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Research Article

Effect of Plant Spacing on Yield and Disease Assessment on Two Varieties of Eggplant (*Solanum melongena* L.) in Awka

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Abstract: Investigation on effect of plant spacing on yield and assessment of disease incidence and severity on two varieties of eggplant (Solanum melongena) was carried out in the Department of Crop Science and Horticulture Research Farm, Nnamdi Azikwe University, Awka, Anambra State. The treatments were two varieties of eggplant: white and green eggplants and three plant spacing: 60cmx30cm, 60cmx40cm and 60cmx50cm, which were replicated three times. The experiment was a 2x3 factorial in Randomized Complete Block Design (RCBD). The results showed that there was no significant difference on some of growth parameters assessed which included: plant height, number of leaves, number of branches, number of flowers, leave area at both 3WAT and 6WAT, but plant spaced at 60cmx40cm had the highest plant height (18.77cm), number of leaves (25.10), number of branches (4.25), leaf area (215.89cm^2) at 3WAT. Variety of eggplant had no significant effect on some agronomic traits measured, although green variety (V_2) recorded the highest plant height (18.84cm), number of leaves (24.60), number of flowers (0.58) and leaf area (189.86cm^2) at 3WAT. Variety had no significant effect on fruit weight. Root length and yield per plot but the highest fruit weight (46.20kg), root length (19.39cm) and yield per plot (0.690tonsha^{-1}) were obtained in green variety. Also, plant spacing did not have significant effect on fruit weight, root length and yield per plot but the highest fruit weight (39.39kg), root length (22.68cm), yield per plot (0.57tonsha^{-1}) were obtained from eggplant spaced 60cmx50cm. Plant spacing and eggplant varieties had significant effect on disease incidence and severity, where eggplant spaced 60cmx50cm had the least disease incidence (37.50%) and severity (2.01) and green variety had the least disease incidence (36.10%) and severity (2.33). Based on findings of this investigation, it is recommended that eggplant farmers in Awka South Local Government Area should adopt plant spacing of eggplant at 60cmx50cm and the green variety because of its high fruit yield and to minimize disease infestation, which affect yield and fruit quality.

Keywords: Eggplants, plant spacing, growth parameters, yield, disease incidence and severity.

INTRODUCTION

Eggplant (*Solanum melongena L.*) is a short-lived perennial herb that belongs to the family *Solanaceae*. It is grown as an annual plant and is one of the most consumed fruit vegetables in tropical Africa; probably the third after tomato and onion, and before okra (Grubben and Denton, 2004). Although excessive rainfall affects both vegetative growth and flower formation, the plant is well adapted to both wet and dry season cultivation. In West Africa, the eggfruits are eaten raw, cooked or fried with spices in stews, or dried and pound as condiments (Fayemi, 1999,). The fruit is rich in essential vitamins and minerals. It contains 89.0g water, 1.4g protein, 1.0g fat, 8.0g carbohydrate, 1.5g cellulose, 130mg calcium, 105mg vitamin c and 1.6 mg Iron (Romain, 2001).Eggplant is a highly valued delicacy in Nigerian society such that its importance cannot be overemphasized to consumers and farmers alike (Pessarakli, . *et al.,* 2003). The eggplant apart from being a source of vegetable also has numerous health benefits which are essential for the overall development of the human body. Its acceptability cuts across religion, tribal, cultural and ethnic groups in Nigeria, hence the wide usage of the garden eggplant (Ubokudom, *et al.,* 2010). Eggplant is a common fruit vegetable and is widely grown in Asia, Africa, and the subtropics, including the southern USA and the Mediterranean region with world production of 42.9

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million tons for the year 2009 (FAO, 2010).Asia has the largest eggplant production, which comprises more than 90% of the world production area and 87% of the world production (Choudhary and Gaur, 2009).

A large indigenous biodiversity exists in eggplant with variation in plant type, stem colour, leaf size, leaf tip, midrib colour, fruit size, fruit shape, fruit color, fruit yield, fruit quality, cooking quality, and tolerance to pests and diseases (Ullah *et al*., 2014).

