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RESEARCH ARTICLE

EFFECT OF INTERCROPPING AND POULTRY MANURE RATES ON THE GROWTH AND YIELD OF MAIZE AND OKRA.

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Abstract

Field experiments were conducted in 2012 and 2013 cropping seasons at the research farm, Michael Okpara University of Agriculture, Umudike to determine the effect of intercropping and poultry manure rates on the yield and yield components of okra and maize. The experimental design was a 2 x 4 split plot in a randomized complete block design with 12 treatment combinations replicated three times. The treatments were cropping system (sole maize or sole okra, maize/okra intercrop) as main plot factor and poultry manure rates (0, 5, 10, 15 t/ha) as sub plot factor. The result obtained showed significant effect ($P < 0.05$) of cropping system on number of leaves per plant and plant height of okra. Intercropping reduced the number of leaves per plant and increased plant height of okra. There was no significant ($P > 0.05$) effect of cropping system on the growth attributes of maize plants. The yield and yield components of maize and okra plants were reduced under intercropping system. Poultry manure increased the fresh pod yield of okra and grain yield of maize up to 10 t/ha application. There was interaction effect of cropping system and poultry manure rates on fresh pod yield in each year. Within each system highest pod production was obtained when 10 t/ha manure was applied.

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Introduction:-

Intercropping is a common cropping system in developing countries such as Nigeria (Li *et al*., 1991). It is the practice of growing two or more crops at the same time during the same growing season on the same piece of land (Geiler *et al*., 1991). Intercropping of crops by smallholder and peasant farmers has been a common practice throughout the years. Monocropping of pure stands have been emphasized because of its advantages (Ijoyah and Jimba, 2012; Gondwe, 1992). Despite the advantages of monocropping, almost all smallholder and peasant farmers in the developing world still practice intercropping (Ijoyah, 2011). More than 70% of food crops consumed in humid tropics, especially in the tropical Africa come from intercropping (Ünlü, *et al*. 2010). Intercropping has recently been recognized as a potentially beneficial system of crop production (Odedina *et al*., 2014). This cropping system increased total productivity per unit land, per unit time and improves the judicious utilization of the land and other resources on farm (Odedina *et al*., 2014). Resources such as water, light and nutrients are utilized more effectively in intercropping. Intercropping ensures efficient utilization of light and other resources, reduces soil erosion and suppresses weed growth (Muoneke and Asiegbu, 1997), thereby helps to maintain greater stability in crop yield in okra/cowpea intercropping system (Susan and Mini, 2005). Other advantages of intercropping include: insurance against crop failure thereby minimizing risk, better use of resources by plants of different heights, rooting depths and nutrient requirements and a more equal distribution of labour through the growing season (Okpara *et al*., 2004). Some studies have indicated that intercropping was more productive than sole cropping because of the complimentary effect of intercrops such studies included amaranth with cowpea (Susan and Mini, 2005), cucumber with cowpea (Susan and Mini, 2005), maize with cowpea (Akande *et al.*, 2006), cassava with cowpea (Mohammed *et al.*, 2006).

Maize (*Zea mays* L.) is the third most important cereal crop after sorghum and millet (FAO, 1997). Okra (*Abelmoschus esculentus* L. Moench) is a crop featuring prominently in mixed cropping system in Nigeria for the supply of vitamins and minerals for man. Okra is consumed on daily basis by most families in Nigeria. It features mainly in intercropping system and more effort is needed to improve its production. Over 75 % of maize and 60 % of okra grown in Nigeria are produced under intercropping system (Ofosu-Anin and Limbani, 2007; Ijoyah and Jimba, 2011). Emphasis should be made on the sustainability of the intercropping system so as to increase productivity, satisfy food demand of an increasing population without depleting the soil resources, hence the need for organic manure incorporation in intercropping system. This can be achieved by incorporating the actual proportion of poultry litter to supply the adequate nutrient necessary for its growth and yield production. Despite the fact that intercropping of maize and okra is a common practice in Nigeria, studies have not been conducted to evaluate the effect of intercropping on the growth and yield of maize and okra using poultry manure rates.
In view of this, the objective of this study was to determine the effect of intercropping and poultry manure rates on the growth and yield of maize and okra.

