FUDMA Journal of Agriculture and Agricultural Technology
ISSN: 2504-9496
Vol. 9 No. 1, March 2023: Pp. 69-77

PRODUCTIVITY OF MAIZE/COWPEA MIXED-INTERCROPPING AS INFLUENCED BY POULTRY MANURE, NITROGEN MANAGEMENT AND COWPEA VARIETIES IN SAMARU

https://doi.org/10.33003/jaat.2023.0901.10

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ABSTRACT

The study assessed the profitability of maize/cowpea intercropping in Samaru. The data was obtained from a field research carried out in the Research and Teaching farm of the Institute for Agricultural Research, Samaru, Zaria, during the 2018 and 2019 cropping seasons. The treatment consisted of three rates of poultry manure (0, 3 and 6 tons/ha), two ways of split N application to maize (two split dose and three split dose), and two cowpea genotypes arranged in a split plot design replicated four times. Results from the research showed that both poultry manure and triple split N dosage application significantly increased maize and cowpea yield in both years; with best economic results obtained with the application of 3 tons ha^{-1} of poultry manure. Assessment of the suitability of the intercropping system as defined by Land Equivalent Ratio (LER) and Relative Yield (RY) showed that higher yields were obtained from the intercrop compared to the sole as reflected in the LER values being more than one (1) units. Application of 3 tons ha^{-1} of poultry manure gave the highest gross margin (GM) with a corresponding return on investment (ROI) of 59% indicating that for every naira invested in the venture (ie 3 tons ha^{-1}), five (5) naira eighty nine kobo (5.89) profit was realized. Research therefore recommended the application of 3 tons ha^{-1} of poultry manure in addition to double split of 45 kg ha^{-1} of nitrogen fertilizer at 2 and 4 WAS to achieve maximum economics benefits of maize-cowpea intercropping system in Savanna Alfisols

Key word: Maize; Relative yield; Land equivalent ratio; Gross margin; split nitrogen application

INTRODUCTION

Cropping systems in Nigeria involve growing several crops in association as mixtures or intercrops. This practice provides farmers with several options for returns from land and labour, increases efficiency with which scarce resources are used, and reduces dependence upon a single crop that is susceptible to environmental and economic fluctuations (Haruna *et al*., 2018). Higher yields have been consistently reported in intercropping system than sole cropping particularly at later stages of growth when a component of the crop is been harvested creating enabling growth environment for the associated crop (Haruna *et al*., 2018). Several intercropping options are presently being practiced in West and East Africa; with cereals and legume mixture accounting to 70 and 60 per cent respectively (Vidigal *et al*., 2019). This practice reduces cost of cultivation, and increases net returns from the same piece of land (Vidigal *et al*. 2019).

The two major crops of interest that have received considerable research interest in intercropping system are maize and cowpea. Maize is highly cherished for its high nutritional values, ease of cultivation, and suitability as a companion crops (Manyong *et al*., 1996). On the other hand, cowpea is grown as an alternative source of cheap protein for low income household who cannot afford animal protein. It also contributes to improving soil fertility via symbiotic nitrogen fixation (Franke *et al*., 2014). Cowpea fixes between 74 – 116 kg N ha$^{-1\text{-yr}}$ (Franke *et al*., 2004).

Intensive crop production requires a balance use of both organic and inorganic fertilizer. This is intended to avoid over reliance on either of the sources whose careless use could result in negative side effects on the environment. One of the most deficient plant nutrient is nitrogen Applied N in either organic or inorganic form is subject to several issues, which include; volatilization, leaching, immobilization and denitrification which according to Jones *et al.* (2013) imposes costs that include loss of productivity, and negative environmental impacts; hence, it is important that applied fertilizer particularly the highly mobile ones end up in the plants tissues.

