Effect of Swine Manure with *Terminalia catappa* leaves Compost and NPK Fertilizer on Growth and Yield of Pepper (*Capsicum chinense* Jacq.) in Ibadan, Nigeria

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Abstract: In order to study the effects of swine manure with *Terminalia catappa* leaves compost and NPK 15-15-15 fertilizer on growth and yield of pepper, an experiment was conducted in the Screenhouse of the Department of Agronomy, University of Ibadan in 2010. Five treatments: control (without fertilizer), 13.0, 16.3, 19.6 t/ha swine manure + almond leaves (SA) compost and 0.3 t/ha NPK 15-15-15 fertilizer were each mixed with 5 kg soil in experimental pots. The treatments were arranged in a completely randomized design with four replications. Data were taken on fruit yield (FY), number of fruits (NF), plant height (PH), stem girth (SG), number of branches (NB) and number of leaves (NL) of pepper. Shoot dry matter (SDM) and nutrient uptake (NU) of pepper were determined at 18 weeks after transplanting (WAT). Data were analyzed using descriptive statistics and ANOVA at $\alpha_{0.05}$.
The SA compost had 11.4% C, 0.5% N, 0.2% P, 0.3% K, 0.6% Ca and 0.3% Mg. Irrespective of the application rates, the NPK fertilizer and SA compost recorded significantly ($p<0.05$) higher PH, NL, SG and NB higher than the control. The NPK recorded the highest PH (34.0±0.8 cm) and NB (7.0±1.2 cm), while the highest NL (43.3±1.1 cm) of pepper was recorded by 13.0 t/ha SA. Significant ($p<0.05$) differences were also observed among the treatments for N, P and K uptake by pepper, where the highest P (2.8±0.1 mg/pot) and K (12.3±0.5 mg/pot) uptake of pepper were recorded under 13 t/ha SA compost. Relative to the control; 13.0, 16.3, 19.6 t/ha SA and 0.3 t/ha NPK significantly ($p<0.05$) increased the SDM of pepper by 133.0, 117.0, 125.0 and 117.0% respectively, while the NF of pepper was also increased by 61.5, 55.8, 56.7 and 49.0% respectively. However, pepper FY significantly ($p<0.05$) increased in the following order: control (44.5±1.0 g/pot) < 19.6 t/ha SA (54.5±1.5 g/pot) < 0.3 t/ha NPK (55.1±0.8 g/pot) < 16.3 t/ha SA (55.3±0.6 g/pot) < 13.0 t/ha SA (56.2±0.9 g/pot), with 13.0 t/ha SA compost recording 2.0% higher FY than that obtained from NPK.

Swine manure composted with almond leaves enhanced the nutritive components and yield of pepper. Thus, SA could be an effective source of organic nutrition for pepper production in Ibadan, especially at 13.0 t/ha.

Keywords: Swine manure, *Terminalia catappa* leaves, Compost, Pepper

1.0 INTRODUCTION

The vegetable (pepper) growers in Nigeria are beginning to show tremendous interest in the use of organic fertilizers to increase vegetable production. This is due to the fact that the use of chemical fertilizer to cultivate food crops can be detrimental to the soil, food and human health (Thomas, 2009). Thomas (2009) further explained that such foods cultivated with chemical fertilizers contain very low amount of Omega-3 oils and its deficiency in the human body could result to heart disease, cancers and mental disorder. Also, regular use of NPK for vegetable production cannot supply trace mineral elements such as Fe, Cu and Zn (Lawrence, 2004), which become gradually depleted over the years by continuous cropping of the same land. This depletion is responsible for a marked decline of up to 75% in the quantities of these minerals present in fruit and vegetables (Lawrence, 2004). Hence, consuming such vegetables could lead to serious deficiency of these minerals in the human body and thus, alter its physiological processes.

