Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.8, No.4, 2018 www.iiste.org

Productivity of Maize/ Bambara Groundnut Intercrop with Poultry Manure Rates.

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Abstract
A field experiment was conducted in 2016 and 2017 cropping seasons at the Teaching and Research Farm of the Federal University of Technology, Owerri, Imo State, Nigeria. The main objective was to determine the productivity of maize/bambara groundnut intercrop with poultry manure in Owerri ultisol. The experiment consists of two (2) factors; poultry manure with 4 levels (0, 4, 8 and 12t/ha) and cropping system; sole cropping system and intercropping system (sole maize, sole Bambara and maize/bambara groundnut intercrop). This was a 4×3 factorial experiment fitted in a randomized complete block design with three (3) replications. Data on the pre and post-soil physicochemical properties, vegetative growth and yield parameters of the component crops were investigated and statistically analyzed. The results indicate that 12t ha^{-1} poultry manure application gave the highest growth and grain yield in maize while 4t ha^{-1} gave the highest grain yield in bambara groundnut as excessive manure led to delayed maturity and lush vegetative growth at the expense of pod production. Productivity indices as indicated by LER shows that maize/bambara groundnut intercropping was productive i.e has yield advantage over sole cropping. The soil pH status was significantly increased with poultry manure application after the experiment in 2016 and 2017 indicating the liming ability of poultry manure. Other soil physicochemical properties were improved with poultry manure and intercropping system. Maize/bambara groundnut intercropping system with 12t ha^{-1} poultry manure rate for maize as main crop and 4t/ha poultry manure rate for bambara groundnut as the inter crop are therefore recommended for adoption by farmers for efficient production and sustainable land use in Owerri ultisol South eastern Nigeria.
Keywords: maize, Bambara groundnut, poultry manure, intercrop, ultisol, productivity.

Introduction

Maize (*Zea mays* L.), a cereal crop of the family Poaceae (gramineae) is one of the most important crops in sub-Sahara Africa. The grains are rich in carbohydrate, dietary fiber and calories and used as food and energy source. It is grown widely throughout the world in a large range of agro-ecological environments. Guinea savannah ecological zone is known to have the greatest potential for maize production in Nigeria because of its location on the fertile basin of river Niger and Benue.

In Nigeria, maize is an important food, fodder and industrial crop grown both commercially and at subsistence level (Ibeawuch *et al*., 2007). The wide range of adaptability and efficiency of production coupled with the ease with which maize can be stored makes it a dependable source of food to man.

Bambara groundnut (*Vigna subterranean* (L.) verdc.) is a legume of the Fabaceae family. It is an indigenous African legume and in Nigeria, bambara is eaten by the people. It is the third most eaten legume after groundnut (*Arachis hypogea*) and cowpea (*Vigna unguiculata*). It is an important source of protein in the diets of a large percentage of the population, particularly the resource poor rural people, who cannot afford expensive animal protein (Bamishaiye *et al*., 2012). According to Brough and Azamali, (1992), it makes a complete balanced food. The fresh pod can be eaten as vegetable snack while the dry seeds are either roasted and eaten as snack in a manner similar to peanut (Bamishaiye *et al*., 2012). The form in which bambara groundnut is commonly consumed is “okpa” (bambara groundnut paste) (Enwere, 1998).

Okpa is a local delicacy and is well a cherished food in Eastern Nigeria. Although it is not greatly utilized, it is one of the indigenous African crops currently receiving attention from researchers across Nigerian Agricultural research centers.

Over the years, efforts have been made to increase food production in Nigeria using the available land in order to meet the food demand of the ever-increasing population. The depletion of the soil nutrients due to continuous cropping, reduces the soil organic matter and leads to significant acidification and reduction of yield. This is coupled with the fact that the soils of Owerri Southeastern Nigeria are ultisols formed from coastal plain sands and are low in mineral reserve and in fertility (Eshiett 1993). Presently, the increasing population pressure in Nigeria is evident and our old farming system of shifting cultivation is no longer sustainable because the length of period the bush fallow are left for maintaining the productivity of the soil is becoming shorter. Today, farmers use inorganic fertilizer to improve crop yield and this has some negative implications on the soil biological life and soil nature. Thus, the continuous use of mineral fertilizer by poor farmers has created serious environmental problems and hence suppressed the expected benefit of high yield, and thus resulting in soil acidity and loss of soil organic matter.

