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A Survey on Anthracnose Disease Intensity in Major Fruit Stalls in Ninthavur Divisional Secretariat of Ampara District

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***Abstract*—**Anthracnose is one of the significant diseases in banana fruits, which is widely reported throughout Sri Lanka. The present study aimed to survey the prevalence and intensity of anthracnose of banana in major fruit stalls in Ninthavur Divisional Secretariat (DS) of the Ampara district. It was a cross-sectional study conducted from May to August 2020. A purposive sampling method was made to select the DS area in the Ampara district, and a random sampling approach was used to choose fruit stalls. About 80 fruit sellers were interviewed by using a pre-tested back-translated questionnaire. Simultaneously, the researcher carried out anthracnose disease intensity assessment for all the varieties by giving 0-4 scale scores. Results revealed that banana anthracnose is prevalence in varieties such as 'Puli kathali' or 'Ambul kesel', Kolikkoodu', 'Etharai' and 'Seeni kathali' or 'Seeni kesel' throughout the study area. In comparison, less anthracnose found in the variety 'Ambon'. There was a significant association (p=0.015) between means of keeping banana during transportation and anthracnose disease intensity for variety 'puli kathali'. However, anthracnose disease intensity of other varieties did not significantly associate each other. Further, ordinal regression analysis showed that disease intensity of varieties' Puli kathali', 'Seeni Kathali' and 'Kolikkoodu' were lesser than the disease intensity of variety "Etharai" irrespective of the handling practices of the seller. It could conclude that varietal differences and improper handling practices during the transport significantly affect the prevalence and intensity of anthracnose disease in banana fruits in the Ampara district's Ninthavur DS area.

***Keywords*—**Anthracnose, Banana, Disease intensity, Fruit stalls, Disease prevalence, Ninthavur DS area

I. Introduction

Banana (*Musa* spp.) is one of the essential fruit crops widely grown in Sri Lanka. It has a cumulative cultivation area of 46,486 acres and 366 acres out of in Ampara district (Department of Census and Statistics, 2014). Further, annual production is about 450,000 (Wasala et al., 2012). Banana is the second-ranking fruit next to citrus globally. It also contributes nearly 16% of the world's fruit production, comparable to stable food next to major cereals (Ellyn, 2011). Ripened banana mainly consumed as a dessert fruit and use in immature stage to all green for cooking purposes and are processed as chips because of the highly digestible ability than all other fruits (Mohapatra et al., 2010).

Sensory characteristics of banana are the primary concern to determine consumer preferences (Robinson and Sauco, 2010). Several factors govern which, but the disease is the prominent one. Contamination in the series of banana physiological stages can occur from growing season, harvesting and post-harvesting stages to consumers table (Warton et al., 2000). Different fungi spoil about 20% to 25% of harvested fruits, and nearly 1.6 million bananas are thrown in developing countries (Idris et al., 2015).

Banana develops many post-harvest diseases which affect the quality of the fresh produce. Anthracnose is the most significant post-harvest banana disease in Sri Lanka. It reduces the annual yield by 20%, about 80,964 metric tones along with crown rot (Anthony et al., 2004). Many commercial banana varieties grown in Sri Lanka are susceptible to anthracnose resulting in post-harvest losses (Adikaram, 1986-1987; Perera and Karunaratne, 1995). In which, 'Ambon' (De Costa et al., 1997) and 'Puli kathali' or 'Ambul kesel' (Abayasekara et al., 2013) are highly susceptible while 'Seeni kathali' or 'Seeni kesel' is resistant to anthracnose (De Costa et al., 1997). It is a fungal disease caused by *Colletotrichum* spp. Commonly, C. *musae* is associated with it in banana. However, C. *gloeosporioides* have also been linked with banana anthracnose (Wijesundera, 1994; Duduk et al., 2009). The symptoms include black and sunken lesions with spore masses or acervuli in the lesion (Wijesundera, 1994; Latiffah, 2009). This disease usually occurs during long transportation and storage period with relatively low temperature and high humidity (Thompson

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and Burden, 1995; Deka et al., 2006).

Anthracnose severely deteriorates the quality and nutritional value of banana fruits. Hence, it affects the consumer preferences of banana fruits in the market and profit loss to the farmers and traders (Deka et al., 2006). However, gentle handling and proper storage facilities and the harvest and post-harvest chain will minimize the contamination (Warton et al., 2000). Study about the banana handling practices of fruit sellers, availability of different banana varieties, the prevalence and intensity of anthracnose disease is paramount for future research in developing control measures to manage the anthracnose of banana in Sri Lanka. There is little literature available in Sri Lanka connecting post-harvest handling practices with anthracnose disease and the varieties.