Split applying N fertilizer has been considered as a base option to confront these challenges (Canadian Fertilizer Institute, 2004). Split application therefore involve dividing the total N requirement of crop, and applying a certain dose at a time; while postponing a portion of the N treatment to a certain time when crop is better able to utilize the nutrient more rapidly and efficiently.

Nigeria poultry sub-sector is the most commercialized of all the agricultural sub-sectors; contributing about 25% of the agricultural GDP (The Cable 08, 2019). The current restriction on the importation of poultry products (meats and eggs) has resulted to a significant increase in the production of poultry products across the country. This trend has led to a corresponding increase in the generation of poultry waste which has been found to possess a significant fertilizing value for crop production and soil health. Consistently positive impact of poultry manure on corn and soybean grain yield has been reported with continuous application of poultry manure by Hoover *et al*. (2019)

Achieving the benefits of intercropping required balance application of both organic and inorganic nutrient sources as well as proper selection of associated crop combination. In Nigeria, farmers do not take into consideration the nutrient needs of each crop but rather rely on soil inherent nutrient supply which indeed has been drastically depleted via years of continuous cultivation without replacement of exported nutrients in the harvested produce (Yusuf *et al*. 2008). This trend could be partly due to dearth of information on the ideal rates of nutrient recommendation for such system, since current recommendations in Nigeria is based on sole cropping. Similarly, with the continuous release of improved crop varieties by National and international research institute, there is also a dearth of information on the most adapted crop varieties particularly legume (cowpea) for intercropping system. The profitability of intercropping system as defined by land equivalent ratio (LER) and gross margin have been widely adopted to assess the relative yield advantage of component crops in mixture in relation to their sole counterpart. This research is aimed at assessing the profitability of maize/cowpea mixed-intercropping as influenced by poultry manure, nitrogen management and varieties in Samaru

MATERIALS AND METHODS

Experimental Site

The experiment was sited at Samaru (latitude 11º11´008´N and longitude 7º36´52.1´´E) in the Northern Guinea agro-ecological zone during the 2018 and 2019 wet season. Samaru soils are classified as Typic Haplustalf according to the United State Department of Agriculture (USDA) soil taxonomy (Ogunwole *et al*., 2001) and Acrisols according to FAO-UNESCO legend (1994). The soil is low in inherent fertility: organic matter, cation exchange capacity and dominated by low activity clays as shown in Table 1 which corroborates the previous work Odunze, (2003).

Treatments

Treatments consist of three levels of poultry manure (0, 3 and 6 tons/ha), two (2) ways of top dressing of N fertilizer (double and triple split application) and two cowpea genotypes (Determinate and indeterminate). Nitrogen was supplied in this trial in form of urea. The sum total of amount of N-fertilizer for application in the trial was 50% of recommended rate (90 kg N ha^{-1}) for early maturing maize. First application of N was 22.5 kg N ha^{-1} at 2 weeks after sowing maize (WASM) to all plots irrespective of treatment. Second application of N was done at 4 WASM whereby 22.5 kg N ha^{-1} (ie balance of total applicable) was applied to half of all the plots, while the other half received 11.25 kg N ha^{-1}. For this group, the remainder of 11.25 kg N ha^{-1} was given at 6 WASM. Maize (*Zea may*) variety SAMMAZ 29 was sown in the first week of June in both years. And at 10 WASM cowpea was then relayed into the maize field after earthen up operation.

Field Layout and Experimental design

In 2018, the experimental area was harrowed twice and ridged 0.75m apart. Land preparation in subsequent year was done manually by retracting the old ridges vis-à-vis incorporating residues of cowpeas and maize obtained from previous harvest. The experiment was laid out in randomized complete block design (RCBD) with split plot arrangement in four replications. Factorial combination of poultry manure and split nitrogen management was assigned to the main plots whereas the sub plots consist of two cowpea genotypes

Varietal characteristics

The maize and cowpea seeds were treated with Apron star (20% w/w thiamethoxam, 20 % w/w metalaxy-M and 2% w/w difenoconazole (0.1 kg a.i/ha) at the product rate of 10 g to 2 kg of seed as described by NAERLS (2012) as a protection against soil borne pests, diseases and bird attack before and after germination. Three maize and cowpea seeds were sown at spacing of 0.75m x 0.25 m and 0.75 m x 0. 30 m later thinned to one and two plants per stands respectively at 2 WAS.

