Journal of Agriculture and Environmental Sciences
June 2014, Vol. 3, No. 2, pp. 299-314
ISSN: 2334-2404 (Print), 2334-2412 (Online)

Published by American Research Institute for Policy Development

Effects of Combining Chemical Fertilizer and Three Different Sources of Organic Manure on the Growth and Yield of Maize in Sub-Sahelian Savanna, Nigeria

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Abstract

Agriculture in the sub-Sahelian savanna of Nigeria is characterized by low productivity due to decline in soil fertility. This is mainly attributed to the mining of nutrients due to continuous cropping without external addition of adequate nutrients coupled with low activity clay and kaolinitic mineralogy which promotes limited and inadequate land productivity. The adoption of combination of organic manure and chemical fertilizers is being taken as one of solutions to the situation. This study was carried out to investigate the effect of chemical fertilizer and three different sources of organic manure on some growth parameters and yield of maize. Field trials were carried out in 2008 and 2009 cropping seasons at the Teaching and Research Farm of the Department of Soil Science, University of Maiduguri, Maiduguri (11° 53' N; 13° 16' E). The treatments consisted of four levels of nitrogen fertilizers (0, 45, 60 and 90 kg N/ha) combined with three types of organic manures (cow dung, municipal wastes and poultry droppings) applied at three rates of each organic manure (0.0, 2.5, and 5.0 tons/ha). The experiment therefore contained twenty-eight (28) treatments laid out in factorial design and replicated three times in a randomized fashion. An extra-early variety of maize (SAMMAZ 28) was obtained from the Promoting Sustainable Agriculture in Borno State (PROSAB), Maiduguri. Plant height, number of leaves per plant, and leaf area were some of the growth parameters measured as well as grain yield in kg/ha. Plant height was not so much affected by the combination of chemical fertilizer and organic manure but chemical fertilizer levels alone significantly affected the plant height in 2008, 2009 and in the combined analysis. Leaf area was also significantly affected by chemical fertilizer levels in 2008, 2009 and in the combined analysis. Leaf area was also significantly affected by organic manure types in 2009 and in the combined analysis but not in 2008. Combining rates of nitrogen fertilizer (90 kg/ha N) with poultry droppings (5.0 tons/ha) gave the highest grain yield especially in 2008 (2466.7 kg/ha) and in the combined analysis (1883.7 kg/ha). It could be deduced that grain yield and yield parameters were significantly increased with the application chemical fertilizer (90 kg N/ha) in combination with cow dung and poultry droppings at the rate of 5.0 tons/ha. Chemical fertilizer rates of 60 or 90 kg/ha in combination with poultry manure or cow dung (5.0tons/ha) will give optimum yield of maize on the savanna soils.

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Keywords: Chemical Fertilizer, Organic Manures, Yield, Maize, sub-Sahelian, Savanna, Nigeria

Introduction

Maize requires heavy fertilizer application for optimum yield in terms of nitrogen derived from chemical or organic fertilizers (Awotundun, 2005). Maize therefore is high demanding crop for nitrogen than any other cereals (Onwueme and Sinha, 1991). However, the amount applied depends mainly on the projected maize yield that appears available and attainable in the locality and the fertility level of the soil as determined by soil test (Shukla, 1990). FPDD (2002) reported a significant difference in grain yield of maize due to application of fertilizer (ammonium sulphate).

Whereas mineral fertilizer and organic manures both separately or combined have beneficial effects upon soil and crop, their combined use is expected to yield rewarding dividends (Rayar, 2000). According to Rayar (2000), application of mineral fertilizer alone to boost the yield may be favorable for a few growing seasons. Such agronomic practice would undoubtedly lead to regrettable consequences. This might involve complete crop failure or a drastic reduction in yield-due largely to non supply of some vital secondary and trace elements to soil because of exhaustive nature of previous crops and initiation of soil degradation. On the other hand, by combining application of organic manures and mineral fertilizers, the yield is expected to stabilize over the years, indicating substantial improvement in soil fertility. The use of poultry droppings, cow dung and household wastes increase the efficiency of mineral fertilizers by providing the secondary and micro-nutrients not present in the mineral fertilizers.

