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Manuring Effects on the Performance of Maize (*Zea mays* L.) and Groundnut (*Arachis hypogaea* L.) in a Relay Intercropping in Akure, Ondo State, Nigeria

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Abstract: Maize and groundnut are crops that are produced under diverse cropping systems using different manuring methods to improve productivity. The effects of poultry manure and NPK fertilizer on the performance of maize and groundnut in a relay intercropping was investigated in Akure, South Western, Nigeria with geographical coordinates 70 30' 0" N, 50 14' 0" E. The 3 x 2 factorial experiment was arranged in a Randomized Complete Block Design (RCBD) with three replications. Factor A (NPK at 200kg/ ha, poultry manure at 5t/ha and no manure (control)) and factor B (Sole maize, sole groundnut and groundnut/maize intercropped at 3 weeks after groundnut establishment) were allocated with balloting method. Parameters of plant height, number of leaves, number of grains/cobs, weight of 100 grains and weight of 1000 grains were subjected to statistical analysis. Results showed that manures (poultry and NPK fertilizer) significantly increased both the growth and yield characters of maize and groundnut, though not significantly different at $p<0.05$ from each other but both were significantly higher at $p<0.05$ at all categories of measurements. Also, intercropping maize/groundnut at 3 WAP significantly influenced the growth and yield values of companion crops than sole maize or groundnut. Manure and intercropped systems interacted to increase groundnut/maize yield significantly than control and groundnut/maize, control and sole maize and control/sole groundnut yield. Maize/groundnut relayed at 3 WAP with application of 5t/ha of organic manure is therefore advocated in place of 200kg of fertilizer for farmers in the study area.

Keywords: Relay – Intercropping, Manure, Sole, Growth, Yield

1. Introduction

Maize (Zea mays L.) is one of the economically important crops among the cereals. It grows well in various agroecologies due to its ability to adapt to diverse environments, high yielding potential and ease of processing, readily digested and costs less than other cereals [1]. Large amounts of maize cultivated yearly are eaten by man as it serves as a vital source of proteins and calories to billions of people in developing countries, particularly in Africa, Mesoamerica and Asia [2]. Maize is a basis of many vitamins (especially vitamin B group) and essential minerals, in addition to fiber.

Groundnut (*Arachis hypogaea* L.) is a leguminous oil seed crop cultivated in the semi-arid and subtropical regions of the world. It serves as a cash crop for local and foreign trade owing to its diverse uses in many parts of the world [3]. Groundnut seeds contain 40-50% fat, 20-50% protein, and 10-20% carbohydrate depending on the variety and some essential minerals and vitamins [4]. It can be eaten raw, boiled, blanched, roasted or crushed and used as additives in local dishes. Its cake and haulms serve as livestock feed and nutrient supplement [5]. It's a source of protein, vitamins (E, K and B) and especially thiamine (B1) and niacin which are less available in cereals.

Despite the importance of these crops, many factors are

limiting their production which prevents farmers from getting maximum yield. Low soil fertility is the major factor militating against their production in Tropical Sub Sahara Africa [6]. Soil acidity leads to an increase in nitrogen (N), inadequate calcium (Ca) and phosphorus (P) thereby limiting the growth and rate of rhizobium infection on plant roots [7]. To circumvent the problem of inadequate soil nutrients, the application of manure is introduced.

Manure is an important Manures agricultural resource [8]. Manures consist of organic and inorganic compounds. Animal manures are considered to be of agricultural importance as they are constituents of micro and macronutrients. Increased crop production largely depends on the types of fertilizer applied to supplement essential nutrients required by plants. In addition, an increase in plant yield highly depends on the available nutrients in the soil which must be sufficient for plants to attain optimum growth [9].