To save our soil and mankind from impending degradation and famine, the improvement in cropping system and compatibility for maximum productivity, the use of organic application to the soil such as poultry manure is inevitable. According to Ewulo (2005), poultry manure contains high percentage of nitrogen and phosphorus for healthy growth of plants. Also, some literatures have it that poultry manure has the ability to reduce soil ability to near neutrality at 15-20 tons $^{ha-1}$. It is in the light of the foregoing that this study was carried out to determine the productivity of maize/bambara groundnut intercrop with organic manure amendment.

Materials and Methods

Site Location: The experiment was conducted during 2016 and 2017 cropping seasons at the teaching and research farm of the Federal University of Technology, Owerri, Imo State, Nigeria. The site lies between latitude 5º27 N and longitude 7º2′E and 55.7m above sea level in the tropical rain forest region of South Eastern Nigeria, with an average rainfall of 2,500mm and temperature range of 25ºC to 32ºC. The land was fallow for $2^1/_2$ years and was covered by small shrubs, legumes and grasses.

Cultural Practices: Land clearing and mapping: The land was cleared manually using local tools like cutlass, hoe and rake and the cut shrubs, legumes and grasses packed. The experimental units were measured and mapped out using measuring tape, line and peg.

Tillage: The required poultry manure rate were broadcasted uniformly on each plot and incorporated into the soil during tillage operation. Tilling was done using hoe and spade. The soil was allowed to stabilize for one week after application of poultry manure before planting.

Weeding: Weeding was carried out three times with hand hoe.

Planting Materials and Planting: An improved variety of maize (Oba super 6) was sourced from Imo State ADP while bambara groundnut was purchased from Ogbaete market in Enugu town. The maize was planted with a spacing of 50×30cm in sole cropping and 100×100cm in intercrop. Bambara spacing was 50×20cm in sole and 100×50cm in intercrop. Intercrop was planted 1 row of maize between rows of bambara.

Experimental Materials, Layout and Design: The field was laid out as a 4×3 factorial experiment fitted into a randomized complete block design (RCBD) and replicated 3 times. Each block contains 12 treatments which gave a total of 36 experimental units.

Treatments: Factor A: four (4) levels of poultry manure (0, 4, 8, 12ton/ha), Poultry manure rate (P), P1= 0tons ha^{-1} manure (control)**,** P2= 4tons ha^{-1}**,** P3= 8tons ha^{-1}**,** P4= 12tons ha^{-1}

Factor B: cropping system, Sole maize = M, Sole bambara groundnut = B, Maize + Bambara groundnut = MB

Treatment combinations:

Sole maize (M) + Poultry manure rate (P) = MP1, MP2, MP3, MP4

Sole bambara nut (B) + Poultry manure rates (P) = BP1, BP2, BP3, BP4

Maize + bambara nut (MB) + Poultry manure rate (P) = MBP1, MBP2, MBP3, MBP

Data Collection Pre-planting and post planting soil physico-chemical properties were determined. A random augur soil sampling taken from the top soil (0-20cm) were collected and the soil physico-chemical properties determined before and after harvest of crop on basis of the experimental plots.

Maize Data

The following parameters were measured from four randomly selected samples in each plot and the mean taken.

Height of plant (cm) at 2, 4, 6, 8 WAP: This was measured from the soil surface to the tip of the plant.

Number of leaves per plant at 2, 4, 6, 8 WAP

Leaf area at 2, 4, 6, 8, WAP**:** The leaf area was measured with tape (in cm) using non-destructive analysis method – length × breath by correction factor of 0.75 according to Enujeke (2013).

Maize girth at 2, 4, 6, 8 WAP, Days for 50% tasselling, Number of cobs/plant

Cob length, Mass of fresh and dry cob, 100-dry seed weight, Grain yield.

Bambara groundnut data Plant height at 2, 4, 6, and 8 WAP

Number of leaves/plant at 2, 4, 6 and 8 WAP. As a trifoliate it is considered as one leaf. Days to 50% flowering, Mass of fresh and dry biomass at harvest, pod number per plant, dry mass of seed/plant, dry mass of shell per plant, 100-dry seed weight and drain yield

Statistical Data Analysis: The data collected were subjected to analysis of variance (ANOVA) using GenStat and the difference among treatment means were separated by Least Significant Difference at 0.05 level of probability.

