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Effect of various organic fertilizers on seed germination and seedling development of eggplant (*Solanum melongena*) var. HORDI Lena-iri 1: A popular vegetable in Sri Lanka

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Abstract

An experiment was carried out to evaluate the germination of seeds and the growth of seedlings of Brinjal as affected by organic fertilizers. Nine different fertilizer treatments and a control with no fertilizer were selected for the study. The experiment was arranged in a Complete Randomized Block Design (CRBD) with three replicates. As the test treatments, seven different organic fertilizers were used, viz. T1- Chicken manure [CM], T2- Cow gung [CD], T3- Goat manure [GM], T4- Rice husk [RH], T5- Compost [CO], T6- Vermicompost [V], T7- a mixture of T1 to T6 [M]. In addition, an Inorganic Fertilizer [IF] was used as the positive control (T8) and a medium with no organic or inorganic fertilizers (T9) was used as the negative control (C). Growth media using organic fertilizers were prepared for two experiments by mixing 25% (w/w) and 50% (w/w) of different organic fertilizers with soil and coir dust. Overall the results showed that the tested parameters such as germination percentage, germination index, and shoot and root lengths of developing seedlings were notably higher in the experiment where 25% of organic fertilizers were used with soil and coir dust ($p < 0.05$) compared to the control treatment. The application of 50 % organic fertilizer in one of the experiments adversely affected the seed germination and seedling development as evidenced by the low germination rate and high seedling mortality. This observation may indicate an inhibitory effect associated with excessive nutrient availability. Hence, application of 50% organic fertilizer is not recommended for the seed germination and seedling development of *S. melongena*.

Keywords: Organic fertilizers, inorganic fertilizers, seed germination, *Solanum melongena*

Introduction

Plants are indeed a significant source of nutritious food for humans and animals. One of the most important processes in the natural life cycles of plants is the germination of their seeds. This is the process known to be the most sensitive to stress conditions [1] and plays a crucial role in determining the crop yield [2]. For any seeds to initiate the process of germination, they have to absorb water under favorable environmental conditions [3]. The characteristic features of the soil such as texture, structure, porosity and water-holding capacity have influences on the germination of seeds and plant growth. If germination fails to occur or goes slowly, it may cause a significant impact on the overall growth and survival of plants. This understanding has led to numerous studies and research efforts focused on improving germination rates and the quality of the seedlings. Faster germination offers several advantages for plants, including early access to

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nutrients and a good start in growth. The quality of seedlings also plays a crucial role in subsequent plant life and their ability to withstand adverse environmental conditions.

Solanum melongena, often known as eggplant, aubergine, or brinjal, is a member of the family Solanaceae [4] and is grown worldwide for its edible fruit. By botanical definition, the fruit is a berry, most commonly purple in colour and popularly used as a vegetable and even can be eaten as a meat substitute in a vegetarian diet. In Sri Lanka, Badulla, Hambantota, and Anuradhapura are the major brinjal cultivation areas, and a few different varieties having a higher farmer and consumer demand are successfully grown in the country.

Eggplants are rich in sufficient amounts of starch, protein, minerals, vitamins, dietary fibers and low-fat content. Eggplants contain phytochemicals that have scavenging properties, as well as minerals, antioxidants, vitamins, and proteins [4] which are beneficial to human health. This vegetable has also been widely used in traditional medicine. The fruits of Eggplant help to reduce cholesterol levels in the blood and regulate high blood pressure, making them suitable for diet and diabetic patients [5].

Providing food for the growing population is currently the most urgent concern in the world. Modern farming practices allow farmers to increase productivity while decreasing environmental impacts. Modern agriculture is largely dependent upon heavy input of pesticides and a range of inorganic fertilizers. Most inorganic fertilizers are readily water soluble and are immediately available for the plants to absorb from soil. When used as recommended levels, these fertilizers efficiently provide the necessary nutrients for plant growth while remaining environmentally safe. However, the application of excessive amounts of synthetic fertilizers to plants has been linked with several problems associated with high residual effects in the soil which can potentially contribute to soil pollution and soil degradation [6].