However, only a small portion of the nutrient is released annually through biological activities or chemical processes. Therefore, fertilizers are designed to supplement the nutrients available for plants in the soil [10]. Moreover, both organic and inorganic fertilizers provide plants with the nutrients needed to grow healthy and strong; each contains different ingredients and makes available these nutrients in different ways. Manures work overtime to create a healthy environment, while inorganic fertilizers provide rapid nutrition. Determining which is better depends largely on the plant's needs and preferences in terms of cost and environmental impact. Manures are slow in releasing nutrients deprive crops of adequate nutrients due to immobility and are required in large quantities by crops [11]. However, inorganic sources pose a substantial residual effect on succeeding crops [12]. Furthermore, the indiscriminate use of inorganic fertilizers in modern agriculture has unanticipated environmental impacts [13], along with soil fertility degradation, depletion of soil organic matter, and reduction in water and nutrient holding capacities and nutrient use efficiency [14].

Relay cropping is a cropping system that allows the cultivation of many crops where one crop is seeded into an established crop field before harvesting [15]. This system enables the farmers to cultivate two crops in a growing season, especially in areas with inadequate land for farming [16]. However, intercropping is a multiple-cropping practice that involves the cultivation of two or more crops simultaneously on the same field [17]. Whereas, relay intercropping of multiple cropping in which a sequential crop is planted when the first crop has reached its reproductive stage [17]. Cereal-legume relay intercropping is capable of reducing risk, efficient use of resources by plants of different morphology (different heights, rooting depth etc.), nutrient requirement and thereby reducing cost of production [18].

Thus, this research was conducted to evaluate the actual effect of manure and inorganic fertilizer on maize and groundnut in a relay intercropping with the view of determining the effects of NPK and Poultry manure on the performance of maize and groundnut in a relay-intercropping system and identify the appropriate time of introducing maize into groundnut fields in relay intercropping.

2. Materials and Methods

2.1. Location of the Study Area

The field experiment was conducted at the Teaching and Research Farm of the Federal University of Technology, Akure (7^0 30' 0" N, 5^0 14' 0" E) in the southwest Nigeria. The soil at the site of the experiment was an alfisol derived from the basement complex rock and it was sandy loam. The average annual rainfall range was about 1,613 mm per annum and the annual mean temperature was 27^0C. The vegetation is tropical rain forest with an average relative humidity of between 56 and 59% during the dry season and 51 - 82% during the wet season.

2.2. Agronomy Practices

2.2.1. Land Preparation

Clearing of farm land was carried out using manual or cultural methods by slashing of grasses from the plot and cultivation of farm land was done using mechanical method.

2.2.2. Planting

In the relay-intercropped plots, maize seeds were sown after 3 weeks between the rows of groundnut spaced at 75 x 30 cm. Spacing for maize was 75 x 50 cm at two seeds per hill.

2.2.3. Weeding

Weeding of the farm plot was done manually at 4 and 8 WAP.

2.2.4. Application of NPK and Poultry Manure

Application of poultry manure was carried out 2 weeks before sowing while NPK was applied 2 weeks after planting.

2.3. Experimental Design

The experiment was a 3 x 3 factorial laid out in a randomized complete block design (RCBD) with 3 replications. There were two factors involved in the study. Factor A consisted of control (no amendment), N.P.K at 200 kg/ha and Poultry manure at 5t/ha. Factor B relay-intercropping system which consisted of groundnut and maize planted at 3 WAP groundnut, sole maize and sole groundnut.

2.4. Data Collection and Statistical Analysis

Data were collected on the basis of growth parameter using height, number of leaves (for maize and groundnut) and number of branches (for groundnuts). Yield data for maize were collected based on number of grains per cob, weight of 100 and 1000 grains; while, yield data of groundnut was collected on number of pods, seed/pod and weight of 100 grains. Data collected were subjected to

analysis of variance (ANOVA) using Minitab software version 19 and means were separated using Turkey's test at 5% probability.

3. Results and Discussion

Results displayed on table 1 indicated that maize height was significantly ($p<0.05$) increased by NPK and poultry manure treatments from the beginning of the experiment till the end. Comparing the effect of NPK and poultry manure treatments, there was no significant difference in their effect on maize height, although, this statistical insignificance was consistent all through the weeks of sampling, NPK treatments had taller plants compared to poultry manure treatments.

The results further indicated that relay-intercropping significantly ($p<0.05$) affected the height of maize plant in this study. At 3 WAP, GO/M3W maize were significantly ($p<0.05$) taller than maize on GO/M3W and sole maize (MO). GO/M3W came first with 129.71 cm while the lowest 109.13 cm was observed in sole maize (MO). This trend was also noticed at the termination of the experiment where maize height ranked GO/M3W >MO.

