EFFECT OF INCORPORATING NPK 15:15:15 FERTILIZER WITH COW DUNG ON GROWTH, YIELD AND ECONOMICS OF GINGER PRODUCTION IN RAIN FOREST ZONE OF NIGERIA

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Abstract
This study was conducted at the National Root Crops Research Institute, Umudike experimental field to determine the effects of incorporation of cow dung and NPK 15:15:15 fertilizer on ginger yield and economics of production. The treatment factors comprise of four rates of cow dung, 0 t/ha, 4 t/ha, 8 t/ha and 12 t/ha and four rates of NPK 15:15:15 fertilizer (0 kg/ha, 100kg/ha, 200 kg/ha and 300 kg/ha). Results obtained indicate that incorporation of cow dung and NPK 15:15:15 significantly ($P<0.05$) enhanced tiller and leaf production. Maximum yield of ginger when cow dung was applied sole was 6.98t/ha at the rate of 12t/ha of cow dung while maximum yield when NPK 15:15:15 was applied soil was 5.64t/ha at the rate of 200kg/ha of NPK 15:15:15. The incorporation of NPK 15:15:15 and cow dung increases yield of ginger significantly. For optimum yield in ginger production the combination of cow dung and NPK 15:15:15 at the rate of 8t/ha and 200kg/ha respectively was recommended. The gross margin analysis showed that applying cow dung alone at 12t/ha gave the maximum return on investment of 58% and NPK 15:15:15 applied as sole had the maximum return on investment of 17% at the rate of 200kg/ha. The optimum gross margin (₦989.53/ha) with return on investment of 62% was obtained from incorporation of 8t/ha of cow dung and NPK 15:15:15 at 200kg/ha. Based on productivity and gross margin analysis, the study recommends the incorporation of cow dung and NPK 15:15:15 at the rates of 8t/ha and 200kg/ha respectively to improve yield and profitability of ginger production.

Keywords: Gross margin, Inorganic Leaves, manure, Organic manure, Tillers and *Zingiber officinale*

Introduction

Ginger (*Zingiber officinale* Rosc.) is one of the spices grown in the world especially in Nigeria for its increasing economic value. The plant produces an underground rhizome valued for its pungent aroma, powder, oil and oleoresin. It is an important raw material for medicinal and pharmaceutical industries. Increasing value addition through processing of ginger has added more to its beneficial uses. Among all the root and tuber crops grown in Nigeria, ginger is the most cultivated on a large scale for export (Emehute, 2003). Maintenance, restoration and enhancement of soil fertility and soil health have been widely acknowledge as key elements in increasing agricultural growth and sustainable agricultural systems (Rushemuka and Bock, 2015). One approach to maintain soil fertility is through the incorporation of both organic and inorganic fertilizers into the soil to improve soil structure and enhance productivity. Low soil fertility is one of the major constraints facing ginger production in rainforest zone of Nigeria. This problem is due to low pH low organic matter, low effective cation exchange, and low buffering capacity of the soil. One of the ways of improving the nutrient status of the soil is through the incorporation of organic manure (poultry manure, sheep and goat manure, and cow dung manure, compost manure) with inorganic fertilizers. Other ways of improving soil nutrient is bush fallowing and crop rotation systems. John *et al*., (2004) and Ndukwe, *et al*. (2011) reported that the incorporation of organic manure and inorganic fertilizers in recommended quantities will increase and sustain optimum crop productivity and profitability and minimize negative environmental impact on the soil. Nwaogu *et al*. (2015) also reported that for

sustainable ginger production in the rain forest and southern guinea savannah ecologies of Nigeria, soil amendment with either organic manure and or inorganic fertilizer will increase rhizome yield up to 148% and increase return per Naira invested three fold.