Materials and Methods:-

The study was conducted at the research farm, Michael Okpara University of Agriculture, Umudike, Nigeria, during the planting seasons 2012 and 2013. The study location has latitude 05^0 29' longitude 07^0 33' and at altitude of 122 m above sea level falls within Umudike agroecological zone. The total rainfall in 2012 and 2013 were 1902. 8 mm and 2160.6 mm respectively. The meteorological information of the area during the trial period was obtained from National Roots Crops Research Institute NRCRI about 7 km from the experimental site. Composite soil samples of the top soils for each experiment were taken at 30cm from different representative locations using a soil auger after land preparation for physical and chemical analyses. The soil textural class was sandy loam and total nitrogen was 0.79 and 0.17 (%) in 2012 and 2013 respectively while the available phosphorous was 23.3 and 27.0 (mg/kg) in their respective years. Poultry manure used in each experiment was bulked in each cropping season for chemical analysis

The experiment was a 2 x 4 split plot design with three replicates. Cropping system (sole okra or sole maize and okra/maize intercrop) was the main plot treatment and poultry manure rates (0, 5, 10, 15 t/ha) were the sub plot treatments. Maize variety (Oba super 2) and okra variety (V-35) used for the experiments were obtained from National Agricultural Seed Council, Umudike and manure type was deep litter system. The treatments were assigned according to the design of the experiment.

The experimental field was ploughed, harrowed and field was marked out. There were three blocks, each consisted of twelve plots measuring 5 m x 2.4 m. the blocks were separated by 1 m apart while the furrows were separated by 0.6 m path. . On 30 May, 2012 poultry manure was worked into each treatment plot before sowing. Each component seed was sown on June 6 and April 22 in 2012 and 2013 respectively. Two seeds were sown per hole and later thinned to one plant per stand ten days after sowing (DAS) at 0.5 m x 0.6 m spacing according to the treatment schedule giving a total plant population of 33,333 plant/ha for each component. Weeding operations were done for each cropping season, 3, 6, and 9 weeks after sowing (WAS) in each year. Weekly spraying of okra with karate (*Lamdacyhalothrin*) at the rate of 500 ml in 100 l per hectare was done 2 WAS to check the incidence of insect pests. Spraying stopped one week before harvest.

Data taken for growth attributes of maize and okra included: plant height, number of leaves per plant of the respective plants. For yield attributes of maize, data collected consisted of number of grains per cob, grain yield and 100 grain weight. Maize was harvested when large portion of the leaves were observed dried and falling off which are signs of senescence (Ijoyah, 2011). Okra was harvested when the tip of pod was observed to break easily when pressed with the finger tip (Usman, 2001). Four okra plants were harvested at four days regular interval for recording of number of fresh pods/plant, fresh pod weight per plant and fresh pod yield/ha. Also, data for 100 seed weight and number of dry seeds per pod were taken.
All the data collected from the field were subjected to analysis of variance (ANOVA) following procedures outlined in split plot in randomised complete block design (Genstat, 2008). The separation of the treatment means for significant effect was by Fisher's Least Significant Difference (F - LSD) at 5% probability level (Obi, 1986).

Results:-

Te organic matter content of the soil was high in 2012 and very high in 2013. For poultry manure, total N was 4.15 % in 2012 and 4.22 % in 2013. The total maximum and minimum temperatures in 2012 were 376.3 and 272.1 (^{0}C) respectively, and 378 and 270 (^{0}C) in 2013 respectively.

Growth attributes of okra:-

Intercropping reduced the number of leaves per plant and increased the height of okra plants in 2012 and 2013 (Table i). The number of leaves per plant increased with increase in manure rates up to 10 t/ha and thereafter declined whereas plant height continued to increase with increase in manure application. There was significant ($P < 0.05$) interaction effect on the number of leaves and plant height in 2012 whereas in 2013, there was no significant interaction effect on number of leaves per plant.

Yield attributes of okra:-

The result obtained showed that intercropping okra with maize reduced number of fresh pods per plant, weight of fresh pods per plant and fresh pod yield in both cropping seasons (Table ii). Fresh pod yield was higher in sole okra with values of 4.06 and 5.21 t/ha in 2012 and 2013 respectively. Poultry manure application was highly significant ($P < 0.01$) on the above yield attributes. The number of fresh pods per plant and fresh pod yield (per plant and per hectare) increased with increase in manure rate up to 10 t/ha and thereafter declined in 2012 (Table ii). Similar trend was observed in 2013. In 2012 and 2013, pod yield increased by 49.2, 139.5 and 102.7 % and by 56.2, 149.2 and 74 %, respectively for 5, 10, 15 t/ha manure application over their control. There was an interaction effect between cropping system and manure rate on the number of fresh pods per plant in 2012 and fresh pod yield (per plant and per hectare) in each

Table i: Effect of cropping system and poultry manure rates on number of leaves per plant and height of sole and intercropped okra in 2012 and 2013 cropping seasons.