Cultural practices

In the two years of the experiment, basal application of 20 kg ha^{-1} each of K as Muriate of Potash (60% K_2O) and P as Single Superphosphate (18% P_2O_5) was applied immediately after land preparation to all plots irrespective of treatments. Poultry manure was weighed, applied and worked into the soil two (2) weeks prior to sowing maize seeds in each year. Glyphosate at a rate of 4.0 L/ha at 1.4 kg a.i./ha was sprayed two weeks before land preparation to control weed while supplementary hoe weeding was done at 6 WAS or as the need arises.

Observation and Measurement

Prior to treatment administration and sowing, composite soil samples were collected to assess the physical and chemical properties of the experimental site. The collected soil samples in 2018 and 2019 were air-dried, sieved using 2 mm mesh sieve and bagged in well labelled polythene bags in readiness for laboratory analyses of selected physical and chemical properties using standard laboratory procedures. Particle size distribution was determined by the hydrometer method, as described by Gee and Or (2002), using distilled water and calgon (sodium hexametaphosphate) as dispersing agents. While textural class was obtained from textural triangle. Similarly, organic carbon was analysed using the method described by Nelson and Sommers (1982). Soil pH was determined electrometrically in a soil to solution ratio of 1:2.5 (Hendershot *et al.*, 1982). Total nitrogen was determined by micro-Kjeldahl digestion method (Bremner and Mulvaney, 1982) and available phosphorus was estimated by the Bray 1 method (Olsen, 1982). Exchangeable Ca^{2+}, Mg^{2+}, K and Na^{+} were extracted with 1N ammonium acetate buffered at pH 7.0 (Anderson and Ingram, 1993). Exchangeable Ca^{2+} and Mg^{2+} was determined by EDTA complexometric titration while exchangeable K^{+} and Na^{+} were estimated by flame photometry; Exchangeable acidity was determined by titration method (McLean 1982). The effective cation exchange capacity (ECEC) was estimated by summation method of all the exchangeable bases and exchangeable acidity.

Estimation and Measurement

Land Equivalent Ratio (LER):

Land equivalent ratio (LER) was used to determine the productivity of the mixed cropping systems over sole cropping (Andrews and Kassam, 1976) while economic analysis was done using gross margin (GM), and returns on investment (ROI) analysis as defined by Olukosi and Erahabor (1988).

Statistical Analysis

Data generated in both years were subjected to combine analysis of variance using the General linear model of SAS, and mean separated at 5 and 1% using standard error of difference (SED).

RESULTS AND DISCUSSION

Soil physico-chemical properties

Results of the soil physical and chemical properties are shown in Table 1. Results showed that the soil texture was sandy loam with higher proportion of sand and silt in both seasons. The proportion of silts was higher in 2019 than 2018. Soil pH in both years was slightly acidic, hence posed no threat to the cultivation of cowpea which is tolerance to slightly acidic condition. Total N, available P and exchangeable bases were all low. However, average effective cation exchange capacity was generally higher in 2019 than 2018. Similarly, the poultry manure applied as treatment as shown in Table 1; had 4.62% N, 2.32 mg/kg P, 7.50 Cmol/kg Ca and 0.10 Cmol/kg K.