FAO, (2000) asserted that chemical fertilizers are commonly used to improve soil fertility. However, Okigbo *et al*.(2000) found that the effect of chemical fertilizer on highly weathered, low organic matter, low nutrient status, low cation exchange capacity and low activity clay, poor soil without any compensatory organic input sources have limited residual effects on crop production. Organic manure is a good source of fertilizer which enhances soil productivity, increases the soil organic carbon content, enhances the activities of soil microorganisms, and improves soil crumb structure and nutrient status of the soil as well as crop yield (Beckman, 1973).The use of organic manures is one technology that have been exploited overtime and across ages because of its ability to restore soil fertility, supply major plant nutrients, such as N. P. K., Ca, Mg and also stabilizer soil pH (Sanchez and Miller, 1986). Increase in soil chemical properties which are quite essential in crop growth and yield have also been associated with organic manures (Adetunji, 1990). Cow dung is high in nitrogen and potash which is good for root and tuber crops. Cow dung is useful organic manure that can be utilized to supplement the quantity and quality of fertilizers needed for root and tuber crops production (Asawalam and Onwudike, 2011). In India for instance, cattle manure is applied at 25t-30t/ha to get high yield of ginger (Ginger extension pamphlet, 2015). From the literatures cited it is pertinent that for sustainable soil fertility and productivity the application of organic and inorganic is imperative.
The process of analysing farm business has been traditionally divided into two parts (MAFF, 1980) a general analysis based primarily upon financial accounts and other appropriate records and a more detail analysis of the individual enterprise on the farm in the form of gross margin for each enterprise. A gross margin analysis for an enterprise is its financial output minus it variable cost. For field experiments, gross margin is more appropriate to determine the performance of each treatment. In organic systems gross margins are also useful for farm planning and for making comparison of conventional and organic enterprises (Lampkin and Measures, 2001). A lot of studies has been done on the economics of organic farming and the gross margin has been basically used for the comparison of performances (Leake, 1999, Cormack and Elliot, 1994). The problem with gross margin analysis is that the costs of field operations are sometimes not accurately recorded; this can cause problems with farm comparisons.

Though many studies have been conducted on the complementary effects of using poultry manure and chemical fertilizer in ginger production, there is paucity of information on the effect of cow dung and NPK fertilizers on ginger rhizome production in the rain forest zone of Nigeria. A lot of cow dung manure is produced by people and institutions that rear cattle in southeast Nigeria. The bulk of this is not properly utilized. This study therefore, was carried out to determine the effects of incorporation of cow dung and NPK 15:15: fertilizer in ginger production and also to determine the economics of ginger production under the incorporation of cow dung and NPK 15:15:15.

Materials and Methods

The study was conducted at the National Root Crops Research Institute Umudike experimental field (Latitude 5^0 29' N and Longitude 7^0 32' E; altitude of 122m) in 2014 and 2015 cropping seasons. The soil of the trial site is Dystric Luvisol with sandy loam top soil over sandy clay (Akpan-Idiok *et al*., 2012). The soil is strongly acidic, low in C.E.C, low in base saturation and poor in nutrient (Ita and Esu, 2013). Annual rainfall for the environment during the trial period was 2289mm.The cow dung for the experiment was collected at Michael Okpara University of Agriculture Umudike livestock (cattle paddock) and stored in shade for 6 weeks for proper

decomposition, and also to kill weed seeds. The nutrient content of the cow dung was analysed in soil laboratory of National Root Crops Research Institute, Umudike.

The treatment factors comprises of four rates of cow dung, 0 t/ha, 4 t/ha, 8 t/ha and 12 t/ha and four rates of NPK 15:15:15 fertilizer (0 kg/ha, 100kg/ha, 200 kg/ha and 300 kg/ha). A total of 16 treatment combinations was replicated 3 times and laid out in randomised complete block design (RCBD). The experimental plot size was 2m x 3m with plant spacing of 20cm x 20cm, giving a total of150 plants per plot. The yellow variety of ginger UG1 was used in the experiment. The cow dung was incorporated into the soil during bed making before the rhizomes were planted. The rhizome setts weighted between 10- 20g and have at least two viable buds. The rhizomes were planted at the depth of 5cm. The beds were mulched with dried guinea grass (*Panicum maximum*) to a thickness of 5 – 10cm immediately after planting. The recommended agronomic practices for ginger production by the National Root Crops Research Institute were carried out during the cropping. The number of tillers per plant and number of leaves were recorded as indices of yield attributes. At harvest, yield from each of the treatments was recorded.