	2012					2013				
	Manure rates (t/ha)					Manure rates (t/ha)				
Cropping system	**0**	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**
Number of leaves per plant 8 WAS										
Sole	5.00	8.17	10.83	6.67	7.67	6.33	9.33	12.67	7.00	8.83
Intercrop	3.43	5.50	7.10	4.40	5.11	6.00	7.67	9.67	5.67	7.25
Mean	4.22	6.83	8.97	5.53		6.17	8.50	11.17	6.33	
Plant height (cm) 8 WAS										
Sole	59.67	55.00	65.33	70.00	62.50	62.70	66.70	70.30	72.00	67.90
Intercrop	63.33	73.67	80.00	91.67	77.17	66.70	76.30	86.00	99.00	82.00
Mean	61.50	64.33	72.67	80.83		64.70	71.50	78.20	85.50	

	2012		2013	
	Number of leaves/plant	**Plant height (cm)**	**Number of leaves/plant**	**Plant height (cm)**
$LSD_{(0.05)}$ for two cropping systems	1.29	4.49	1.40	9.75
$LSD_{(0.05)}$ for two manure rates	0.59	5.13	0.96	6.49
$LSD_{(0.05)}$ for two cropping systems × manure rates	1.03	6.58	NS	9.34

Table ii: Effect of cropping system and poultry manure rates on number of fresh pod and fresh pod yield of sole and intercropped okra in 2012 and 2013 cropping seasons.

	2012					2013				
	Manure rates (t/ha)					Manure rates (t/ha)				
Cropping system	**0**	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**
Number of fresh pods per plant (g)										
Sole	6.33	8.33	11.67	11.33	9.42	9.00	12.00	15.33	12.67	12.25
Intercrop	3.83	5.83	6.67	5.50	5.46	4.87	8.67	11.33	7.50	8.09
Mean	5.08	7.08	9.17	8.42		6.13	10.33	13.33	10.08	
Weight of fresh pods per plant (g)										
Sole	67.67	95.67	173.33	150.00	121.67	92.00	118.40	234.40	171.70	156.40
Intercrop	43.33	69.33	92.33	74.83	69.96	63.70	125.10	145.70	100.20	108.70
Mean	55.50	82.50	132.83	112.42		77.80	121.80	194.5	135.90	
Fresh pod yield (t/ha)										
Sole	2.26	3.19	5.78	5.00	4.06	3.07	3.95	8.11	5.72	5.21
Intercrop	1.44	2.31	3.08	2.50	2.33	2.12	4.17	4.86	3.34	3.62
Mean	1.85	2.76	4.43	3.75		2.60	4.06	6.48	4.53	

	2012			2013		
	No. of fresh pod/plant	**Weight of fresh pod/plant**	**fresh pod yield**	**No. of fresh pod/plant**	**Weight fresh pod/plant**	**Fresh pod yield**
$LSD_{(0.05)}$ for two cropping systems	1.59	10.58	0.35	1.81	30.77	1.03
$LSD_{(0.05)}$ for two manure rates	1.20	5.74	0.19	1.16	26.43	0.88
$LSD_{(0.05)}$ for two cropping systems × manure rates	1.66	9.05	0.30	NS	35.42	1.18

year. There was significant ($P < 0.05$) effect of cropping system on 100 seed weight and number of dry seeds per pod in each year except pod length in 2012 (Table iii). These yield attributes increased in sole okra than when intercropped with maize plants. 100 seed weight and number of dry seeds per pod had interaction effect in both years. Each manure application increased the seed production and weight in each system. Application of manure 100 seed weight and number of dry seeds per pods up to 10 t/ha and declined thereafter in each year. Each manure application increased seed production and seed weight in both systems although sole cropping was more than intercropping.

Table iii: Effect of cropping system and manure rates on seed weight and number of seeds per pod of sole and intercropped okra in 2012 and 2013 cropping seasons.

