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Effect of Application of Palm Bunch Ash on the Growth and Yield of Eggplant (*Solanum melongena* L.) in a Pineapple Orchard

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Abstract: The experiment was conducted at Akwa Ibom State University Teaching and Research Farm Obio Akpa Campus during the 2020 first planting season to evaluate the effect of application of palm bunch ash on the growth and yield of eggplant (Solanum melongena L.) in an established pineapple orchard. The experiment was laid out in a randomized complete block design and replicated three times. The treatments were five (5) different rates of Oil palm bunch ash - 1.0ton/ha, 2.0tons/ha, 3.0tons/ha, 4.0tons/ha and a control (0ton/ha - no fertilizer). Data collected for the growth and yield parameters were subjected to analysis of variance. Significant means were compared with least significant differences ($P<0.05$) at 5% probability level. Result showed significant differences ($P<0.005$) in all the growth parameters (plant height, number of leaves, stem girth, leaf area) and yield parameters (number of fruits/ plant, length of fruits/plant, circumference of fruits/plant, yield of fruits/plant). Treatment with 4.0tons/ha palm bunch ash produced higher values of plant at 2, 4 6, 8 weeks after planting, while the lowest values of plant height was recorded with 1.0ton/ha treatment at 2, 4, 6, 8 weeks after planting compared to the control treatment. The treatment with 4.0tons/ha oil palm bunch ash also had significantly values of number of leaves, stem girth and leaf area at 2, 4, 6, 8 weeks after planting. The least values of stem girth and leaf area at 2, 4, 6, 8 weeks after planting were recorded with 1.0ton/ha treatment. Higher values of number of fruits/plant (17.30), length of fruits/plant (12.50cm), circumference of fruits/plant (15.75cm) and fruit yield (20.13t/ha) were obtained with 4.0tons/ha oil palm bunch ash treatment while least values of number of fruits/plant (4.77), length of fruits/plant (10.43cm), circumference of fruits/plant (13.11cm) and fruit yield (5.42t/ha) were recorded with 1.0t/ha compared with the control treatment.

Keywords: Eggplant, Palm Bunch Ash, Pineapple Orchard

1. Introduction

Solanum melongena L. (known as eggplant in the United States and aubergine in France and England) is one of the few cultivated solanaceous species originating from the Old World. It is known as brinjal in its home country, India, where it was domesticated long ago and where the greatest diversity is found. According to Trujilo [32], the plant species is believed to have originated in India, where it continues to grow wild and has been cultivated in Southern and Eastern Asia since prehistory [22]. The first known written record of the plant was found in Qimi Yaoshu, an ancient Chinese agricultural monograph completed in 544 C. E. [11]. The numerous Arabic and North African names for it, along with the lack of the ancient Greek and Roman names, indicated that it was grown throughout the Mediterranean area by the Arabs in the early Middle Ages, who introduced it to Spain in the 8th century [26].

Eggplant is an important solanecious crop of sub-tropics and tropics [33]. As a member of the genus *Solanum*, it is related to tomato, chili pepper and potato. Eggplant (*Solanum melongena* L.) is a warm-weather crop mostly cultivated in tropical and subtropical regions of the world. Two other cultivated eggplant species, the scarlet eggplant (*Solanum aethiopicum* L.) and the gboma eggplants (*Solanum macrocarpon* L.) are less known but have local importance in sub-Saharan Africa [30, 10]. Based on [14] data, the global production of eggplant is around 50 million tons annually, with a net value of more than US$10 billion a year, which makes it the fifth most economically important solanaceous crop after potato, tomato, pepper, and tobacco. The top five producing countries are China (28.4 million tons; 57% of world's total), India (13.4 million tons; 27% of world's total), Egypt (1.2 million tons), Turkey (0.82 million tons), 0.75 million tons for Iran. In Asia and the Mediterranean, eggplant ranks among the top five most important vegetable crops [15]. It is also ranked among the top 10 vegetables in terms of oxygen radical absorption capacity [7]. The plant is grown worldwide for its edible fruits, used in several cuisines and also serves as a vegetable in cooking. Eggplant is nutritionally low in macronutrient and micronutrient content when cooked, but the fruit has the capability to absorb oils and flavours into its flesh through cooking thus expanding its uses in the culinary arts.

Nutritionally, eggplant has a very low caloric value and is considered among the healthiest vegetables for its high content of vitamins, minerals and bioactive compounds for human health [25, 23, 13]. The bioactive properties of eggplant are mostly associated with high content in phenolic compounds [23], [24], which are mostly phenolic acids, particularly chlorogenic acid in the fruit flesh [28] and anthocyanins in the fruit skin [21]. Both phenolic acids and anthocyanins have multiple properties beneficial for human health [23, 5]. The fiber, potassium, vitamin C, vitamin B-6, and antioxidants in eggplants all support heart health by reducing inflammatory markers that increase the risk of heart disease. [2].