Eggplant is grown during the dry and wet seasons and because of its relatively high yield, it is an important commodity in the local trade and a source of income to the farmers (Aliyu *et al.,* 1992). The yield of eggplant in Nigeria is generally low due to the use of varieties that are of narrow genetic base which are grown on soils that are of inherent low fertility (Dauda *et al.,* 2003). The unimproved local cultivars commonly grown in the tropics with scanty plant stands, improper planting distance and lack of other improved agricultural inputs in the management of the crops has resulted in low yield (Law *et al.* 2009). Furthermore, it has been reported that plant spacing greatly influenced fruit yield and marketing of eggplant. Likewise, Godfrey- Sam-Aggrey *et al*. (1985) and Mehla *et al*. (2000) also reported that yield parameters in eggplant are affected by narrow spacing. Wider spacing on the other hand leads to increase in fruit yield per plant with bigger fruits and more cracked fruits per plant. However, in Nigeria, farmers get lower yield mainly due to the fact that eggplant is sensitive to a number of environmental stresses, especially extreme temperature, salinity, drought, excessive moisture and environmental pollution, diseases and pests as well as improper planting distance.

Disease incidence refers to the number of plant entities which are visually diseased out of the total number of plant units measured (Campbell and Madden, 1990). Disease incidence is the proportion or percentage of diseased entities within a sampling unit (Seem, 1984)

Disease assessment or phytopathometry usually involves the measurement and quantification of plant disease. Therefore it is a primary significance in the study and analysis of plant disease epidemics. Nutter *et al*., (2006), also distinguished disease assessment and phytopathometry, the former being as the process of quantitatively measuring disease intensity and the second as the theory and practice of quantitative disease assessment.

The impact of a disease on yield is often determined by the extent of disease on the nearly mature plant (e.g. on the flag leaf and fruit). At this stage, disease severity is usually a better predictor of crop loss than disease incidence.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at Department of Crop Science and Horticulture Research Farm, Nnamdi Azikiwe University Awka, Anambra State. The area is located between latitude $06^0$15' N and longitude $07^0$08'E. It has a minimum and maximum average temperature of 25.3^{o}C and 26.5°C, respectively and with average annual rainfall of 1828cm.

Experiment Design and Treatment

The experiment was a 2x3 factorial in a Randomized Complete Block Design (RCBD) replicated three times**.** Treatments were two varieties of eggplant: White and Green and Plant spacing: 60cm x 30cm, 60cm x 40cm and 60cm by 50cm which were combined to give Six treatment combinations. The total land area used for the experiment was 19m x 9m which equals 171m^2. The distance between blocks and within plots was 1m respectively. Each plot measured 2m x 2m and each Block measured 2m x 19mequals 38m^2. The total number plots were eighteen.

Nursery making:

Two varieties of eggplant were planted in a ground nursery. The ground nursery was not manured and sowing was done manually on the top of beds. The seeds were broadcast on separate beds. Shades were also provided using bamboo poles and palm fronds.

Transplanting

The seedlings were transplanted at four weeks after planting in the morning by uprooting with a ball of earth. Transplanting was done using the different planting distances of 60cm x 30cm, 60cm x 40cm and 60cm x 50cm. During field establishment poultry manure was applied on each bed at the rate of 10tonnes per hectare. Each plot had twelve plants.

Weeding:

This operation was also carried out manually with the use of hand hoe and was done at two weeks interval.

Data Collection:

The data was collected on the following parameters while using four plants at the middle of each plot to avoid border effect.

Number of leaves:

This was done by counting the leaves of the sample plant in each plot at 3WAT and 6WAT.

Leaf area (cm^2):

This was the multiplication of Leaf length and Leaf width at the widest diameter at 3WAT and 6WAT.

Plant height (cm):

This was measured as the distance from the soil level to the tip of the shoot at harvest at 3WAT and 6WAT.

Number of branches:

This was done by counting the number of branches per plant at 3WAT and 6WAT.

Number of flowers per plant:

This was determined by counting the total number of flowers produced by each plant at 3WAT and 6WAT.

Fruit weight per plant:

This was done by weighing the fruit harvested per sample plant in each plot using the sensitive weighing balance.

Fruit yield per plot (tons/ha):

This was determined by multiplying fruit weight per plot by 1ha and divided by the area of the plot; it is further divided by 100,000.