Table 1: Physical and chemical properties of the soil of the experimental site during 2018 and 2019 rainy season and poultry manure

Soil Properties	Manure	2018	2019
Sand (%)	-	65.55	54
Silt (%)	-	19.90	32
Clay (%)	-	14.55	14
Textural class	-	Sandy-loam	Sandy-loam
pH 1:2.5 water	9.70	5.65	6.20
pH 1:2.5 $CaCl_2$	9.22	5.13	5.40
Organic Carbon (g kg^{-1})	25.94	2.83	6.30
Total Nitrogen (%)	4.62	0.18	0.18
Available P (mg kg^{-1})	2.32	9.66	9.89
Exchangeable Ca^{2+}(Cmol/kg)	7.50	2.74	4.40
Exchangeable Mg^{2+} (Cmol/kg)	12.19	0.71	1.18
Exchangeable K^{+}(Cmol/kg)	0.10	0.18	0.52
Exchangeable acidity(Cmol/kg)	-	0.15	0.16
ECEC (Cmol/kg)	-	3.78	6.26

Source: Field survey

Relative Yield

The result of analysis of variance for relative yields of maize and cowpea in 2018 and 2019 is presented in Table 2. Results showed that both poultry manure and nitrogen management had no significant ($p<0.05$) effects on RY of cowpea in both 2018 and 2019. However, varietal effects was significant in both years whereby SAMPEA 11 reported the highest values in both 2018 (0.89) and 2019 (1.47). On the other hand, relative yield (RY) of maize was significantly influenced by poultry manure rates in both 2018 and 2019; although with an inconsistence trend. In 2018, 3 tons/ha of poultry manure gave significantly higher (1. 60) values; whereas in 2019 the highest (2. 15) value was reported with 6 tons/ha rate of application which was statistically at par with 3 tons/ha application rates. Nitrogen management regime was significant in 2018 with the highest (1. 59) values reported in split dose of N application. In both years, RY-maize was not significantly affected by cowpea varieties. Generally, average values for RY (cowpea and maize) were higher in 2019 than 2018.

Table 2: Influence of poultry manure, methods of nitrogen application and varieties on relative yield and Land Equivalent Ratio (LER) of maize/cowpea mixture in 2018 and 2019 wet season in Samaru

	2018			2019		
Treatment	RY-Maize	RY-Cowpea	LER	RY-Maize	RY-Cowpea	LER
Poultry manure (t ha^{-1}) (PM)						
0	1.20b	0.65c	1.85b	1.72b	1.07b	2.79b
3	1.60a	0.77b	2.37a	2.13a	1.30a	3.43a
6	1.44a	0.83a	2.27a	2.15a	1.27a	3.42a
SE±	*	NS	*	*	NS	*
Significance	0.146	0.071	0.250	0.326	0.130	0.456
Methods of N application (N)						
Single dose	1.26b	0.87	2.13	2.02	1.21	1.62
Split application	1.57a	0.82	2.39	1.98	1.22	3.20
SE±	*	NS	NS	NS	NS	NS
Significance	0.119	0.058	0.204	0.266	0.106	0.372
Varieties (V)						
SAMPEA 14	1.44	0.73b	2.17	1.87	0.96b	2.83
SAMPEA 11	1.39	0.89a	2.28	2.13	1.47a	3.60
SE±	NS	**	NS	NS	**	NS
Significance	0.129	0.038	0.165	0.138	0.076	0.214
Interactions						
PM X N	NS	NS	NS	NS	NS	NS
PM X V	NS	NS	NS	NS	NS	NS
V X N	NS	NS	NS	NS	NS	NS

*PM=poultry manure, N= methods of N application. * and ** represent significance difference at 5 and 1 % level of probability. Means having the same letter within a column are statistically similar while those with different letters within the same column are statistically dissimilar.*

Land Equivalent Ratio (LER)

Land Equivalent Ratio (LER) was significantly influenced by both poultry manure application and cowpea varieties in both 2018 and 2019 (Table 2). In both years, the application of 3 and 6 tons/ha of poultry manure produced statistically higher values which were at par, but differed significantly from the control. In a similar vein, SAMPEA 14 returned the highest values in both years. Results further showed that split application of nitrogen had no significant effects on LER. It was further observed that LER in both years were more than one (1) unit.