Eggplant does well in a variety of soil textures such as sandy loam or silt loam soils free of physical barriers for proper plant growth and development [4].

Production of eggplant in the tropics is limited by poor soil fertility and adequate land caused by erosion, flooding and over grazing. In order to encourage production to meet the increasing population and the attendant consumption, fertilization is therefore required in the form of organic or inorganic. However, there seems to be some level of specificity in crop adaptation to the type of fertilizer and available land in order to increase its growth and yield potentials. In spite of the positive effects of fertilizer regimes on the growth and yield of crops and its relative abundance, published work on the effect of fertilizer on the growth and yield of eggplants are limited. In view of the scarcity and high cost of inorganic fertilizers during growing season, the use of organic fertilizer is advocated. Thus, this study will serve as a guide to farmers both subsistence and commercial on their choice of fertilizers that will minimize cost and maximizes their profits while optimizing the available land. This, however informs the use of palm bunch ash applied at various rates to the eggplant in an established pineapple orchard. Aside, the pre-emptive belief on the fact that pineapple can only be grown as a sole crop as oppose to intercropping with other crops, gave credence to the research. In this case, the pineapple was intercropped with eggplant and various rates of palm bunch ash were applied.

2. Materials and Methods

The research was conducted at the Akwa Ibom State University teaching and research farm Obio Akpa Campus, Akwa Ibom State in Nigeria. The farm lies between latitude 4 30°S and 5 30°N and longitude 7.30°W and 8.00°E with an altitude of 38.1 m above sea level and has annual rainfall range between 2000mm - 2600mm with bimodal pattern, which peaks in June and October [31]. The annual temperatures ranges between 24°C and 30°C being highest in the months of February and April, while the relative humidity ranges from 75 - 79% [31]. The vegetation of the place is a tropical rain forest though much of the climatic vegetation has been destroyed and now under arable crops. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each treatment plot measured 4 x 4m and demarcated from one another by 1m path. The Experimental area measured 28×16m. The treatments were five (5) different rates of Oil palm bunch ash - 1.0ton/ha, 2.0tons/ha, 3.0tons/ha, 4.0tons/ha and a control (0ton/ha - no fertilizer) applied after transplanting the seedlings.

The land was cleared and levelled manually using spade, the refuse was parked and the experimental field marked-out for the establishment of the pineapple orchard. The pineapple suckers were later planted with the spacing of 1×1m and allowed to established.

The eggplant seeds were sown in polybags for 3weeks and the seedlings were transplanted to the field at 4weeks with a spacing of 1×1m along the rows and between stands of established pineapple plants. Palm Bunch Ash (PBA) was applied uniformly around the base of the eggplant using the ring method at the stipulated rates. Weeding of the treatment plots were done 3 times at 4weeks, 8weeks and 14weeks after transplanting.

Harvesting of the fruits were done five times at 10, 12, 14, 16, 18 weeks after transplanting at intervals of two (2) weeks, when the fruits had reached a mature size and firm with a glossy coating which serve as a sign of readiness and maturity. A hard surface with dull coating indicates maturity of fruits and subsequent ripening. Harvesting was done using a sharp knife and this entailed cutting a short piece of the stem above the calyx (cap) attached to the top of the fruit.

The following growth and yield parameters were collected – plant height (cm), number of leaves, stem girth (cm), leaf area (cm^2) for the growth parameters while number of fruits/

plant, length of fruits/plant (cm), circumference of fruits/plant (cm), yield of fruits/plant (tons/ha) were collected for the yield parameters. Data collected from the listed parameters were subjected to analysis of variance (ANOVA).

3. Result

Leaf area of eggplant as influenced by application of palm bunch ash is shown in Table 1. There were significant differences (P<0.05) in the leaf area of eggplant at 2, 4, 6, 8 weeks after transplanting at different rates of applications. The result showed that application of 4tons/ha palm bunch ash enhanced significant larger leaf area of eggplant (92.15, 195.85, 242.23, 543.28 cm^2) at 2, 4, 6, and 8 weeks after transplanting. The treatment with 3.0 tons/ha had leaf areas of 90.17, 193.44, 221.45 and 478.47cm^2 at 2, 4, 6 and 8 weeks respectively. The least leaf area (84.31, 155.88, 165.88 and 220.54 cm^2) were recorded with 1ton/ha treatment in comparison with the control treatment.

