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Full Length Research Article

GROWTH AND YIELD RESPONSE OF IRRIGATED MAIZE (*ZEA MAYS* L.) TO THE APPLICATION OF DIFFERENT RATES OF INORGANIC FERTILIZER AND POULTRY MANURE

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ABSTRACT
The growth and yield response of irrigated maize (*Zea mays* L.) under varying levels of inorganic fertilizer and poultry manure was evaluated during 2019/2020 dry season at two locations (Teaching and Research Farm of the Department of Crop Science, Kaduna State University, Kafanchan Campus and Kadawa, Irrigation Research Farm of Ahmadu Bello University Zaria, Nigeria) using a complete randomized block design with three replications. The experimental treatments consist of varying quantities of poultry manure: 1.5, 3.0, and 4.5 tonnes per hectare that were incorporated in to the soil along with four levels of inorganic fertilizer 0, 100, 120, and 140 kg N ha^{-1}. The results of the field trials showed that all growth and yield parameters were significantly affected by poultry manure rate in both Kafanchan and Kadawa. However, the effect of poultry manure on maize plant height and cob diameter was not significant in Kafanchan. The application of inorganic fertilizer had a positive and significant influence on all maize growth and yield attributes in both locations. Irrigated maize yield showed significant increase with increasing quantities of inorganic fertilizer and poultry manure in both Kafanchan and Kadawa. The results of the field trial indicated that a combination of 120 kg N ha^{-1} inorganic fertilizer and 3.0 t ha^{-1} poultry manure is desirable for optimum irrigated maize yield in Kafanchan and Kadawa.

Keywords: Maize, Irrigation, Poultry manure, Mineral fertilizer; Grain yield

INTRODUCTION
Maize (*Zea mays* L.) is one of the three leading global cereals that feed the world (Shiferaw *et al.* 2011) and together with rice and wheat, dominate human diets and provide at least 30% of the food calories of more than 4.5 billion people in 94 developing countries (Ignaciuk & Mason-D'Croz 2014). Maize alone contributes over 20% of total calories in human diets in 21 low-income countries, and over 30% in 12 countries that are home to a total of more than 310 million people. Maize's central role as a staple food in Africa and Central America is comparable to that of rice or wheat in Asia, with consumption rates being the highest in eastern and southern Africa (ESA). Maize is the third most important cereal crop after sorghum (*Sorghum bicolor*) and millet (*Pennisetum glaucum*) in Nigeria and it is a major staple food that is used as fodder and industrial material with its production at both subsistence and commercial levels in the country (Eleweanya *et al.* 2005).

Modern crop production system is facing a sustainability problem due to indiscriminate use of chemical fertilizers and pesticides (Hidayatullah, 2015) that has resulted in a decline in crop productivity, depletion of soil organic carbon and a depletion of mineral nutrient content. In addition, the continuous and indiscriminate use of chemical fertilizers without organic sources (OSs) leads to gradual decline of organic matter content and a change in native N status of the soils (Amanullah, 2016), which results in yield decline and low crop productivity. Therefore, adequate N sources (organic and mineral) and rates are very important to increase yield and reduce the cost of production and environmental pollution (Fu *et al.,* 2014; Pei *et al.,* 2015).

Many crop species respond well to the application of organic manure as it sustains yield under continuous cropping on most soils unlike equivalent amount of NPK fertilizer. Organic manure is considered to produce higher crop productivity for sustainable agriculture (Myint, *et al.* 2010), as such a judicious use of chemical and organic fertilizers can improve maize plant growth, increase its yield and quality. Nutrient rich organic manures can serve as an effective substitute to reduce the costs of chemical fertilizers (Masarirambi, *et al.* 2012). Furthermore, soil organic manures can not only provide nutrients to the soil but also improves water holding capacity and assist the soil to maintain better aeration for seed germination and plant root development (Zia, *et al.,* 1998).