Table 1. *Main effect of manure and relay-intercropping on Maize height.*

Treatments	Weeks after planting		
	2	6	12
Manure			
Control	13.57b	119.50b	172.51b
NPK	32.389a	152.71a	240.71a
Poultry manure	31.60a	141.33a	224.53a
Relay-intercropping			
MO	24.51a	109.13b	169.68b
GO/M3W	24.59a	129.71a	214.87a

Means that do not share a letter are significantly ($p<0.05$) ($p<0.05$) different
GO/M3W- maize relayed 3 weeks of planting groundnut
MO- Sole Maize.

The interaction between manure and relay-intercropping on table 2 showed inconsistent significant effect on the height of maize plants in this study. No significant difference was observed till the 12 WAP, where GO/M3W had the highest value of this parameter under.

The results of this study demonstrated that NPK fertilizer and poultry manure didn't differ The results of this study demonstrated that NPK fertilizer and poultry manure didn't differ significantly ($p<0.05$) on their effects on plant height. This similar effect on plant height could be as a result of poultry manure being able to provide balanced nutrients to compete with NPK's ability to release nutrients faster. This was in agreement with the findings of Uwah *et al.* who reported similar occurrence in the plant height on poultry manure amendment compared to NPK [19].

Table 2. *Interaction effect of manure and relay-intercropping on Maize height.*

Manure	Relay-intercropping	Weeks after planting		
		2	6	12
Control	GO/M3W	12.35b	126.88b	174.49c
	MO	13.85b	96.89b	164.29c
NPK	GO/M3W	30.62a	129.62b	234.87b
	MO	30.04a	123.12b	178.75c
Poultry manure	GO/M3W	30.56a	132.62b	235.25b
	MO	29.88a	107.37b	166.00c

Means that do not share a letter are significantly ($p<0.05$) different.
GO/M3W- maize relayed after 3 weeks of planting groundnut
MO- Sole Maize

From the results, number of leaves (for both groundnut and maize plants), and number of branches in groundnut on plots treated with NPK and poultry manure were not statistically different but higher than the control. Plots treated with poultry manure producing higher values of these parameters in both crops, could be explained by the ability of organic amendment to provide necessary nutrients for plant growth over a longer period compared to NPK. Similar occurrence was reported by Tungos who observed higher leaf number and leaf area index in maize treated with organic amendments compared to inorganic amendments [20].

In cereal-legume intercropping systems, it is possible that the cereal accumulated nitrogen that was released by legume root and root nodule-system, resulting from efficient utilization of nutrients [21]. Therefore, the increase in growth parameters (height and number of leaves) observed in relay-intercropping system and GO-M3W compared to MO may be attributed to the entry of N from groundnut which is taken up by the maize plant. This was corroborated by Mattuso *et al.* who explained grains intercropped with legumes especially groundnuts would be able to utilize N from synthesized by

the legumes [22].

Height, number of leaves and number of branches of groundnuts intercropped with maize were higher than in sole groundnut. This increase in growth parameters correlated with findings of Addo – Quaye *et al*, who reported increased growth in legumes sowed weeks before planting maize. They explained further, that legume sowed 28 days before maize had higher growth indices compared to sole soyabean [23].

Table 3. *Main effect of manure and relay-intercropping on number of leaves of maize.*

Treatments	Weeks after planting		
	2	6	12
Manure			
Control	7.01a	10.89b	12.67b
NPK	7.03a	12.67a	14.43a
Poultry manure	7.13a	12.38a	14.03a
Relay-intercropping			
GO/M3W	7.33b	12.29a	13.78ab
MO	5.23c	10.74b	13.01b

Means that do not share a letter are significantly ($p<0.05$) different.
GO/M3W- maize relayed 3 weeks of planting groundnut
MO- Sole Maize

Table 4. *Interaction effect of manure and relay-intercropping on number of leaves of maize.*

Manure	Relay-intercropping	Weeks after planting		
		2	6	12
Control	GO/M3W	5.375b	11.00cd	12.89cd
	MO	5.25b	10.33d	12.11d
NPK	GO/M3W	7.38ab	13.13ab	14.125bc
	MO	5.083b	11.00cd	13.5bc
Poultry manure	GO/M3W	7.88ab	12.75abc	14.33b
	MO	7.89ab	10.88cd	13.42bcd

Means that do not share a letter are significantly ($p<0.05$) different.
GO/M3W- maize relayed 3 weeks of planting groundnut
MO- Sole Maize.