The Eastern region of Sri Lanka significantly engaged with fruit cultivation, including banana (Department of Census and Statistics, 2014). The banana anthracnose in the Ampara district is not sufficiently studied. Hence, this study aimed to survey the prevalence and intensity of anthracnose of banana in central fruit stalls in the Ampara district particular reference to Ninthavur DS area.

II. Methodology

It was a cross-sectional study. It was administered in which owners of major banana fruit stalls in the Ninthavur DS area of Ampara district a pre-tested and back-translated questionnaire from May to August 2020. The selected respondents were interviewed about the details of the availability of bananas' varieties and other fruits for sale in the study area and banana fruit handling practices. Further anthracnose disease intensity of the available varieties from each stall was observed and recorded by the researchers.

A. Study Design

Selection of Ninthavur DS area was purposefully made since it has many banana fruits stalls. Further, random sampling method was used for the selection of fruit shops from the selected DS area. In which eighty fruit shops' owners were interviewed during the survey period.

B. Anthracnose Disease Intensity Assessment

In each shop, a bunch of fruit was randomly selected, and in each bunch, five hands were examined. Observations were recorded concerning the intensity of the disease. Disease intensity was assessed as average fruit areas covered by anthracnose symptoms for five hands per bunch. The same procedure was followed to all available varieties in selected shops. A 0-4 scale was given for scoring the disease intensity as observed by the method of Unnithan and Thammaiah (2017).

Where,

0 = No disease symptoms.

1 = Small restricted lesions covering 25 per cent of the fruit surfaces.

2 = Large restricted lesions covering 50 per cent of fruit surface.

3 = Radiating lesion formed by coalescence of small ones covering 75 per cent of the fruit surface.

4 = Fruits completely rotten.

C. Data Validation

All questionnaires were completed according to the responses of the respondents. The respondent's native language was used without technical jargon, and it was understandable to the individual's educational condition. Further clarity has been given for the unknown sections.

D. Statistical analysis

The collected primary data were coded, entered, cleaned, and analyzed using the Statistical Package for Social Science (SPSS) version 22. Descriptive statistics such as frequency and percentage were calculated to determine the distribution of the study variables. Chi-square test was used to test the significant difference between variables under investigation. Further ordinal regression analysis was performed to check the relationship between variables. The significant level of 0.05 (95%) was selected as a criterion for determining significances.

III. Results and discussion

A. The Details of Availability of Bananas' Varieties and Other Fruits for Sale in the Study

Area: Among the 80 banana sellers interviewed; type of shop category 51% was market while 49% was roadside shops (Table 1). Principally, surveyed shops had fruits such as papaya (66.25%), mango (63.75%), grapes (35%), pomegranate (16.25%) and orange (6.25%) other than a banana for sale. As per the data got, five banana varieties were available for the study area. In which, majority of the fruit shops had 'Seeni kathali' or 'Seeni kesel' (100%) followed by 'Puli kathali' or 'Ambul kesel' (99%), 'Etharai' (94%), 'Kolikkoodu' (90%) and 'Embon' (1%). At the same time 'cavendish' and 'anamalu' varieties were not available for sale. About 91% of retailers received banana from the middle market who collect the fresh produce from one or more farmers and sell them to the retailers or whole sellers directly, followed by the whole seller (81%). Only 14% of respondents reported that they have sold banana got from their garden.

B. Banana Fruits Handling Practices in Study Area:

Kuyu and Tola (2018) stated that a wide range of mishandling practices favour fungal developments and result in fruit losses. This survey included a few of the banana handling practices to assess the occurrence of banana anthracnose in the study area. Most of the banana fruits sold in the Ninthavur DS area were brought from distant places using different means of transport. About 85% of the respondents were used a mini-open truck('batta') to take a banana from where they supposed to collect followed by a lorry (69%), motorbike (54%) and also a minimum percentage of roadside shop sellers (5%) brought their fruits via foot cycle.