Poultry manure has been reported to be the most valuable of all manures produced by livestock. The nutrient content of poultry manure is among the highest of all animal manure, and the use of poultry manure as soil amendment for agricultural crops provides appreciable quantities of all the major plant nutrients (Laekemariam & Gidago 2013). Hence, combine use of organic poultry manure with inorganic fertilizers holds a considerable potential as a remedial measure in fertility management to boost the production of maize crop. Studies conducted by various researchers demonstrated the positive outcomes of integrated nutrient management in many areas (Ahmed *et al.* 2007; Laekemariam & Gidago, 2012).

The search for an optimum application rate of poultry manure in combination with mineral fertilizer in irrigated maize production is the principal justification of the research. Therefor this study was conducted to evaluate the agronomic performance of irrigated maize under the application of varying levels of inorganic fertilizer and different rates of composted poultry manure (CPM).

MATERIALS AND METHODS
Two field experiments were conducted under irrigation during 2019/2020 dry season at the Teaching and Research Farm of the Department of Crop Science, Kaduna State University, Kafanchan Campus and Kadawa Irrigation Research Station of the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria

Nigeria. The soils at the two experimental sites were well drained, often-leached Ultisol and sandy loam in texture.

The experiments were laid out in a randomized complete block design with three replications. Three quantities of Poultry Manure: 1.5, 3.0, and 4.5 t ha^{-1} were incorporated into the soil prior to planting while different levels of Inorganic Fertilizer (N_{20} P_{10} K_{10} grade) at the rate of 0, 100, 120, and 140 kg N ha^{-1} were applied in two split dose; half was drilled into the soil 2 weeks after planting (WAP) and half was top dressed onto the soil surface 6 WAP. All plots were uniformly irrigated after planting to establish a stand. Water was subsequently applied to each plot at weekly interval using gated pipe with approximately 100 mm of water applied every irrigation.

The experimental sites were ploughed, harrowed and ridged and the fields were marked into plots that were 3 x 6 m in size, consisting of six rows of maize spaced 0.75 m apart. The maize variety SAMMAZ 140 was planted on November 15 and 12, at Kafanchan and Kadawa respectively in the dry season by direct seeding in the soil and covering lightly. The recommended agronomic and plant-protection practices for maize production were employed during the growing season.

Maize growth parameters such as plant height, stem girth, leaf area index (LAI), dry matter yield, 50% silking and 50% tasseling were taken from a random sample of five tagged plants at 3, 6 and 9 weeks after planting. At final harvest, cob weight, cob size, 1000-grain weight, and grain yield were determined. All data collected were analyzed statistically using the GLM procedure of the SAS software (SAS, Institute Inc. 1985). Irrigation and nitrogen effects were evaluated by mean comparison using DMRT at 5% significant level.

RESULTS

Growth Parameters

The effect of the application of different quantities of poultry manure and varying levels of inorganic fertilizer on maize plant height is presented in Table 1. The data showed an increase in maize plant height with increasing quantities of poultry manure in Kafanchan and Kadawa, with significant ($P \le 0.01$) increases recorded only in Kadawa. Highly significant increases in maize height was observed with increasing levels of inorganic fertilizer in both locations with the highest value of 249.98cm and the lowest 122.67cm recorded in Kafanchan and Kadawa respectively.

Result with respects to leaf nitrogen content as influenced by different quantities of poultry manure and varying levels of inorganic fertilizer is presented in Table 1. Significant ($P \le 0.01$) effect of the combined application of poultry manure and inorganic fertilizer on maize leaf nitrogen content was recorded in the two experimental sites. There was a linear increase in leaf nitrogen content with each increase in the amount of poultry manure applied in Kafanchan and Kadawa. Similarly, in both experimental sites, each increase in inorganic fertilizer significantly increases leaf N content except the insignificant variation in maize plant height due to an additional application from 0 to 100 Kg N ha^{-1}.

The influence of different quantities of poultry manure and varying levels of inorganic fertilizer maize on dry matter is presented in Table 1. The data showed a positive and highly significant response of maize dry matter to the application poultry manure and inorganic fertilizer in Kafanchan and Kadawa. Each increase in poultry manure rate resulted in an increase in dry matter accumulation in the two research locations, with the lowest (120g) and the highest (180g) dry matter yield observed in Kadawa and Kafanchan respectively. An increase in the quantity inorganic fertilizer from 0 to 100 Kg N ha^{-1} had no significant effect on dry matter, however subsequent addition from 100 to 140 Kg N ha^{-1} resulted in a significant increase in the parameter in the two research sites.

