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Knowledge and Adaptation Strategies of Eggplant Farmers to the Effect of Bacterial Wilt Disease in Nsukka Agricultural Zone of Enugu State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author JCI designed and wrote the protocol of the study as well as the first draft of the manuscript. Author GNA managed literature search, administered the questionnaires and collected data. Authors SAO and CEU managed data analyses and interpretations. Author SAO also wrote subsequent draft of the manuscript. Author VAO assisted in manuscript editing. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To ascertain knowledge and adaptation strategies of eggplant (*Solanum melongena*) farmers to the effect of bacterial wilt disease in Nsukka Agricultural zone of Enugu state, Nigeria**.**
Study Design: Multi-stage and Simple Random Sampling Design/Technique were used in the study.
Place and Duration of Study: Department of Agricultural Extension, University of Nigeria, Nsukka Enugu State, Nigeria. The study took place between October 2017 and September 2018.
Methodology: One hundred and eight eggplant farmers were selected from three blocks and nine circles for the study. Percentage and mean scores were used to present the data.
Results: Findings reveal that the majority (96.30%) of the respondents had high knowledge on eggplant bacterial wilt disease. Some of the major effects of bacterial wilt disease on eggplant as perceived by the respondents were reduction in yield/output ($\bar{x}$=2.84) and reduction in quality of

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harvested eggplant ($\bar{x}$=2.81). Some adaptive strategies employed by the respondents to the effect of bacterial wilt disease were use of fertilizer (97.20%) and early planting of eggplants (96.30%). Constraints to egg plant farmers' adaptation to bacterial wilt disease were: drudgery involved in controlling the disease ($\bar{x}$=2.83) and high cost of good/disease free planting material ($\bar{x}$= 2.80). Proper weeding (84.30%) and fumigation of the entire farmland before cultivation (79.60%) were some of the possible solutions to the destructive effects of bacterial wilt diseases.

Conclusion: The respondents had high knowledge on bacterial wilt disease, which helps them to adapt to the deleterious effects of the disease on their eggplants.

Recommendation: The study recommends that governments and non-governmental organizations should invest in eggplants research in order to solve farmers' problems; through evolvement and provision of resistant variety, recommended agronomic practices and agrochemicals of eggplants to farmers. Dissemination of output of the research through extension will boost the capacity of the farmers in order to adapt and overcome the disease.

Policy Implications: The investments on eggplants should be innovative and it should explore possible production and management strategies that not only boost but also, make eggplant enterprises sustainable. Policy must be focused on educating eggplant farmers on improved production and management practices on eggplant enterprises. This can be disseminated by agricultural extension workers and other relevant institutions. Policy must also focus on specific and pragmatic programs such as input supply programs (improved seeds, resistant varieties, fertilizer, pesticides, herbicides etc.) at affordable or subsidized prices. This must be designed in such a way that it identifies the right pathways to get to the eggplant farmers on appropriate time.

Keywords: Adaptation strategy; bacterial disease; eggplant; knowledge; wilt infestation.

1. INTRODUCTION

Solanum melongena L commonly known as brinjal or eggplant or aubergine is one of the vegetable crops belonging to solanaceae family. It is also a self- pollinated annual perennial vegetable extensively cultivated both in temperate and tropical zones of the world especially in Asian countries like India, Bangladesh, Pakistan, China, Japan, Indonesia and Philippines [1]. Demand of eggplant as a fruit vegetable is increasing gradually all over the world because of its low price and high nutritive values [2]. It is also one of the most commonly consumed fruit vegetable in the tropical Africa [3]. Notably, different local species/varieties are in existence and are grown by different ethnic groups in Nigeria for local consumption and other uses.

Eggplant is consumed on daily basis by both rural and urban families and also represents the main source of income for producing households in West Africa [4]. Eggplant nutrient value is comparable to the values of other common vegetables. Its flesh is composed of 92.7% moisture, 1.4% protein, 1.3% fibre, 0.3% fat, 0.3% minerals and the remaining 4% consist of various carbohydrates and vitamins (A and C) [5]. Nonetheless, small scale growers' account for at least 86% of the total production [6].

