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APPLICATION OF ORGANIC MANURE DERIVED FROM FOUR SOURCES AS SOIL FERTILITY MANAGEMENT STRATEGY FOR GINGER (*Zingiber officinale*) PRODUCTIVITY IN NIGERIA

BY

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Abstract

Nutrition is found to exert a great influence on growth and yield of ginger and an agronomic technologies influencing its productivity. Imbalance, low or no fertilizer application is one of the most important factors in obtaining poor yield. Hence, the trial was taken to study the effect of four organic manures (cow dung, pig, poultry, and household waste) on growth and yield of ginger (Zingiber officinale) at the Department of Agricultural Science experimental station Federal College of Education Pankshin, located at 9^0*10``N and* $9^0$*26``E. Soil sample of the experimental site were collected with soil auger, air-dried and sieved with wire mesh; Bouyoucos hydrometer method were used to determine particle size. The experimental designed used was randomized Complete Block Design laid out in a split-plot design with 3 replications. Ginger rhizomes was cut into sett and planted at the depth of 5cm and at 3 different planting distances at their respective plots. The growth and yield parameters observed were plant height, leaf number, number of tillers; rhizome fresh weigh, and rhizome size. Data collected were subjected to Analysis of Variance (ANOVA) and significantly different means were separated using LSD and DMRT at 5% level of probability. Results showed that growth parameters treated with household waste produced the highest (55.26cm, 126.11cm, and 6.08cm). This was followed by pig manure (52.02cm, 115.58cm, and 5.89cm) respectively. The least mean values of 43.04cm, 72.31cm, and 4.27cm were obtained from the control. While* T_3 *recorded highest fresh weight (313.07) followed by* T_4 *(203.13) and least at* T_0 *(195.66). The general results indicated that organic manures in the forms of household waste, pig dung, poultry manure, and cow dung have great tendency to increase productivity of ginger.*

Keywords: *Organic fertilizer, Ginger productivity. Growth parameter, Yield components.*

Introduction

Ginger (*Zingiber officinale* Rosc.) is a spice and root crop grown as cash crop in Nigeria for exports. It is an underground rhizome that belongs to the family Gingiberaceae. Nigerian ginger is known to produce the highest quality essential oils (Oleoresin and gingero) and are valued for their aroma and pungency [1, 2]. The production of ginger has increased due to its high demand in chemical, food processing, and agro-allied industries [3, 4], it is used domestically for spicing food and also for local medicinal purposes [2, 5]. In western countries, ginger is used for culinary purposes. Ginger is one of the high-value species and has the potentialities of marketing in the domestic as well as international level.

According to [6], Nigeria is the third largest producer of ginger in the world (after India and China). Nigerian ginger is among the best in the world, with its aroma, pungency, and high oil and oleoresin content as distinct features. Nigeria could use ginger to position itself in different ways on the domestic, regional, and EU markets by focusing among others on quality improvement with points related to improving farming techniques, quality management mediating the challenges of low yields. It has been reported that Nigerian ginger production is lower in yield compared to its peer-producing countries, for example, 0.5tha^{-1} to China's production yield of 1.2 tha^{-1} (FAOSTAT, 2018). Sector experts claim that the lower yield is mainly due to the use of unimproved varieties, decline in soil fertility, and poor knowledge and application of Good Agricultural Practices (GAP) [7, 8].

Ginger can be cultivated on any available land except stony and waterlogged or marshy land. Unlike most tuber crops which are usually grown on either mounds or ridges, ginger is grown on flat bed. An anointed belief is that when grown on mounds or ridges, it will not yield much and the quality (flavour and pepper spices) would not be the same than if cultivated on flat bed [9]. Nigeria is a powerhouse economically and politically in Africa, however, its large population experience everything from extreme wealth and comfort to stark poverty and hardship; it also have a diverse landscape ranging from tropical rainforest to dry Savannah lands. Also enjoyed the humid tropical climate with two clear identifiable seasons, the wet and dry seasons [1, 8, 9, 10].