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TABLE I
THE DETAILS OF AVAILABILITY OF BANANAS' VARIETIES AND OTHER FRUITS FOR SALE IN THE STUDY AREA

Variables	Categories	N	Frequency	Percentage (%)
Type of shop:	Market	80	41	51
	Roadside fruit shop	80	39	49
Variety	'Puli Kathali'	80	79	99
	'Seeni Kathali'	80	80	100
	'Kolikkoodu'	80	72	90
	'Etharai'	80	75	94
	'Ambon'	80	01	01
Sources	Own garden	80	11	14
	Middle market (Collectors)	80	73	91
	Whole seller	80	65	81
Other Fruits	Papaya	80	53	66
	Mango	80	51	64
	Grapes	80	28	35
	Pomegranate	80	13	16
	Orange	80	05	06

TABLE II
DETAILS OF GENERAL BANANA HANDLING PRACTICES ADOPTED IN STUDY AREA

Variables	Categories	N	Frequency	Percentage (%)
Mode of Transport	Lorry	80	55	69
	Mini open truck ('Batta')	80	68	85
	Motorbike	80	43	54
	Foot cycle	80	04	05
Means of keeping banana fruits while transportation	Piling of bunches with covering banana leaves	80	53	67
	Piling of bunches without covering banana leaves	80	27	33
At which physiological stage is collected	All green	80	76	94
	Green with trace of yellow	80	71	88
	Greener than yellow	80	68	85
	Half green/ half yellow	80	72	90
	More yellow than green	80	31	39
	Yellow with green tips and green necks	80	29	36
	All yellow	80	28	35
	All yellow with brown flacks	80	06	08

Further, it was noted, about 67% of shop owners were piled banana bunches with banana leaves as a packaging material in any means of vehicle they used. In contrast, the remaining 33% of respondents were left the banana bunches with no covering materials during their transportation (Table 2). It was observed that the banana they brought with no packaging material was crushed and discarded a few of the hands before the sale. Mulualem et al. (2015) reported a high injury of fruits to occur mechanically while improper packaging materials are used during transportation because of compression and surface bruising damages. However, the fruits hurt slightly while transport might be hugely influenced by the anthracnose associated fungal development. In the study area, respondents reported physiological stage of banana when they collect varied over time. It included fruits in all green to all yellow with brown flacks. The majority of the fruit sellers used to get banana when fruits at the green in stage (94%) followed by half green and half yellow stage (90%), green fruit with a trace of yellow (88%), and fruits are in greener than yellow stage (85%). However, some sellers (35%) used to get ripped banana, especially when they bought their garden. Some respondents (35%) also reported they accepted the banana at all yellow stages when their demand is high. Chillet et al. (2006) conveyed harvesting bananas at an earlier physiological age reduced the susceptibility of bananas to C. *musae* and the development of banana anthracnose.

C. Relationship between Method of Keeping Banana while Transportation and Disease Intensity of Banana:

When bruises wound the banana fruits during storage and transportation, anthracnose becomes significant (Zakaria et al., 2009). In this context, the association between keeping banana methods while transporting and anthracnose disease intensity was tested. Initially, both variables data were checked for their normal distribution by using the Kolmogorov-Smirnov normality test. It revealed that the data were not normally distributed. Therefore, the non-parametric analysis was considered. As per the chi-square test analysis performed between two variables, different p- values were obtained in Table 3.

Chi-square test revealed significant association (p=0.015) between means of keeping banana during transportation and anthracnose disease intensity based on the data got at present survey for variety 'puli kathali' or 'ambul kesel'. At the same time, the other three types were not significantly associated with each other. It showed that the variety 'Puli kathali' is more susceptible to getting infected by anthracnose, causing fungi if they have any prior injuries or damages because of mishandling. This finding was in agreement with Priyadarshanie and Vengadaramana (2015) studies which showed in an experiment, and all tested C. *musae* fungal isolates were pathogenic on banana fruits variety 'Kathali' when fruits are artificially wound.

TABLE III
RESULTS OF CHI- SQUARE ANALYSIS BETWEEN METHOD OF KEEPING BANANA WHILE TRANSPORTATION AND DISEASE INTENSITY OF BANANA ANTHRACNOSE

Name of Banana Variety	p- Value from Chi- Square Analysis
'Puli kathali'	0.015
'Seeni Kathali'	0.234
'Kolikkoodu'	0.416
'Etharai'	0.363

D. Ordinal Regression Analysis between Disease Intensity and Variety:

Ordinal regression analysis revealed that about 40.5% of fruits were completely rotten (score =4). In comparison, 4.6% of fruits were affected by small restricted lesions covering 25 per cent of the fruit surface irrespective to the variety (Fig. 1). Further, there is a significant difference between the baseline and final models (Table 4) from the ordinal regression analysis. It has confirmed that there is an independent variable influenced by the dependent variable. Accordingly, an independent variable variety would significantly affect the dependent variable, the intensity of anthracnose in banana (Significant value- 0.000). It also confirmed that the observed

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data are considerably having goodness-of-fit with the fitted model (Pearson value= 0.054) (Table 5).