Fruit yield (tons/ha) = (Fruit weight per plot x 1ha) /Area of the plot = (Fruit yield in g/ha) /1000g = Fruit yield kg/ha/1000kg = Fruit yield (tons/ha).

Root length per plant:

This was done after harvest as the total plant mass was harvested and then the length was measured using a measuring tape from the bottom of shoot to the tip of the longest root.

Assessment of Disease Incidence and Severity of Individual Visible Pathogen:

Assessment of disease incidence and severity was carried out in the experimental farm during the field stage. Disease incidence was assessed by visual observation of eggplant infected in the plots sampled. The percentage disease incidence of egg plants was determined according to formula suggested by Snedecor and Cochran, (1994) as follows

Disease incidence

$$= \frac{\text{Number of Diseased plants}}{\text{Total number of plant Sampled}} \times \frac{100}{1}$$

The disease severity was assessed by recording the extent or degree of the disease in the infected eggplants of the sampled plots. A five-point scale of 0-5 was used (IRRI, 2006). Where:

0 =No infection
1 =1-20% 0f plants infected
2 = 21-40% of plants infected
3 = 41-60% of plants infected
4 = 61-80% of plants infected
5 = 81-100% of plants infected.

The data collected were subjected to Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD) using GenStat 4.23AE version (2005). Mean separation was done using Fisher's Least Significant Difference (F-LSD) at 5% level of probability.

RESULTS

Effect of Egg plant Varieties on some Agronomic traits of eggplant (*Solanum melongena*) at 3 and 6 weeks after transplanting (WAT)

Table 1 shows that there was no significant ($p<0.05$) effect of variety on plant height, number of leaves, number of branches on egg plant at 3WAT and 6WAT. However,V_2 (green variety) recorded a higher value for plant height (18.84cm),number of leaves (24.6),number of flowers (0.58) which were similar to V_1 (white variety) at 3WAT,while V_1 (white variety) recorded a higher value for number of branches (4.17) and leaf area (204.42cm^2) which were statistically similar to the V_2 (green variety) at 3WAT.

At 6WAT V_2 (green variety) recorded a higher value for plant height (845.9cm),number of leaves (68.2),number of branches (8.50) and leaf area (328cm^2) which was statistically similar to V_1 (white variety).

Table 1: Effect of Variety on some Agronomic traits of eggplant (*Solanum melongena*) at 3 and 6 weeks after transplanting (WAT)

Days after planting										
Treatment		**3WAT**					**6WAT**			
Variety	**Plant height (cm)**	**No of leaves**	**No of flowers**	**No of branches**	**Leaf Area (cm^2)**	**Plant height (cm)**	**No of leaves**	**No of flowers**	**No of branches**	**Leaf Area (cm^2)**
V1	16.26	21.7	0.25	4.17	204.42	39.4	66.9	0.167	7.39	312
V2	18.84	24.6	0.58	4.06	189.96	45.9	68.2	0	8.50	328
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

V_1 =white garden eggplant, V_2 =green garden egg plant

Effect of Plant Spacing on some agronomic traits of eggplant (*Solanum melongena*) at 3 and 6 weeks after transplanting (WAT)

Table 2 shows that there was no significant ($p<0.05$) effect of plant spacing on plant height, number of leaves, number of flowers, number of branches and leaf area at 3WAT and 6WAT. However, plant spacing of S_2 (60cm x 40cm) recorded the highest value for plant height (18.77cm), number of leaves (25.10), number of

branches (4.25), leaf area (215.89cm^2) at both 3WAT and 6WAT which were statistically similar with the values of planting spaces S_1 (60cm x 30cm) and S_3 (60cm x 50cm) (Table 2).

Table 2: Effect of Plant Spacing on some agronomic traits of eggplant (*Solanum melongena*) at 3 and 6 weeks after transplanting (WAT)

Days after planting										
Treatment		**3WAT**					**6WAT**			
Plant Spacing	**Plant height (cm)**	**No of leaves**	**No of flowers**	**No of branches**	**Leaf Area (cm^2)**	**Plant height (cm)**	**No of leaves**	**No of flowers**	**No of branches**	**Leaf Area (cm^2)**
S_1	17.18	23.00	0.46	4.04	195.95	39.7	65.1	0.250	8.00	325
S_2	18.77	25.10	0.42	4.25	215.89	47.7	73.4	0	8.17	347
S_3	16.70	21.40	0.38	4.06	179.73	40.6	64.2	0	7.67	288
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