Agricultural potential have not been met due to decline in soil fertility and productivity resulting from soil nutrient, mining, and practices which reduce soil organic matter content leading to soil loss and degradation. Soil degradation and attendant depressed yields have already reached severe proportions in several parts of the country. The need to apply mineral nutrient elements to depleted soils to resuscitate plant productivity heralded the birth of series of fertilizer in the world in terms of fertilizer nutrients/ha. This study is necessitated by the obvious need for Nigeria to intensify fertilizer use, improve agricultural production and productivity, and raise rural income in the face of a rapidly growing population and worsening poverty incidence.

Ginger (*Zingiber officinale*) requires the right kind of nutrients to sustain its growth and maximum yield like any other plant. Plant nutrients usually supplied by the soil in most environment are often inadequate and sometimes in plant unavailable form, hence, the need to be augmented with other sources that are cheap and environmentally friendly. The use of organic manure is one technology that have been exploited over time and across ages because of its ability to restore soil fertility [4, 11, 12, 13]. Increase in soil chemical properties which are quite essential in crop growth and yield have also been associated with organic manures.

Ginger as part of the rhizome family is propagated through planting its buds. The selection of ginger seed is guided by the size and fatness of the ginger tuber [14, 15]. Other properties being considered in ginger selection are the number of budding tendencies (about 5 and above) and non-physical mutilation or damage of the ginger tuber. Like other operations, ginger planting is labour intensive, planting operation is usually carried out in the month of April to early May [3, 4, 5].

Materials and Method

Study Site and Treatment

The field study was carried out at the Federal College of Education, Pankshin Agricultural Science Experimental Station. The area lies between $9^0$10``N and $9^0$26``E, located at the central part of Plateau State. The soil of the experimental field was sandy-loam having pH 5.85. The climate is generally characterized by alternating dry and wet seasons. The rainfall usually starts in April and ends in October, while the dry season sets in early November and ends in early April.

The experiment was laid out in a randomized complete block design replicated three times using four types of organic manures namely: poultry manure, pig dung, household waste, and cow dung. Ginger rhizomes (*Zingiber officinale*) weighing 20 – 25g, having at least two healthy buds were planted. Fertilizers were applied at three splits. The first dose was given as basalt application, second dose were top dressed at 45 days after planting, and the last at 90DAP.

Growth Parameters

Growth parameters, i.e. plant height, number of tillers, and leaves per plant were measured and sampled on a monthly basis for each treatment. Plant height (cm) was measured from the base of the plant to the apex using a measuring tape. Number of tillers and leaves were monitored by manual counting. Data on plant growth were measured at fortnightly intervals for the period of study.

Yield

Ten (10) plants in each plot replicate were labelled and sampled for yield. Yield was measured at harvest, six months after planting. Rhizomes were removed from the soil and the fresh rhizomes were weighed.

Data Analysis

The data recorded were subjected to Analysis of Variance (ANOVA) using SPSS software version 21.0. The LSD and DMRT mean separation methods at 5% probability level were used to treatment means.

Results and Discussion

Perusal of the data revealed a number of interesting features of growth and yield parameters under different treatments. The chemical and physical properties of the soil used for the experiment before planting are presented in table 2. The soil is sandy loam with slightly acidic pH with total N, available P, exchangeable K, and organic carbon at 0.066%, 7.00%, 1.0Cmolkg$^{-1,}$ and 5.60Cmolkg^{-1} respectively. The result of the soil test values indicated the nutrient status of the soil at the experimental site before planting. The nutrient content in the organic manures used for the study is presented in table 1, while table 3 is the result of soil properties as influenced by treatments.

Table 1: Laboratory analysis of nutrient in the organic manures used for the study.

Characteristics	Organic Sources / Values Obtained			
	CDM	PgM	PM	HWM
N (%)	1.06	1.67	2.57	5.00
P (%)	0.52	2.36	3.08	3.98

K (%)	0.97	0.75	2.47	2.30
Ca (%)	1.07	3.83	12.68	12.93
Mg (%)	0.88	0.54	0.93	1.02
Fe (Mg Kg^{-1})	572	1691	1756	1867
Mn (Mg Kg^{-1})	344	505	573	532
Zn (Mg Kg^{-1})	123	623	722	731
Cu (Mg Kg^{-1})	22	510	82	523