Table 1: Effects of Inorganic fertilizer levels and poultry manure rates on the growth of irrigated maize in Kafanchan and Kadawa research fields

	Plant Height (cm) 7WAS		Leaf N Content (%)		Dry Matter Wt (g) 7WAS	
Treatments	Kafanchan	Kadawa	Kafanchan	Kadawa	Kafanchan	Kadawa
Poultry Manure (t/ha)						
1.5	209.03	142.42a	1.27c	1.19c	128c	120c
3.0	212.58	137.42ab	1.62b	1.52b	164b	154b
4.5	220.77	134.92b	1.77a	1.71a	180a	174a
SE ±	4.42	1.94	0.04	0.04	4.04	4.04
Significance	N	*	**	**	**	**
Inorganic fertilizer (kg N ha^{-1})						
0	192.45c	122.67d	1.26c	1.20c	127c	121c
100	199.20c	130.22c	1.34c	1.25c	136c	127c
120	223.33b	143.98b	1.70b	1.60b	173b	163b
140	249.98a	156.22a	1.93a	1.83a	197a	180a
SE ±	5.11	2.24	0.05	0.05	5.05	5.05
Significance	**	**	**	**	**	**

Means followed by the same letter(s) within a column of a treatment group are not statistically different using DMRT. *, ** = significant at 5 % and 1 % levels, respectively. NS = not significant

Yield Components and Grain Yield

Table 2 showed the effect of different quantities of poultry manure and varying levels of inorganic fertilizer on maize cob diameter. The result indicated that the application of poultry manure had no significant effect on cob diameter in Kafanchan. However, significant variation in cob diameter was observed due to the application of manure in Kadawa, where the highest maize cob diameter (10.00cm) due to the addition of 4.5 t/h manure was statistically at par with the cob diameter recorded at 3.0 t/h. Application 1.5 t/h poultry manure resulted in least (9.25cm) cob diameter in Kadawa. Significant variation ($P \le 0.05$) in maize cub diameter was observed due to the application of inorganic fertilizer in both Kafanchan and Kadawa. Addition of inorganic fertilizer from 0 to 120 t/h resulted in linear increase in cob diameter while further increase to 140 t/h had no significant effect on the parameter in Kafanchan. The highest cob diameter of 12.22cm was obtained with application of 140 t/h manure at Kadawa while the lowest (07.56) was recorded when no fertilizer was added to the crop.

The response of 1000-grain weight to the application of different quantities of poultry manure and varying levels of inorganic fertilizer is presented in Table 2. Result from this experiment showed significant ($P \le 0.01$) variation in 1000-grain weight with the application of poultry manure in both Kafanchan and Kadawa. There was a significant increase in 1000-grain weight with increasing levels of poultry manure from 1.5 up to 4.5 t/h in Kafanchan. In Kadawa, the Weight of 1000-grains produced by 4.5 t/h poultry manure (320.92g) was significantly higher than that produced by the application of 1.5 and 3.0 t/h manure (288.58g and 290.08g respectively) that were statistically at par. While the addition of inorganic fertilizer had no significant effect on 1000-grain weight in Kadawa, its application had a significant ($P \leq 0.01$) effect on the parameter in Kafanchan where an increase in inorganic fertilizer from 0 to 120 Kg N ha^{-1} resulted in linear increase in 1000-grain weight after which it levels up.

The influence of different quantities of poultry manure and varying levels of inorganic fertilizer on maize grain yield is presented in Table 2. The data presented showed that application of poultry manure and inorganic fertilizer had significant ($P \leq 0.01$) influence on irrigated maize grain yield in the two locations. In Kafanchan the poultry manure applied at 1.5 t/ha had significantly lower maize yield compared with poultry manure applied at 3.0 and 4.5 t/ha that were statistically at par ($P \leq 0.01$). In Kadawa however, each successive increase in poultry manure had resulted in a significant increase in irrigated maize yield. With regard to the effect of inorganic fertilizer, significant increases in maize yield were observed with successive increase in inorganic fertilizer in both Kafanchan and Kadawa. The highest maize grain yield (8.35 t/ha) due to the application of inorganic fertilizer was recorded in Kafanchan while the lowest (3.66 t/h) was observed in Kadawa.