Results and Discussion: Results Table 1, showed the soil chemical and physical properties before and after the experiment. The pre-soil physicochemical analysis indicated that the soil was a sandy loam soil with pH of 4.92 which shows that the soil was strongly acidic thus low in fertility as reflected by low organic carbon (1.21%), total nitrogen (0.14%), phosphorus (18.21ppm), and potassium (0.12cmol/kg). This agreed with the finding of Eshiett (1993) that soils of the humid tropics are comprised of strongly leached soil, (ultisols) characterized by low inherent nutrient statues.

However, the post soil analysis showed an increase in soil pH, % organic carbon, total nitrogen, available phosphorus and potassium (Table 1) in all the treatments that received poultry manure with highest value obtained from 12t/ha poultry manure application. However, 4t ha^{-1} poultry manure gave highest nitrogen level in sole bambara and in intercrop. This could be attributed to the nitrogen fixation ability of the bambara groundnut, a legume crop. This shows why even the traditional resource poor farmers include legumes in their cropping systems because of its enormous benefits to soil fertility revitalization and sustenance.

Table 1. Soil physical and chemical properties before and after planting

Poultry manure (tons/ha)	pH (H_2O)	Org. C %	Total N %	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	Avail. P (ppm)	Al+H	Sand %	Silt %	Clay %	Soil texture
Pre-planting	4.92	1.21	0.14	1.42	0.39	0.05	0.12	18.21	1.61	84.26	4.78	6.24	Sandy loam
After planting													
Sole maize													
0.0	4.92	1.22	0.14	1.42	0.39	0.05	0.12	18.20	1.61	84.26	4.78	6.24	Sandy loam
4.0	4.94	1.51	1.45	3.49	5.58	0.06	0.74	23.03	1.64	84.12	7.70	5.83	Sandy loam
8.0	5.21	1.78	1.74	4.24	5.80	0.07	0.13	24.51	1.76	83.97	8.21	4.02	Sandy loam
12.0	6.71	2.59	1.86	6.99	5.87	0.07	0.14	26.74	2.01	83.84	11.32	3.79	Sandy loam
Sole bambara													
0.0	4.93	1.23	0.16	1.43	0.40	0.06	0.12	18.22	1.61	84.27	4.78	6.25	Sandy loam
4.0	5.10	1.63	3.68	3.62	5.61	0.07	0.76	26.51	1.65	84.00	7.62	6.01	Sandy loam
8.0	5.62	1.81	3.01	4.70	5.63	0.07	0.16	26.63	1.87	83.61	7.98	5.78	Sandy loam
12.0	6.87	3.01	2.42	5.31	5.66	0.08	0.15	27.13	2.11	82.10	10.03	4.12	Sandy loam
Intercrop													
0.0	4.92	1.23	0.15	1.42	0.39	0.05	0.12	18.22	1.60	84.28	4.77	6.23	Sandy loam
4.0	5.54	1.61	3.03	5.01	5.50	0.06	0.61	25.11	1.77	84.01	7.87	5.59	Sandy loam
8.0	5.75	1.79	2.31	6.12	5.76	0.07	0.14	26.19	1.91	83.54	9.31	4.22	Sandy loam
12.0	6.61	2.56	2.67	6.33	5.81	0.07	0.14	26.72	2.00	82.13	10.91	3.63	Sandy loam

The results on Table 2 showed the effect of cropping system and poultry manure on the leaf number of maize at 2, 4, 6 and 8WAP. Cropping system only produced significant effect (p=0.05) at 6WAP and sole cropping had the highest mean number of leaf 11.25 and the intercrop had the least leaf number of 10.50. At 4, 6 and 8WAP, there were significant effect (p=0.05) of poultry manure on the leaf number of maize. Maize grown with 12t ha^{-1} poultry manure produced highest leaf number at 8WAP with mean value of 14.08 followed by 8t ha^{-1}, 4t ha^{-1}, and 0t ha^{-1} with mean values of 12.68, 12.10, and 10.08 respectively. Infact, the higher the poultry manure quantity, the higher the number of leaves. Poultry manure which releases nutrients slowly to plant, has the necessary nutrients needed by Maize as it helped to improve Maize growth and development through fast Maize leaf increase.

