

# Effects of Mineral Fertilizer and Different Sources of Organic Manure Combination on the Growth and Grain Yield of Maize in Sudano-Sahelian Savanna, Nigeria

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**Abstract** – 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 objective of the study was to ascertain the effects of the mineral fertilizer in combination with the three different organic manure sources on the growth and yield of Maize in the study area. 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. Soil texture (particle size analysis), soil pH, electrical conductivity (EC), effective cation exchange capacity (ECEC), percentage base saturation (PBS), soil organic carbon (SOC), total N, C:N ratio, available P (Bray-1), and exchangeable K. 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 growths parameters measured as well as grain yield in kg/ha. Plant height was not so much affected by the combination of nitrogen fertilizer and organic manure but nitrogen levels alone significantly affected the plant height in 2008, 2009 and in the combined analysis. Leaf area was also significantly affected by nitrogen 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 deduce that grain yield and yield parameters 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. 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.

**Keywords** – Mineral Fertilizer, Organic Manure, Grain Yield, Nitrogen Fertilizers.

## I. 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.

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

## II. 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°53'N; 13°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<sup>2</sup>) 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<sub>0</sub>P<sub>0</sub>K<sub>0</sub>, N<sub>45</sub> P<sub>30</sub> K<sub>30</sub>, N<sub>60</sub> P<sub>30</sub> K<sub>30</sub> and N<sub>90</sub> P<sub>30</sub> K<sub>30</sub> 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<sup>2</sup>) and net plot =2m×2m (4m<sup>2</sup>) 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 11<sup>th</sup> 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 10<sup>th</sup> October and 12<sup>th</sup> 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.

### **III. 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<sup>2</sup>)*

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.

## **IV. 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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### REFERENCES

[1] Awotundun, J.S. 2005. Comparative Effects of organic and inorganic fertilizer on the yield of pop-corn. In: Proceedings of the 29<sup>th</sup> Annual Conference of the Soil science society of Nigeria. December, 6<sup>th</sup>-10<sup>th</sup>, 2004. University of Agriculture Abeokuta, Nigeria: 175-179.

[2] Azeez J.O, Adetunji M.T, and Adetunji B. 2007. Effects of Residue burning and Fertilizer application on soil Nutrient dynamics and dry grain yield of maize (*Zea mays* L.) in an Alfisols. *Nigerian Journal of Soil Science*. 7: 71-80.

[3] Bationo, A. and Lompo F, 2003. Available technologies for combating soil Nutrients losses in West Africa. In: Gichuru, M.P., A. Bationo, M.A. Bekunda, H.C. Goma, P.K.Mafungoya, D.N. Mugendi and H.J. Swift (Eds). Soil fertility management for Sustainable Land use in the West African Sudano-Sahelian Zone. Soil Fertility Perspective. Academic Science Publication. Nairobi, Kenya. pp. 31-48.

[4] Duncan, O.B. 1955. Multiple Range and Multiple F-tests. *Biometrics* 11: 1-42.

[5] Fagbola, O. and Ogunpe P.W, 2007. Growth and yield response of some maize Cultivars to organic mineral fertilizers application in stimulated degraded soils under green-house conditions. *Nigerian Journal of Soil Science*. Vol. 17:81-86.

[6] FPDD 2002: Fertilizer use and Management Practices for Crops in Nigeria. The Fertilizer Procurement and Distribution Division of the Federal Ministry of Agriculture, Water Resources and Rural Development, Abuja Pp 1-20.

[7] Gaur, A.C 1982. Organic manures and Bio fertilizer. *Review of soil Research in India*. 278-301.

[8] Kwari, J.D and Bibinu A.T.S 2002. Response of two millet cultivars to sub-optimum rates of N.P.K. fertilizer and Sheep

manures in different Agro ecological zones of North- east Nigeria. *Journal of Soil Research*. 3:33-38.

[9] Olomilua, A.I, Akanbi O.S.O, and Ojeniyi S. O. 2007. Effects of Pig manure on Nutrient composition growth yield of okra. *Nigerian Journal of Soil Science*. 17:109-112.

[10] Onwueme, I.C. and Sinha T.D. 1991. Field crop production in tropical Africa. *Technical centre for Agriculture and Rural Cooperation* pp. 159-175.

[11] Onyibe, J. E., Kamara, A. Y. and Omoigui, L. O. 2006. Guide to soybean production in Borno State, Nigeria: Promoting Sustainable Agriculture in Borno State (PROSAB). Ibadan, Nigeria. 1-13 pp.

[12] Rayar, A.J. 2000. Sustainable Agriculture in sub-sharan Africa. The Role of soil productivity. AJR publishers India. P 104-156.

[13] Shuaib, B. Adamu A. and Bakishi J.S. 1997. (Eds) Nigerian National Agricultural Research Strategic Plans; 1996-2010. Department of Agric, Science. Fed Min. of Agriculture and National Resources, Abuja Nigeria. pp. 46-48.

[14] Shukla, U.C. 1990. Role of soil fertility and fertilizer management in enhancing Agricultural production. All over view 18<sup>th</sup> Annual Conference of Soil Science Society of Nigeria, Maiduguri. November, 1990.