Grain yield (Kg/ha): Result of the influence of poultry manure and methods of N application on maize and cowpea grain yield is shown in Table 3. Results of the analysis of variance indicated that poultry manure had significant ($P<0.05$) effects on maize grain yield in both years.

In terms of poultry manure rate, the highest maize grain yield was obtained with the application of 3 tons per hectare which was at par with 6 tons ha^{-1} in both 2018 and 2019. However, overall average maize grain yield was higher in 2019 than 2018. Method of N application was not significant in both years. However, 24% increase in maize grain yield with three splits N dosage was observed in 2018. In contrast, the gains on split N application in 2018 was however, neutralized in 2019.

Cowpea yield varied significantly with increased rates of poultry manure in both 2018 and 2019. In 2018, the highest (1524 kg ha^{-1}) was reported with 6 tons ha^{-1} rate of application. In contrast 3 tons ha^{-1} gave the highest (2139 kg ha^{-1}) grain yield in 2019 which was at par with 6 tons ha^{-1}. Methods of N application had no significant effects on the yield of cowpea genotypes in both years. However, varietal effects was significant ($P<0.05$) in both years with SAMPEA 14 consistently reporting higher values in both 2018 (1473 kg ha^{-1}) and 2019 (2021 kg ha^{-1})

Table 3: Influence of poultry manure, methods of nitrogen application and varieties on maize and cowpea grain yield in 2018 and 2019

	2018		2019	
Treatment	Maize grain yield (kg/ha)	Cowpea grain yield (kg/ha)	Maize grain yield (kg/ha)	Cowpea grain yield (kg/ha)
Poultry manure (t ha^{-1}) (PM)				
0	2815b	1188c	4041c	1753b
3	3743a	1424b	4917a	2139a
6	3383a	1524a	4674b	2076a
Significance	**	*	*	*
SE±	341.800	94.000	251.600	126.300
Methods of N application (N)				
Double split	2960	1378	4736	1986
Three splits	3667	1383	4633	1993
Significance	NS	NS	NS	NS
SE±	299.900	49.300	217.700	103.100
Varieties (V)				
SAMPEA 14	3366	1473a	4385b	2021
SAMPEA 11	3261	1284b	4983a	1958
Significance	NS	*	*	NS
SE±	299.90	77.021	205.50	118.100
INTERACTION				
PM x N	NS	NS	NS	NS
PM x V	NS	NS	NS	NS
N xV	NS	NS	NS	NS

*PM=poultry manure, N= methods of N application, V = Variety * and ** represent significance difference at 5 and 1 % level of probability. Means having the same letter within a column are statistically similar while those with different letters within the same column are statistically dissimilar.*

Economic Analysis:

Result of the economic analysis as depicted by gross margin and returns on invested is presented in Table 4. Results showed that the highest gross margin was reported with the application of 3 tons ha^{-1} of poultry manure which was significantly different from other rates. Furthermore, neither methods of nitrogen application and varieties was not significant. Similar trend of results was also reported in the ROI which indicates that for every naira invested in the venture (ie 3 tons ha^{-1}), five naira eighty nine kobo (5.89) profit is realized.

Table 4: Gross margin and return on investment (ROI) of maize/cowpea Intercrop as influence by poultry manure rates, nitrogen management and varieties

Treatment	Gross margin	ROI
PM rates(tons/ha)		
0	529985b	9.07a
3	614763a	5.89b
6	539528b	3.91c
Significance	**	*
SE±	33108	0.381
Methods of N application (N)		
Double split	545091	6.14
Three splits	577760	6.43
Significance	NS	NS
SE±	29403	0.311
Varieties (V)		
SAMPEA 14	559081	6.28
SAMPEA 11	563769	6.30
Significance	NS	NS
SE±	29403	0.732
INTERACTION		
PM x N	NS	NS
PM x V	NS	NS
N x V	NS	NS

