Uganda Journal of **Agricultural Sciences**
ISSN: 1026-0919 (Print); 2410-6909 (Online)
Volume 22 Number 1 (2024) pp. 45 – 54
DOI: http://dx.doi.org/10.4314/ujas.v22i1.4

https://www.ajol.info/index.php/ujas

Incidence and Severity of Bacterial Wilt Disease on Three Eggplant (*Solanum melongena* L.) Varieties in Central Uganda

Mugisa I. O.[1, *], Allen M. M.[2], Aool W. O.[3], Muyinda M.[1], Gafabusa R.[1], Atim J. K.[1], Kabanyoro R.[1], Sseruwu G.[1], Akello, B. O.[1]

[1] Mukono Zonal Agricultural Research and Development Institute (MuZARDI). [2] National Livestock Resources Research Institute (NaLIRRI). [3] National Research Laboratories (NaRL).
*Corresponding author. immaculatemugisa@gmail.com

Received 21/6/2023. Accepted 17/4/2024. Published online 17/5/2024.

Abstract. This study was aimed at evaluating three eggplant varieties for response to bacterial wilt disease, to guide recommendations to farmers in central Uganda. Experiments were conducted at four sites under field conditions in 2016 and 2017 in central Uganda during three planting seasons. Two commercial eggplant varieties, namely, "Black beauty" and "Long purple", were tested alongside one newly introduced variety, the "Thai long green". Data was collected on disease incidence, severity and fruit yield. Analysis of variance revealed statistically significant differences in disease incidence, severity, and fruit yield across seasons, varieties and sites. The "Thai long green" variety proved to be a superior in terms of bacterial wilt resistance, showing the lowest levels of mean disease severity (1.5) and incidence (14%). The long purple variety was the most susceptible. "Thai long green" also attained highest average yields (14.86 t/ha), fruit weight per plant (1.2 kg) and fruit number per plant (9), across all locations for the three seasons. Therefore, we recommend promotion of the "Thai long green" variety in the region.

Keywords: *Ralstonia solanacearum*, tolerance, resistance, vegetable, fruit yield.

Introduction

The common eggplant (*Solanum melongena* L.), also known as "brinjal" in India and "aubergine" in Europe, is a popular vegetable crop produced throughout the world, particularly in the tropics and sub-tropics. It is currently the 3rd most important solanaceous crop produced globally, after potato and tomato (FAOSTAT, 2023). The crop is believed to have originated in Asia (Daunay and Hazra, 2012), and then it spread to other parts of the world including Africa. Although it's grown in many parts of the world, China (36.6 million tons), India (12.8 million tons) and Egypt (1.3 million tons) are currently the leading producers. Africa as a continent only produces 3.5% (2 million tons) of the total global eggplant production (FAOSTAT, 2023). In Uganda, eggplants are cultivated by many urban and peri-urban farmers for both domestic and commercial use. They were ranked as the 6th most important vegetable crop for food security by urban and peri-urban farmers in a survey that was conducted in central Uganda (Mugisa et al., 2017). Information on the market value of eggplants in Uganda is rather scanty and inconclusive, however, some reports indicate that eggplants produced within Uganda are mainly consumed locally, with the export value estimated at USD 5,000 in 2019 (Wamucii, 2024).

Eggplants are a preferred vegetable for several reasons. Not only are they cheap and fast-cooking, but they are also nutritious and healthy, mainly due to their low caloric value and their high content of vitamins, minerals, and bioactive compounds, mainly phenolic acids and anthocyanin (Docimo et al., 2016). They contain a considerable amount of anthocyanin, which are rich in antioxidants that are known to possess anti-cancer, anti-diabetic, and anti-inflammatory effects (Sekara *et al*., 2007; Azuma *et al*., 2008). These characteristics make them quite desirable for human consumption.