Key: CDM = Cow Dung Manure; PgM = Pig Manure; PM = Poultry Manure; HWM = Household Waste Manure

Table 2: Soil properties at the start of experiment (0 – 30cm depth)

Parameter	Value
Moisture content (%)	10.92
Bulk density (g/m^3)	1.226
Total porosity (%)	43.2
Physical characteristics	
Total sand (%)	61.84
Silt (%)	18.00
Clay (%)	20.16
Textural Class	Sandy loam
pH in HO_2 (1:1)	5.85
Organic matter (%)	2.28
Total Nitrogen (%)	0.066
P (ppm)	7.0
Ca ($Cmolkg^{-1}$)	5.60
Mg ($Cmolkg^{-1}$)	8.2
K ($Cmolkg^{-1}$)	1.0
Al ($Cmolkg^{-1}$)	Nil
H^+ ($Cmolkg^{-1}$)	8.6

Source: Field Survey

Table 3: Soil properties as influenced by treatments

Treatment	M.C. (%)	B.d. (gm^3)	POS (%)	Total Sand (%)	Silt (%)	Clay (%)	Textural Class	pH (HO_2)	N (%)	O.M. (%)	H^+	P (ppm) $Cmolkg^{-1}$	C $Cmolkg^{-1}$	Mg	K	Al
T_1	10.82	1.24	44	61.84	18.00	20.16	Sand, Clay loam	5.95	0.042	1.38	8.6	7.0	580.0	74.0	10.0	Nil
T_2	10.8	1.28	46	61.82	18.20	20.2	Sand, Clay loam	5.8	0.041	1.28	7.2	6.4	560.0	72.0	10.0	Nil
T_3	11.8	1.28	47	61.74	18.40	20.0	Sand, Clay loam	5.85	0.042	1.20	6.2	6.6	58.0	71.0	10.1	Nil
T_4	10.0	1.21	41	61.45	17.50	20.5	Sand, Clay	5.82	0.039	1.19	6.1	6.7	50.0	70.0	10.0	Nil

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loam

*T_1 = Control	T_3 = Pig Manure	M.C. = Moisture Content	POS = Porosity
T_2 = Cow dung Manure	T_4 = Household Waste	B.d. = Bulk density	O.M. = Organic Matter

With the application of organic manure, soil physical properties like granulation is encouraged while plasticity and cohesion are reduced. This is in line with the findings of [9, 16, 19, 20], who had earlier reported that organic manure facilitates easy supply and availability of nutrients, whereas, nutrients supplied through inorganic fertilizers are not fully utilized by the crops and availability is reduced due to losses through leaching, volatilization, and fixation. Gradual availability of nutrients through decomposition of organics throughout the growth phase may be probable cause for better growth and development of plant and ultimately yield when inorganics were substituted by the organics at different levels.

Three unique growth phases can be used to categorize ginger's development: active growth (90 – 120DAP), Sluggish vegetative growth (120 – 180DAP), and senescence (180DAP), during which the rhizome continues to develop up to harvest. Table 4 shows the effect of different organic manure applications on growth characteristics of ginger in the study area.

Table 4: Effect of different organic manure application on growth characteristics of ginger.

	Growth Characteristics		
Treatment	**Plant Height (cm)**	**Number of Leaves**	**Number of Tillers**
T_0	43.04[a]	72.31[a]	4.27[a]
T_1	47.29[ab]	88.52[ab]	5.2[ab]
T_2	50.95[ab]	107.69[b]	5.30[ab]
T_3	52.02[b]	115.58[b]	5.89[b]
T_4	55.36[b]	126.11[b]	6.08[b]
Mean	42.804	110.142	6.14
SEd	0.7450	1.2101	0.120
LSD ($P \leq 0.05$)	1.6645**	2.6623**	0.264**

The number in the column followed by the same letter show no real difference in the DMRT level of 5%.

Plant Height

Plant height is one of the most important plant growth variables used to determine the effect of the treatment on plants. The giving of organic fertilizers can provide macro and micro nutrients that plants need to increase plant growth. This study is in agreement with [16, 18, 21] whose various works maintained that nitrogen has a major role in stimulating overall growth and that the availability of macronutrients enough for plants can increase the plant height and optimal nitrogen uptake can support plant growth.