2012						2013				
Manure rates (t/ha)						Manure rates (t/ha)				
Cropping system	**0**	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**
100 seed weight (g)										
Sole	2.50	5.03	7.83	5.50	5.22	9.33	16.77	26.00	22.33	18.61
Intercrop	3.33	3.07	4.77	3.20	3.27	3.17	4.90	5.77	4.10	4.48
Mean	2.27	4.05	6.03	4.35		3.75	5.87	7.85	6.07	
Number of seeds per pod (g)										
Sole	6.50	102.70	134.00	132.00	108.50	125.00	113.30	163.30	140.70	135.60
Intercrop	52.00	68.70	84.70	68.70	68.50	71.30	88.30	99.70	81.00	85.10
Mean	58.70	85.70	109.30	100.30		98.20	100.30	131.50	110.80	

	2012				2013			
	100 seed weight		**Number of seeds/pod**		**100 seed weight**		**Number of seeds/pod**	
$LSD_{(0.05)}$ for two cropping systems	0.96		10.83		0.19		7.76	
$LSD_{(0.05)}$ for two manure rates	0.31		6.43		0.18		7.59	
$LSD_{(0.05)}$ for two cropping systems × manure rates	0.74		9.69		0.24		9.93	

Growth attributes for maize:-

There was no significant ($P > 0.05$) effect of cropping system, manure rate nor cropping system x manure rate interaction on number of leaves and maize height 8 WAS in both years (Table iv).

Yield and yield components of maize:-

In 2012 and 2013 cropping seasons, maize intercrop reduced grain production (Table v). 100 grain weight, number of grains per cob and grain yield gave the highest yield and grain production at 10 t/ha manure application and reduction set in at 15 t/ha manure application (Table 5). Grain yield obtained in 2012 and 2013 increased by 30, 43.2, 14.8, % and 21.1, 43 and 12 % respectively with manure application rates of 5, 10, 15 t/ha relative to the control. There

Table iv: Effect of cropping system and poultry manure rates on number of leaves per plant and height of sole and intercropped maize in 2012 and 2013 cropping seasons.

	2012					2013				
	Manure rates (t/ha)					Manure rates (t/ha)				
Cropping system	**0**	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**
Number of Leaves Per Plant 8 WAS										
Sole	10.42	10.50	10.67	9.58	10.29	11.08	10.50	12.08	11.08	11.19
Intercrop	9.92	10.08	10.33	9.50	9.96	9.00	10.17	11.00	10.42	10.15
Mean	10.17	10.29	10.50	9.54		10.04	10.35	11.54	10.75	
Plant height (m) 8 WAS										
Sole	1.70	1.50	1.45	1.39	1.51	1.66	1.62	1.45	1.53	1.57
Intercrop	1.47	1.54	1.49	1.44	1.49	1.47	1.84	1.89	1.57	1.69
Mean	1.59	1.52	1.47	1.42		1.57	1.73	1.67	1.55	

	2012		2013	
	Number of leaves/plant	**Plant height (cm)**	**Number of leaves/plant**	**Plant height (cm)**
$LSD_{(0.05)}$ for two cropping systems	NS	NS	NS	NS
$LSD_{(0.05)}$ for two manure rates	NS	NS	NS	NS
$LSD_{(0.05)}$ for two cropping systems × manure rates	NS	NS	NS	NS

Table v: Effect of cropping system and manure rates on grain yield of sole and intercropped maize in 2012 and 2013 cropping seasons.

2012						2013				
Manure rates (t/ha)						Manure rates (t/ha)				
Cropping system	**0**	**5**	**10**	**15**	**Mean**	**0**	**5**	**10**	**15**	**Mean**
Number of grains per cob										
Sole	217.70	252.30	302.30	258.70	257.80	233.30	265.00	318.30	268.70	271.30
Intercrop	159.00	179.70	245.70	168.00	188.10	170.00	186.00	253.70	186.70	199.20
Mean	188.30	216.00	274.00	213.00		201.70	225.80	286.00	227.70	
100 grain weight (g)										
Sole	23.07	24.87	26.43	20.83	23.80	24.67	29.00	30.33	22.67	26.67
Intercrop	15.70	20.00	23.10	17.87	19.17	16.00	22.67	25.00	19.33	20.73
Mean	19.38	22.43	24.77	19.35		20.33	25.83	27.67	21.00	
Grain yield (t/ha)										
Sole	0.93	1.10	1.27	1.07	1.09	1.07	1.20	1.42	1.17	1.21
Intercrop	0.68	0.87	1.04	0.79	0.84	0.73	0.98	1.16	1.84	0.93
Mean	0.81	0.98	1.16	0.93		0.90	1.09	1.29	1.07	