Table 5. *Main effect of manure and relay-intercropping on height of groundnut.*

Treatments	Weeks after planting		
	2	6	12
Manure			
Control	11.31c	41.32b	50.51b
NPK	16.96a	51.57a	61.10a
Poultry manure	15.15b	49.42a	57.93a
Relay-intercropping			
GO-M3	14.29ab	47.66ab	56.67a
GO	14.02b	45.62b	55.96a

Means that do not share a letter are significantly ($p<0.05$) ($p<0.05$) differ.
GO-M3- Groundnut planted 3 weeks before Maize
GO- Sole groundnut

Table 6. *Interaction of manure and relay-intercropping on height of groundnut.*

Manure	Relay-intercropping	Weeks after planting		
		2	6	12
Control	GO	10.44e	40.44c	49.64a
	GO-M3	11.69e	41.69c	50.89a
NPK	GO	13.81cd	50.17ab	56.37a
	GO-M3	16.69ab	51.00ab	64.67a
Poultry manure	GO	14.94bc	44.5bc	61.88a
	GO-M3	16.25ab	51.92ab	55.17a

Means that do not share a letter are significantly ($p<0.05$) ($p<0.05$) different.
GO-M3- Groundnut planted 3 weeks before Maize
GO- Sole groundnut

Table 7. *Main effect of manure and relay-intercropping on number of groundnut leaves.*

Treatments	Weeks after planting		
	2	6	12
Manure			
Control	9.25c	18.54a	20.89b
Fertilizer	11.50b	19.29a	22.42ab
Poultry manure	11.92a	20.25a	24.60a
Relay-intercropping			
GO-M6	11.67a	20.58a	24.68a
GO-M3	10.75b	19.38ab	22.00a
GO	10.25c	18.13b	21.22b

Means that do not share a letter are significantly ($p<0.05$) ($p<0.05$) different.
GO-M3- Groundnut planted 3 weeks before Maize
GO- Sole groundnut

Table 8. *Interaction effect of manure and relay-intercropping on number of groundnut leaves.*

Manure	Relay-intercropping	Weeks after planting		
		2	6	12
Control	GO	8.75e	16.88b	19.50a
	GO-M3	9.00e	18.00ab	20.25a
NPK	GO	11.00c	19.00ab	21.25a
	GO-M3	12.00ab	19.50ab	23.92a
Poultry manure	GO	10.75cd	19.50ab	21.50a
	GO-M3	11.50bc	19.75ab	23.25a

Means that do not share a letter are significantly ($p<0.05$) ($p<0.05$) different
GO-M3- Groundnut planted 3 weeks before Maize
GO- Sole groundnut.

Table 9. *Main effect of manure and relay-intercropping on Maize yield.*

Treatments	Grains/Cob	Weight of 100 grains (g)	Weight of 1000 grains (g)
Manure			
Control	429.92b	19.62b	192.35b
NPK	535.36a	31.58a	315.65a
Poultry Manure	529.85a	30.31a	305.85a
Relay intercropping			
GO/M3W	512.35a	28.02b	281.27a
MO	457.17b	24.51c	247.76b

Means that do not share a letter are significantly ($p<0.05$) ($p<0.05$) different.
GO/M3W- maize relayed 3 weeks of planting groundnut
MO- Sole Maize

Table 10. *Interaction effect of manuring and relay – intercropping on maize yield parameters.*

Manure	Relay intercropping	Grains per cob	Weight of 100 grains (g)	Weight of 1000 grains (g)
Control	G0/M3W	459.56e	20.30d	204.29c
	MO	365.61f	17.10e	169.54c
NPK	G0/M3W	541.17ab	32.26a	319.94a
	MO	506.11bc	29.64b	298.52ab
Poultry manure	G0/M3W	536.33ab	31.51ab	319.6a
	MO	499.78cd	26.78c	275.22b