The production of eggplants in warm climates is hampered by wilt diseases which are particularly severe within the humid tropics, where central Uganda is located. Wilts are known to cause crop losses of up to 100% (Ali *et al*., 1994). Bacterial wilt, caused by *Ralstonia solanacearum,* is one of the most devastating diseases of eggplant and is an endemic disease for *Solanaceae* crops in the tropics and subtropics (Rotino *et al*., 1997; Oliveira *et al*., 2014). *Ralstonia solanacerum* is a soil-borne pathogen that infects the xylem tissue of plants through natural openings or wounds (Vasse *et al*., 1995; Huet, 2014). It usually manifests as wilt that begins from the upper parts of the plant, eventually spreading to the entire plant, causing death under favourable environmental conditions such as warm temperatures (between 25°C and 37°C) and high soil moisture (Lopes, 2009). Under unfavourable conditions (such as temperatures below 15°C or higher than 37°C and drought conditions), plants grow slowly and may appear to be stunted. This disease is very difficult to manage because pathogens survive for many years in the soil and in host plants (Wenneker et al., 1999). Host plant resistance is believed to be the best control option for this disease since other options such as the application of chemicals and antibiotics are neither effective nor feasible (Huet, 2014; Manickam et al., 2021). Resistance sources to bacterial wilt in eggplant have previously been successfully identified and resistant varieties developed in countries like India which is one of the main producers of eggplant worldwide (Lebeau et al., 2011; Wang et al., 1998).

In Uganda however, hardly any research has been done to identify bacterial wilt disease resistant or tolerant eggplant varieties, despite the prevalence of this disease in the country. This is unlike the case for tomato which is also affected by *Ralstonia solanacerum* (Osiru et al., 2001; Ramathani et al., 2021). Farmers usually purchase any varieties that are available on the market and continue to make losses from this disease. The present study was undertaken in Central Uganda to establish the occurrence and severity of bacterial wilt disease on three eggplant varieties. The main goal was to identify the most bacterial wilt-resistant eggplant varieties that are also high-yielding, under conditions of natural infestation, for recommendation to farmers within the region.

Materials and Methods

The study was conducted at four sites, located in four different districts within central Uganda, for three growing seasons: the 2nd season of 2016 (2016B), 1st season of 2017 (2017A), and the 2nd season of 2017 (2017B). Study sites included Ntawo (0°22'59"N, 32°43'57"E) in Mukono district, Namulonge (0°31'20"N, 32°37'34"E) in Wakiso district, Kamenyamiggo (0°18'12"S, 31°39'55"E) in Lwengo district and Kiwongoire (1°16'17"N, 32°26'51"E) in Nakasongola district. Central Uganda is located within the Lake Victoria Crescent Agro-ecological zone of Uganda, an area that lies within the humid tropics (MAAIF, 2021). The region has a bi-modal rainfall pattern. Kiwongoire village in Nakasongola district, located in the cattle corridor of Central Uganda receives the least rainfall and has the highest temperatures compared to the other three experimental sites (Table 1).

Table 1. Weather characteristics at the four study sites

Study site	Mean Relative Humidity	Annual Rainfall (mm)	Mean Temp (ºC)
Kiwongoire	66.6	890	29.0
Kamenyamiggo	70.4	1253	27.5
Ntawo	69.0	1245	27.2
Namulonge	68.0	1260	27.0

Prior to trial establishment, soil samples were taken from the study sites and tested at the National Research Laboratories (NaRL), Kawanda to determine their general chemical properties. These are presented in Table 2.

Table 2. Selected soil chemical properties of the study sites

Site	pH	OM (%)	N	P (ppm)	K	Ca
Ntawo	5.3	3.2	0.18	8.1	239	1560
Namulonge	6.0	7.1	0.33	0.7	441	1275
Kamenyamiggo	4.5	2.4	0.22	3.4	174	365
Kiwongoire	6.2	8.8	0.55	4.5	453	1480

OM= organic matter; N= nitrogen; P= phosphorus; K= potassium; Ca= calcium

Experimental design

Experiments were conducted under field conditions in soils that were naturally infested with *R. solanacearum*. Three eggplant varieties were tested, including two that were the most common on the Ugandan market and readily available to farmers: "black beauty" (dark purple, oval shaped) and "long purple" (dark purple, elongated). The third variety, the "Thai long green" eggplant, was newly introduced into the region and had previously been observed to display more resistance to bacterial wilt in on-station trials at Mukono Zonal Agricultural Research and Development Institute (MuZARDI), compared to the market types. The trials were established using the randomized complete block design (RCBD) with four replications at each location. The long purple variety, which is the commonest on the Ugandan market and most preferred, was used as a susceptible check.