Costs and returns data

The costs and prices of Inputs used in the experiment were recorded and standardised per hectare. The seed cost was obtained from the prevailing market price of ginger during the period of production. Included in the seed cost is the costs of sorting and seed treatments before planting. The cost of land preparation was pooled from cost incurred in three operations ploughing, harrowing and bed preparations. The cost of labour was calculated by adding up the amounts paid per man-days for operations such as planting, weeding, rogueing, and harvesting. Fertilizer and agrochemicals cost includes the cost of fertilizer, sprays (herbicides, fungicides, pesticides) and their applications. The cost of mulching and mulching materials, transportation and applications were also calculated and recorded. The yield from each treatment was recorded and use in the gross margin analysis as indicated below.

Gross margin analysis

Gross margin for each of the treatments was calculated as income derived from each treatment less the variable costs incurred in the treatment. Gross margin analysis as defined below was applied in determining the economic return from treatments.

GM=GI-TVC *(1)*

Where: GM= Gross Margin

GI= Gross Income

GI=Gross Output x Price *(2)*

TVC= Total Variable Cost.

Data analysis

Analysis of variance (ANOVA) was used to partition and determine the significance of treatments and the separation of treatments means differences was done using Fischer's least significant differences method.

Results and Discussion

The chemical composition of cow dung shown in table 1, indicates that the nutrient content in cow dung have high percentages of N, P, K. Nwaogu *et al*. (2015) reported that total Nitrogen available in Umudike soil is 0.16%, Available Phosphorus is 10.1 mg/kg and potassium 0.11 cmol/kg. High nutrient content of organic manure is essential for optimum production of crops as reported in Asawalam and Onwudike, (2011).

Table 1: Result of laboratory analysis of nutrient content in cow dung

Elements	Percentage Nutrient content
Nitrogen	2.66
Phosphorus	0.868
Potassium	0.595
Sodium	0.250
Calcium	3.41
Magnesium	1.58

Source: NRCRI, soil laboratory.

It is expected that the high nutrient content of cow dung when integrated with NPK fertilizer, will improve soil fertility leading to significant increase in yield of ginger cultivated.

Effect of incorporating cow dung and N.P.K 15:15:15 on number of tillers produced

Tiller numbers presented in table 2 show that both cow dung and fertilizer greatly influenced number of tillers produced. There was significant interaction ($P< 0.05$) between the cow dung and fertilizer with the highest tiller mean number/plant obtained at 4.80 tillers/plant at treatment combination of 8t/ha and 200kg/ha. It is expected that the more the tiller numbers the more the expected yield.

Table 2: Effect of cow dung and fertilizer N.P.K 15:15 on the number of tillers/plant at 8 WAP in

Cow dung (t/ha)	N.P.K 15:15:15 (kg/ha)				Mean
	0	100	200	300	
0	3.33	3.46	3.87	3.40	**3.51**
4	3.52	3.73	4.13	3.87	**3.81**
8	3.70	4.53	4.80	4.53	**4.39**
12	3.66	3.93	4.33	4.40	**4.08**
Mean	**3.56**	**3.91**	**4.28**	**4.05**	

L.S.D (0.05) for cow dung = 0.38, L.S.D (0.05) for fertilizer = 0.38, L.S.D (0.05) for cow dung X fertilizer = 0.076

Effect of incorporating cow dung and N.P.K 15:15:15 on number of leaves produced

The effect of incorporating cow dung and NPK 15:15:15 fertilizer on number of leaves is presented in table 3. Number of leaves at 8wks after planting increased with in quantity of cow dung and NPK fertilizer up to 8 t/ha and 200kg/ha respectively. Cow dung and fertilizer interaction effect on number of leaves was not significant.

Table 3: Effect of cow dung and fertilizer N.P.K 15:15 on the mean number of leaves at 8 WAP

Cow dung (t/ha)	N.P.K 15:15:15 (kg/ha)				Mean
	0	100	200	300	
0	14.53	19.33	19.93	18.47	**18.07**
4	17.47	19.87	20.93	19.47	**19.44**
8	20.73	21.00	22.33	22.17	**21.56**
12	16.73	17.27	19.47	22.13	**18.9**
Mean	**17.37**	**19.37**	**20.67**	**20.56**	

L.S.D (0.05) for cow dung = 0.38; L.S.D (0.05) for fertilizer = 0.38, L.S.D (0.05) for cow dung X fertilizer = NS

The results in Table 2 and Table 3 are in line with Asawalam and Onwudike, 2011, who reported that cow dung and inorganic fertilizers increases productivity crop yield and quality.