Table 2: Effects of Inorganic fertilizer levels and poultry manure rates on the growth of irrigated maize in Kafanchan and Kadawa research fields

	Cob Diameter (cm)		1000-grain Weight (g)		Grain Yield (t/ha)	
Treatments	Kafanchan	Kadawa	Kafanchan	Kadawa	Kafanchan	Kadawa
Poultry Manure (t/ha)						
1.5	11.75	9.25b	290.92c	288.58b	6.31b	4.65c
3.0	11.42	10.17a	330.00b	290.08b	7.25a	5.51b
4.5	12.17	10.00a	340.67a	320.92a	7.19a	6.22a
SE ±	0.23	0.24	0.36	0.22	1.00	0.67
Significance	NS	*	**	**	**	**
Inorganic Fertilizer (kg N ha^{-1})						
0	08.89c	07.56c	290.33c	290.78	5.15d	3.66d
100	11.11b	08.33c	220.22b	300.22	6.27c	4.50c
120	13.22a	11.11b	330.89a	300.44	7.89b	6.20b
140	13.89a	12.22a	340.67a	300.33	8.35a	7.49a
SE ±	0.26	0.28	04.1	02.6	1.15	0.77
Significance	**	**	**	NS	**	**

Means followed by the same letter(s) within a column of a treatment group are not statistically different using DMRT. *, ** = significant at 5 % and 1 % levels, respectively. NS = not significant

DISCUSSION

The influence of mineral fertilizer on all maize growth and yield parameters was positive and significant in both Kafanchan and Kadawa experimental sites. This result is in line with previous observation by Laekemariam & Gidago (2013). The influence of mineral fertilizer on crop could be linked to the availability of N required for plant growth and development. In addition, inorganic fertilizer normally, releases its nutrients quickly as against poultry manure, which does that slowly as it takes organic fertilizers longer time to mineralize. Similar results were reported by Ghafoor & Akhtar (1991) who stated that application of high N rates had significant effect on plant height and subsequent growth of the maize crop.

It was observed in Kafanchan and Kadawa that the influence of inorganic fertilizer on maize dry matter yield and subsequent crop growth was highly significant. Dry matter is an expression of the crops biological yield and a measure of plant relative growth rate and is a reflection of the net assimilation rate (Khan *et al.* 2008). The increase in biological yield of maize could reflect the better growth and development of the plants due to the availability of nutrients throughout the growing period. This result was in agreement with the findings of Laekemariam & Gidago (2013).
The effect of inorganic fertilizer on maize cob diameter was not significant in Kafanchan but was observed to be significant ($P \leq 0.01$) in Kadawa. The statistically significant effect observed could be due to the fact that more photosynthetic activities of the plant on the account of adequate supply of nitrogen. Nitrogen is an essential requirement of cob growth. Therefore, the bigger the cob size, the better the crop development and the higher the economic yield of maize crop as reported previously (Khan *et al.* 2008). This finding is in agreement with that of Rajeshwari *et al.* (2007), and Laekemariam & Gidago (2013) who reported a significant increase in cob size and length with increasing rates of nitrogen fertilizer application.

This study clearly demonstrates that application of poultry manure had an influence on growth parameters such as plant height, leaf nitrogen content and dry matter weight. This is in line with the findings of Mitchell & Tu (2005) and Dauda *et al.* (2008) who reported that application of poultry manure had resulted in increased plant height. The significant effect on maize growth with respect to increase in plant height and dry mater may be linked to ability of poultry manure to supply plant nutrients on a continuous basis as reported by Farhad *et al.* 2009. In addition, Kareem *et al.* (2017) were of the opinion that application of poultry manure may have enhanced the activities of shoot apical meristem, which, in turn led to an increase in height.