Production is however constrained by a wide range of pests and diseases, reducing total production as well as production quality. *Solanum melongena* bacteria wilt diseases has been one of the devastating and serious bacteria disease attacking eggplant throughout the sub-tropical and temperate region of the world [6]. The disease is characterized by sudden wilting of the plant at the flowering stage, yellowing of foliage and stunting of the plant growth with initial brownish discoloration of vascular tissues or cambium tissues, which may be accompanied by browning and rotting of the vascular bundles [6]. Bacteria wilt disease of eggplant caused by *Ralstonia solanacearum* is a very deadly disease that can lead to the death of the whole plant. Eggplants productivity in most part of tropical Africa region had been seriously altered resulting to decline in food production due to the deadly incidence of bacteria wilt disease [7].

The continuing vulnerability of the crop to the disease should be the driving force toward the development of sustainable adaptive strategies for the management of this disease [8]. It also necessitates the need to create and boost awareness and knowledge levels of farmers about the disease and collate coping/adaptive strategies they employ. This is necessary in order to scrutinize these strategies for suitability and document them for posterity. In view of the aforementioned facts, the study sought to

ascertain knowledge and adaptation capacities of eggplant farmers to the effect of bacterial wilt disease (*Solanum melongena*) in Nsukka Agricultural zone of Enugu state, Nigeria**.** Specifically the study ascertained knowledge levels of the farmers about the disease, effects of bacteria wilt disease on eggplants; adaptive strategies they employed and constraints that they face in adapting to the disease.

2. METHODOLOGY

The study was carried out in Nsukka agricultural zone of Enugu State, Nigeria. Nsukka Agricultural zone is made up of six (6) local government areas (LGAs) with many major markets. The population of the study comprised all eggplant farmers in the zone. A multi-stage sampling procedure was used in selecting the respondents. In the first stage, simple random sampling technique was used to select three blocks (Nsukka I, Igbo-Etiti and Igbo-Eze South) out of the eight blocks in the zone. In the second stage, simple random sampling technique was used to select three out of eight circles in each of the selected blocks giving a total of nine circles for the study. In the third stage, simple random sampling technique was also used to select 12 eggplant farmers out of the list of eggplant farmers compiled by the village head-extension agent in each of the circles that were selected. This gave a sample size of 108 eggplant farmers for the study.

Data were collected using structured interview schedule. In order to assess farmers' level of knowledge on eggplant bacteria wilt disease. The respondents were required to tick yes' or no' on the fifteen knowledge statements (such as yellow leaves on eggplant indicate the presence of bacterial wilt disease, bacteria wilt disease causes fruit rot etc) about eggplant bacteria wilt disease that were presented to them. Score of one mark was assigned to each correct answer making a total of 15 marks, while zero was assigned to a wrong answer. Each of the respondents were marked and scored over 0-15. The respondents were categorized into four groups of knowledge levels based on their scores as follows;

No knowledge (for those respondents with 0 score)
Low knowledge (for those respondents with 1-5 scores)
Moderate knowledge (for those respondents with 6-10 scores) and
High knowledge (for those respondents with 11-15scores)

Perceived effects of bacteria wilt disease on eggplant were measured in terms of what farmers feel they experience because of this disease such as reduction in quantity and quality of harvested eggplant. To achieve this, a list of possible effects of this disease was provided on a four point Likert-type scale of; to a great extent, moderate extent, little extent and no extent with values of 3, 2, 1, and 0 assigned to them respectively. The mean was 1.5. The respondents were asked to tick variables on the scale. Variables with mean scores greater or equal to 1.5 were perceived as major effects while those with mean values less than 1.5 were regarded as minor effects of eggplant bacteria wilt disease on the crop. Respondents were also asked to indicate adaptive strategies they employed against the disease such as use of antagonistic bacteria, routine spraying of farm with bactericides (chemicals) etc. Constraints to farmer's adaptation to the effects of eggplant bacteria wilt disease was achieve using four point Likert-type scale of; to a great extent, moderate extent, little extent and no extent with values of 3, 2, 1, and 0 assigned to them respectively and a mean value of 1.5. Variables with mean scores greater or equal to 1.5 were perceived as major constraints while those with mean values less than 1.5 were regarded as minor constraints. Data were presented in percentage and mean scores.