Table 2. Effects of cropping systems and poultry manure on the leaf number of maize

	Cropping systems											
	Weeks after planting											
	……2……			……4……			……6……			……8……		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	5.417	4.833	5.125	6.67	6.33	6.50	9.00	8.33	8.67	10.42	9.75	10.08
4.00	5.167	4.833	5.000	7.50	7.00	7.25	11.00	9.67	10.33	12.33	11.86	12.10
8.00	5.090	5.333	5.212	7.42	7.83	7.62	11.33	11.00	11.17	12.54	12.81	12.68
12.00	5.417	5.750	5.583	8.00	8.08	8.04	13.67	13.00	13.33	13.58	14.58	14.08
Mean	5.272	5.188		7.40	7.31		11.25	10.50		12.22	12.25	
$LSD_{0.05}$ (cropping syst.)			Ns			Ns			0.679			Ns
$LSD_{0.05}$ (poultry manure)			Ns			0.677			0.960			1.362
$LSD_{0.05}$ (cropping syst. X poultry manure)			ns			ns			ns			Ns

Results Table 3, showed the effect of cropping system and poultry manure on the plant height of maize at 2, 4, 6 and 8WAP. Results indicate that at 2, 4, 6 and 8WAP, poultry manure had a significant effect (p=0.05) on the mean plant height. Maize manured with 12t ha^{-1} poultry manure produced the tallest maize plants at 8WAP with a mean of 99.0cm which differed significantly (p=0.05) from the height of maize treated with 8t ha^{-1}. Maize grown with 0t ha^{-1} (control) produced significantly (p=0.05) shorter maize plants at 2, 4, 6 and 8WAP (12.03, 32.46, 56.5, 76.5cm) respectively

Table 3. Effect of cropping systems and poultry manure on the plant height of maize

	Cropping systems											
	Weeks after planting											
	……2……			……4……			……6……			……8……		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	12.25	11.81	12.03	32.58	32.33	32.46	55.00	57.90	56.5	76.3	76.6	76.5
4.00	17.33	18.58	15.46	37.92	34.67	36.29	72.6	61.70	67.1	98.6	91.1	94.9
8.00	15.00	16.08	15.54	36.75	36.83	36.79	80.10	80.30	80.2	98.2	102.1	95.1
12.00	18.75	16.92	17.83	42.17	45.58	43.88	99.80	87.90	93.8	121.3	119.7	99.0
Mean	15.83	14.60		37.35	37.35		76.90	72.0		98.6	97.4	
$LSD_{0.05}$ (cropping syst.)			Ns			Ns			Ns			Ns
$LSD_{0.05}$ (poultry manure)			3.216			4.860			8.84			35.25
$LSD_{0.05}$ (cropping syst. X poultry manure)			ns			ns			ns			Ns

The results on Table 4, showed the effect of cropping systems and poultry manure on the mean leaf area of maize at 2, 4, 6 and 8WAP. The results showed that Maize in the sole cropping system produced higher leaf area ($21.84cm^2$) than those in the intercrop ($17.48cm^2$) which differed significantly (P=0.05) at 2WAP. However, at 4,6 and 8WAP, maize in the intercropping system produced largest leaf area than the sole cropping system with the mean value of $240.8cm^2$ in intercrop at 8WAP which differed significantly (p=0.05) from sole crop ($226.2cm^2$), indicating that the wider spacing 100x100cm used in intercropping system allowed more air, sunlight, water and nutrient uptake by the Maize plants. Poultry manure had significant effect at 2 and 6WAP. Maize grown with 12t ha^{-1} poultry manure had the largest leaf area ($238.5cm^2$) which differed significantly from the leaf area of maize treated with 8t ha^{-1} which had a mean leaf area value of $206.9cm^2$, $151.8cm^2$ (4t ha^{-1}), and $118.5cm^2$ (0t ha^{-1}) respectively. Intercropping system at all times produce good effect due to complementary use of resources by the intercrops and it also helped to protect the soil from erosion and improved the soil nutrient availability, macro and micro soil organisms and in nutrient recycle.