Table 1. *Effect of different rates of palm buch ash on leaf area (cm^2) of eggplant.*

Rates (tons/ha)	Weeks after transplanting			
	2	4	6	8
1.0	84.31	155.88	165.88	220.54
2.0	87.60	166.15	173.90	250.13
3.0	90.17	193.44	221.45	478.47
4.0	92.16	195.86	242.23	543.28
Control	84.12	93.04	121.19	155.14
LSD (P<0.05)	1.05	1.52	2.90	3.21

Table 2 shows significant differences (P< 0.05) on the different rates of palm bunch ash (PBA) at 4, 6, 8weeks after transplanting whereas at 2 weeks, there was no significant difference. The treatment with 4.0tons/ha of palm bunch ash had significantly bigger stem girths (4.30, 5.09, and 6.26cm) at 4, 6, and 8weeks respectively. The treatment with 3.0 tons/ha had stem girths of 3.90, 4.50 and 5.33 cm respectively at 4, 6 and 8 weeks. The treatment with 2.0 tons/ha of palm bunch ash (PBA) had values of 2.71, 3.99 and 4.60cm stem girth at 4, 6 and 8 weeks while 1.0 tons/ha had 2.37, 3.94 and 4.18cm at 4, 6, and 8 weeks after transplanting as the least stem girth in comparison to the control treatment (1.99, 2.02 and 2.31cm) at 4, 6, and 8 weeks after transplanting.

Table 2. *Effect of different rates of palm bunch ash on stem girth (cm) of eggplant.*

Rates (tons/ha)	Weeks after transplanting			
	2	4	6	8
1.0	1.24	2.37	3.94	4.18
2.0	1.37	2.71	3.99	4.60
3.0	1.52	3.90	4.50	5.33
4.0	1.59	4.30	5.09	6.26
Control	1.23	1.99	2.02	2.31
LSD (P<0.05)	NS	1.72	2.16	2.40

NS = Not significant

Table 3 shows the effect of application of different rates of palm bunch ash (PBA) on the plant height of eggplant. The result showed significant differences (P<0.05) on plant height at 4, 6, and 8 weeks after transplanting. At 2 weeks after transplanting, there was no significant differences (P<0.05) in plant height. Result showed significant increase in plant height at 4, 6, 8 weeks with application of 4.0tons/ha of palm bunch ash (PBA) producing the tallest plant (40.11, 45.75, and 52.13cm) at 4, 6, and 8weeks respectively. This was followed by the application of 3.0tons/ha of palm bunch ash (PBA) with plant heights of 39.50, 42.55 and 48.35cm at 4, 6, and 8 weeks, while 2.0tons/ha of palm bunch ash application had plant heights of 30.33, 37.12 and 46.55cm at 4, 6, and 8 weeks after transplanting. The shortest plant height (21.05, 26.84, and 29.25cm) was recorded with 1.0ton/ha at 4, 6, and 8 weeks in comparison with the control treatment.

Table 3. *Effect of different rates of palm bunch ash on the plant height of eggplant (cm).*

Rates (tons/ha)	Weeks after transplanting			
	2	4	6	8
1.0	18.11	28.72	32.40	38.84
2.0	18.39	30.33	37.12	46.55
3.0	19.50	39.50	42.55	48.35
4.0	19.52	40.11	45.75	52.13
Control	18.20	21.05	26.84	29.35
LSD	NS	4.66	6.40	7.39

Table 4 shows the effect of application of different rates of palm bunch ash (PBA) on the number of leaves of eggplant. There were significant differences (P<0.05) on the number of leaves of eggplant at 4, 6, and 8 weeks after transplanting. The treatment with 4.0tons/ha of palm bunch ash (PBA) had significantly higher number of leaves per plant (18.40, 38.34 and 63.13) at 4, 6, and 8 weeks after transplanting respectively. The treatment with 3.0tons/ha of palm bunch ash (PBA) had values of 16.77, 32.20, and 50.30 number of leaves per plant, whereas the least values for the number of leaves per plant (9.16, 26.70, and 32.17) were recorded with 1 ton/ha when compared to the control treatment with 7.06, 22.15, and 26.50 at 4, 6, and 8 weeks respectively.