3. RESULTS AND DISCUSSION

3.1 Knowledge of Eggplant Farmers on Bacterial Wilt Disease

Entries in Table 1 show that the majority of eggplant farmers in the study area had knowledge of bacterial wilt disease. Specifically, (99.10%) of the respondents knew that bacterial wilt disease is a contagious disease, another 99.10% knew that some yellowish colouration on the leaves of eggplant indicate the presence of bacterial wilt disease, 98.10% knew that the disease causes fruit rot while 97.20% knew it causes total defoliation of eggplants. Also, the respondents knew that it encourages fruit abortion on eggplants (96.30%), it causes shrinking of fruit of affected eggplant and dark brown leisure on leaves of eggplant (96.30% each), it causes wilting of the leaves of eggplant (96.30%), it is a soil borne disease (95.40%), it is spread by rain splash (94.40%), high

temperature encourages bacterial wilt disease on eggplant (94.40%), it is pronounced during rainy season (94.40%) and it causes stem rots (92.20%). With such a good knowledge, it is expected that eggplant farmers will know better management and adaptation strategies to employ in combating such farm ills. However, this may not always be the case since knowledge is merely a prerequisite to action, knowing is merely a preliminary stage which must be complemented by actions in order to actualize the ultimate goal. If eggplant farmers refuse to utilize this knowledge towards the desired direction, positive impact of the knowledge on the enterprise and agriculture generally may be a mirage. In congruence, [9] asserted the symptoms bacteria wilt disease of eggplant include wilting of the foliage and collapse of the entire plant, dropping and slight yellowing of leaves and vascular discoloration as well as drying of plants at the time of flowering and fruiting.

3.2 Knowledge Level of Farmers on Bacterial Wilt Disease

Fig. 1 shows that the majority (96.30%) of the respondents had high knowledge on eggplant bacterial wilt disease, 2.80% had moderate knowledge while 0.90% of the respondents had low knowledge on eggplant bacterial wilt disease. This finding corroborates that of Table 1 implying that high knowledge level of the respondents and utilization of this knowledge will make them to be less vulnerable to bacterial wilt disease, which may eventually lead to total eradication of the disease in the area.

3.3 Farmer's Perceived Effects of Bacteria Wilt Disease on Eggplant

Table 2 shows that the respondents perceived all the variables as effects of bacterial wilt disease on eggplant. Some of these effects are: reduction in the quantity of yield/output ($\bar{x}$=2.84); reduction in quality of harvested eggplant ($\bar{x}$=2.81); reduction in market value of eggplant ($\bar{x}$=2.76); death of eggplant ($\bar{x}$=2.75); increase in cost of production ($\bar{x}$=2.64); loss of planting materials ($\bar{x}$=2.62); loss of income ($\bar{x}$=2.62) and mass starvation ($\bar{x}$=2.35) (Table 2). Eggplants affected by bacterial wilt diseases if survived do not give required output per hectare and normally with low quality. The finding is in line with the assertion of [7] that reduction level caused by bacterial wilt disease impacts can be devastating. Also there are instances where plant disease has resulted to hundreds of thousands of deaths due to the destructions of staples food crops and consequent starvation. Thus, plant disease has general impacts on the farmers as well as the environment [8]. This necessitates the need to channel more research activities towards plant diseases especially on bacterial wilt disease so as to reduce the negative effect to the barest minimum.