Long-term studies in Northern Nigerian savanna showed that five tons (5 t/ha) of cow dung annually will maintain yield of maize under continuous cultivation especially in combination with chemical fertilizers (FPDD, 2002). Kwari and Bibinu (2002), recommended a rate of 7.5 to 10.0 t/ha of animal manure for cereals in general. Tisdale *et al* (1985) and Olomilua *et al*., (2007), reported that 5.5 to 7.5 t/ha of FYM will be adequate for maize. Bationo and Lompo (2003), reported significant increase in yield of maize with application of mineral fertilizer. But yield was higher when mineral fertilizer was combined with organic manure.

Gaur (1982), found a significantly higher yield of maize with mineral fertilizer application. But yield did not differ from that with FYM application.

Phosphorus up take in maize was increased with application of poultry droppings in combination with chemical fertilizer. A tremendous response of maize to foliar application of boron in the presence of FYM was also recorded. Awotundun (2005), found increased height and grain yield of pop-corn with application of FYM and NPK fertilizers when applied in combination. Azeez *et al*., (2007) also observed good response of maize to application of crop residues in form of burnt ash. But the response was for a short time. For a sustained increase in soil nutrient levels and yield of maize, incorporation of ash should be complemented with mineral fertilizers. There is the need therefore for the combined use of organic and inorganic fertilizers to improve and maintain the fertility status and enhance maize production in the study area.

Statement of the Problem

Most soils of savanna zone of Northern Nigeria are weakly buffered and chemically fragile. These soils are inherently low in organic matter content and low activity clay and subsequently low in fertility status. Improvement of the fertility status of these soils by application of either mineral or organic fertilizers and their effects on other cereal crops such as millet and sorghum are well studied (Rayar and Haruna, 1985; Kumar and Rowland, 1993). However, the influence of these fertilizers on Maize growth and yield has not received adequate attention in the study area and need more research investigations. Mineral fertilizers in particular induce soil acidity, reducing CEC and buffering capacity of the soil, thereby leaving the soil with nutrient imbalance (Rayar, 2000; Olomilua, *et al*., 2007). Excessive application of organic manures on the other hand can induce alkalinity and micronutrient deficiencies especially zinc. There is the need for the combined use of organic and inorganic fertilizers to improve the soil chemistry and improve and maintain the fertility status and enhance maize production in the study area.

Scope of the Study

The study was conducted at the University of Maiduguri, Teaching and Research Farms during the 2008 and 2009 cropping seasons. Three different sources of organic manures, cow dung, poultry droppings and municipal wastes were used in combinations with four levels of nitrogen fertilizer (0, 45, 60 and 90 kg/ha N) on one maize variety (SAMMAZ 28).

Significance of the Study

Application of fertilizer either inorganic or organic form to improve the chemical properties, enhancing the fertility status of the soil and increase maize production in the area is of paramount importance. However, applications of inorganic or organic fertilizer alone have their own side effects on the soil. The need to study the effects of nitrogen fertilizer and organic manure combination on the yield of maize cannot be over-emphasized. This study will provide information on response of NPK fertilizers and manure on maize yield. By complementing three different sources of organic manure and chemical fertilizers, soil productivity and smallholder farmers' livelihoods can be improved through higher yields of maize and thus income. Lastly, the study will result into useful information to guide extension services.

Objective of the Study

Generally, this study was aimed to determine the optimal rates of chemical fertilizer and organic manure combinations for maize production in the study area.

Potential for future Research

This is unlimited and inexhaustible study in the field of Agriculture. Future Researches and Researchers can be carried out on the effects of these fertilizer combinations on different crops or looking at their effects of the populations and activities of Soil microbes, or on distribution and availability of micronutrients and so on.

Literature Review Summary

One of the major problems affecting food production in Africa is the rapid depletion of nutrients in smallholder farms (Rayar, 2000). Soil nutrient replenishment is therefore a prerequisite for halting soil fertility decline. This may be accomplished through the application of chemical in combination with organic fertilizers. Animal manures are valuable sources of nutrients and the yield-increasing effect of manure is well established (Leonard, 1986). Organic matter in the soil improves soil physical conditions by improving soil structure, increases water –holding capacity, and improves soil structure and aeration, as well as regulating the soil temperature (Gachene and Gathiru, 2003).