Table 4. Effect of cropping systems and poultry manure on the leaf area of maize

	Cropping systems											
	Weeks after planting											
	……2……			……4……			……6……			……8……		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	18.50	11.25	14.89	124.4	113.1	118.8	118.2	118.7	118.5	188.8	200.7	194.8
4.00	22.37	16.63	19.50	163.7	138.6	151.1	122.5	181.0	151.8	239.6	240.4	240.0
8.00	21.87	18.16	20.02	153.8	165.8	159.8	189.7	224.1	206.9	223.2	233.0	228.1
12.00	24.61	23.85	24.23	185.4	215.5	200.5	229.6	247.5	238.5	253.1	289.1	271.1
Mean	21.84	17.48		156.8	158.2		165.0	192.8		226.2	240.8	
$LSD_{0.05}$ (cropping syst.)			3.669			36.89			11.43			30.63
$LSD_{0.05}$ (poultry manure)			5.189			Ns			16.16			Ns
$LSD_{0.05}$ (cropping syst. X poultry manure)			ns			ns			22.85			Ns

Results on the effects of cropping system and poultry manure application on maize stem girth at (Table 5) showed that cropping system produced a significant larger stem girth of maize at 4, 6, and 8WAP. Whereas, at 4WAP, maize in the intercropping system had the largest stem girth (3.602cm) which differed significantly (p=0.05) from the maize in sole cropping (3.517cm). Maize in sole cropping system produced the highest stem girth at 6 and 8WAP (4.022cm and 5.278cm) which differed significantly (p=0.05) from the intercropped maize at 6 and 8WAP (3.905cm and 5.010cm). The highest mean stem girth was recorded at 8WAP by the maize treated with 8t ha^{-1} (5.655cm) and at 12t ha^{-1} (5.17cm) which differed significantly (p=0.05) from the maize treated with 4 and 0t ha^{-1} with mean value of 5.655cm, 4.945cm and 4.337cm respectively. From the results on Table 3, it could be noted that poultry manure which gradually releases its nutrient must have reached its peak of release at 8WAP, and the nutrient uptakes helped in cell elongation and expansion of the Maize stem.

Table 5. Effect of cropping systems and poultry manure on the stem girth of maize

	Cropping systems											
	Weeks after planting											
	……2……			……4……			……6……			……8……		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	1.620	1.630	1.625	2.97	2.77	2.870	3.330	3.410	3.370	4.443	4.230	4.337
4.00	1.920	1.950	1.935	3.12	3.50	3.310	4.310	3.990	4.150	5.100	4.790	4.945
8.00	2.600	2.410	2.505	4.12	4.01	4.065	4.470	4.220	4.345	6.240	5.070	5.655
12.00	3.230	3.110	3.170	3.86	4.13	3.995	3.980	4.000	3.990	5.330	5.010	5.170
Mean	2.342	2.275		3.517	3.602		4.022	3.905		5.278	4.775	
$LSD_{0.05}$ (cropping syst.)			Ns			0.0497			0.1114			0.1792
$LSD_{0.05}$ (poultry manure)			0.3179			0.0703			0.1576			0.2535
$LSD_{0.05}$ (cropping syst. X poultry manure)			Ns			0.0994			0.2229			0.3585

Results Table 6, indicate the number of days to 50% tasselling, length of cob, number of cob plant^{-1} of maize, and it showed that cropping system did influence tasselling with application of poultry manure at 12t ha^{-1} and that intercropping had 65.33 days to tasselling in maize crops. However, the poultry manure by intercropping delayed tasselling as 4t ha^{-1} and 8 t ha^{-1} took maize crops 60.33days each to tassell. The results also showed that in sole cropping and control experiments, maize crops tassel earlier than those of intercrop where 4t ha^{-1} and 8t ha^{-1} poultry manure were applied (Table 6). In the first part, the application of 12t ha^{-1} manure helped the crops grow fast because of nutrient uptake, early maturity and thus tasselling early. On the either hand, taselling was delayed as a result of competition for natural resources such as nutrients, water and air. Cropping system had significant effect on the length of cob in sole crop maize hence producing longest cob 10.897cm as against inter cropping system and manure with 10.165cm.

In intercropping, maize grown with 12t ha^{-1} poultry maize produced long cob length of 12.620cm which differed significantly from that of 8t ha$^{-1,}$ 4t ha^{-1} and the control (0t ha^{-1}) which had mean values of 11.320cm, 9.860cm and 8.325cm respectively indicating that manuring can influence production of crops through elongation of the crops at the developmental stage and number of cobs per plant. Poultry manure also had significant effect on number of cobs with mean values of 2.545, 2.200, 1.665, 1.250 produced by 12t ha^{-1}, 8t ha^{-1}, 4t ha^{-1} and 0t ha^{-1} respectively.