Organic fertilizers have the potential to supply both the soil macro and trace nutrient elements required for pepper growth and yield (Alabi, 2006; Awodun *et al.*, 2007). In realization of this, most consumers prefer buying organically grown vegetables to chemically grown vegetables in the market. This encourages farmers to use organic fertilizer such as goat, poultry, cattle and swine manure to grow their vegetables in Nigeria. However, swine manure is not widely adopted by farmers when compared to the use of poultry and cattle manure for improving soil fertility for pepper production in Nigeria. This could be due to the fact that swine manure has higher concentration of heavy metals compared to poultry and cattle manure. Accumulation of such heavy metals in the soil over time will lead to soil pollution (Wel and Chen, 2001). However, Zhang *et al.* (2012) established that typical swine manure contained 642.1, 8.6 and 15.1 mg/kg dry matter of Cu, As and Cd respectively. Generally, vegetable (pepper) cultivated with raw organic manure have higher risks of being contaminated with heavy metals and *Escherichia coli* bacteria. Eating foods containing *E. coli* bacteria would result to food poisoning (Ann and Steven, 2015). The best approach in solving the problem is the use of compost. Research efforts have shown the ability of compost to kill pathogens and break down phytotoxic compound contained in such organic materials (Rynk *et al.*, 1992; Pace *et al.*, 1995). Aiyelari *et al.* (2011) reported that the application of 5 and 10 t/ha poultry manure with almond leaves composts recorded significantly greater okra fresh pod yield than 250 kg/ha NPK fertilizer by 12.6% and 27.5% respectively. Therefore, it is also possible to obtain good quality compost from swine litter and almond leaves to support plants development in a very similar way to those of poultry litter with almond leaves compost. However, information are limited in the use of swine manure with almond leaves compost for the production of *Capsicum chinense*. Hence, the effects of swine manure with almond leaves compost and NPK 15-15-15 fertilizer on nutrient uptake and yield of pepper in the Screenhouse were evaluated in Ibadan.

2.0 MATERIALS AND METHODS

The study area

The experiment was carried out in Ibadan, Southwest Nigeria in 2010. It lies between latitudes 7° 25′ and 7° 31′ N and longitudes 3° 51′ and 3° 56′ E in the Rainforest Zone. The annual rainfall, daily air temperature and relative humidity recorded in Ibadan in 2010 was 1625.5 mm, 27.7°C, and 79.9%, respectively. The soil of the area is Alfisol according to the USDA classification. It is formed from Basement Complex rocks. It is classified locally as Iwo series (Smyth and Montgomery, 1962).

2.1 Compost preparation

A 1:1 w/w Swine manure + Almond leaves compost (SA) was composted in 2009, under a shed located behind the Department of Agronomy, University of Ibadan using a static pile method (Yuh-MingHuang, 2005). The mixtures (Swine manure + Almond leaves) were turned and watered fortnightly. Temperature readings were taken at 50 cm depth from five spots in the compost pile at 10.00 am daily, using a glass bulb thermometer. The daily temperature was compared with the ambient temperature. The stability of the SA compost was taken as when the compost temperature was at equilibrium with the ambient temperature. The SA compost stabilized in 84 days at 55.3°C. Plates 2.1 and 2.2 shows the SA compost at the initial stage of preparation and after 84 days of composting, respectively.

Plate 2.1. Swine manure + Almond leaves at initial stage of composting

Plate 2.2. Swine manure + Almond leaves compost after 84 days of composting

2.2 Screenhouse Experiment

The experiment was conducted in the Screenhouse of the Department of Agronomy, University of Ibadan, between March and July, 2010. Effects of five fertilizer treatments: control (without fertilizer), 13.0, 16.3, 19.6 t/ha SA compost and 0.3 t/ha NPK 15-15-15 on the growth and yield of *Capsicum chinense* were investigated. Each treatment was mixed with 5 kg soil in pots and the experiment was arranged in a completely randomised design with four replications. The soil used for the experiment was collected from the experimental site at the Teaching and Research Farm, University of Ibadan. There were two pots per treatment and 10 pots per replicate. One seedling of *Capsicum chinense* was transplanted into each pot at 4 WAS in the nursery, a week after treatments application, to enhance mineralization. Watering was carried out weekly and weeding was done fortnightly during the experimental period.

2.3 Plant analysis

The initial materials (almond leaves and swine manure) were analysed for C, N, P, K, Ca and Mg. At maturity, the compost was air-dried and five samples were taken from the compost pile. The samples were milled and sieved with 0.5 mm wire mesh before being subjected to chemical analysis. Carbon was determined by ash method using furnace. Nitrogen was determined using Micro-Kjeldahl procedure (IITA, 1975). The mixture of concentrated nitric, perchloric and sulphuric acid in a ratio of 25:4:2 respectively, was used to digest 0.5 g of each sample. Phosphorus was determined using vanadomolybdate yellow colorimetry method (Jackson, 1962). Potassium was determined by flame photometry. Calcium and magnesium was measured with Atomic Absorption Spectrophotometer (Okalebo *et al.*, 1993).