Seedlings were initially raised in a greenhouse at Ntawo, MuZARDI, located in Mukono district, in central Uganda. Seeds were propagated in seed trays containing good quality sterile seed starting soil mixture. Prior to potting, soil was sterilized using the drum and steam method (Broekhuizen and van der Post C.J., 1974) and thereafter mixed with compost manure and charcoal dust in the ratio 3:2:1 (sterile soil: compost manure: charcoal dust). After sowing, the trays were kept moist to facilitate germination. When seedlings acquired two sets of true leaves, they were potted into larger pots (1.5 litre capacity) and regularly watered until they were 6 weeks old and ready for transplanting. They were then transplanted onto raised beds of 10m length and 1m width. Prior to transplanting, compost manure was applied at a rate of 2 tons per acre. A spacing of 60cm x 60cm was used with 20 plants per plot/ridge. All trial plots were fully mulched with dry grass. Irrigation was done twice a day (morning and evening) using a watering can during dry periods. Trial plots were sprayed bi-weekly in 3-4 day intervals with a pesticide (active ingredient (a.i.), dimethoate) and fungicide (a.i., mancozeb) at recommended rates throughout the growth period with the exception of the week preceding harvesting. Trials were harvested at about 4 months after transplanting, when fruits were showing indicators of maturity such as firmness and external glossiness.

Data collection and analysis

During the course of the growing seasons, bacterial wilt symptoms of the three varieties were observed and recorded. At each location, disease incidence and severity were assessed on a weekly basis by observation of the ordinary visual symptoms typical of bacterial wilt disease such as rapid plant wilting and death or dwarfing of plants. The natural occurrence of bacterial wilt disease at the trial sites was confirmed by cutting a piece of eggplant stem taken from the guard rows, followed by immersion in a glass of water and subsequent observation of a milky ooze (Lopes *et al.*, 1997). At harvest, data was recorded on the following parameters: number of fruits per plant (marketable and unmarketable), fruit weight per plant, number of infected or dead plants per plot, total number of plants per plot and bacterial wilt severity. Fruit yield was calculated as the total marketable fruit weight (t/ha) and number by summing the respective plot yields. Additionally, a yield index was computed based on two parameters, number of fruits per plant and fruit weight per plant, with the number of fruits considered as the most important parameter since it's the measure of trade on Ugandan markets. Yield index was computed as:

$$\mathrm{I} = \frac{(a * \mathrm{N}) + (\mathrm{b} * \mathrm{W})x^2}{(\mathrm{N} + \mathrm{W})}$$

Where: I is the yield index
a is the weight given to the number of fruits (0.7)
b is the weight given to the weight of fruits per plant (0.3)
N is the number of fruits per plant
W is the weight of fruits per plant

Bacterial wilt severity in the plots was scored using a scale of 0-5 as described by (Hussain et al., 2005), with slight modifications, as follows:
= Highly Resistant (HR) with no wilt symptoms
= Resistant (R), with 1 - 10% wilted plants
= Moderately Resistant (MR) with 11 -20% wilted plants
= Moderately Susceptible (MS), with 21-30% wilted plants
= Susceptible (S) with 31- 40% wilted plants
= Highly Susceptible (HS) with > 40% wilted plants

Disease incidence was calculated by expressing the number of infected plants as a percentage of the total number of plants per plot. Incidence data were used to compute the Area Under Disease Progress Curve (AUDPC) as described by (Campbell and Madden, 1990);

$$\mathrm{AUDPC} = \sum_{\mathrm{i}=1}^{\mathrm{n}} [(\mathrm{X}_{\mathrm{i}+1} + \mathrm{X}_{\mathrm{i}})/2][\mathrm{t}_{\mathrm{i}+1} - \mathrm{t}_{\mathrm{i}}]$$

Where: X_i = disease incidence at the i^{th} observation
t_i= time (days) at the i^{th} observation
n = total number of observations

Multi-location analysis of variance (ANOVA) was done using R statistical software, version 3.6.2 (R Core Team, 2020). Data were transformed by square root transformation to reduce on right skewness and ensure normality before analysis.