Effect of incorporating cow dung and N.P.K 15:15:15 on rhizome yield of ginger

The effect of cow dung and NPK: 15:15:15: on mean ginger yield over two seasons is presented in Table 4. Yield of ginger progressively increased as the rate of NPK 15:15: 15 increased from 0kg /ha (4.17t/ha) to 5.6t/ha at 200kg/ha and thereafter declined. Yield of ginger also increases

as cow dung rate increased, when NPK15:15:15 was at zero level, the highest yield (6.98t/ha) was obtained at 12t/ha application. Combined application of cow dung and NPK15: 15:15 gave higher rhizome yield compared to control and their applications as single source of nutrients. The optimum combination that gave the highest rhizome yield (14.38t/ha) was obtained at the rate of 200kg/ha of fertilizer and 8t/ha of cow dung.

Table 4: Effects of cow dung and N.P.K 15:15 on rhizome yield (t/ha) of ginger

Cow dung (t/ha)	N.P.K 15:15:15 (Kg/ha)				Mean
	0	100	200	300	
0	4.17	5.06	5.64	5.56	**5.11**
4	6.59	7.95	7.67	6.81	**7.25**
8	4.90	9.22	14.38	8.98	**9.37**
12	6.98	8.90	12.84	11.97	**10.17**
Mean	**5.66**	**7.78**	**10.13**	**8.33**	

L.S.D (0.05) for cow dung 2.23; L.S.D (0.05) for fertilizer 2.23; L.S.D (0.05) for fertilizer X cow dung NS

This result agree with Forbes and Watson (1994), who found that the application of cow dung and NPK fertilizer enhanced higher nutrient uptake by plants resulting in increased yield. Increase in the yield of ginger could be attributed to N, P, K and Ca increased uptake.

Gross Margin Analysis

In Table 5, the gross margin analysis of different rates of fertilizer indicates that, application of fertilizer at 200kg/ha gives a gross margin of N609/ha followed by 300kg/ha with N580/ha respectively. Zero application of fertilizer (control) was the least in terms of yield and gross margin. There was a marginal increase in gross margin from control application 0kg/ha to 200kg/ha of NPK15:15:15. After 200kg/ha rate of NPK 15:15:15 application diminishing return in gross margin sets in. This implies that NPK 15:15:15 should be applied at 200kg/ha for optimum production and profitability.

Table 5: Gross Margin analysis of ginger production under different rates of fertilizer in southeast agro ecological zone of Nigeria

S/n	Value of output/cost of inputs (₦000/ha)	N.P.K 15:15 rates (kg/ha)			
		0	100	200	300
1.	Value of rhizome yield	834	1012	1128	1112
2.	Seed cost	385	385	385	385
3.	Land preparation	19.32	19.32	19.32	19.32
4.	Labour	38.18	43.88	49.58	46.38
5.	Cost of mulching and mulching material	15	15	15	15
6.	Cost of NPK: 15:15:15/application	0	18.76	34.76	50.76
7.	Sprays/application (herbicides, fungicides, pesticides)	15.23	15.23	15.23	15.23
8.	Total Variable Cost (TVC) (2-7)	472.73	497.19	518.87	531.69
9.	Gross Margin (GM) (1-8)	361.27	514.81	609.13	580.31
10.	Gross Margin/Naira invested	0.76	1.04	1.17	1.09

Analysis of gross margin of ginger production under different rates of cow dung (Table 6), shows irregular trend in returns in terms of total revenue and gross margin per hectare. The highest gross margin of ₦796.57/ha and ₦830.07/ha were obtained respectively when cow dung were applied at the rates of 4t/ha and 12t/ha. The decrease in revenue when cow dung was applied at 8t/ha when compared to 4t/ha and 12t/ha may be due to some edaphic factors or environmental factors affecting the cow dung at the time of application although it is not statistically significant. The Zero application of fertilizer produced the lowest gross margin of ₦365/ha, showing that for each one Naira spent only seventy six kobo is return which does not break-even and it is not profitable to produce without application of organic and inorganic

fertilizers. This is expected because without application of organic manure the soil fertility will be low and the ginger plant will not grow and develop properly.