Organic matter contains varying amounts of plants nutrients, especially nitrogen, phosphorus and potassium, which are slowly released into the soil for plant uptake (Gachene and Gathiru, 2003). Chemical fertilizers are used in modern agriculture to correct known plant nutrient deficiencies; to provide high levels of nutrition, which aid plants in withstanding stress conditions; to maintain optimum soil fertility conditions; and to improve crop quality. Adequate fertilization programmers supply the amounts of plant nutrients needed to sustain maximum net returns (Leonard, 1986). The broad aim of Integrated Soil Fertility Management (ISFM) is to utilize available organic and inorganic sources of nutrients in a judicious and efficient manner (Rayar, 2000). Based on the evaluation of soil quality indicators, Dutta et al. (2003) reported that the use of organic fertilizers together with chemical fertilizers, compared to the addition of organic fertilizers alone, had a higher positive effect on microbial biomass and hence soil health. Sutanto et al. (1993) in their studies on acid soils for sustainable food crop production noted that farmyard manure and mineral fertilizer produced excellent responses. Boateng and Oppong (1995) studied the effect of farmyard manure and method of land clearing on soil properties on maize yield and reported that plots treated with poultry manure and NPK (20-20-0) gave the best yield results.

Materials and Methods

Description of the Study Area

Field trials were conducted during the rainy seasons of 2008 and 2009 at the Teaching and Research Farm of the Department of Soil Science, University of Maiduguri (11^{o}53'N; 13^{o}16'E), on the northern fringes of the Sudan savanna belt of Nigeria.

This belt forms part of the semi-arid zone. It is characterized by a short rainy season of 100 – 150 days with a long dry season of at least 7 months, and a mean annual rainfall of about 500 mm (Yunusa and Ikwelle, 1990).

The major soil type found in the study area is *Typic ustipsament* as described by Rayar (1987) derived primarily from the recent Aeolian sand deposits of the Sahel savanna. Thus, the soils are characterized by sandy texture with low organic matter content, low CEC and inherent low fertility status.

Millet is the dominant crop cultivated in the area. Sorghum and maize are also cultivated to lesser extent around Ngom area. According to Shuaib *et al*., (1997), other agricultural activities and land use are also practiced. These include irrigation, livestock, poultry, forestry and fishery among others. Meteorological (rainfall) data of the area for the two cropping season (2008 and 2009) were obtained from the Meteorological station of Borno College of Agriculture, Maiduguri.

Land Preparation and Experimental Design

Field experiments were conducted in two successive cropping seasons, 2008 and 2009. The field was ploughed and harrowed to a fine tilth and marked out into plots of 4x4 m (16 m^2) during the first year. In the second year the plots were prepared by hand hoes so as not to disturb the plots.

The treatments were $N_oP_oK_o$, N_{45} P_{30} K_{30}, N_{60} P_{30} K_{30} and N_{90} P_{30} K_{30} which were combined with three sources of organic manures (cow dung, municipal wastes and poultry droppings) at three (3) rates each (0, 2.5 and 5.0 tons/ha). The experiment was a factorial design of 3x4x3 factorial, consisting of twenty-eight (28) treatments laid out in a randomized Completely Block Design replicated three times giving a total of 84 plots.

The nitrogen fertilizer used was NPK 15-15-15 (standard) supplemented by urea (46 % N). The three types of organic manures used were cow dung (CD), municipal wastes (MW) and poultry droppings (PD), respectively. Cow dung was collected from the animal farm of the Borno College of Agriculture, Maiduguri in June, 2008 and 2009. Municipal wastes were also collected from the refuse dump within the Staff Quarters of the College in the same years of experiment.

Poultry droppings were collected from the poultry production unit (PPU), a division of the Borno State Ministry of Agriculture, Maiduguri in the same years of experiment.

Complete doses of organic manures (2.5 t/ha or 4.0 kg/ net plot and 5.0 t/ha or 8.0 kg/net plot) were applied at land preparation. Half of nitrogen (45 kg/ha or 72 g/net plot, 60 kg/ha or 96 g/net plot and 90 kg/ha or 144 g/net plot) was applied at planting, while the last half was applied two weeks after planting.

Planting and Harvesting

Before planting, the field was harrowed once, leveled and the plots were laid out. The sub-plots measuring 4 x 4 m ($16m^2$) and net plot =2m×2m ($4m^2$) were marked out and fertilizer was applied at rates contained in the fertilizer treatments. At planting, a certified seed was used and planted in holes about 3 cm deep on 11th July in 2008 and 2009, respectively. Seedlings were thinned to two plants per stand at about 2 weeks after sowing (WAS). The inter row spacing was 60 cm and intra-row spacing was 30 cm. An extra-early variety of maize (SAMMAZ 28) was obtained from the Agronomy Department, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria through the project, Promoting Sustainable Agriculture in Borno State (PROSAB), Maiduguri. Weeds were controlled manually using a hand hoe at 3, 6, and 9 WAS.