Results and Discussion

Variations in bacterial wilt incidence, severity and eggplant yields

Significant differences in bacterial wilt incidence, severity and AUDPC were recorded across seasons, varieties, and sites (p≤ 0.001) (Table 3). Likewise, the interaction of season, site and variety significantly (p≤ 0.001) affected the severity and incidence of bacterial wilt disease. On the other hand, there was no significant difference in the interaction between site and season for incidence, severity and AUDPC. Highly significant variations (p≤ 0.001) were observed in eggplant yields, fruit weight and fruit number per plant between varieties, sites, and seasons as well as the interaction between sites and seasons (Table 3). However, the interaction between site and variety only impacted on fruit number among the yield related parameters.

Table 3. Effect of season, site and variety on bacterial wilt incidence, severity, AUDPC, yield, fruit number per plant and fruit weight

	df	BWI (%)	BWS	AUDPC	Yield (t ha^{-1})	FNo.	Fwt (Kg)
Site	3	28.9***	50.5***	19.0***	62.6***	23.6***	71.3***
Season	2	15.5***	20.1***	24.0***	211.6***	19.6***	195.2***
Variety	2	123.1***	165.6***	145.3***	36.4***	48.2***	80.2***
Site x Season	6	0.4	0.5	1.29	28.5***	10.1***	35.1***
Site x Variety	6	7.7***	10.3***	14.0***	3.4**	3.78**	4.3***
Season x Variety	4	1.6	2.4	7.4***	20.3***	14.8***	37.3***
Site x Season x Variety	12	1.6	2.9**	4.6***	1.3	3.7***	1.95*
Residuals	97						

Note: df = degrees of freedom; Significance levels: * $P \leq 0.05$, **$P \leq 0.01$ and ***$P \leq 0.001$; BWI= Bacterial wilt incidence; BWS = Bacterial wilt severity; AUDPC = area under disease progress curve; FNo. = Fruit number per plant; Fwt = Fruit weight per plant

Incidence and severity of bacterial wilt disease

The study results revealed that the Thai long green eggplant was superior to the rest in terms of bacterial wilt resistance, having recorded the lowest levels of severity and percentage bacterial wilt incidence compared to the rest. It maintained the best performance even under conditions of high disease pressure at all the four sites (Table 4). This particular variety displayed resistance with the least mean disease severity (1.5) and incidence (14%) across the sites over the period of three seasons. It was followed by the black beauty which showed moderate resistance (overall mean severity 2.9, incidence 51%), while the long purple variety performed poorest (overall mean severity 3.2, incidence 58%) (Table 4).

Table 4. Mean bacterial wilt incidence and severity

Season	Site	Incidence (%)			Severity (scale:0-5)		
		Black beauty	*Long purple*	*Thai Long*	*Black beauty*	*Long purple*	*Thai Long*
2016B	Kamenyamiggo	60	65	20	3.4	3.4	1.8
	Ntawo	72	63	6	3.8	3.4	1.2
	Kiwongoire	10	29	12	1.2	2.1	1.3
	Namulonge	57	61	1	3.1	3.1	1.0
	Mean	50	55	10	2.9	3.0	1.3
2017A	Kamenyamiggo	81	88	35	4.0	4.0	2.2
	Ntawo	68	66	22	3.5	3.5	1.8
	Kiwongoire	32	35	22	2.2	2.4	1.9
	Namulonge	80	73	12	4.1	3.8	1.4
	Mean	65	66	23	3.5	3.4	1.8
2017B	Kamenyamiggo	46	71	11	2.8	3.8	1.4
	Ntawo	54	63	4	3.0	3.5	1.1
	Kiwongoire	18	18	14	1.7	1.5	1.4
	Namulonge	37	67	15	2.3	3.7	1.5
	Mean	39	55	11	2.5	3.1	1.4