Table 6: Gross Margin analysis of ginger production under different rates of cow dung application

S/n	Value of output/cost of inputs (₦000/ha)	Cow dung rates 0 (t/ha)	4 (t/ha)	8 (t/ha)	12 (t/ha)
1.	**Value of rhizome yield (₦000)**	**834**	**1318**	**980**	**1396**
2.	Seed cost	385	385	385	385
3.	Land preparation	25.32	25.32	25.32	25.32
4.	Labour	38.18	55.88	39.58	60.38
5.	Cost of mulching and mulching material	15.00	15.00	15.00	15.00
6.	Cost of cow dung/application	0	25.00	45.00	65.00
7.	Sprays/application (herbicides, fungicides, pesticides)	15.23	15.23	15.23	15.23
8.	Total Variable Cost (TVC) (2-7)	478.73	519.43	513.13	523.93
9.	Gross Margin (GM) (1-8)	355.27	796.57	454.87	830.07
10.	Gross margin/Naira invested	0.74	1.53	0.87	1.58

The essence of treatment combination of inorganic and cow dung manure was to determine the interaction effect of combining the two factors for optimum productivity. Table 7, shows that treatment combination of cow dung at 8t/ha and NPK fertilizer at 200kg/ha gave the optimum gross margin of ₦989.54/ha. Even though gross margin at 8t/ha of cow dung applied as a single treatment was low, it was found out that at the rate of cow dung at 8t/ha in combination with 200kg/ha of NPK fertilizer gave the optimum performance in terms of gross margin. It also shows that for every one spent on production of ginger, sixty kobo was return as gross margin.

Table 7: Gross Margin analysis of ginger production under optimum combination rates of cow dung at 8 tonnes per hectare and NPK: 15:15:15 at 200 kg/ha

S/n	Value of output/cost of inputs (₦000/ha)	Treatment: Cow dung (8t/ha) x Fertilizer (200kg/ha)
1	Value of rhizome yield	1600
2.	Seed cost	385
3.	Land preparation	25.32
4.	Labour	89.16
5.	Cost of Mulching/mulching materials	15.00
6.	Cost of NPK: 15:15:15 and application	35.76
7.	Cost of cow dung/application	45
8.	Sprays/application (herbicides, fungicides, pesticides)	15.23
9.	Total Variable Cost (TVC)	610.47
10.	Gross Margin (GM) (1-9)	989.53
11.	Gross Margin/Naira invested	1.62

Conclusion

The incorporation of cow dung and NPK 15:15:15 fertilizer greatly enhanced number of tillers and leaves produced. There was significant positive interaction ($P< 0.05$) between the cow dung and fertilizer with the highest tiller mean number/plant and number of leaves/plant of 4.80 and 22.33 respectively obtained at treatment combination of 8t/ha and 200kg/ha. The maximum yield of ginger when cow dung was applied sole was 6.98t/ha at the rate of 12t/ha and the maximum yield when NPK 15:15:15 was applied sole was 5.64t/ha at the rate of 200kg/ha. The incorporation of NPK 15:15:15 and cow dung increases yield of ginger significantly. For optimum yield and profitability in ginger production the combination of cow dung and NPK 15:15:15 at the rate of 8t/ha and 200kg/ha respectively is recommended. The gross margin analysis also showed that applying cow dung sole at 12t/ha gave the maximum gross margin of

₦806.67/ha and NPK 15:15:15 applied without cow dung had the maximum gross margin of ₦619/ha at the rate of 200kg/ha. The optimum gross margin (₦989.53/ha) in ginger production was obtained from incorporation of 8t/ha of cow dung and NPK 15:15:15 at 200kg/ha. Based on gross margin analysis, the study recommends the incorporation of cow dung and NPK 15:15:15 at the rates of 8t/ha and 200kg/ha respectively to maximize production.

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