Table 1. Respondents knowledge of bacterial wilt disease

Variables	Percentage (n=108)
Yellow leaves on the eggplant indicate the presence of bacterial wilt disease	99.10
Bacterial wilt disease causes fruit rot on eggplant	98.10
Presence of bacterial wilt causes stem rots	92.20
Bacterial wilt disease cause total death of affected eggplant	96.30
Bacterial wilt disease causes wilting of the leaves of eggplant	95.40
Bacterial wilt disease encourages fruit abortion on eggplant	97.20
Presence of dark brown leisure on leaves of eggplant	96.30
Bacterial wilt disease cause shrinking of fruit of affected eggplant	96.30
Bacterial wilt disease on eggplant is pronounced during raining season	93.50
High temperature encourages bacterial wilt disease on eggplant	94.40
Bacterial wilt disease is spread by rain splash	94.40
Bacterial wilt disease is a contagious disease	99.10
Bacterial wilt disease causes total defoliation of eggplant	97.20
Bacterial wilt disease is a soil born disease	94.40
Bacterial wilt disease causes stunted growth of eggplant	96.30

Source: Field survey August, 2018

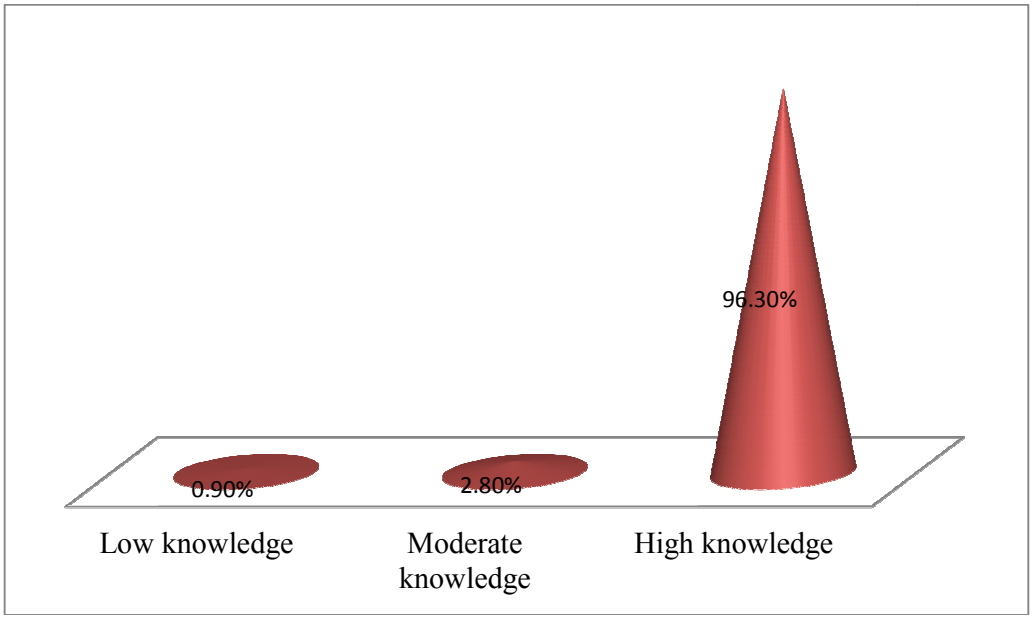

Fig. 1. Knowledge level of farmers on bacterial wilt disease

Table 2. Perceived effects of bacterial wilt disease on eggplant

Variables	Mean($\bar{x}$)	Standard deviation
Mass starvation	2.35	1.04
Increase in cost of production	2.64	0.76
Loss of income	2.62	0.77
Loss of planting material	2.62	0.84
Bacterial wilt disease causes death of eggplant	2.75	0.60
Reduction in quality/market value of fruits	2.76	0.61
Reduction in the quantity of yield/output	2.84	0.44
Increase in price of eggplant in the market	2.75	0.63

** $\bar{x}$=1.50, Source: Field survey August, 2018*

3.4 Adaptation Strategies Employed by Farmer's against Bacterial Wilt Disease of Eggplant

Table 3 shows that only pruning and thinning to eliminate sources of infection (38.90%) was adaptive strategy that the majority of the respondents did not use in order to adapt to bacterial wilt disease. Prominent among those strategies the majority of them employed were: use of fertilizer (97.20%); planting eggplant early (with the first rainfall) (96.30%), crop rotation (93.50%), mixed cropping, planting eggplant in a well-drained soil and treating seed with wood ash before planting (91.70% each), and treating seed with fungicides prior to planting (90.70%). In line with the findings [10] reported that farmers practiced adjustment of planting dates (early planting or late planting) in order to adapt to disease effects on crops. This strategy targets at planting early before the invasion and later after the invasion of the disease so as to reduce the effects.