The crop was harvested on 10th October and 12th October in 2008 and 2009, respectively. Two middle rows of each net plot were harvested and used as net weight after which the general harvest followed.

Data Collection

Plant height (cm)

Plant height was measured using a graduated meter rule measuring from the base to the inner most leaf of the plant. Five randomly selected plants in each net plot were measured. Measurements were taken at maturity (8 weeks after sowing), and the mean of the five plant heights was recorded.

Leaf area (LA)

The leaf area was measured using a graduated meter rule. The length and breadth of each leaf from the net plot was measured and the leaf area was calculated by multiplying the length with the breadth (Area = length x breadth x 0.76).to get the (LA).

Grain yield (kg/ha)

The cobs harvested from the net plots were sun-dried, threshed using mortar and pestle and then winnowed. Grains were weighed with a physical balance on the farm after sun drying and the grain yield expressed in kg/ha.

Results and Discussion

Physico-Chemical Characteristics of the Soil of the Experimental Site

The soil of the study was sandy loam in texture with high proportion of sand (76.20%). This implies that basic cations such as Ca, K, Na and Mg would be leached more easily as texture determines the degree of retention or ease of leaching of basic cations. Bationo and Mokwunye (2003) reported that Entisols and Alfisols occupy most of the soils of Sudano-Sahelian zones of West Africa which are mainly composed of quartz sand, with low water and nutrient holding capacity.

The soil was slightly acidic in pH (6.20) and low EC (0.0173 dS/m). Effective cation exchange capacity (ECEC) was low in the soil with high percentage base saturation (PBS). Organic carbon content, total nitrogen and available P were also low in the soil. Low organic carbon and organic matter in the soil of the experimental site was probably as a result of high proportion of sand content of the soil.

Jones and Wild (1975) reported that organic matter content decreased latitudinal from the south to the north as the amount of rainfall received and vegetation cover decreases. Low organic carbon is attributed to inadequate supply of organic litter, bush burning, long dry season and intensive mineralization during the rainy season (Dugje *et al*., 2008).

Wapa and Kwari (2004) also observed that the soils of northern savanna of Nigeria are characteristically sandy, low in active clay content but high in kaolinite and variable in cation exchange capacity. Furthermore, the low N levels observed in the soil can be attributed to continuous cropping and increased land use intensity. Mafongaya *et al*. (2003) cautioned that soil fertility depletion would be a serious problem in areas where land use intensification was on the increase. The low available P agrees with reports of Jones and Wild (1975) and Dugje *et al.* (2008), that P is one of the limiting nutrients to crop production in northern Nigeria. Based on FAO (1984) ratings, nutrient contents of the soil were within the low rating scale.

Selected Chemical Properties of the Different Organic Manures used

All the three organic manures used were neutral in pH (cow dung = 7.3, municipal wastes = 7.3 and poultry droppings = 6.85), yet the pH was slightly higher (alkaline) in municipal wastes and lowest in poultry droppings. The EC was highest in municipal wastes and lowest in poultry droppings. On the other hand nitrogen content was highest in poultry droppings and lowest in municipal wastes. The higher content of nitrogen in poultry droppings might be as a result of higher content of uric acid in the poultry droppings. Delin (2011) reported that poultry manure differs from that of mammals because of its content of uric acid, which is rapidly converted to ammonium and therefore has a higher fertilizer value than other organic nitrogen in manures. Nahm (2003) earlier observed that the amount of N that mineralizes from poultry manure after application depends on the amount of uric acid that has already been transformed during storage.

Effect on Grain Yield in 2008 and 2009

The effect of nitrogen fertilizer and organic manure combination on grain yield of maize in 2008, 2009 and combined analysis are presented in Table 3. Application of nitrogen fertilizer in combination with cow dung, municipal wastes or poultry droppings all gave significant increase in grain yield in 2008, 2009 and the combined analysis, with higher rates giving higher yields.