Application of high levels of poultry manure could increase plant height, its dry shoot and root weight as previously reported by Hossain *et al.* (2012). Dry matter production in plant is a determinant of photo-assimilate production with N availability that will ultimately result in increased vegetative production. This is because poultry manure has long been recognized as the most desirable organic fertilizer because it improves soil fertility by adding essential nutrients, as well as soil organic matter, which improves soil moisture and nutrient retention (Farhad *et al.* 2009).

Combined application of fertilizer had a highly significant influence on maize grain yield in this field studies. Statistically significant increase in grain yield was recorded in this field experiment with application of poultry manure in Kafanchan and Kadawa. The observed yield increase could be due to an ample supply of the needed nutrients for growth and development of the plant, which in turn led to production of higher assimilate, that was judiciously partitioned into the economic parts of the crop as reported by Udom & Bello (2009).

Grain yield is the end result of many complex morphological and physiological processes occurring during the growth and development of crop (Khan *et al.* 2008). The better grain yield with combine application of inorganic fertilizer and poultry manure could be associated to improved plant growth and development; higher yield attributes and increased nutrient use efficiency. This result is in line with those reported previously, Nagassa *et al.* (2005) and Shah *et al.* (2009), who revealed that grain yield was significantly affected by N fertilizer in combination with farm yard manure. Similarly, Ayoola & Makinde (2009) observed increased nutrient use efficiency with the application of organic manure in combination with inorganic fertilizers.

It is noteworthy that maize cob thickness, 1000-grain weight and yield per unit area were all significantly improved by application of 3.0 and 4.5 t/ha poultry manure. However, the yield difference between the applications of these two quantities of organic fertilizer was marginal and not significant particularly in Kafanchan. The existence of marginal difference between application of 3.0 and 4.5 t/ha could be attributed to luxury consumption beyond 3.0 t/ha application. Therefore application of poultry manure beyond that level could neither be economical nor profitable.

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REFERENCES
Ahmed A.U.H., Qadir I. and N. Mahmood (2007): Effect of integrated use of organic and inorganic fertilizers on foffer yield of sorghum (*Sorghum bicolar* L.). *Pakistan Journal of Agric. Science.* 44:415-421.

Amanullah, H. (2016): Influence of organic and inorganic nitrogen on grain yield and yield components of hybrid rice in Northwestern Pakistan. *Rice Science,* 23(6): 326-333. Available online at www.sciencedirect.com.

Ayoola, O. T. and E. A. Makinde (2009): Maize growth, yield and soil nutrient changes with N enriched organic fertilizers. *African Journal of Food, Agriculture and Nutrition.* 9:580-592

Dauda, S. N., Ajayi, F.A., and E. Ndor (2008): Growth and yield of watermelon (*Citrullus lanatus*) as affected by poultry manure application. *Journal of Agriculture and Social Science.* 4(3):121-124

Eleweanya, N.P., Uguru, M.I., Enebong, E.E. & Okocha, P.I. (2005): Correlation and path coefficient analysis of grain yield related characters in maize (*Zea mays* L.) under Umudike conditions of South Eastern Nigeria. *Agro-Science Journal of Agriculture, Food, Environment and Extension,* 4(1):24-28.

Farhad, W., Saleem, M. F.. Cheema, M. A. and Hammad, H. M. (2009): Effect of poultry manure levels on the productivity of spring maize (*Zea mays* L.). *JAPS* 19(3):122-125

Fu J., Wang Z. Q., Yu L. M., and J.C. Yang (2014): Effect of nitrogen rates on grain yield and some physiological traits of super rice. *China Journal of Rice Science* 28(4):391-400. (in Chinese with English abstract)

Ghafoor, A. and S. Akhtar, (1991): Response of spring maize cv. Agatti-72 to nitrogen fertilization under saline sodic soil culture. *Pakistan Journal of Agric. Science* 23:374-378.