2.4 Dry matter determination

Pepper shoots were harvested from the ground level with the root cut off at 18 WAT in the Screenhouse and oven-dried at 70°C to a constant weight and mean weights were recorded as shoot dry matter yield. The dried plant samples were milled and sieved with 0.5 mm wire mesh. Nitrogen, phosphorus and potassium contents were determined using the same procedure described in 2.3. Nutrient uptake (mg/pot) was determined by multiplying nutrient content (%) with total dry matter yield (g).

2.5 Soil analysis

The topsoil samples (0-15 cm) used for the Screenhouse experiment, were randomly collected from the Teaching and Research Farm, University of Ibadan with the aid of a soil auger. The soil samples were air-dried, crushed and passed through 2 mm wire mesh for the determination of pH, P, K, Ca, Mg and Na. The soil pH was determined with a pH meter in 1:1 (soil/water) mixture. Available phosphorus was determined by Bray P1 method, in which colour was developed in soil extracts using the ascorbic and acid blue method (Murphy and Riley, 1962). Exchangeable K, Ca, Mg and Na were determined by neutral ammonium acetate extraction method. Potassium and Na concentration in the extract were determined using the flame photometer; while Ca and Mg were determined by atomic absorption spectrophotometer (Okalebo *et al.*, 1993). Organic carbon and total N was determined from the soil sieved with 0.5 mm wire mesh. Soil organic carbon was determined using the Walkley- Black oxidation method (Nelson and Sommers, 1982). Total N was also determined using the Macro-kjeldahl procedure (Bremner and Mulvancy, 1982). Particle size analysis was determined using Bouyoucos hydrometer method (Bouyoucous, 1962).

2.6 Data collection

Data were collected on plant height, stem girth, number of leaves and number of branches of pepper at 12 weeks after transplanting (WAT). Plant height was taken from the ground level to the tip of the plant using a measuring tape, while stem girth was measured at 5cm above the ground level with the aid of a rope. Average fruits weights were determined with the aid of a weighing balance after harvesting.

2.7 Statistical analysis

The data collected were subjected to analysis of variance and the significant difference among the treatment means were separated using Duncan Multiple Range Test (DMRT) at 0.05 level of probability.

3.0 RESULTS

Table 3.1 shows the physico-chemical properties of the soil before cropping. The results of the analysis revealed that the soil was sandy loam with a pH of 6.1; SOC, 7.3g/kg; Total N, 0.9 g/kg; Available P, 8 mg/kg. The exchangeable cation was in the following order K (0.1 cmol/kg) < Na (0.4 cmol/kg) < Mg (1.5 cmol/kg) < Ca (1.8 cmol/kg). The CEC of the soil had 4.3 cmol/kg. Table 3.2 shows the chemical composition of the raw organic material before composting. The Almond leaves (A) had 39.7% C, 0.4% N, 0.1% P, 0.8% K, 3.6% Ca, 0,2% Mg and 99.0 C/N; while the Swine manure (S) had 11.2% C, 1.1% N, 0.1% P, 1.4% K, 3.9% Ca, 1.7% Mg and 10.7 C/N (Table 3.2). Swine manure with almond leaves compost (SA) had 11.4%, C, 0.5% N, 0.2% P, 0.3% K, 0.6% Ca, 0.3% Mg and 22.0 C/N (Table 3.3). The initial carbon content of the Almond leaves (A) was reduced by 71.1% after composting, while the initial N, P and Mg content of the leaves were increased by 23.1, 60.9 and 42.3% after composting, respectively. The initial K and Ca content of the leaves were decreased by 67.9 and 83.4% after composting respectively (Tables 3.2 and 3.3). Figure 3.1 shows the daily temperature of swine manure with almond leaves compost. The SA compost peaked at 55.3°C and stabilized in 84 days at 30°C. The N uptake of pepper under SA and NPK treatments were significantly ($p<0.05$) higher than the control, while the P uptake of pepper significantly ($p<0.05$) increased in the following order: control (0.5 mg/pot) < 19.6 t/ha SA (1.9 mg/pot) < 16.3 t/ha SA (2.1 mg/pot) < 13.0 t/ha SA (2.8 mg/pot). The K uptake of pepper significantly ($p<0.05$) increased in the following order: control (1.4 mg/pot) < 16.3 t/ha SA (8.1 mg/pot) < 19.6 t/ha SA (10.0 mg/pot) < 0.3 t/ha NPK (12.2 mg/pot) < 13.0 t/ha SA (12.3 mg/pot). The highest P (2.8 mg/pot) and K (12.3 mg/pot) uptake of pepper were both recorded from the soil amended with 13.0 t/ha SA compost (Table 3.4). The plant height, stem girth, number of leaves and branches of pepper under SA and NPK treatments were significantly ($p<0.05$) higher than the control. The highest plant height (34.0 cm) and number of branches (7.0) recorded under NPK were not significantly ($p<0.05$) different from other treatments. However, the SA applied to pepper at 16.3 and 13.0 t/ha recorded the highest values for stem girth (2.0 cm) and number of leaves (43.3), respectively (Table 3.5).