However, application of nitrogen fertilizer in combination with poultry droppings gave the highest grain yield in 2008, 2009 and in the combined analysis. Application at the rates of 90 kg N/ha combined with 5.0 tons/ha of poultry droppings had the highest quantities of grain yield in 2008 (2533.3 kg/ha), 2009 (1720.7 kg/ha) and in the combined analysis (2127.0 kg/ha).

According to Rayar (2000), application of mineral fertilizer alone to boost the yield may be favorable for a few growing seasons. Such agronomic practice would undoubtedly lead to regrettable consequences. This might involve complete crop failure or a drastic reduction in yield-due largely to non supply of some vital secondary and trace elements to soil because of exhaustive nature of previous crops and initiation of soil degradation.

On the other hand, by combining application of organic manures and mineral fertilizers, the yield is expected to stabilize over the years, indicating substantial improvement in soil fertility. However, several instances could be quoted where application of mineral fertilizer actually increases yield of crops at least for short time. For example, in Tanzania, high yielding maize and sorghum varieties combined with application of mineral fertilizer increased yield and gross return by more than 200% (Bationo and Lompo (2003). They reported significant increase in yield of maize with applications of mineral fertilizer in combination with farm yard manure (FYM). Gaur (1982) earlier found an increase in phosphate up take in maize with application of poultry dropping in combination with chemical fertilizer in India. Azeez *et al*., (2007) observed good response of maize to application of crop residues in form of burnt ash, but the response was for a short time in Ogun State, Nigeria.

Effects on Plant Height

Plant height was not significantly affected by organic manure types and their application rates. However there was slight increase in height as the rate of organic manure was increased.

There was also no significant effect on plant height due to interaction among all the treatment factors in the two years and in the combined analysis. This showed that application of organic manure in combination with nitrogen fertilizer does not have increasing effect on plant height.

Effects on Leaf area (LA cm^2)

Effects between nitrogen levels and organic manures combination on LA was presented in Table 4. There was significant effect between nitrogen levels and the organic manures combinations on leaf area in 2008, 2009 and in the combined analysis. However, there was no regular trend in the leaf area with the application of nitrogen fertilizer in combination with either cow dung, municipal wastes or poultry droppings in 2008, 2009 or in the combined analysis. Generally, nitrogen fertilizer in combination with poultry droppings had the highest leaf area.

The leaf area was significantly affected by nitrogen fertilizer levels. The LA increased significantly with increase in fertilizer application in 2008, 2009 and combined analysis. This was because leaf area is one of the important growth parameters and it requires much nitrogen.

Correlations between Grain Yield and NPK Contents of Maize Leaves in 2008 and 2009.

Table 5 shows the correlation coefficient between grain yield and NPK content of leaf as affected by nitrogen fertilizer and organic manures in 2008.

Grain yield correlated with leaf area. There was also significantly positive correlation between plant height and leaf area. There was no significant correlation between N and P, N and K or P and K contents in 2008.

Grain yield showed positively significant correlation with plant height, leaf area, N content of leaf and P content of leaf respectively. Leaf area (LA) showed positively significant correlation only with N content of leaves.

Conclusion and Recommendation

Grain yield and yield parameters of maize were significantly increased with the application nitrogen fertilizer (90 kg N/ha) in combination with cow dung and poultry droppings at the rate of 5.0 tons/ha. It could be concluded, therefore, that cow dung (5.0 tons/ha) could be regarded as best among the three organic manures used in respect of grain yield of maize especially when combined with 90 kg N/ha of nitrogen fertilizer.

From the findings of this study, the following recommendations were proposed;

1. Nitrogen fertilizer rate of 60 or 90 kg/ha in combination with poultry manure or cow dung (5.0tons/ha) will give optimum yield of maize on the savanna soils..
2. Municipal wastes should not be applied for improving soil properties or for increasing grain yield of maize because of its significantly low nitrogen content.