Pseudo R-Squared showed that the proportion of the variance explained by the independent variable, variety on the dependent variable, disease intensity in the regression model. According to the Nagelkerke value (0.148) (Table 6), the analysis revealed that more independent variables such as mode of transport, method of storage while transportation and physiological stage at harvesting need to be selected to increase the Nagelkerke value. However, in this analysis, the only variety was considered.

Disease intensity level against variety was tested through parameter estimates (Fig. 2). Variety 'Etharai' was considered as a referential variety, and the disease intensity level of all other varieties was compared. Results revealed estimates values of varieties 'Puli kathali', 'Seeni Kathali' and 'Kolikkoodu' were negative. Therefore, it could be concluded that disease intensity level of anthracnose of varieties 'Puli kathali', 'Seeni Kathali' and 'Kolikkoodu' were lesser than the disease intensity level of anthracnose variety "Etharai". Further, the disease intensity of anthracnose of banana varieties 'Puli kathali' (Sig. 0.00) and 'Seeni kathali' (Sig. 0.00) was significantly differed from the variety 'Etharai' while there is no significant difference between variety 'Etharai' and 'Kolikkoodu' in terms of the level of disease intensity (Sig. 0.06).

		N	Marginal Percentage
Disease intensity	No disease symptoms	16	5.2\%
	Small restricted lesions covering 25 percent of the fruit surfaces	14	4.6\%
	Large restricted lesions covering 50 percent of fruit surface	30	9.8\%
	Radiating lesion formed by coalescence of small ones covering 75 percent of the fruit surface	122	39.9\%
	Fruits completely rotten	124	40.5\%
Variety	'Puli kathali'	79	25.8\%
	'Seeni kathali'	&80	26.1\%
	'Kolikkoodu'	72	23.5\%
	'Etharai'	75	24.5\%
Valid		306	100.0\%
Missing		0	
Total		306	

Fig. 1. Case Processing Summary of Ordinal Regression Analysis between Disease Intensity and Variety)

TABLE IV
MODEL FITTING INFORMATION OF ORDINAL REGRESSION ANALYSIS BETWEEN DISEASE INTENSITY AND VARIETY

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	114.971			
Final	70.163	44.&808	3	.0
Link function: Logit.				

IV. CONCLUSION

The survey results showed that the anthracnose disease was prevalent in the study area in all assessed varieties. However, intensity varied depending on the handling practices and the varietal differences. It could conclude that variety 'Puli Kathali' was more susceptible to anthracnose disease when they physically damaged. Further, the disease intensity of varieties 'Puli kathali', 'Seeni Kathali' and 'Kolikkoodu' were lesser than the disease intensity of variety 'Etharai' regardless to the handling practices adopted by the fruit sellers in Ninthavur DS area of Ampara district. Future research should identify anthracnose's causal organisms in banana in the study area, followed by environmentally sound management strategies to minimize anthracnose post-harvest fruit losses in the Ampara district.

TABLE V
GOODNESS-OF-FIT OF ORDINAL REGRESSION ANALYSIS BETWEEN DISEASE INTENSITY AND VARIETY.

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	16.701	79	.054
Deviance	22.574	9	.007
Link function: Logit.			

TABLE VI
PSEUDO R- SQUARE OF ORDINAL REGRESSION ANALYSIS BETWEEN DISEASE INTENSITY AND VARIETY

Cox and Snell	.136
Nagelkerke	.148
McFadden	.058
Link function: Logit.	

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		Estimate	Std. Error	Wald	df	Sig.	95\% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Disease intensity = 0.00]	-4.163	.355	137.237	1	.000	-4.859	-3.466
	[Disease intensity = 1.00]	-3.453	.310	123.971	1	.000	-4.061	-2.845
	[Disease intensity = 2.00]	-2.584	.279	86.060	1	.000	-3.130	-2.038
	[Disease intensity = 3.00]	-.591	.238	6.166	1	.013	-1.057	-.124
Location	[Variety=1.00]	-1.724	.324	28.307	1	.000	-2.359	-1.089
	[Variety=2.00]	-1.768	.324	29.816	1	.000	-2.402	-1.133
	[Variety=3.00]	-.616	.327	3.536	1	.060	-1.258	.026
	[Variety=4.00]	0[a]	.	.	0	.	.	.
Link function: Logit.								
a. This parameter is set to zero because it is redundant.								

Fig. 2. Parameter Estimates of Ordinal Regression Analysis between Disease Intensity and Variety.)

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