Table 3.1. Physico-chemical properties of the soil of the experimental site

Parameter	Value
pH 1:1	6.1
Organic carbon (g/kg)	7.3
Total N (g/kg)	0.9
Available P (mg/kg)	8
Exchangeable cation (cmol/kg)	
Ca	1.8
Mg	1.5
K	0.1
Na	0.4
Effective CEC (cmol/kg)	4.3
Particle size distribution (g/kg)	
Sand	712
Silt	180
Clay	108
Textural class	Sandy loam

Table 3.2. Chemical properties of raw organic materials used for composting

Organic material	C	N	C:N	P	K	Ca	Mg
	%				%		
Almond leaf	39.7	0.4	99.0	0.1	0.8	3.6	0.2
Swine manure	11.2	1.1	11.0	0.1	1.4	3.9	1.7

Table 3.3. Chemical properties of raw organic materials used for composting

Organic material	C	N	C:N	P	K	Ca	Mg

ISSN 2250-3153

	%			%			
SA	11.5.	0.5	22.0	0.2	0.6	0.6	0.3

SA = Swine manure + Almond leaves

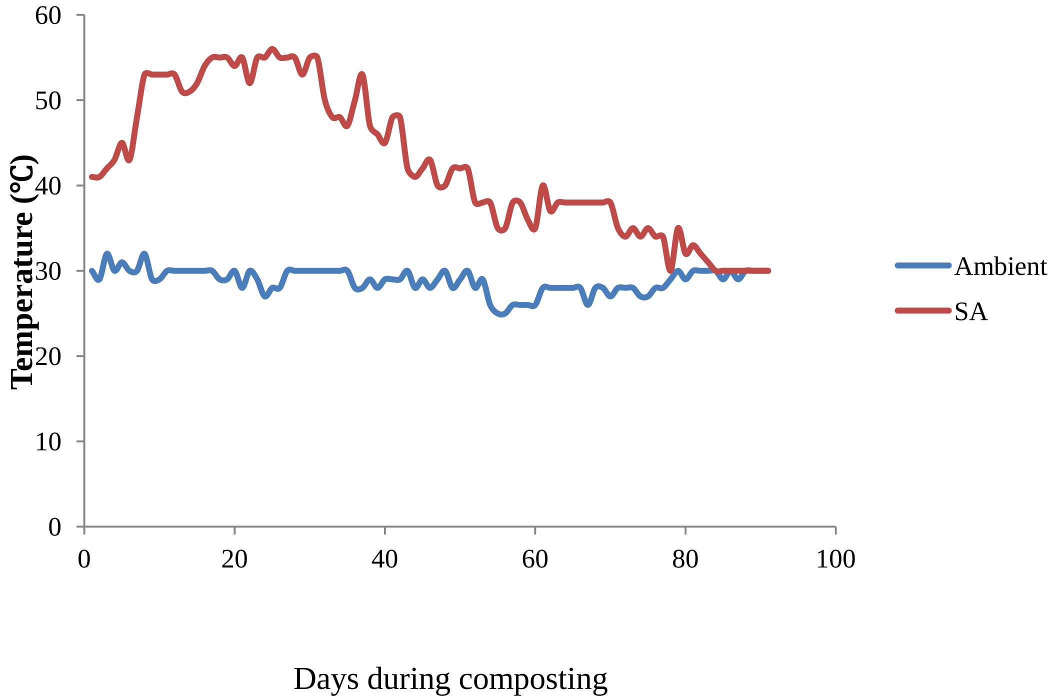

Fig. 3.1. Mean daily temperatures of almond leaves and swine manure combination during composting