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Table 1. Physico-Chemical Characteristics of the Soil of the Experimental Site

Soil characteristics	**Value**
pH (1:2.5 H_2O)	6.20
EC (dS/m)	0.01
ECEC (Cmol/kg)	4.66
Percentage Base Saturation (PBS %)	95.71
Organic carbon (g/kg)	19.0
Total Nitrogen (g/kg)	1.0
C : N Ratio	19.0
Available Phosphorus (Bray-1 P mg/kg)	2.80
Exchangeable Potassium (Cmol/kg)	0.24
Percentage Sand (g/kg)	762.0
Percentage Silt (g/kg)	116.0
Percentage Clay (g/kg)	122.0
Textural class	Sandy loam

Table 2. Some Chemical Characteristics of the Different Organic Manures use

Sample	pH (1:2.5 H	Org. C (%	N (%)	C : N	P (g/ kg)	K (g/kg)
Cow dung (CD)	7.31	14.63	0.39	37.52	2.9	19.7
Municipal wastes (WM)	7.34	6.83	0.34	20.08	0.5	6.0
Poultry droppings (PD)	6.85	11.31	0.45	26.13	0.5	5.7

Table 3. Interaction Effects of Nitrogen Fertilizer and Organic Manures on Grain Yield (Kg/Ha) of Maize in 2008 and 2009 Cropping Seasons

	N-level (kg/ha)			
Organic source	**0**	**45**	**60**	**90**
		2008		
Control	166.7^{i}	1100.0^{f-h}	1766.7^{b-f}	2000.0^{a-d}
CD at 2.5 t/ha	179.3^{i}	1373.3^{d-g}	2246.0^{a-c}	1916.7^{a-d}
CD at 5.0 t/ha	558.3^{hi}	1310.0^{d-g}	1687.7^{b-f}	1985.0^{a-d}
MW at 2.5 t/ha	234.3^{i}	1900.0^{a-d}	1861.0^{a-e}	2000.0^{a-d}
MW at 5.0 t/ha	812.7^{g-i}	1180.0^{e-h}	1666.7^{c-f}	2337.3^{a-c}
PD at 2.5 t/ha	196.0^{i}	1372.7^{d-g}	2487.3^{a}	1687.7^{b-f}
PD at 5.0 t/ha	846.7^{g-i}	1700.0^{b-f}	2375.0^{ab}	2533.3^{a}
SE±		345.71		
		2009		
Control	72.7^{i}	347.3^{e-i}	840.7^{bc}	706.0^{c-e}
CD at 2.5 t/ha	173.3^{hi}	407.7^{d-i}	1171.3^{b}	801.0^{b-d}
CD at 5.0 t/ha	353.3^{e-i}	510.3^{c-h}	1176.7^{b}	885.3^{bc}
MW at 2.5 t/ha	501.7^{c-h}	660.0^{c-e}	605.0^{c-g}	880.0^{bc}
MW at 5.0 t/ha	213.0^{g-i}	344.0^{e-i}	610.0^{c-g}	1158.7^{b}
PD at 2.5 t/ha	364.3^{e-i}	234.7^{f-i}	620.7^{c-f}	784.0^{b-d}
PD at 5.0 t/ha	436.0^{d-i}	560.0^{c-h}	671.7^{c-e}	1720.7^{a}
SE±		198.99		
		Combined		
Control	119.7^{i}	723.7^{e-i}	1303.7^{b-f}	1353.0^{b-f}
CD at 2.5 t/ha	176.3^{i}	890.5^{c-h}	1708.7^{ab}	1358.8^{b-e}
CD at 5.0 t/ha	455.8^{g-i}	910.2^{c-h}	1432.2^{a-e}	1435.2^{a-e}
MW at 2.5 t/ha	368.0^{hi}	1280.0^{b-f}	1233.7^{b-f}	1440.0^{a-d}
MW at 5.0 t/ha	512.8^{g-i}	762.0^{d-i}	1138.3^{b-g}	1748.0^{ab}
PD at 2.5 t/ha	280.2^{hi}	803.7^{d-i}	1554.0^{a-c}	1233.8^{b-f}
PD at 5.0 t/ha	641.3^{f-i}	1132.5^{b-g}	1523.3^{a-c}	2127.0^{a}
SE±		360.63		

KEY:

Means in a column followed by similar letters are not significantly different at 5% level of probability by DMRT test.