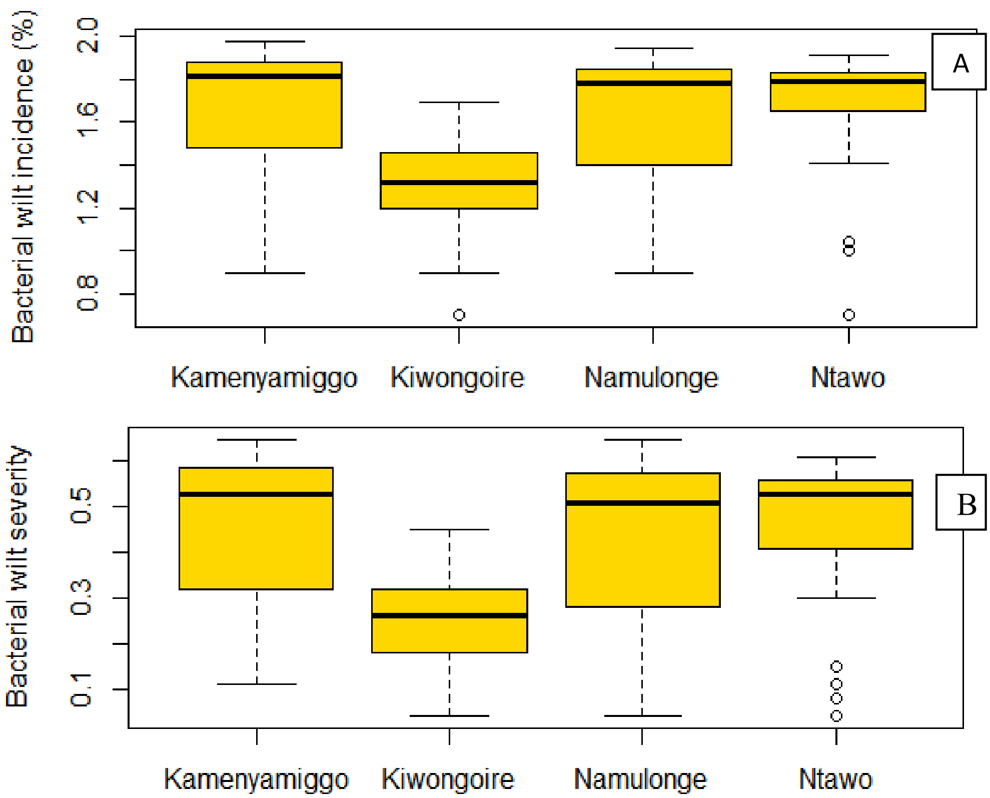

Figure 1. Distribution of bacterial wilt incidence (%) (A) and mean bacterial wilt severity (B)

Among the four trial sites, Kiwongoire recorded the lowest average disease incidence (21%) and severity (1.7) whereas Kamenyamiggo recorded the highest levels of disease (fig. 1). Kiwongoire generally has lower relative humidity and higher temperatures compared to the other sites, whereas the reverse is true for Kamenyamiggo (Table 1). The experimental site in Kiwongoire also had the highest levels of pH, organic matter and nitrogen compared to the rest (Table 2). The weather and soil conditions at this particular site probably contributed to less disease. It's also possible that this site initially had lower levels of inoculum since the levels were not established at the various sites prior to trial establishment.

In terms of seasons, 2017B and 2016B recorded the lower levels of disease whereas 2017A had the highest (Table 4). The wet condition, coupled with higher levels of relative humidity, usually provide favourable conditions for the development and spread of bacterial wilt disease leading to higher severity and incidence. The assumption when setting up the experiments was that the bacterium, *R. solanacearum,* naturally occurred in the soil. Because of this, we expected the last season (2017B) to have the highest bacterial wilt severity and incidence due to consecutive build-up of inoculum and repeated cultivation of the same solanaceous crop. However, this wasn't the case as season 2017B recorded the least average incidence across all the four locations.

Eggplant yields

The Thai long green eggplant attained the highest average yields (14.86 t/ha), fruit weight per plant (1.2 kg), and fruit number per plant (9), across all locations for the three seasons whereas the long purple variety produced the lowest average yields (6.9 t/ha), fruit weight per plant (1.2 kg). However, considering the yield index that was computed, the long purple variety outperformed black beauty coming 2nd after the Thai long green across all trial sites (Figure 2).