Hidayatulla, A. (2015): Sources, ratios and mixtures of organic and inorganic nitrogen influence influence on plant height of hybrid rice (*Oryza sativum*) at various growth stages. *E. C. Agric.* 2(3):328-337

Hossain, N., Kibria, M. G and K. T. Osman (2012): Effect of poultry manure, house hold waste compost and inorganic fertilizers on growth and yields of maize (*Zea mays* L.). *IOSR-JPBS.* 3(2):38-43

Ignaciuk, A., and Mason-D'Croz, D. (2014): Modeling adaptation to climate change in agriculture, OECD *Food, Agriculture and Fisheries Papers, No. 70, OECD Publishing.*

Kareem, I., Jawad, O.B., Eifediyi, E.K., Bello, W.B. and Y. Oladosu (2017): Improvement of growth and yield of maize (*Zea Mays* L.) by poultry manure, maize variety and plant population. *Cercetari Agronomice in Maldova.* Vol. L. No. 4 (172)/2017: 51- 64

Khan, H. Z., Malik, M. A. and M. F. Saleem (2008): Effect of rate and source of organic material on the production potential of spring maize (*Zea mays* L.). *Pakistan Journal of Agric. Science 45: pp. 40-43*.

Laekemariam, F and G. Gidago (2012): Response of maize (*Zea mays* L) to integrated fertilizer application in Wolaita, *Southern Ethiopia. Advance Life Science.]Technology 5:21-30*

Laekemariam, F and G. Gidago (2013): Growth and yield response of maize (*Zea mays* L) to variable rates of compost and inorganic fertilizer integration in Wolaita, Southern Ethiopia. *American Journal of Plant Nutrition and Fertilization Technology 3 (2):43-52*

Masarirambi M. T., Mandisodza F. C., Mashingaidze A. B. and E. Bhebhe (2012): Influence of plant population and seed tuber size on growth and yield components of potato (*Solanum tuberosum*). *International Journal of Agric. Biol.* 14:545-549.

Mitchell. C. C. and S. Tu (2005): Long term evaluation of poultry litter as a source of nitrogen for cotton and corn. *Agronomy Journal* 97: 399-407

Myint A. K.., Yamakawa T., Kajihara Y. and T. Zenmyo T. (2010): Application of different organic and mineral fertilizers on the growth, yield and nutrient accumulation of rice in a Japanese ordinary paddy field. *Science World Journal* 5(2):47-54.

Nagassa, W., Heluf, G., Abdena, D. and Geremew, E. (2005): Effect of integrated use of farm yard manure, N and P fertilizers on maize in Western Oromia of Ethiopia. *Indian*

Journal of Fertilizer, 1:47-58.

Pei P. G., Zhang J. H., Zhu L. F., Hu Z. H. and Q. Y. Jin (2015): Effects of straw returning coupled with N application on rice photosynthetic characteristics, nitrogen uptake and grain yield formation. *China Journal of Rice Science* 29(3): 282-290. (in Chinese with English abstract)

Rajeshwari, R. S., Hebsur, N. S., Pradeep and Bharamgoudar, (2007): Effect of integrated nutrient management on growth and yield of maize. *Karnataka Journal of Science* 20:399-400.

SAS Institute, Inc. (1985). SAS/STAT™ guide for personal computer. 6th ed. *SAS Inst. Cary NC.*

Shah, S. T. H.. Zamir, M. S. I., Waseem, M., Tahir. M. and Khalid, W. B. (2009): Growth and yield response of maize (*Zea mays* L.) to organic and inorganic sources of nitrogen. *Pakistan Journal of Life Social Science* 7:108-111

Shiferaw, B., Prasanna, B.M., Hellin, J., Bänziger, M. (2011): Crops that feed the world. Past successes and future challenges to the role played by maize in global food security. *Food Security* 3: 307-327.

Udom, G. N. and H. M. Bello, (2009): Effect of poultry litter on the yield of two maize varieties in the northern Guinea Savannah. *Journal of Tropical Agriculture, Food, Environment and Extension.* 8(1):51-54

Zia M. S., Baig M. B. and M. B. Tahir (1998): Soil environmental issues and their impact on agricultural productivity of high potential areas of Pakistan. *Science Vision* 4:56-61