Inorganic fertilizers affect the function of soil in many ways such as affecting the existing physical and chemical environment, and influencing the activity and diversity of microorganisms in soil [7]. The long-term application of chemical fertilizers may lead to a reduction in soil organic matter content and alter the activity of soil biota leading to changes in soil microbial composition and soil invertebrates [8, 9]. On the other hand, the use of organic materials as an alternative source of fertilizer shows potential in agriculture as it benefits soil structure and crop yield while minimizing environmental damage [6, 10].

Organic fertilizers comprise all the essential nutrients required for plant growth and the long-time application of an organic fertilizer enhances the availability of soil nutrients [11]. Organic fertilizers are produced by composting materials like animal manure (livestock manure), human excreta, or plant matter such as straw and garden waste by microorganisms fermenting at elevated temperatures. Studies have shown that the application of livestock manure has exhibited promising outcomes in enhancing plant growth as they improve the physical, chemical and biological properties of soil that directly affect soil fertility [12, 13].

Organic fertilizers provide several benefits to agricultural systems. The addition of organic fertilizers improves the soil structure, enhances the activity of soil-beneficial microorganisms and plant nutrient availability, plant growth, and yield [14, 6]. Additionally, studies showed that the addition of organic fertilizers changes soil cation exchange capacity, enhances soil moisture content, influences soil fauna, promotes soil porosity, aeration, drainage, granulation, soil organic matter and aggregation, root penetration and overall health of the soil [15, 16, 17].

However, sometimes it is disadvantageous in the utilization of organic fertilizers based on their source. This may cause the risk of introducing antibiotics, toxic organic and inorganic compounds, and pathogenic microorganisms to soil [18]. Therefore, it is very important to study the efficiency of organic fertilizers before applying them to agricultural fields. Despite these facts, there is an increasing demand from consumers for higher quality and safer food, with a particular interest in organic products [19] that are produced by environmentally sustainable organic farming practices which minimize or avoid the use of synthetic chemicals such as fungicides, pesticides, and inorganic fertilizers to maintain soil fertility and crop productivity.
To address the aforementioned problem, a study was designed to assess how seven different types of frequently used organic fertilizers used by Sri Lankan farmers affected the germination of brinjal (var. Lena-iri) seeds. Brinjal was chosen as the representative plant in this study since it is a widely consumed vegetable worldwide. The present study has a greater value as currently Sri Lanka is facing a significant issue in food security due to a lack of synthetic fertilizers and is searching for innovative ways to utilize organic fertilizers in agriculture.

Materials and methods

Materials

Freshly harvested seeds of *Solanum melongena* var. HORDI Lena-iri 1 were used for the study. All fertilizer types were bought from a leading fertilizer outlet in Matara, Sri Lanka, that distributes a variety of fertilizers to the growers in and around the Matara district.

Study site

Seedling tray experiments were conducted at the Matara Regional Centre of the Open University of Sri Lanka, Nupe, Sri Lanka.

Experimental design and treatments

Seeds were screened for homogeneity before sowing and were soaked overnight in water to enhance germination.. High-quality seeds were chosen from the soaked lot for sowing. Nine different fertilizer treatments and a control with no fertilizer were selected for the study: T1 - Chicken manure (CM), T2 Cow dung (CD), T3 Goat manure (GM), T4 Rice husk (RH), T5 Compost (CO), T6 Vermicompost (V), T7 Mixture of T1 to T6 (M), T8 Inorganic fertilizer (IF). For the inorganic fertilizer treatment (T8), 2 g of a commercial fertilizer was added to each replicate with 90% soil and 10% coir dust, as recommended by the manufacturer. Soil and coir dust mixture (90% soil and 10% coir dust) was used as the T9 control (C) treatment without adding any fertilizer. Complete Randomized Block Design (CRBD) was applied for all nine treatments, each with three replicates.