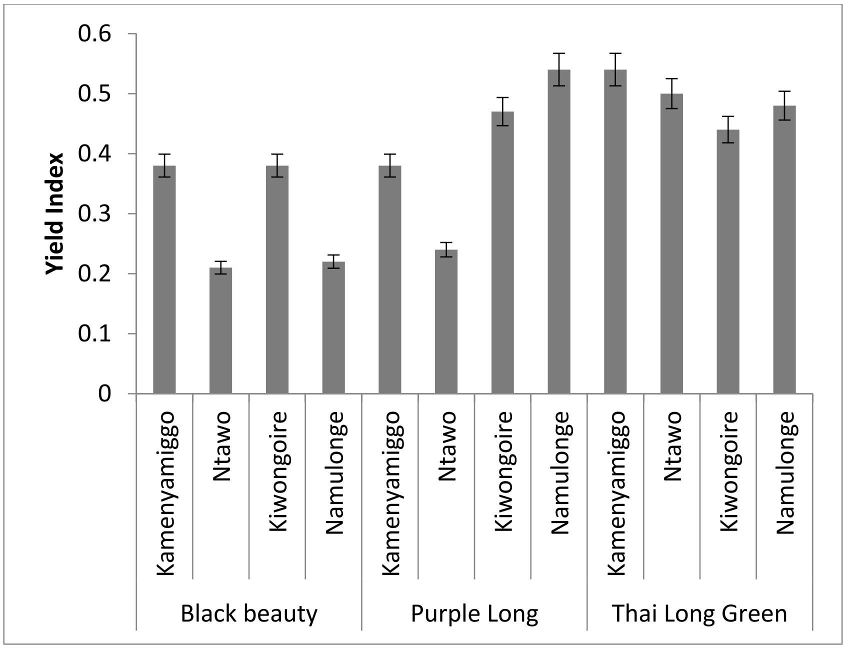

Figure 2. Variety performance across three seasons based on a yield index

The better performance of the long purple variety in terms of fruit number which is the measure of trade of eggplants in Uganda, could be the reason why it is preferred by farmers within the region despite its susceptibility to bacterial wilt. The highest yields obtained during the trial period were recorded from the Thai long eggplant (65 t/ha) in Kiwongoire, season 2017A. This figure is comparable to eggplant yields previously reported in Brazil that ranged between 30 to 65 t/ha in the field (Oliveira *et al*., 2014).

Generally, the highest average yields were obtained in Kiwongoire (24.9 t/ha), followed by Namulonge (5.62 t/ha), Ntawo (5.47 t/ha) and Kamenyamiggo (3.95 t/ha). Season 2017A performed best in terms of yields with a mean of 21.24 t/ha. The relatively low average yields observed in Namulonge, Ntawo and Kamenyamiggo was due to total crop loss that was recorded in some varieties by the time of full maturity, and yet yields were obtained and calculated on whole plot basis. For instance, fruits of the long purple variety were in some cases totally lost to bacterial wilt disease in season 2017B. This also occurred for black beauty in Namulonge during season 2017A. However, there was no record of total crop loss for the Thai long green variety at any of the trial sites during the entire course of this study. (Ali *et al*., 1994) reported that the production of eggplants within the humid tropics can severely be affected by wilt diseases which can result in crop losses of up to 100%. It should be noted that Central Uganda is located within the Lake Victoria agro-ecological zone of Uganda, an area that is within the humid tropics.

Eggplant yield is partly dependent on environmental conditions. Less favourable or extreme weather conditions such as drought, flooding or heavy rain and high temperatures have been documented to lower yield and fruit quality of eggplants (Abney and Russo, 1997; Taher et al., 2017). Eggplants perform well on deep well-drained sandy loam soils which are light-textured, having a soil pH ranging from 6.0-7.0 (Wang et al., 2014). Excessive soil humidity on the other hand, negatively affects eggplant production by providing conditions that favour the spread of bacterial wilt (Adamczewska-Sowińska *et al*., 2016). This could further explain why the highest yields were recorded in Kiwongoire which generally has moderate temperatures, lower relative humidity, and well drained soils with a pH above 6. Presently in Africa, the average yield of eggplants is estimated to be 17.7 t/ha (FAOSTAT, 2023). Despite being substantially greater than the overall mean yield (10 t/ha) in the current study, the mean yield observed in Kiwongoire (24.9 t/ha) where no crop loss occurred was actually higher than the estimated mean yield for Africa (17.7 t/ha) (FAOSTAT, 2023). This implies that eggplant yields would potentially be much higher if management of bacterial wilt disease were undertaken through the use of resistant varieties and other cultural practices during eggplant production in Uganda.