*PM=poultry manure, N= methods of N application, VTY = Variety * and ** represent significance difference at 5 and 1 % level of probability. Means having the same letter within a column are statistically similar while those with different letters within the same column are statistically dissimilar.*

DISCUSSION

Poultry manure significantly increase both maize and cowpea yield in both years. The high grain yield reported in the finding with increase application of poultry manure could be a function of better growth condition; and to a larger extent on inherent genetic variability dominant in the species in agreement with Russel, (1991) and Dhillon, (2001). Also, the high content of npk content of the poultry manure would have probably increased the availability of mineral nutrients in the soil for easy uptake by the crops. The overall maize yield of 3743 and 3383 kg ha^{-1} reported in this trial contradict the average 2220 kg ha^{-1} reported by Garba and Namo, (2013) on the same variety. The additional yield increased in our case could be attributed to the combined positive influence of the integrated use of organic and inorganic fertilizer which has been widely reported. Similar trend was also reported by Boateng *et al.* (2006) who attributed same to the importance of fertilizing or manuring the soil in maize production. The authors further reported that Poultry manure application registered over 53% increases of N levels in the soil, from 0.09% to 0.14% which visa a vis translated to significant yield increased in poultry manure treated plots than the control.

The 24% increase in maize grain yield with triple N dose application in 2018 could be as a result of increase N availability to the crop particularly at grain filling stage. In contrast, continuous application of poultry manure vis-à-vis incorporation of cowpea residues tend to negate the gains reported with triple N dose application in 2018 leading to higher grain yield of both maize and cowpea varieties in 2019. This is because of increased availability of nutrients in the soil.

Result further indicated higher LER and relative yield of maize and cowpea in both years. The higher LER is an indication of higher yield advantage of the intercropping system relatives to their sole crop counterpart. This entails a high complementary association between the cowpea and maize and, efficient utilization of land and applied amendment. This result corroborate the findings of Ribas *et al*. (2020) and Herry *et al*. (1998) who consistently reported higher LER in intercropping system than sole crop. Similarly, Herry *et al*. (1998) ascribed the trend of yield advantage in intercropping system to efficient water use resulting from reduce evaporation due to canopy formation by both crops. Similarly, the consistently higher LER obtained for the crop mixtures confirmed the often expressed conclusion that intercropping is beneficial to traditional farmer relatives to sole cropping (Ugen and Wein, 1996)

Results of the economic analysis of crop mixture as depicted by gross margin indicated a steady increase in gross margin with increasing application of poultry manure up to 3 tons ha^{-1}. Factors such as lower operating cost (I.e TVC) could be responsible for the profitability reported. Ogaji (2010) reported that the lower the gross and operating ratios, the higher the profitability of the enterprise and vice versa. However, Momirovic *et al.* (2015) stated that growing pumpkins in mixture with maize probably cost a small farmer very little more effort; than the production of a sole stands of either maize or pumpkin but with the returns overweighing the stress.

Conclusion

Evidences from the research showed that both poultry manure and triple split N dosage application significantly increased maize and cowpea yields in both years; however, with best economic results obtained with the application of 3 tons ha^{-1} of poultry manure. Assessment of the suitability of the intercropping system as defined by LER and RY showed that higher yields were obtained from the intercrops relative to the sole as reflected in the LER values being more than one (1) unit. Application of 3 tons ha^{-1} of poultry manure gave the highest gross margin with a corresponding ROI of 59% indicating that for every naira invested in the venture (ie 3 tons ha^{-1}), five (5) naira eighty nine kobo (5.89) profit was realized. Based on these finding, it is therefore recommended that farmers should apply 3 tons ha^{-1} of poultry manure in addition to double split of 45 kg ha^{-1} to achieve maximum benefits of maize-cowpea intercropping system in the northern guinea savanna alfisols

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