	2012			2013		
	100grain weight (g)	Number of grains per cob	Grain yield (t/ha)	100 grain weight (g)	Number of grains per cob	Grain yield (t/ha)
$LSD_{(0.05)}$ for two cropping systems	0.45	25.08	0.08	0.95	10.25	0.17
$LSD_{(0.05)}$ for two manure rates	0.73	12.93	0.06	2.11	12.37	0.09
$LSD_{(0.05)}$ for two cropping systems × manure rates	0.91	20.97	NS	NS	NS	NS

was significant ($P < 0.05$) interaction effect of poultry manure rates and cropping system on 100 grain weight and number of grains per cob in 2012.

Discussion:-

The application of poultry manure increased the vegetative growth of okra. The significant variation from the effect of manure rates on the number of leaves per plant and plant height could be associated with release of nutrients which must have conditioned the soil for availability and better uptake of these nutrients by the roots of the crop which however encouraged plant growth. This is in conformity with the report by Cooke (2002) that when organic manure is applied in sufficient quantity to the soil, it would supply all the necessary primary and secondary nutrients required for crop growth. The result revealed that optimum leaf production was obtained at 10 t/ha. This suggested that nutrients supplied were adequate at this rate. The plants were taller with intercrop and leaf production was more irrespective of the manure rates which could possibly be attributed to the adequate nutrient supply that encouraged plant growth. The increase in okra pod yield under sole cropping could be attributed to increase in pod production. This view supports Ijoyah and Jimba (2012) and Ijoyah *et al*. (2010) who obtained similar result and reported that number of pods depend on the intensity growth of plant. Ojo *et al*. (2012) observed a positive correlation between fresh pod yield and number of fresh pod. This is not in conformity with Chaudary (1990), who reported that growing okra plant under the same system led to serious defoliation and subsequent reduction. The yield reduction under intercropping system could be as a result of inter plant competition that existed among the plants for growth

resources such as light, water, and nutrient and also because of shading effect of maize canopies over okra. Iremiren *et al*. (2013) reported increase in grain yield of maize under sole cropping in maize-okra intercrop. Okpara and Omaliko (1995) gave similar report on the lowest grain yield obtained in intercropping system due to competition. 100 grain weight always reduced in intercropping system and irrespective of the system, grains were heaviest with 10 t/ha manure application. This could be attributed to easy solublisation effect of released plant nutrients that improved the nutrient status and water holding capacity (Tiamiyu *et al*., 2012) and plants needs

Poultry manure at 10 t/ha application produced the highest number of fresh pod per plant, weight of fresh pod per plant and fresh pod yield. This could be as a result of sufficient nutrient released in adequate amount and its availability for optimum development of pod. This agrees with the report of Tiamiyu *et al*. (2012) who stated that increase in fresh pod weight per plant could be attributed to easy solublisation effect of released plant nutrients that improved the nutrient status and water holding capacity of the soil. Akanbi *et al*. (2007) reported that plants nourished with efficient amount of nutrient in the right proportion are expected to give higher yields. The reduction in pod production at 15 t/ha could be attributed to excess manure application which promoted vegetative growth at the expense of reproductive growth (Odeleye *et al*., 2005). Within each system, pods weighed more at 10 t/ha manure due to better supply of nutrients to the plants.

Yield and yield components were highest at 10 t/ha. Generally, optimum yield for fresh pod yield and grain yield at 10 t/ha could be that the plants efficiently utilized the essential nutrient element released from poultry manure responsible for yield development. Similar findings were reported by other researchers including Zublena *et al*. (1993) and Silva *et al*. (2003). Haynes and Beare (1994) reported positive effect of poultry manure on the yield components and increase in organic matter content since poultry manure is capable of improving crop yield to a certain level of application and its ability to increase organic matter content and changes in the chemical composition and enhancement of the soil. The significant interaction effect on the poultry manure rates and cropping system on 100 grain weight showed that for each manure rate intercropping always reduced 100 grain weight and irrespective of cropping system the grains were heaviest with 10 t/ha manure application.

Conclusion:-

Based on the result of this study, manure rates at 10 t/ha weighed higher fresh pod yield and fresh cob yield. Therefore, the application of 10 t/ha of manure is recommended to farmers to achieve optimum yield of the component crop in intercropping system.

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