Table 3.4. Effects of swine manure with almond leaves compost on nutrient uptake of pepper

Treatment	Rate	N	P	K
	t/ha		mg/pot	
Control	0	0.6c	0.5c	1.4c
SA	13.0	4.2ab	2.8a	12.3ab
	16.3	3.9ab	2.1ab	8.1b
	19.6	4.9a	1.9ab	10.0ab
NPK	0.3	4.9a	2.1ab	12.2ab
S.E.±		0.9	0.4	2.5

Means with the same letter(s) in a column are not significantly (p=0.05) different according to Duncan Multiple Range Test. SA = Swine manure + Almond leaves Compost, S.E.± = Standard error of the differences of means

Table 3.5. Effects of swine manure with almond leaves compost on morphological traits of pepper at 12 WAT

Treatment	Rate	Plant	Stem	Number of	Number of

		height	girth	leaves	branches
	t/ha	cm			
Control	0	23.8b	1.4b	24.8b	3.6c
SA	13.0	30.5a	1.9a	43.3a	6.0ab
	16.3	30.8a	2.0a	38.8ab	5.3abc
	19.6	31.3a	2.0a	35.9ab	4.0bc
NPK	0.3	34.0a	1.8a	36.3ab	7.0a
S.E.±		1.9	0.1	3.4	0.7

Means with the same letter(s) in a column are not significantly (p=0.05) different according to Duncan Multiple Range Test. SA = Swine manure + Almond leaves Compost, S.E.± = Standard error of the differences of means

Table 3.6 shows the effect of swine manure with almond leaves compost on shoot dry matter yield of pepper at 18 WAT in the Screenhouse. The shoot dry matter yield recorded under the SA and NPK were significantly ($p<0.05$) higher than the control. Relative to the control, 13.0, 16.3, 19.6 t/ha AS and 0.3 t/ha NPK significantly ($p<0.05$) increased the shoot dry matter yield of pepper by 133.0, 117.0, 125.0 and 117.0% respectively (Table 3.6). The fertilizer treatments significantly ($p<0.05$) increased the number and fruit yield of pepper. Relative to the control; 13.0, 16.3, 19.6 t/ha SA and 0.3 t/ha NPK significantly ($p<0.05$) increased the number of fruit of pepper by 61.5, 55.8, 56.7 and 49.0% respectively. Similarly, fruit yield was significantly increased by the same treatments by 26.3, 24.3, 22.5 and 23.8% respectively. The highest fruit yield of pepper (56.2 g/pot) under 13.0 t/ha SA was higher than the control and 0.3 t/ha NPK by 26.3 and 2.0% respectively (Table 3.7).

Table 3.6. Effects of swine manure with almond leaves compost on shoot dry matter yield of pepper at 18 WAT

Treatment	Rate	Shoot dry matter yield	Increase in shoot dry matter yield
	t/ha	g/pot	%
Control	0	1.2b	0
SA	13.0	2.8a	133.0
	16.3	2.6a	117.0
	19.6	2.7a	125.0
NPK	0.3	2.6a	117.0
S.E.±		0.3	

Means with the same letter(s) in a column are not significantly (p=0.05) different according to Duncan Multiple Range Test. SA = Swine manure + Almond leaves Compost, S.E.± = Standard error of the differences of means

Table 3.7. Effects of swine manure with almond leaves compost on fruit yield of pepper

Treatment	Rate (t/ha)	Number of fruits/pot	% increase in number of fruits	Fresh fruit yield (g/pot)	% increase in fruit yield
Control	0	10.4b	0	44.5b	0

SA	13.0	16.8a	61.5	56.2a	26.3
	16.3	16.2a	55.8	55.3a	24.3
	19.6	16.3a	56.7	54.5a	22.5
NPK	0.3	15.5a	49.0	55.1a	23.8
S.E.±		1.3		2.4	