All fertilizer types and soil samples were sieved to remove the unwanted waste particles. Organic fertilizer (OF) mixtures for each treatment (T1 - T7) were prepared by mixing the particular organic fertilizer with soil and coir dust. The experiments were conducted at two fertilizer concentration levels, 50 % and 25 %. For each concentration level, each organic fertilizer was mixed with soil and coir dust according to the proportions shown in Table 1.

Table 1: Treatment combinations of the organic fertilizers, inorganic fertilizer and control

25% Organic Fertilizer (25% OF)	25% organic fertilizer + 65% soil + 10% coir dust (T1-T6)
50% Organic Fertilizer (50% OF)	50% organic fertilizer + 40% soil + 10% coir dust (T1-T6)
Mixture of organic fertilizers (M)	Equal amounts of six organic fertilizers (T7)
Inorganic Fertilizer (IF)	2g of inorganic fertilizer + 90% soil and 10% coir dust (T8)
Control (C)	90% soil and 10% coir dust (T9)

Seed germination test

After preparing the fertilizer mixtures, an equal amount of the mixture prepared for each treatment was filled into plastic seed trays (30 cm x 20 cm). The trays were arranged in a Completely Randomized Block Design (CRBD). For each treatment, 32 seeds of *S. melongena* were sown in separate seed trays. This sample size was selected expecting a reliable estimate of germination percentage while avoiding overcrowing and ensuring a uniform growth of seedlings across the treatments. An equal amount of water was added to each replicate as required and the seeds were regularly observed for a period of two weeks. Throughout the monitoring period, the emergence of seedlings in each tray was observed and the total number of germinated seeds in each tray was counted daily. The seedlings were maintained for 42 days until they reached the transplanting stage to collect the remaining data.

Seed germination indicators

Germination Percentage (GP): Expressed as the ratio of germinated seeds at day ‘n’ to the total number of seeds. This parameter was calculated using the following formula.

Germination percentage = (Number of seeds germinated / total number of seeds sown) x100

Germination Index (GI): Expressed as the speed of germination and it was calculated using the following formula [20].

$$GI = \Sigma\, Gt/Dt$$

Where; GI = Germination index
Gt = Number of germinated seeds
Dt = Time corresponding to Gt in days

Shoot and root length of developing seedlings

The developing seedlings were maintained for forty-two days and their shoot and root lengths were measured. Shoot length (cm) of each seedling was measured from the soil contact point to the tip of the shoot. For root measurements, the seedlings were carefully taken out from each compartment of the seed trays, in order to safely separate the whole root system from the soil. In each seedling length of the tap root was measured (cm) from the soil contact point to the tip of the root.

Data analysis

Data collected from this experiment were statistically analyzed by one way Analysis of Variance (ANOVA) using Minitab Version 17.

Results and discussion

Effect of organic fertilizers on germination of *S. melongena* seeds and shoot and root development of growing seedlings

Germination percentage

Figure 1 displays the percentage of *S. melongena* seeds germinated over a period of 14-days. According to the results, the percentage of eggplant seeds that germinated with 25% different organic fertilizers ranged from 6.25 to 87.5, whilst the percentage with 50% different organic fertilizers ranged from 2.08 to 82.29. This result indicated that the use of 25% organic fertilizer was more favourable for eggplant seed germination than that that of 50% concentration. Among all treatments, the seed lot sown in the chicken manure (CM) showed the lowest percentage of germination in both concentrations. In contrast, 25% rice husk (RH) yielded the highest germination followed by goat manure (GM) and compost (CO). This finding indicated that the addition of organic fertilizers had lower impact on germination of *S. melongina* seeds. The superior performance of rice-husk may be attributed to its high silica (SiO_2) content, as silicon (Si) is known to be a beneficial element in plant growth [21]. Further, [22] investigated the effects of exogenous silicon on the seed germination of tomato (*Solanum lycopersicum* L.) and found that silicon application significantly enhanced the seed germination percentage. Their results further suggested that exogenous silicon could alleviate oxidative stress in emerging seedlings of tomato by enhancing antioxidant defense system.