S_1 = 60cm x 30cm, S_2 = 60cm x 40cm, S_3 = 60cm x 50cm

Interaction Effect Of Variety And Plant Spacing On Some Agronomic Traits Of Eggplant (*Solanum Melongena*) At 3 And 6 Weeks After Transplanting (WAT)

Table 3 shows that there were significant ($p<0.05$) interaction of variety and plant spacing on the leaf area of garden egg plant at 3WAT and 6WAT. The highest leaf area (253 cm^2) at 3WAT and (394cm^2) at 6WAT were obtained in the interaction between V_1 (white eggplant) and plant spacing S_2 (40cm x60cm), followed by 226.86cm2 in V_2 x S_1 at 3WAT while the least leaf area (105.01cm2) was obtained in V_2 x S_3 at 3WAT (Table 3). Meanwhile, there was no significant ($p<0.05$) interaction effect of variety and plant spacing on the other physiological parameters at 3WAT and 6WAT.

Table 3: Interaction effects of Egg plant Varieties and Plant spacing on some agronomic traits of eggplant (*Solanum melongena*) at 3 and 6 weeks after transplanting (WAT)

Days after planting											
Treatment			**3WAT**					**6WAT**			
Variety	**Plant Spacing**	**Plant height (cm)**	**No of leaves**	**No of flower**	**No of branch**	**Leaf area (cm^2)**	**Plant height (cm)**	**No of leaves**	**No of flowers**	**No of branches**	**Leaf area (cm^2)**
V1	S1	15.78	20.90	0.42	3.92	165.04	37.40	60.90	0.50	7.33	256.00
	S2	16.90	22.70	0.17	4.08	253.77	41.70	70.50	0	7.25	375.00
	S3	16.09	21.40	0.17	4.50	194.45	39.10	69.40	0	7.58	305.00
V2	S1	18.58	25.10	0.50	4.17	226.86	41.90	69.20	0	9.00	394.00
	S2	20.63	27.50	0.67	4.42	178.02	53.70	76.20	0	8.75	318.00
	S3	17.32	21.30	0.58	3.61	165.01	42.10	59.00	0	7.75	270.00
$LSD_{0.05}$		NS	NS	NS	NS	71.53	NS	NS	NS	NS	118.40

V_1 =white garden eggplant, V_2=green garden egg plant
S_1= 60cm x 30cm, S_2= 60cm x 40cm, S_3= 60cm x 50cm

Effect of Variety and Plant Spacing On Fruit Weight and Root Length

Table 4 shows that there was no significant ($p>0.05$) effect of variety on the fruit weight and root length of eggplant. However, V_2 (Green eggplant) recorded higher value of (46.20kg) and (19.39cm) for fruit weight and root length respectively which was similar to those of the white eggplant (V_1) (Table 4).

It also shows that there was no significant ($p<0.05$) effect of plant spacing on fruit weight and fruit length of the eggplant. Meanwhile, the plant spacing S_2 (60cm x 50cm) gave the highest value for fruit weight (39.39kg) followed by 38.15kg from S_2 (60cm x 40cm) while the least was 26.04kg from S_1 (60cm x 30cm) and also gave the highest value for root length (22.68cm) followed by 17.40cm from S_2 (60cm x 40cm) while the least was 17.13cm from S_1 (60cm x 30cm) which was statistically similar to those of plant spacing S_2 (60cm x 40cm) and S1(60cm x 30cm) for fruit weight and S_1 (60cm x 30cm) and S_3 (60cm x 50cm) for root length (Table 4).

Table 5: Effect of Variety and Plant spacing on Fruit weight and Root lengthSome yield and growth parameters

Treatments	Fruit weight (kg)	Root length (cm)
V_1	22.85	18.76
V_2	46.20	19.39
$LSD_{0.05}$	NS	NS
S_1	26.04	17.13
S_2	38.15	17.40
S_3	39.39	22.68
$LSD_{0.05}$	NS	NS

Interaction Effects of Egg Plant Varieties and Plant Spacing On Fruit Weight and Root Length

Table 5 shows a significant ($p<0.05$) interaction effect of variety and plant spacing on the root length of eggplant, but there was no significant ($p<0.05$) interaction effect of variety and plant spacing on the fruit weight of eggplant. The highest value of root length (24.22cm) was recorded in the interaction of V_2 x S_2 and where the highest fruit weight (62.47kg) was recorded in the interaction of V_2 x S_3.