Means with the same letter(s) in a column are not significantly (p=0.05) different according to Duncan Multiple Range Test. SA = Swine manure + Almond leaves Compost, S.E.± = Standard error of the differences of means

4.0 DISCUSSION

The results of the soil analysis showed that the soil N (0.9 g/kg), P (8 mg/kg) and K (0.1 cmol/kg) were below the critical limit of 1.5 g/kg N, 10 mg/kg P and 0.16-0.20 cmol/kg K set for crop production in southwest Nigeria (Akinrinde and Obigbesan, 2000). The SOC (7.3 g/kg) was also lower than the critical value of 8.7 g/kg established for soils in southwest Nigeria (Sobulo and Adepetu, 1987). The soil pH (6.1) was moderately acidic and adequate for pepper production, when compared with the critical range of 5.5 to 6.5 reported for pepper (Whittaker *et al.*, 1959). The soil fertility was low in major plant nutrients and hence it was expected to benefit from swine manure with almond leaves compost which is an organic source of nutrition. The raw Almond leaves (A) had 39.7% C, 0.4% N, 0.10% P, 0.8% K, 3.6% Ca and 0.20% Mg. These values were in contrast to 2.0% N, 0.14% P, 1.0 % K, 1.9 % Ca and 0.25% Mg recorded for almond leaves by David *et al.* (2011). The Swine manure (S) had 11.2% C, 1.1% N, 0.1% P, 1.4% K, 3.9% Ca and 1.7% Mg. The values for C, P, Ca and Mg did not fall within the range of 20.0- 22.0% C, 0.6-0.9% P, 0.4-0.9% K, 0.4-0.6% Mg and 1.0-1.5% Ca respectively, reported for swine manure by Tennakoon and Hemamala (2003). However, N (1.1%) was within range of 1.0-2.0% (Tennakoon and Hemamala, 2003). The swine manure with almond leaves compost (SA) had 5.2 g/kg (0.52%) N, 2.3 g/kg (0.23%) P and 2.6 g/kg (0.26%) K and these were contrast to the values of 5.1 g/kg (0.51%) N, 0.9 g/kg (0.09%) P and 7.3 g/kg (0.73%) K recorded from almond leaves with poultry manure compost established by Aiyelari *et al.* (2011).

The decrease in the temperature of the compost pile to ambient temperature is an indicator of the stability of the compost. The compost temperature of 55.3°C recorded in this study was high enough to kill pathogens, weed seeds and break down phytotoxic compounds in the compost (Rynk *et al.*, 1992). This ensured that the compost was safe for application into the soil for pepper use. The addition of SA compost increased soil nutrients which also led to higher uptake of N, P and K by pepper plants. This could be the reason why there was significant increase in plant height, stem girth, number of leaves and branches of pepper in this study. In another Screenhouse study on the effects of sawmill wastes, animal manure, and NPK fertilizer on the performance of okra, Aduloju *et al.* (2011) discovered that plant height of okra was significantly ($p<0.05$) affected by the fertilizer treatments irrespective of the levels of application. They also noted that number of leaves of okra under the fertilizer treatments was not significantly ($p<0.05$) affected.

The SA compost applied to pepper at 13 t/ha produced the highest fruit yield of pepper than other treatments. For instance, its fruit yield was higher than that of NPK by 2%. In terms of nutrient compositions, 19.6 t/ha SA compost had higher nutrient values than the rest, recording 101.9 kg N/ha, 45 kg P/ha and 51 kg K/ha; while 16.3 t/ha SA had 84.8 kg N/ha, 37.5 kg P/ha and 42.4 kg K/ha and 13 t/ha SA had 67.6 kg N/ha, 30 kg P/ha and 33.8 kg K/ha. This result revealed that more of the nutrient was supplied by 19.6 t/ha AS compost and the least by 13.0 t/ha SA compost. Thus, it could be inferred that the quantity of nutrient supplied to the soil by a specific organic fertilizer may not determine the overall yield of crops.

5.0 CONCLUSIONS

It can be concluded from this study that addition of swine manure to *Terminalia catappa* leaves enhanced the rate of decomposition, thus resulting to increased mineralization and release of nutrients for pepper growth and yield. Also, application of swine manure with *Terminalia catappa* leaves compost at 13 t/ha produced the highest fruit yield of pepper, hence it is recommended for optimizing pepper production.

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