Table 6. Effect of cropping systems and poultry manure on the number of days to 50% tasselling, length of cob, number of cob/plant of maize

	Cropping system								
	Days to 50% tasselling			Length of cob (cm)			Number of cob/plant		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	58.33	58.33	59.83	8.66	7.99	8.325	1.25	1.25	1.250
4.00	58.67	60.33	59.50	9.98	9.74	9.860	1.83	1.50	1.665
8.00	58.67	60.33	59.50	11.94	10.70	11.320	2.40	2.00	2.200
12.00	59.00	56.33	57.67	13.01	12.23	12.620	2.66	2.43	2.545
Mean	59.17	59.38		10.897	10.165		2.035	1.795	
$LSD_{0.05}$ (cropping syst.)			Ns			0.1812			Ns
$LSD_{0.05}$ (poultry manure)			1.920			0.2563			0.2262
$LSD_{0.05}$ (cropping syst. X poultry manure)			2.716			0.3624			ns

From the results Table 7, cropping system had no significant effect on the fresh and dry grain weight of maize. Maize treated with 12t ha^{-1} of manure produced the highest fresh grain weight (236.54g) which differed significantly from the ones manured with 8t ha^{-1}, 4t ha^{-1}, and control (0t $ha^{-1)}$ with mean values of 229.19g, 217.16g, and 208.93g respectively. Furthermore, cropping system had significant effect on the dry grain weight and the sole crop produced the highest grain weight of 81.16g which differed significantly (p=0.05) from that of the intercrop (72.60g). Increasing rate of poultry manure helped in increased dry grain weight, application as 12t ha^{-1} poultry manure produced highest grain weight of 96.28g (p=0.05) followed by 8t ha^{-1}, 4t ha^{-1} and 0t ha^{-1} with mean value of 84.42g, 68.11g and control (0t ha^{-1}) respectively (Jaja and Ibeawuch, 2015). Results of the 100 seed weight had no significant effect in response to cropping system, poultry manure and the interaction between them. Sole cropping produced the highest grain yield 1.69t ha^{-1} which differed significantly from the intercropped maize with 1.36t ha^{-1} grain yield. Poultry manure had no significant effect but increased grain yield when applied at 12t ha^{-1} producing highest mean grain yield 2.04t ha^{-1} (Table 7) more than the control (0t ha^{-1}) with 0.77t ha^{-1}.

Table 7. Effect of cropping systems and poultry manure on the Fresh and dry grain weight with cob, 100 seed weight and Grain yield of maize

	Cropping systems											
	Fresh grain weight with cob (g)			Dry grain weight with cob (g)			100 seed weight (g)			Grain yield (tons/ha)		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	210.75	207.11	208.93	61.66	55.78	58.72	12.54	10.92	11.74	0.83	0.71	0.77
4.00	219.50	214.82	217.16	74.00	62.21	68.11	13.21	13.12	13.17	1.37	0.98	1.18
8.00	227.22	231.17	229.19	87.74	81.09	84.42	14.16	13.47	13.82	2.14	1.84	1.99
12.00	239.00	234.09	236.54	101.23	91.33	96.28	14.93	13.71	14.32	2.17	1.91	2.04
Mean	224.12	221.80		81.16	72.60		13.71	12.75		1.69	1.36	
$LSD_{0.05}$ (cropping syst.)			Ns			2.432			Ns			1.803
$LSD_{0.05}$ (poultry manure)			2.165			3.439			Ns			Ns
$LSD_{0.05}$ (cropping syst. X poultry manure)			3.062			Ns			Ns			Ns

The results on Table 8, showed that leaf number of bambara groundnut had significant difference (p=0.05) in response to cropping system at 2 and 6WAP. However, sole bambara had the highest mean leaf number at 2 and 6WAP (7.958cm^2 and 118.62). However, at 8WAP, the mean leaf number increased in sole cropping system (129.0) and 117.5 in intercropping system but was not significantly different. Leaf production is an inherent factor in crops and could only be improved by manure application like in this experiment.