Animal manures have been effectively used as fertilizers for centuries. Given the high nutrient contents of chicken manure, it is widely used as organic fertilizers in agriculture. But in many research work, it was concluded that little is known about how animal manure affects the germination of seeds, especially chicken manure, which contains high amounts of phytotoxic substances and a high content of nitrogen [23]. In this study as well, the lowest percentage of germination observed for chicken manure treatment may therefore be associated with its potential inhibitory effects.

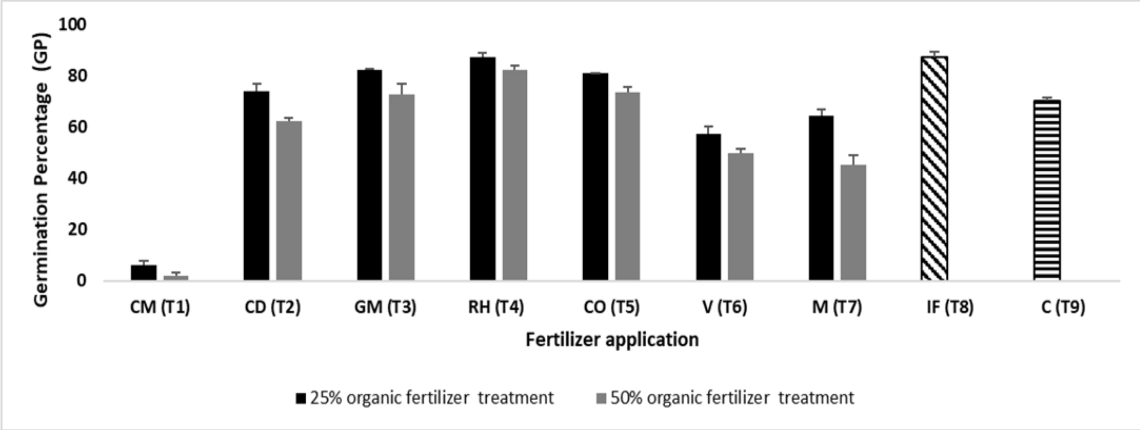

Figure 1: Comparison of means of organic fertilizer treatments on percentage of germination of S. *melongena* seeds (T1- T7) with T8 and T9 representing the inorganic fertilizer and the control treatment respectively.

Germination Index (GI)

Germination index appears to be the most comprehensive parameter for evaluating seed germination as it combines both germination percentage and speed of germination of seeds. A higher GI value indicates not only a higher number of seeds germinated but also a fast rate of germination. Figure 2 represents the germination indices of eggplant seeds subjected to different inorganic and organic fertilizer treatments.