Although, soil amendments like organic manures use can suppress bacterial wilt pathogen in the soil, some adaptation strategies (such as fertilizer use, seed treatment, fumigation, spraying of fungicides, irrigation mechanism etc.) may pose more variable cost threat which may increase cost of production thereby increasing prize of commodity and this may affect the business gross margin/profit [11]. Also some of these strategies are not healthy and sustainable in terms of their effect on human being and the environment. These serve as critical issues to observe and adhere to when inventing, disseminating and using prevention/ adaptation methods to erase or cushion the effects of plant disease like bacterial wilt.

Table 3. Strategies employed in adapting to the effect of bacterial wilt disease

Adaptation Strategies	Percentage (n = 108)
Mixed cropping	91.70
Mulching	87.80
Planting eggplant early with first rainfall	96.30
Treating of seed with wood ash before planting	91.70
Wide spacing of eggplant to reduce disease spread	89.80
Use of fertilizer	97.20
Planting eggplant in a well drain soil	91.70
Burning of the whole plant residues immediately after harvesting	85.20
Use of antagonistic bacterial	34.30
Crop rotation	93.50
Spraying of fungicides at early stage of the crop	73.10
Quarantine practices	62.00
Fallowing practice to reduce infestation	82.40
Planting of resistance variety	77.80
Removal of whole infected plant	75.00
Complete destruction of every plant species after harvesting	58.30
Removal of infected leaf part during the early stage	76.90
Treating the seed with fungicides prior to planting	90.70
Selection of sites surrounded by forest as a barrier to disease spread	64.80
Pruning and thinning to eliminate sources of infection	38.90
Fumigating the soil for some week before planting	84.30
Irrigation mechanism	80.60
Planting of eggplant during dry season	86.10

**Multiple responses Source: Field survey August, 2018*

3.5 Constraints to Farmer's Adaptation to the Effects of Bacterial Wilt Disease

Table 4 shows that the major constraints to farmers adaptation to bacterial wilt disease were drudgery involved in controlling the disease ($\bar{x}$=2.83); high cost of good/disease free planting material ($\bar{x}$= 2.80); poor access to credit ($\bar{x}$= 2.80); high labour cost ($\bar{x}$=2.79); poor extension delivery or services ($\bar{x}$=2.77); poor access to resistant variety ($\bar{x}$=2.77); insufficient information about eggplant bacterial wilt disease ($\bar{x}$=2.75); poor government support on control programme ($\bar{x}$=2.73) , secondary disease outbreak ($\bar{x}$=2.71), over usage of a particular chemical ($\bar{x}$=2.69), poor response of infected plant toward control measure ($\bar{x}$=2.69), lack of access to agro-input suppliers ($\bar{x}$=2.60) and inadequate finance to buy chemicals ($\bar{x}$=2.39). Poor access to credit could be a serious constraint to farmers' adaptation to bacteria wilt diseases since the farmer may not afford buying chemicals to control the disease. Also, the farmer may not have fund to buy eggplant disease resistant seeds, which may be very costly. This finding is in line with the fact that limited access to credit, poor extension service on information dissemination; unavailability and poor access to inputs (for example land, labour, seed and fertilizer) are problems farmers face [12] even in adapting to plant diseases. Extension can help to overcome this challenge by providing quality information about the disease and adaptation options to the farmers in simple and clear terms, which the farmers will apply in order to adapt and ameliorate the effects of the disease.