Table 5: Interaction effects of Egg plant Varieties and Plant spacing on Fruit weight and Root length.

Treatment		Yield and growth Parameters	
Variety	Plant spacing	Fruit weight (kg)	Root length (cm)
V_1	S_1	16.67	16.69
	S_2	35.58	21.14
	S_3	16.31	18.43
V_2	S_1	35.42	17.57
	S_2	40.72	24.22
	S_3	62.47	16.38
$LSD_{0.05}$		NS	3.26

Effect of Variety and Plant spacing on Disease Incidence and Severity

Table 6 shows a significant ($p<0.05$) effect of variety on disease incidence and severity of eggplant. Green eggplant (V2) had the lesser disease incidence and severity of eggplant with the values (36.1%) and (2.33) respectively which was slightly different from the white eggplant (V_1) with the values (71.7%) and (4.67) respectively (Table 6).

It also shows that there was a significant ($p<0.05$) effect of plant spacing on disease incidence and severity of eggplant. The plant spacing S_3 (60cm x 50cm) recorded the least disease incidence and severity having the values of (37.5%) and (2.01) respectively which was significantly different from the values from other plant spacing S_1 (60cm x 30cm) and S_2 (60cm x 40cm). While the highest disease incidence and severity was (81.70) and (4.67) respectively (Table 6).

Table 6: Effect of Variety and Plant spacing on Disease Incidence and Severity

Treatments	Disease Incidence (%)	Disease Severity
V_2	71.70	4.67
V_2	36.10	2.33
$LSD_{0.05}$	23.32	1.01
S_1	47.50	3.33
S_2	81.70	4.67
S_3	37.50	2.01
$LSD_{0.05}$	28.56	1.234

Interaction effects of Variety and Plant Spacing on Disease Incidence and Severity

Table 7 shows that there was a significant ($p<0.05$) interaction effect of variety and plant spacing on the disease incidence and severity of eggplant. The least disease incidence (16.7%) and severity (1.33) were obtained in the interaction of V_2 (green variety) and plant spacing S_1 (60cm x 30cm) while the highest disease incidence (81.7%) and severity (4.67) were obtained in the interaction between V_1 (white variety) and S_2 (60cm x 40cm) (Table 7).

Table 7: Interaction effects of Variety and Plant Spacing on Disease Incidence and Severity

Treatment			
Variety	Plant Spacing	Disease Incidence (%)	Disease Severity
V_1	S_1	58.30	3.33
	S_2	81.70	4.67
	S_3	37.50	2.00
V_2	S_1	16.70	1.33
	S_2	61.70	3.67
	S_3	50.00	3.00
$LSD_{0.05}$		40.40	1.758

Effect of Variety and Plant spacing on Fruit yield per plot (tons/ha)

Table 8 shows that there was no significant ($p<0.05$) effect of variety on the fruit yield in ton/ ha of eggplant. However, V2 (Green eggplant) recorded higher value of 0.690 tons/ha which was similar to those of the white eggplant (V1) which had 0.356tons/ha (Table 8).

It also shows that there was no significant ($p<0.05$) effect of plant spacing on fruit yield in tons/ha of the eggplant. Meanwhile, the plant spacing S3 (60cm x 50cm) gave the highest value for fruit yield (0.573tons/ha) followed by 0.522tons/ha from S2 (60cm x 40cm) while the least was 0.474 from S1 (60cm x 30cm) (Table 8).