Conclusion

Our results demonstrated that the Thai long green eggplant is superior in terms of bacterial wilt resistance compared to the other two varieties tested. This variety displayed resistance, whereas black beauty and long purple showed moderate resistance and moderate susceptibility respectively. On this premise, we recommend planting the Thai long green eggplant variety in areas with high bacterial wilt incidence and severity in Central Uganda. Further research with more varieties is recommended to ascertain the performance of this particular genotype in other bacterial wilt prone areas within the country. Given the scarcity of the Thai long green eggplant seed on the Ugandan market, we recommend that seed businesses take up the multiplication and dissemination of this seed and make it more accessible to farmers. Additionally, extension workers are encouraged to disseminate the Thai long green eggplant to promote a healthier disease free crop, to boost food, nutrition and income security and to increase diversity in eggplant production in the country.

Conflict of Interest

The authors declare that they have no conflicts of interest in relation to this article.

Acknowledgement

This study was funded by the World Bank through the Agricultural Technology and Agribusiness Advisory Services (ATAAS) project of the National Agricultural Research Organization (NARO), Uganda. Specifically, it was conducted under the Crop Urban and Peri-Urban farming project of MuZARDI. The authors would also like to acknowledge all research and field assistants who took part in trial establishment and data collection.

References

Abney, T. D., & Russo, V. M. (1997). Factors Affecting Plant Height and Yield of Eggplant. *Journal of Sustainable Agriculture*, *10*(4), 37–48. https://doi.org/10.1300/J064v10n04_05

Adamczewska-Sowińska, K., Krygier, M., & Turczuk, J. (2016). The yield of eggplant depending on climate conditions and mulching. *Folia Horticulturae*, *28*(1), 19–24. https://doi.org/10.1515/fhort-2016-0003

Ali, M., Alam, M.Z., & Akanda, M.A.M. (1994). *Grafting: A technique of control soil borne diseases of tomato and eggplant*. Institute of Post Graduate Studies in Agriculture (IPSA), Gazipur, IPSA-JICA Publication No. 4, 10.

Azuma, K, Ohyama, A, Ippoushi, K, Ichiyanagi, T, Takeuchi, A, Saito, T., & Fukuoka, H. (2008). *Structures and antioxidant activity of anthocyanin in many accessions of eggplant and its related species*. *56*(21), 10154–10159.

Broekhuizen W.K.W & van der Post C.J. (1974). *Steam sterilisation of soil with simple methods*. Wageningen (Holland) Institute for Horticultural Engineering. https://edepot.wur.nl/524181

Campbell, C.L. & Madden, L.V. (1990). *Introduction to Plant Disease Epidemiology*. John Wiley & Sons, Inc.

Daunay, M.C & Hazra, P. (2012). Eggplant. In *Handbook of Vegetables* (pp. 257–322). Stadium Press LLC.

Docimo, T., Francese, G., Ruggiero, A., Batelli, G., De Palma, M., Bassolino, L., Toppino, L., Rotino, G. L., Mennella, G., & Tucci, M. (2016). Phenylpropanoids Accumulation in Eggplant Fruit: Characterization of Biosynthetic Genes and Regulation by a MYB Transcription Factor. *Frontiers in Plant Science*, *6*. https://doi.org/10.3389/fpls.2015.01233

FAOSTAT. (2023). *Food and Agricultural Organization of the United Nations. Statistical Database. Rome, FAO*. http://faostat.fao.org/

Huet, G. (2014). Breeding for resistances to Ralstonia solanacearum. *Frontiers in Plant Science*, *5*. https://doi.org/10.3389/fpls.2014.00715

Hussain, Z. M, Rahman, M.A, & Bashar, M.A. (2005). *Screening of brinjal accessions for bacterial wilt caused by Ralstonia solanacearum*. *34*, 53–58.

Lebeau, A, Daunay, M.C, Frary, A, Palloix, A, Wang, J.F, Dintinger, J., Chiroleu, F, Wicker, E, & Prior, P. (2011). *Bacterial wilt resistance in tomato, pepper, and eggplant: Genetic resources respond to diverse strains in the Ralstonia solanacearum species complex*. *101*, 154–165.

Lopes, C. A. (2009). *Bacterial wilt or wither – an enemy of the tomato plant in hot climates*. Brasília: Embrapa Vegetables.7p.