Means that do not share a letter are significantly ($p<0.05$) ($p<0.05$) different.
GO/M3W- maize relayed 3 weeks of planting groundnut,
MO- Sole maize

Yield is the end results of many complex morphological and physiological processes occurring during the growth and development of crop [24]. In general, similar performances were observed between NPK and poultry manure on yield of maize and groundnut. This could be attributed to increase in organic carbon, nitrogen and essential nutrients due to addition of NPK and poultry manure to the soil. The results of this experiment is in conformity with the findings of] Shuaibu *et al*. who reported that yield kg/ha, weight of 1000 grains of sorghum was significantly ($p<0.05$) affected by poultry manure and NPK added to the soil [25].

Time of introduction in a relay-intercropping system involving legume-cereal combination has been proven to have effect on yield of components crop [22]. The increased grains per cob, weight of 100 and 1000 g grains of GO-M3W than in MO may be attributed to the availability of nutrients resulting

from N fixed and decomposition of harvested groundnut residue. According to [22] Mattuso *et al* soil may be replenished with N through decomposition of legume residues as legumes species commonly used for provision of grain and green manure have potential to fix between 100 and 300 kg-N/ha from the atmosphere. Abdel Aziz *et al* reported a similar increase in grains/ear, weight of 100 grains of maize planted 14 days and 28 days after a legume than sole maize [26].

Parameters considered for yield in groundnut (pods/plant, weight of 100 seeds and seeds/plant) were observed to be higher in GO-M3W than GO. This increase may be attributed to reduced competition in GO-M3W as a result of the time which maize was sowed after groundnut. This result was corroborated by Addo-Quaye *et al*. who reported that planting legumes earlier before cereal is sowed gave significantly ($p<0.05$) higher yield than planting legumes at the same time or after the cereal and when sowed alone [23].

The interaction between manure and relay-intercropping system improved the performance of both maize and groundnut. This improvement in both crops could be attributed to the availability of nutrient provided by the amendments and the lesser competition between both crops as due to the differences in the time they were sowed. According to Muoneke *et al*. reduced performance of legumes and increased performance of cereal in a relay-intercropping system was attributed to inter specific competition and depressive effect of cereals C4 species on legumes, a C3 crop [18]. Abdel Aziz *et al* further showed that performance of both grains and legumes were improved in plots where maize was planted 21 days before soyabean [26]. This result correlated with findings of Alejandro *et al.* who reported manuring improved performance of both maize and groundnut in an intercropping system [27] while Adeola *et al.* reported improved performance of pepper and cassava under NPK and poultry manure in a cassava-pepper relay-intercropping system [28].

Table 11. *Main effect of manure and relay-intercropping on groundnut yield.*

Manure	Relay intercropping	Weight of 100 seeds	Seeds/plant	No of pods
Control	GO/M3	14.94a	25.00cd	16.33c
	GO	13.41a	22.00d	11.67c
NPK	GO/M3	26.80a	54.00ab	24.00abc
	GO	18.11a	40.33bcd	25.00abc
Poultry manure	GO/M3	25.03a	48.67abc	33.00ab
	GO	15.45a	34.33bcd	20.00bc

Means that do not share a letter in a column are significantly ($p<0.05$) different.
GO-M3- Groundnut planted 3 weeks before maize
GO-Sole groundnut.

4. Conclusion

The application of poultry manure at t/ha was able to boost production of groundnut and maize as sole crops and in a relay-intercropping system. Furthermore, Maize performed better when it was relayed into groundnut at 3 weeks and sole maize respectively. Groundnut's performance was also improved when maize was relayed at 3 weeks after sowing. Poultry manure at t/ha can sufficiently improve maize and groundnut production especially in a relay-intercropping system. If maize is to be sowed after legumes in a relay-intercropping system, I strongly recommend it is sown 3 weeks after groundnut must have been established. I also recommend further investigation into the effect of other organic manures on the relationship between legumes and cereals when sowed in a relay-intercropping system.

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