Number of Leaves

Leaves are where the photosynthesis process takes place and also play a role in capturing sunlight. The more leaves on the plant indicate that photosynthesis is going well. Good plant growth can be shown by the number of leaves produced. Table 4 reveals that control (T_0) had a lower number of leaves while T4 had the highest number of leaves. Other workers [4, 18, 20, 21] had reported that the number of leaves is influenced by the environment and the availability of nutrients in the growing place. They also maintained that plants get enough nutrients, especially nitrogen, will form leaves that are high in chlorophyll for photosynthesis. Once photosynthate is formed it shall be allocated to plants vegetative parts such as leaves and stems and such allocation will be transferred to the rhizome when ginger enters rhizome development phase.

Number of Tillers

These are shoots that grow at the top of the rhizome and become new ginger plants. Table 4 showed that the number of tillers produced in each treatment was different. T_4 had the highest number of tillers and T_0 (control) had the lowest tillers compared to each treatments. The formation of tillers is influenced by nitrogen and phosphorus elements [20, 21]. Element P is needed at the beginning of growth in sparring additional tillers while N plays a role in stimulating the number of tillers. The number of tillers form is as a result of the photosynthesis process that produces photosynthate whose amount affect the plant in generating new tillers. It therefore indicate that ginger plants will slow optimal growth response when given sufficient nutrients.

Yield attributes of ginger as influenced by the four sources of organic manures observed in this study were fresh weight of ginger and rhizome size (Table 5 and 6). Low soil fertility has been implicated for the decreasing yield trends of ginger in the tropics [18]. The findings of this study agrees with previous workers [17, 22, 23] who had reported that ginger need organic matter, which can be obtained from a variety of sources; and that when humus and organic matter are available, ginger grows and has a favourable relationship with yield.

Table 5: Effect of different organic manure application on fresh weight of ginger.

Treatment	Weight of fresh rhizome (g)
T_0	195.06[a]
T_1	202.00[a]
T_2	313.07[b]
T_3	203.13[a]
T_4	

The numbers in the column followed by the same letter show no real difference in the DMRT level of 5%.

Fresh Weight

Control treatment had the lowest weight compared to other treatments (table 5). The fresh weight is related to the accumulation of photosynthate and the water content in the plant. The findings from these study revealed that fresh weight of ginger indicates the effectiveness of plants in absorbing water and nutrients. This agrees with [16, 21] who had reported that plants that were not fertilized generally had a lower fresh weight compared to plant fertilized. In table 5, the fresh weight did not significantly differ in all treatments because of harvest time, at that age, the ginger plant has passed an active vegetative growth phase, and they were harvested in dry conditions.

Table 6: Effect of different organic manure application on rhizome size of ginger.

Treatment	Rhizome Size Length (cm)	Width (cm)	Thickness (cm)
T_0	16.42	7.21[a]	3.44
T_1	17.68	7.95[ab]	3.54
T_2	18.53	8.08[ab]	3.67
T_3	18.02	8.29[ab]	3.88
T_4	19.95	8.83[b]	3.82

The number in the column followed by the same letter show no real difference in the DMRT level of 5%.

Rhizome Size (Length, Width, and Thickness)

The size of ginger rhizome is influenced by external factors. The result in table 6 showed that it did significantly differ in length, width or thickness. This also concur with other workers [1, 20, 24, 25] who had reported that rhizome producing plants such as ginger require quite a lot of nutrients. Similarly, they posited that ginger plants that grow and can adapt well to the environment will produce large rhizomes.

Conclusion

An organic production system is designed to: maintain long-term soil fertility, rely on renewable resources, recycle wastes of plants and animal origin in order to return nutrients to the soil, thus minimizing the use of non-renewable resources. The use of organic manures held a very prestigious position with farmers. The study had shown considerable increase in ginger yield, quality and exert significant influence on physical, chemical, and biological properties of soil. It can be concluded that the growth and yield of ginger were increased under the application of these organic manures. It is, therefore, crucial to provide the soil with sufficient levels of vital nutrients in a balanced proportion at the proper time and in the right manner for the cultivation of ginger crop, since agricultural development is fundamentally affected by productivity status of land resources.

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