Table 4. *Effect of different rates of palm bunch ash on the number of leaves of eggplant.*

Rates of application (tons/ha)	Weeks after transplanting			
	2	4	6	8
1.0	4.58	9.16	26.70	32.17
2.0	4.66	13.63	30.11	47.06
3.0	6.25	16.77	25.20	50.30
4.0	6.40	18.40	28.34	63.13
Control	4.70	7.06	22.15	26.50
LSD	NS	3.01	3.95	4.25

NS = Not Significant

Table 5 shows the effect of application of different rates of palm bunch ash (PBA) on the yield and yield components of eggplants. There were significant differences (P<0.05) on the yield and yield components of eggplants. With the palm bunch ash of 4.0tons/ha, higher values were recorded for number of fruits per plant (17.30), fruit length (12.50cm), fruit circumference (15.75cm) and fruit yield (20.13 tons/ha). This was followed by 3 tons/ha and 2.0 tons/ha sequentially. The least values were obtained with 1.0 tons/ha (10.95, 10.43cm, 13.11cm, 10.30 tons/ha) in comparison to the control treatment with values of 4.77, 6.25cm, 10.30cm, and 5.42 tons/ha.

Table 5. *Effect of different rates of palm bunch ash on the yield components of eggplant.*

Rates (tons/ha)	Number of fruits per plant	Fruit length (cm)	Fruit circumference (cm)	Fruit yield (tons/ha)
1.0	10.95	10.43	13.11	10.30
2.0	16.30	11.60	14.33	16.93
3.0	15.40	12.40	15.40	18.06
4.0	17.30	12.50	15.75	20.13
Control	4.77	6.25	10.30	5.42
LSD	3.22	2.27	3.10	2.50

4. Discussion

Healthy soils are important to growing healthy crops, raising healthy animals and supporting a healthy human population through nutritionally balanced diet and healthy habitats. Therefore, favourable soil organic matter content is very critical to attaining such a vital interconnectivity. The importance of soil organic matter content to crop yield has been known to ancient civilization for millennia [20], soil organic matter content affects crop yield through its role in enhancing and sustaining soil quality and soil health [18].

The application of palm bunch ash (PBA) to eggplant strongly influenced its growth and yield. The increase in ash rate significantly increased the number of leaves per plant, leaf area, stem girth of eggplant, number of fruit per plant and fruit yield. This observation is in line with the report of [1] that the application of oil palm bunch enhances good growth and yield of cassava in an ultisol of southern Nigeria. [16] also affirms significant increase in yield with application of crop residue ash. The report of [16] further affirms increase in yield with application of ash irrespective of the source. High rate of ash promoted high vegetative growth such as number of leaves per plant, leaf area and fruit yield. This could be attributable to the amount of nutrients contained and released by the ash. This observation also corroborated the reports of 1] that organic waste (palm bunch ash) improves soil fertility and water holding capacity of the soil hence an improvement in crop growth and performance. Stored plant nutrient acted as buffering agent against undesirable nutrient fluctuations and hence availability for plants to improve their vegetative growth and yields. Planting eggplant in an established pineapple orchard is intercropping. Asten [3] observed that intercropping pineapple with other crops of economic interest maybe a viable alternative, thereby maximizing the use of environmental resources and labour for sustainable family farming. The systems sought to increase the production and yield of cultivated products as well as adopt ecological and socioeconomic conditions of certain regions [8, 19]. Costa [9] observed competition among plants though dependent on plant species, but generally, he opined that it improves the development and yield of the attendant crops.

Palm bunch ash is organic manure that is sufficiently rich in desirable nutrients for plant growth [29]. This accounts for the high values of the growth parameters with increase tonnage palm bunch ash. This is in agreement with [17] who opined that the integration of organic sources and synthetic sources of nutrients do not only supply essential nutrients but also have some positive interactions which increases their efficiency and thereby reduce environmental hazards that could inhibit growth. Organic amendments come from plants and animals [12] and improves soil aeration, water infiltration, water and nutrient holding capacity of soils. They increase water retention by the soil and are important in maintaining soil tilt [27], the totality of which ultimately improves the plant. Accordingly, [6] explained that organic fertilizers are also responsible for the formation of soil aggregates which are very essential in maintaining soil fertility.

5. Conclusion

The treatment with 4.0tons/ha of palm bunch ash (PBA) produced significantly higher values of plant height, number of leaves, leaf area and stem girth (growth parameters); high values of fruit per plant, length of fruit per plant and fruit yield (yield parameters). This was followed by treatment with 3.0tons/ha palm bunch ash (PBA) as well as 2.0tons/ha in descending order, while the least values for the growth and yield parameters were obtained with 1.0ton/ha when compared with the control treatment.

6. Recommendation

Eggplant farmers were recommended to apply 4.0tons/ha of palm bunch ash (PBA) to eggplant grown in a pineapple orchard since the yield obtained from it was higher when compared with other rates (1.0, 2.0, 3.0tons/ha) of palm bunch ash (PBA).

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