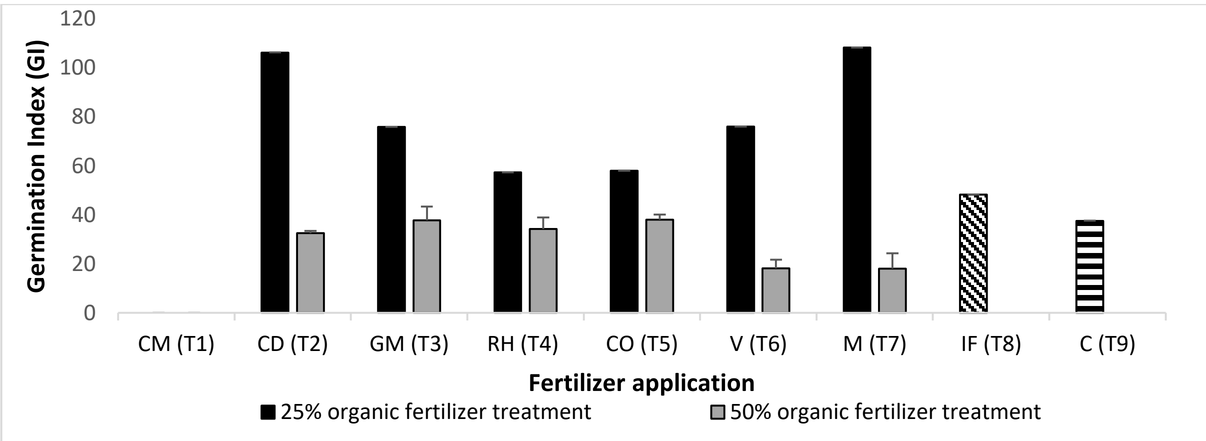

Figure 2: Comparison of means of organic fertilizer treatments on germination index of *S. melongena* seeds (T1-T7) with T8 and T9 representing the inorganic fertilizer and the control treatment respectively.

The highest germination index was recorded for the mixture of 25% organic fertilizer (T7) followed by the same concentration of cow dung (T2). Since all organic fertilizers were applied in equal amounts in this T7 treatment, it can be concluded that this mixture created a favourable environment enriched with required macronutrients and micronutrients, thereby supporting an efficient seed germination. Since cow dung also contains essential macronutrients such as nitrogen, phosphorus and potassium as the primary macronutrients with some micronutrients, it also has contributed a better environment for seed germination showing a higher germination performance, resulting in a higher germination index. Several treatments such as, cow dung, goat manure, rice husk and compost showed relatively a higher germination percentage. However, their germination index values were considerably lower, indicating that although many seeds were germinated, germination occurred more slowly and less uniformly than in other treatments with higher germination index values. Low germination index for the said fertilizers could be due to some reasons such as slow release of nutrients and the presence of phytotoxic substances. Seed germination is used as an indicator of the phytotoxicity of organic fertilizers. Similar to the present findings, previous studies have reported that chicken manure can strongly inhibit the seed germination in radish and caused irreversible suppression owing to its high phytotoxicity (Germination Index = 0%) [24].

Shoot and root lengths of developing *S. melongena* seedlings

The types of fertilizer used had an influence on the shoot and root lengths of developing *S. melongena* seedlings. As observed during the seed germination phase, the 25% fertilizer mixture resulted the longest root and shoot development compared to 50% fertilizer concentration. Among the different organic fertilizers tested at 25% concentration, shoot lengths varied from 5.9 cm to 11.3 cm, while root lengths from 1.3 to 5.8 cm (Figures 3 and 4). There was no data recorded for chicken manure since the few seeds that germinated, decayed with time and failed to develop into normal seedlings.

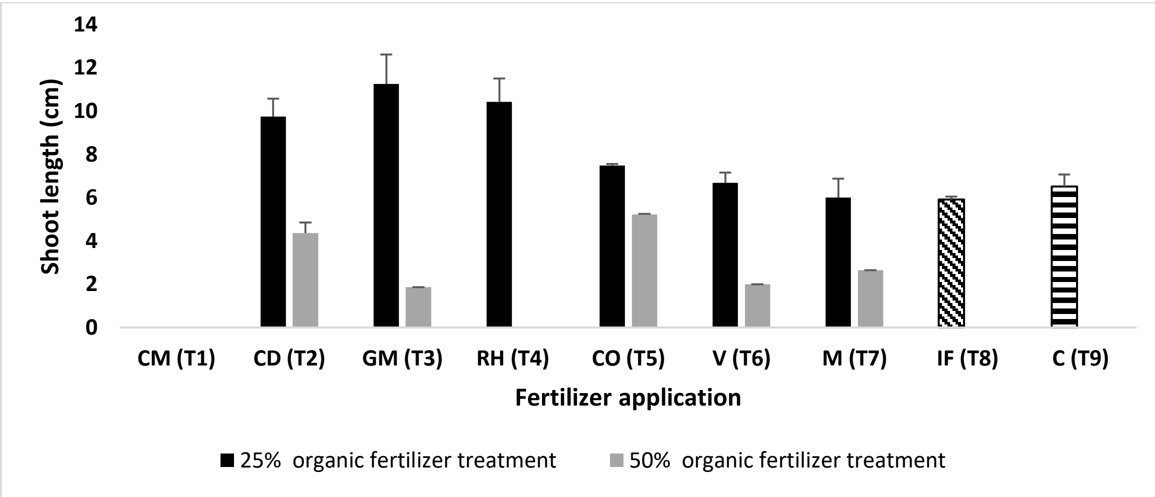

Figure 3: Comparison of means of organic fertilizer treatments on shoot lengths of *S. melongena* seedlings (T1-T7) with T8 and T9 representing the inorganic fertilizer and the control treatment respectively.

