confirmatory Factor Analysis in Identifying the nature of Mental Health in Jaffna Society - A follow-up study", *Proceedings of the papers presented at FARS-2021,* 12(1), pp. 18-23.

Fergusson, D.M., Horwood,L.J., and Shannon,F.T. (1986) "Social and Family factors in Childhood hospital admissions", *Journal of Epidemiology and Community Health,* 40(3), pp. 50-58.

Janice, T. and Janet, C. (1990) "Public knowledge of dietary fat and coronary heart disease:, *Health Education Journal,* 49(1), pp. 32-35.

Jenkins, C.D., Robert, W.T., Tannenbaum, S.I. and Kirby, C. (1979) "Social stressors and excess mortality from hypertensive diseases", *Journal of Human Stress,* 28(3), pp. 29-40.

Jenkins, C.D. (1983) "Social environment and Cancer mortality in men", *New England Journal of Medicine,* 308(15), pp. 395-398.

Kawachi, I., Marshall, S., and Pearce, N. (1991) "Social class inequalities in the decline of coronary heart disease among New Zealand men", *International Journal of Epidemiology,* 20(2), pp. 1-6.

Kodama, A.M., Halfon, S.T., and Chung, C.S. (1991) "An epidemiologic study on differences in Health status between employed men and women in Hawaii", *Asia-Pacific Journal of Public health,* 5(1), pp. 79-85.

Lagasse, R., Kittel, F., Dramaix, M., Gheyssens, H., Backer, G., and Kornitzer, M. (1986) "Ischemic Heart Disease and regional variations of socio-cultural characteristics in Belgium", *Social Science and Medicine,* 22(9), pp. 901-913.

Lenz, R. (1988) "Jakarta Kampung Morbidity variations: Some policy implications", *Social Science and Medicine,* 26(6), pp. 641-649.

Mantel, N. and Haenszel, W. (1959) "Statistical aspects of the analysis of data from retrospective studies of diseases", *Journal of the National Cancer Institute,* 22(4), pp. 719-747.

Mock, N.B., Sellers, T.A., Abdoh, A.A., and Franklin,R.R. (1993) "Socio-Economic, Environmental, Demographic, and Behavioral factors associated with occurrence of diarrhea in young children in the republic of Congo", *Social Science and Medicine,* 36(6), pp. 807-816.

Morgan, M., Heller, R.F., and Swerdlow, A. (1989) "Changes in diet and coronary disease mortality among social classes in Great Britain", *Journal of*

*Epidemiology and Community Health,* 43(3), pp. 162-167.

Pearce, N., Davis, P.V., Smith, A.H. and Foster, F.H. (1983) "Mortality and social class in New Zealand – Male mortality by disease groupings", *New Zealand Medical Journal,* 96(740), pp. 711-716.

Porrini, M., Simonetti,P., Testolin,G., Roggi,C., Laddomada,M.S. and Tenconi,M.T. (1991) "Relation between diet composition and coronary heart disease risk factors", *Journal of Epidemiology and Community Health,* 45(148), pp. 148-151.

Rahkonen, O. and Lahelma,E. (1992) "Gender, Social Class and Illness among young people", *Social Science and medicine,* 34(6), pp. 649-656.

Sivarajah, N. (1997) "War and Health in Jaffna. Sectional Chairman's address (Medical Sciences)", *Proceedings of Jaffna Science Association University of Jaffna,*18(2), pp. 39-51.

Wong, S.L. and Donnan, S.P.B. (1992) "Influence of socioeconomic status on Cardiovascular diseases in Hong Kong", *Journal of Epidemiology and Community Health,* 46(9), pp. 148-150.

World Health Organization (1992) "International Statistical Classification of Diseases and Related Health Problems Tenth Revision", *World Health Organization,* 170(19), pp. 186-226.

Zaidi, S.A. (1988) "Poverty and Disease: Need for Structural change*", Social Science and Medicine,* 27(2), pp. 119-127.