3.6 Possible Solutions to the Destructive Effects of Bacterial wilt Disease

Table 5 shows that the majority (84.30%) of the respondents indicated proper weeding of the farm, 79.60% indicated fumigation of the entire farmland before cultivation, 79.70% indicated use of right chemicals while 69.40% indicated use of clean and treated seeds as solutions to the destructive effects of bacterial wilt disease on egg plants. Excessive use of chemicals for control of the disease as pointed out by the respondents may not be commendable. Farmers need to be exposed to a more sustainable control strategies like crop and land rotations because they are more or less harmless and do not constitute devastation to the environment and ecosystem. [13] asserted that to manage bacterial wilt of eggplant, multiple measures such as use of resistant cultivar, grafting seedlings with wild rootstock, crop rotation, soil fumigation, and chemical controls have been recommended.

Table 4. Constraints to farmers' adaptation to the effect of bacterial wilt disease

Variables	Mean ($\bar{x}$)	Std. Dev.
Poor extension delivery/service	2.77	0.664
Insufficient information about bacterial wilt disease	2.75	0.672
High cost of good/disease free planting material	2.80	0.608
Over usage of a particular chemical pesticide	2.69	0.574
Poor access to credit	2.80	0.623
Disease resistivity toward a particular chemical use	2.75	0.295
Inadequate finance to buy chemical	2.39	0.681
Poor expertise in control techniques	2.60	0.579
Poor access to resistance variety	2.77	0.590
Poor government support on control programme	2.73	0.692
Lack of access to agro-inputs suppliers	2.66	0.566
High labour cost for control	2.79	0.433
Drudgery of control	2.83	0.464
Secondary disease breakout	2.71	0.642
Poor response of infected plant towards control measures	2.69	0.590

** $\bar{x}$=1.50; Source: Field survey August, 2018*

Table 5. Possible solutions to the destructive effect of bacterial wilt disease

Variable	Percentage (n = 108)
Making use of the right chemical	78.70
Fumigation of the entire farmland before cultivation	79.60
Proper weeding	84.30
Proper sanitation	6.50
Making use of treated seed	69.40
Supply of chemicals to the farmer by government	10.20
Proper management of the farm land	18.50
Cultural practices	27.80
Biological practices	29.60
Proper management of nursery seedbed	2.80

Source: Field survey August, 2018

4. CONCLUSION AND RECOMMENDATIONS

The respondents had high knowledge on bacterial wilt disease, which affects eggplant by reducing the quantity and quality of eggplant harvested. The farmers adapted to the effect of the disease by using fertilizer and planting eggplant early. Drudgery and high cost of good/disease free planting materials constrained eggplant farmers from adapting to the disease. Thus, the study recommends that governments and non-governmental organizations should invest in eggplant research in order to solve farmer's problems; through evolvement and provision of resistant variety, recommended agronomic practices and agrochemicals of eggplant to farmers. Extension should disseminate output of this research and educate farmers on the need to de-emphasize use of chemical especially for a prolonged period as a control measure for the disease as this may pose health and environmental threats.

POLICY IMPLICATIONS

The investments on eggplants should be innovative and it should explore possible production and management strategies that not only boost but also, make eggplant enterprises sustainable. Policy must be focused on educating eggplant farmers on improved production and management practices on eggplant enterprises. This can be disseminated by agricultural extension workers and other

relevant institutions. Policy must also focus on specific and pragmatic programs such as input supply programs (improved seeds, resistant varieties, fertilizer, pesticides, herbicides etc.) at affordable or subsidized prices. This must be designed in such a way that it identifies the right pathways to get to the eggplant farmers on appropriate time.

LIMITATION

The study was faced with challenges of insufficient fund as neither grant nor any form of funding was obtained from any institution. Thus, authors' decision to limit the study to only one agricultural zone out of the six agricultural zones in the State.

SCOPE FOR FURTHER RESEARCH

Similar study should be carried out on other agricultural zones in the State since the present study did not cover all the zones. Further study should be carried out to ascertain farmers' capacity to sustain and improve on the adaptation strategies.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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