Table 8: Effect of Variety and Plant spacing on Fruit yield per plot (tons/ha)

Treatment	Fruit Yield
V_1	0.356
V_2	0.690
$LSD_{0.05}$	**NS**
S_1	0.474
S_2	0.522
S_3	0.573
$LSD_{0.05}$	**NS**

DISCUSSION

Although plant spacing was not significant in some of the agronomic parameters, the planting spaces of 60cm x 40cm recorded the highest plant height (18.77cm), number of leaves (25.10), number of branches (4.25), leaf area (215.89cm^2) at 3WAT and also recorded the highest plant height (47.7cm), number

of leaves (73.4), number of branches (8.14) and leaf area (347cm^2) at 6WAT. This is in agreement to Hossain *et al*., (2001) and Rastogi *et al.,* (2001), who reported that planting spaces ranging from 20cm to 50cm within rows and 30cm to 60cm between rows for eggplant for maximum growth parameter and yield. Plant height increased as plant spacing increases from 60cm × 30cm to 60cm × 40cm and decreased from 60cm x 40cm to 60cm x 50cm. This concurs with the report of Ibeawuchi *et al.,* (2005) who observed that the productive nodes of eggplant, okra and groundnut increases with increasing row spacing. The plant with highest value was recorded in the plant spacing of (60cm × 40cm) might have resulted from the competition for light, space and other growth resources among the plants that were in the wide plant spacing (60cm × 50cm). These results were in conformity with the findings of Singh *et al*., (1996) and Hossain *et al*., (2001). This corroborates the report of Ibeawuchi *et al.*, 2005; Ijoyah *et al.,* (2010); Islam *et al*, (2011); Ekwu and Nwokwu, (2012). Maurya *et al.*, (2013) recorded taller plant height, more branches and higher weed suppression in moderate plant spacing.

Green variety (V_2) a had highest value for fruit weight (46.20kg) and root length (19.39cm) which was statistically similar ($p<0.05$) with the white variety (V_1) which gave 22.85kg and 18.76cm for fruit weight and root length respectively. This could be as a result of similarity in the gene level controlling the traits (Doku, 2011).

There were significant difference between the plant spacing compared. The result showed that there was significantly ($p<0.05$) higher disease incidence per plot under moderately spaced plants (60cm x 40cm) than widely spaced plants (60cm x 50cm) and closely spaced plants (60cm x 30cm). Egg plants spaced at 60cm x 40cm had the highest disease incidence and severity followed by egg plants spaced at 60cm x 30cm, while egg plants spaced at 60cm x 50cm had the least disease incidence and severity. This agrees with the findings of Aina (1980) and Owusu-Ansa *et al* (2001) who reported that disease incidence and severity is more on moderately planted egg plants than widely spaced plants.

This is also similar to the report of (Rashid *et al*, (2008), Naik *et al*, (2008), Ghosh and Senapati, (2009), Chakarborti and Sarkar, (2011), who posited that widely spaced plants discourages the breeding and infestation by pests while narrowly spaced plants encourages pest infestation of plants particularly when rainfall and relative humidity are high

The fruit yield per plot was higher on eggplant spaced at 60cm x 40cm. This agrees with the findings of Naik *et al* (2008), Ghosh and Senapati (2009). Plant spacing is very vital in crop production and protection (Aina, 1980). For any meaningful and sustainable production of vegetables, good agronomic practices like adopting the recommended plant spacing, farm sanitation and timely planting must be encouraged among crop farmers (Roman, 2001, Ekwu and Okporie, 2002). The result revealed that *Fusarium* wilt was noticed in most of the plants but the incidence was highest in egg plants spaced at 60cm x 40cm but was least in egg plants spaced at 60cm x 50cm.This is in agreement with Ranjit and Surajit (2013), who reported in that Late blight disease in tomatoes decreases as plant spacing increases.

CONCLUSION

The study showed that some agronomic characters were not significant affected by the treatments-variety and plant spacing, but spacing at 60cm x 40cm recorded higher values of agronomic characters assessed.

It was also observed that increased plant spacing leads to decrease in incidence of wilt in eggplant in Awka South LGA of Anambra State.

Also the investigation showed clearly that eggplants spaced closely favoured pest and disease attack, reduced fruit weight and fruit yield. Spacing egg plants at 60cm x 50cm had reduced disease incidence and severity on the plant, and improved fruit weight and fruit yield.

However, green variety had reduced disease incidence and severity and improved fruit weight and fruit yield than the white variety.

Recommendation

It is therefore recommended that eggplant farmers in Awka South LGA of Anambra State should adopt the spacing of egg plant at 60cm x 50cm and also make use of the Green variety to minimize infestation of wilt of eggplant and to have increased fruit yield and quality.

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