Lopes, C. A. & Quezado-Soares, A. M. (1997). *Bacterial diseases of vegetables: Diagnosis and control.* Brasilia: Embrapa/SPI. 70 p.

MAAIF. (2021). *Climate smart agriculture: Community of Practice Guide.* https://careclimatechange.org/wp-content/uploads/2021/06/The-Climate-Smart-Agriculture-book-2021.pdf

Manickam, R., Chen, J.-R., Sotelo-Cardona, P., Kenyon, L., & Srinivasan, R. (2021). Evaluation of Different Bacterial Wilt Resistant Eggplant Rootstocks for Grafting Tomato. *Plants*, *10*(1), 75. https://doi.org/10.3390/plants10010075

Mugisa, I. O., Fungo, B., Adur, S. O., Ssemalulu, O., Molly, A., Atim, J., Nakyagaba, W., Kizza, T., Kabanyoro, R., Sseruwu, G., & Akello, B. O. (2017). Urban and peri-urban crop farming in Central Uganda: Characteristics, constraints and opportunities for household food security and income. *African Journal of Plant Science*, *11*(7), 264–275. https://doi.org/10.5897/AJPS2016.1477

Oliveira, I. T., Lopes, C. A., & Moura, A. B. (2014). Fruit yield and bacterial wilt symptoms on eggplant genotypes grown in soil infested with Ralstonia solanacearum. *Horticultura Brasileira*, *32*(4), 453–457. https://doi.org/10.1590/S0102-053620140000400013

Osiru, M. O, Rubaihayo, P. R, & Opio, A. F. (2001). *Inheritance of resistance to tomato bacterial wilt and its implication for potato improvement in Uganda*. *9*(1), 9–16.

R Core Team. (2020). *R: A language and environment for statistical computing.* [Computer software]. https://www.R-project.org/.

Ramathani, I, Ddamulira, G., Kangire, A., Wasswa, P., & Tusiime, A. (2021). *Evaluation of tomato genotypes for tolerance to major diseases in Uganda*. *29*(2), 241–258.

Rotino, G. L, Perri, E., Acciarri, N, Sunseri, F, & Arpaia, S. (1997). *Development of eggplant varietal resistance to insects and diseases via plant breeding*. *11*, 193–201.

Sekara, A, Cebula, S, & Kunicki, E. (2007). *Cultivated eggplants-origin, breeding objectives and genetic resources, a review*. *191*, 97–114.

Selina Wamucii. (2024). *Export values for Uganda aubergines (eggplants).* https://www.selinawamucii.com/insights/prices/uganda/aubergines/

Taher, D., Solberg, S. Ø., Prohens, J., Chou, Y., Rakha, M., & Wu, T. (2017). World Vegetable Centre Eggplant Collection: Origin, Composition, Seed Dissemination and Utilization in Breeding. *Frontiers in Plant Science*, *8*, 1484. https://doi.org/10.3389/fpls.2017.01484

Vasse, J, Frey, P, & Trigalet, A. (1995). *Microscopic studies of intercellular infection and protoxylem invasion of tomato roots by Pseudomonas solanacearum*. *8*, 241–251.

Wang, J.-F., Chen, N.-C., & Li, H.-M. (1998). Resistance Sources to Bacterial Wilt in Eggplant (Solanum melongena). In P. Prior, C. Allen, & J. Elphinstone (Eds.), *Bacterial Wilt Disease* (pp. 284–289). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-662-03592-4_41

Wang, M., Wu, C., Cheng, Z., Meng, H., Zhang, M., & Zhang, H. (2014). Soil Chemical Property Changes in Eggplant/Garlic Relay Intercropping Systems under Continuous Cropping. *PLoS ONE*, *9*(10), e111040. https://doi.org/10.1371/journal.pone.0111040

Weather and climate. (2020). *Climate and average weather in Uganda: 2010-2024*. https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine-in-Uganda

Wenneker, M., Verdel, M. S. W., Groeneveld, R. M. W., Kempenaar, C., van Beuningen, A. R., & Janse, J. D. (1999). Ralstonia (Pseudomonas) solanacearum Race 3 (Biovar 2) in Surface Water and Natural Weed Hosts: First Report on Stinging Nettle (Urtica dioica). *European Journal of Plant Pathology*, *105*(3), 307–315. https://doi.org/10.1023/A:1008795417575.