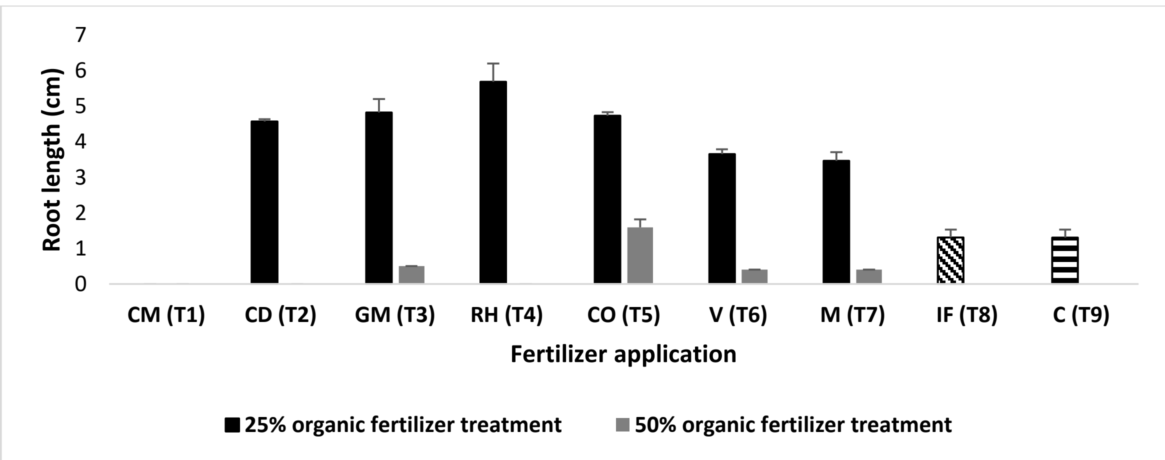

Figure 4: Comparison of means of organic fertilizer treatments on root length of *S. melongena* seedlings (T1-T7) with T8 and T9 representing the inorganic fertilizer and the control treatment respectively.

The results indicated that at 25% application of organic fertilizers - specifically cow dung (CD), goat manure (GM), rice husk (RH) and compost (CO) had an effect on both root and shoot development of *S. melongena* var. HORDI Lena-iri 1 seedlings. As shown in the Figure 3, goat manure (GM) resulted the highest shoot length followed by rice husk (RH). In contrast, rice husk (RH) showed the highest root length followed by followed by compost (CO), Goat manure (GM) and cow dung (CD). Overall, the study supports that the application of cow dung (CD), goat manure (GM), rice husk (RH) and compost (CO) can be successfully used at 25% (w/w) concentration to enhance the seed germination and seedling development of *S. melongena* var. HORDI Lena-iri 1.

Conclusions

The results demonstrated that different fertilizer treatments significantly affected the seed germination and development of seedlings of *S. melongena*. It can be concluded that applying cow dung (CD), goat manure (GM), rice husk (RH), and compost (CO) at 25% (w/w) concentration is effective in promoting a better seed germination and seedling development. When comparing the seed germination rates, chicken manure showed the lowest germination rate while the other organic fertilizers exhibited considerably higher germination rates. But it was evident that still the use of 50% of organic fertilizer by weight had a negative effect on seed germination of *S. melongena* and could associated with the inhibitory effect such as osmotic stress or nutrient imbalance at higher concentrations. Hence application of 50% organic fertilizer is not recommended for the seed germination of *S. melongena*. High fertilizer levels during germination are unnecessary and may negatively affect the seed performances.

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