Table 8. Effect of cropping systems and poultry manure on the leaf number of bambara groundnut

	Cropping systems											
	Weeks after planting											
	……2……			……4……			……6……			……8……		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	7.833	6.833	7.333	29.97	25.83	27.70	114.42	88.00	101.21	114.9	111.9	113.4
4.00	7.917	7.417	7.667	33.33	26.50	29.92	115.25	97.17	106.21	123.3	108.2	105.7
8.00	8.000	8.250	8.125	30.08	30.17	30.12	122.33	100.75	111.54	130.0	128.2	129.1
12.00	8.083	7.833	7.958	33.25	32.75	33.00	122.50	106.67	114.58	147.8	141.6	144.7
Mean	7.958	7.583		31.66	28.81		118.62	98.15		129.0	117.5	
$LSD_{0.05}$ (cropping syst.)			0.3506			Ns			3.714			Ns
$LSD_{0.05}$ (poultry manure)			0.4958			Ns			5.252			Ns
$LSD_{0.05}$ (cropping syst. X poultry manure)			ns			Ns			ns			Ns

The results on Table 9 indicate that cropping system and poultry manure had no significant effect on the plant height of bambara groundnut though sole cropping produced taller plants (25.25cm) than the intercrop plants (21.77cm) and 8t ha^{-1} poultry manure gave the highest plant height (25.08cm) followed by 12 ha^{-1}, 4t ha^{-1} and the control (0t ha^{-1}). This means that the issue of height is inherent within the bambara groundnut and cannot be influenced by either cropping system or manure application at any rate.

Table 9. Effect of cropping systems and poultry manure on the plant height of bambara groundnut

	Cropping systems											
	Weeks after planting											
	……………………2…………………			……………………4……………………			……………………6…………………..			…………………8…………………		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	12.56	11.52	12.04	18.50	17.83	18.17	20.17	17.83	19.00	21.67	21.83	21.75
4.00	11.92	10.75	11.33	18.92	17.50	18.21	20.42	17.50	18.96	23.75	22.83	23.29
8.00	12.50	12.67	12.58	19.25	19.92	19.58	20.42	19.91	20.17	26.17	24.00	25.08
12.00	13.08	13.33	13.21	20.25	19.92	20.08	22.75	19.92	21.34	29.42	26.75	23.92
Mean	12.51	12.07		19.23	18.79		20.94	18.79		25.25	21.77	
$LSD_{0.05}$ (cropping syst.)			Ns			Ns			Ns			Ns
$LSD_{0.05}$ (poultry manure)			Ns			Ns			Ns			Ns
$LSD_{0.05}$ (cropping syst. X poultry manure)			Ns			Ns			Ns			Ns

From the results Table 10, sole cropping flowered earlier than the intercrop with a mean value of 37.5days which differed significantly (p=0.05) from the intercropped bambara crop (39.83days). It was observed that increasing rate of poultry manure delayed flowering with the earliest bambara crop in the control flowering at 35.67days. The higher the manure rate, the more flowering is delayed. This could be attributed to the nutrient availability and uptake which helped leaf development at the expense of early flowering.

Poultry manure produced significantly the effects on the fresh and dry weight of the crop biomass with the highest weight recorded by treatments that received 4t ha^{-1} poultry manure (284.4g and 68.10g) which was significantly different (p=0.05) from the treatments that received 12t ha^{-1} poultry manure which had the lowest fresh and dry weight of biomass (207.0g and 48.40g). For the legume crop, the application of manure produced and release nutrient 'N' to the soil coupled with that which was fixed thereby enhancing leaf and stem development to the expense of yield. Therefore, where legumes such as bambara are to be intercropped with cereals like maize with high doses of poultry manure should not be applied to help the crops utilize the fixed 'N' by the legume effectively and efficiently too.

Intercropping produced highest number of pods/plant (25.19) which differed significantly (p=0.05) from sole cropping with 21.31pods $plant^{-1}$. Again, 4t ha^{-1} poultry manure had the highest number of pods $plant^{-1}$ (28.33) which differed significantly (p=0.05) from 0t ha^{-1}, 8t ha^{-1} and 12t ha^{-1} with mean values of 22.95, 22.5 and 19.22 in that order (Table 10). This established that bambara groundnut does not require much manuring as indicated in this experiment.