* = significant at 5% level of the F-test

** = significant at 1% level of the F-test

Table 4: Interaction Effects of Nitrogen Fertilizer and Organic Manures on Leaf area (LA cm^2) in 2008 and 2009 Cropping Seasons

	N-level (kg/ha)			
Organic source	**0**	**45**	**60**	**90**
		2008		
Control	171.33^{i}	337.67^{d-g}	330.00^{e-h}	493.33^{ab}
CD at 2.5 t/ha	207.67^{hi}	409.00^{a-e}	409.00a-e	437.33^{a-f}
CD at 5.0 t/ha	271.00^{f-i}	334.00^{d-h}	459.67^{a-d}	458.00^{a-e}
MW at 2.5 t/ha	205.00^{hi}	373.33^{b-f}	415.67^{a-e}	443.33^{a-e}
MW at 5.0 t/ha	186.00^{i}	351.00^{c-f}	535.67^{a}	463.33^{a-d}
PD at 2.5 t/ha	218.00^{g-i}	420.67^{a-e}	337.33^{d-g}	471.33^{a-c}
PD at 5.0 t/ha	270.00^{f-i}	377.00^{b-f}	489.33^{ab}	515.00^{a}
SE±		64.526		
		2009		
Control	178.00^{e-h}	261.67^{b-e}	101.00^{h}	185.33^{e-h}
CD at 2.5 t/ha	150.00^{f-h}	343.00^{a-c}	351.67^{ab}	306.00^{a-d}
CD at 5.0 t/ha	237.67^{c-g}	383.33^{a}	331.33^{a-c}	321.67^{a-c}
MW at 2.5 t/ha	159.00^{e-h}	298.67^{a-d}	107.00^{h}	381.67^{a}
MW at 5.0 t/ha	125.67^{gh}	406.33^{a}	241.33^{b-f}	323.67^{a-c}
PD at 2.5 t/ha	201.33^{d-h}	350.00^{ab}	325.33^{a-c}	394.67^{a}
PD at 5.0 t/ha	336.00^{a-c}	409.67^{a}	375.33^{a}	314.00^{a-c}
SE±	55.424	55.424	55.424	55.424
		Combined		
Control	174.67^{g}	299.67^{c-f}	215.50^{fg}	339.33^{a-e}
CD at 2.5 t/ha	178.83^{g}	376.00^{a-c}	380.33^{a-c}	371.67^{a-d}
CD at 5.0 t/ha	253.83^{e-g}	361.67^{a-e}	395.50^{a-c}	389.50^{a-c}
MW at 2.5 t/ha	182.00^{g}	336.00^{a-e}	361.33^{d-g}	412.50^{a-c}
MW at 5.0 t/ha	155.83^{g}	378.67^{a-c}	388.50^{a-c}	393.50^{a-c}
PD at 2.5 t/ha	209.67^{fg}	385.33^{a-c}	331.33^{a-e}	433.00^{a}
PD at 5.0 t/ha	303.00^{b-f}	393.33^{a-c}	432.33^{a}	414.50^{ab}
SE±		57.409		

Means in a column followed by similar letters are not significantly different at 5% level of probability by DMRT test.
* = significant at 5% level of the F-test
** = significant at 1% level of the F-test

Table 5: Correlation Coefficient (R) Between Grain Yield and NPK Content in Grain as Affected by the Different Treatments in 2008 and 2009 Cropping Seasons

	GYD	PHT	LA	NLS	PLS	KLS	NGS	PGS	KGS
GYD	1.00								
PHT	0.12^{ns}	1.00							
LA	0.63***	0.20*	1.00						
NLS	0.15*	0.02^{ns}	0.30**	1.00					
PLS	-0.10^{ns}	-0.16*	-0.03^{ns}	0.13^{ns}	1.00				
KLS	-0.12^{ns}	0.04^{ns}	-0.13^{ns}	-0.20*	0.01^{ns}	1.00			
NGS	0.26**	0.08^{ns}	0.21*	0.47***	0.05^{ns}	-0.19*	1.00		
PGS	0.05^{ns}	0.01^{ns}	0.05^{ns}	0.23*	-0.02^{ns}	0.01^{ns}	-0.07^{ns}	1.00	
KGS	0.03^{ns}	0.03^{ns}	-0.06^{ns}	-0.20*	-0.11^{ns}	0.05^{ns}	-0.13^{ns}	0.10^{ns}	1.00

Key: GYD = Grain Yield (Kg/ha), PHT = Plant height (cm), LA = Leaf Area, NLS = nitrogen content in leaf samples, PLS = Phosphorus content in leaf samples, KLS = Potassium content in leaf samples, NGS = Nitrogen in grain samples, PGS = Phosphorus in grain samples, KGS = Potassium in grain samples

*** = Significant at 0.1%, ** = Significant at 1%, * = Significant at 5%, ns = Non significant