[15] Tisdale, S.L; Nelson W. L. and Beaton T.D. 1985. Soil fertility and fertilizers 4<sup>th</sup> Ed. Mac Millan, N.Y. 350-413.

[16] Yunusa, I. A. M. and Ikwelle, M. C. 1990. Yield response of soybean (*Glycine max* (L.) Merr.) To planting density and row spacing in a semi-arid tropical environment. *Journal of Agronomy and Crop Science* 164:

Table 1: Physico-chemical characteristics of the soil of the experimental site

Soil characteristics	Value
pH (1:2.5 H <sub>2</sub> O)	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 <sub>2</sub> O)	Org. C (%)	N (%)	C : N Ratio	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

Organic source	N-level (kg/ha)			
	0	45	60	90
	<b>2008</b>			
Control	166.7 <sup>i</sup>	1100.0 <sup>f-h</sup>	1766.7 <sup>b-f</sup>	2000.0 <sup>a-d</sup>
CD at 2.5 t/ha	179.3 <sup>i</sup>	1373.3 <sup>d-g</sup>	2246.0 <sup>a-c</sup>	1916.7 <sup>a-d</sup>
CD at 5.0 t/ha	558.3 <sup>hi</sup>	1310.0 <sup>d-g</sup>	1687.7 <sup>b-f</sup>	1985.0 <sup>a-d</sup>
MW at 2.5 t/ha	234.3 <sup>i</sup>	1900.0 <sup>a-d</sup>	1861.0 <sup>a-e</sup>	2000.0 <sup>a-d</sup>
MW at 5.0 t/ha	812.7 <sup>g-i</sup>	1180.0 <sup>e-h</sup>	1666.7 <sup>c-f</sup>	2337.3 <sup>a-c</sup>
PD at 2.5 t/ha	196.0 <sup>i</sup>	1372.7 <sup>d-g</sup>	2487.3 <sup>a</sup>	1687.7 <sup>b-f</sup>
PD at 5.0 t/ha	846.7 <sup>g-i</sup>	1700.0 <sup>b-f</sup>	2375.0 <sup>ab</sup>	2533.3 <sup>a</sup>
SE±		345.71		

	<u>2009</u>			<b>Th</b>
Control	72.7 <sup>i</sup>	347.3 <sup>e-i</sup>	840.7 <sup>bc</sup>	706.0 <sup>c-e</sup>
CD at 2.5 t/ha	173.3 <sup>hi</sup>	407.7 <sup>d-i</sup>	1171.3 <sup>b</sup>	801.0 <sup>b-d</sup>
CD at 5.0 t/ha	353.3 <sup>e-i</sup>	510.3 <sup>c-h</sup>	1176.7 <sup>b</sup>	885.3 <sup>bc</sup>
MW at 2.5 t/ha	501.7 <sup>c-h</sup>	660.0 <sup>c-e</sup>	605.0 <sup>c-g</sup>	880.0 <sup>bc</sup>
MW at 5.0 t/ha	213.0 <sup>g-i</sup>	344.0 <sup>e-i</sup>	610.0 <sup>c-g</sup>	1158.7 <sup>b</sup>
PD at 2.5 t/ha	364.3 <sup>e-i</sup>	234.7 <sup>f-i</sup>	620.7 <sup>c-f</sup>	784.0 <sup>b-d</sup>
PD at 5.0 t/ha	436.0 <sup>d-i</sup>	560.0 <sup>c-h</sup>	671.7 <sup>c-e</sup>	1720.7 <sup>a</sup>
SE±		198.99		
	<u>Combined</u>			
Control	119.7 <sup>i</sup>	723.7 <sup>e-i</sup>	1303.7 <sup>b-f</sup>	1353.0 <sup>b-f</sup>
CD at 2.5 t/ha	176.3 <sup>i</sup>	890.5 <sup>c-h</sup>	1708.7 <sup>ab</sup>	1358.8 <sup>b-e</sup>
CD at 5.0 t/ha	455.8 <sup>g-i</sup>	910.2 <sup>c-h</sup>	1432.2 <sup>a-c</sup>	1435.2 <sup>a-c</sup>
MW at 2.5 t/ha	368.0 <sup>hi</sup>	1280.0 <sup>b-f</sup>	1233.7 <sup>b-f</sup>	1440.0 <sup>a-d</sup>
MW at 5.0 t/ha	512.8 <sup>g-i</sup>	762.0 <sup>d-i</sup>	1138.3 <sup>b-g</sup>	1748.0 <sup>ab</sup>
PD at 2.5 t/ha	280.2 <sup>hi</sup>	803.7 <sup>d-i</sup>	1554.0 <sup>a-c</sup>	1233.8 <sup>b-f</sup>
PD at 5.0 t/ha	641.3 <sup>f-i</sup>	1132.5 <sup>b-g</sup>	1523.3 <sup>a-c</sup>	2127.0 <sup>a</sup>
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<sup>2</sup>) in 2008 and 2009 cropping seasons

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