Table 10. Effect of cropping systems and poultry manure on the number of days to 50% flowering, fresh and weight of biomass and number of pods of bambara groundnut

	Cropping systems											
	Days to 50% flowering			Fresh weight of biomass (g)			Dry weight of biomass (g)			Number of pods/stand		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	35.33	36.00	35.67	211.1	237.8	224.4	50.00	56.90	53.40	21.00	24.89	22.95
4.00	36.33	39.33	37.83	275.6	293.3	284.4	68.20	68.10	68.20	25.56	31.11	28.33
8.00	38.00	41.33	39.67	217.8	233.3	225.6	47.30	53.50	50.40	22.44	22.55	22.50
12.00	40.33	42.67	41.50	207.3	206.7	207.0	47.70	49.20	48.40	16.22	22.22	19.22
Mean	37.50	39.83		227.9	242.8		53.30	56.90		21.31	25.19	
$LSD_{0.05}$ (cropping syst.)			0.934			Ns			Ns			3.906
$LSD_{0.05}$ (poultry manure)			1.320			38.82			7.40			5.524
$LSD_{0.05}$ (cropping syst. X poultry manure)			Ns			Ns			Ns			Ns

The results Table 11, showed that poultry manure had significant effect (p=0.05) on the dry mass of seed plant^{-1} and 4t ha^{-1} manure produced the highest weight of seed per plant (23.16g) followed by 0t ha^{-1}, 8t ha^{-1}, and 12t ha^{-1}.

The application of 4t ha^{-1} manure also had the highest dry weight of shell plant^{-1} (15.12g) which differed significantly from 0t ha^{-1}, 8t ha^{-1} and 12t ha^{-1} with mean values of 11.64, 9.75, and 9.54g respectively.

Poultry manure treatment and the intercropping produced significant effect on 100 seed weight of bambara groundnut (Table 11).

Sole cropping system produced the highest grain yield 1.588t ha^{-1} which differed significantly (p=0.05) from the intercrop 1.076t ha^{-1} and the application of 4t ha^{-1} manure treatment produced the highest grain yield 1.82t ha^{-1} and this differed significantly (p=0.05) from 0t ha^{-1}, 8t ha^{-1}, and 12t ha^{-1} manure with mean values of 1.327, 1.177 and 1.005t ha^{-1} grain yield respectively. Results Table 12, showed the productivity indicies as explained by the land equivalent ration (LER) indicated that Maize/Bambara groundnut intercropping had yield advantage over sole cropping and was more productive than the sole cropping system.

Table 11. Effect of cropping systems and poultry manure on the dry mass of seed/plant, dry mass of shell/plant, 100 seed weight and the grain yield of bambara groundnut

Cropping systems												
	Dry mass of seed/plant (g)			Dry mass of shell/plant (g)			100 seed weight (g)			Grain yield (t/ha)		
Poultry manure (tons/ha)	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
0.00	14.05	18.61	16.33	9.74	13.53	11.64	64.5	75.6	70.1	1.340	1.313	1.327
4.00	20.57	25.74	23.16	13.81	16.43	15.12	75.0	84.3	79.7	2.113	1.527	1.820
8.00	16.59	10.44	13.52	11.12	8.38	9.75	74.4	61.4	67.9	1.727	0.627	1.177
12.00	11.43	13.17	12.30	8.78	10.29	9.54	75.8	56.8	66.3	1.173	0.837	1.005
Mean	15.66	16.99		10.86	12.16		72.4	69.5		1.588	1.076	
$LSD_{0.05}$ (cropping syst.)			Ns			Ns			Ns			0.3060
$LSD_{0.05}$ (poultry manure)			4.468			2.456			10.00			0.4327
$LSD_{0.05}$ (cropping syst. X poultry manure)			Ns			Ns			14.14			Ns

The result in table 12 shows that all the intercropping treatment gave LER values greater than 1.0

Table 12. Grain yield and land equivalent ratio (LER)

	Grain yield (t/ha)				LER
Poultry manure (t/ha)	Maize		Bambara groundnut		
	sole	intercrop	sole	intercrop	
0.0	0.83	0.71	1.340	1.313	1.84
4.0	1.37	0.98	2.113	1.527	1.44
8.0	2.14	1.84	1.727	0.627	1.22
12.0	2.17	1.91	1.173	0.837	1.59

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