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Effect of Organic and Inorganic Fertilization on Some Soil Physical Properties, Growth and Yield of wheat (*Triticumaestivum* L.)in El Multaga Area, Northern State, Sudan

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Abstract

A field study was conducted for two successive winter seasons; 2009/10 and 2010/11, at the research farm of the National Institute of Desert Studies – University of Gezira, new Hamdab scheme - Northern State of Sudan. The objective of the study was to investigate the effect interactions application of nitrogen (43 and 86 Kg fed^{-1}) and chicken manure (zero and 4 ton ha^{-1}) fertilization on wheat (*Triticumaestivum* L.) growth, yield and some physical properties of soil in El Multaga Area, Northern State, Sudan.The treatments were arranged insplit-plot design with four replicates. The main plots were assigned to nitrogen fertilizer application and sub-plot to chicken manure application.The results showed very highly significant reduced in the soil bulk andvery highly significant increased soil moisture content percentage at 80 days after sowing (DAS) as compared to the control during the two seasons. Also the results showed significant differences on plant height, number of seeds/spike, thousand seed weight, straw yield and harvest index in both seasons and highly significant differences on number of spikes m^{-2}, number of tillers m^{-2}, grain yield (ton ha^{-1}) and biological yield (ton ha^{-1}) in both seasons with the application of chicken manure and nitrogen fertilization. The combination of (86 Kg fed^{-1}) nitrogen fertilizer and (4 ton ha^{-1}) chicken manure application ofproduced the highest means values of growth, yield and yield components of wheat(*Triticumaestivum* L.) in both seasonsat El Multaga soil series - Northern State of Sudan.

Key Words: Nitrogen fertilizer, Chicken Manure, ElMultaga Soil Series

1. Introduction

Wheat (*Triticumaestivum*L.) is mainly grown in the Sudan under irrigation, during winter months; its cultivation has recently expanded into latitudes lower than 15° N (Ageeb*et al.*, 1996; Almeu and Hazem, 2011).Demand for wheat in the past was not very high because the nutritional habit of the majority of the Sudanese people was based mainly on sorghum. At present, wheat consumption has increased and the government is attempting to attain self-sufficiency in this commodity. In order to fulfill this objective, it is necessary to increase the cultivated area and obtain maximum output from each unit volume of water consumed. Manures are natural sources of organic matter. The sources of organic matter in soil are animal and plant residues, plant roots, leaves dropped on the surfaces and incorporated into the soil in addition to green manure, farmyard manure, poultry composite manure, press mud, rice and wheat straw (Ali, 2005) Poultry manureincreased significantly soil organic matter, nitrogen, available phosphorus and potassium. Agdede et al, (2008).Also, the soil nitrogen and phosphorus contents increased significantly due to organic manure application (Mahmuod*et al*, 2009). Ahmed (2010) stated that application of manure in desert plain soil in the Northern Sudan significantly improved the soil chemical properties and minor increased in organic carbon, nitrogen; available phosphorus and potassium were observed. The soil pH was not affected by the source of organic manure. The poultry manure application on sandy loamy soil in Southwestern Nigeria improved soil chemical properties.

It increased soil organic matter, total N, available P , exchangeable Mg, Ca, K and nutrient uptake and lowered exchange acidity (Adeleye*et. al*., 2010). Chicken manure and sewage sludge application on the poor physical and chemical properties of sand dune soil in Elrawakeeb Dry Land Station, Khartoum State, Sudan resulted in very highly significantly increased soil organic carbon, available P, total nitrogen and mineral nitrogen and decreased soil pH (Elhadi*et. al,* 2016). Nitrogen is an integral component of the chlorophyll, amino acids, proteins and enzymes as well as organic compounds and it comprises about 16% of the weight of the plant protein, the uptake of nitrogen from the soil is when it is in an inorganic form, mainly as nitrate or ammonium. The most common N-fertilizer is Urea. Urea (46% N) is the dominant source of nitrogen that is used commercially for wheat production, also wheat nitrogen requirements depend on season, soil type, soil moisture and yield potential (Bolland and Melppelink, 1991).Adequate nitrogen supply produces good leaf and stem development, whereas an oversupply of nitrogen may cause lodging and inferior grains quality Moreover, excessive levels of nitrogen decreases grain yield slightly, when compared with sufficient levels of nitrogen, through enhancement of vegetative growth at the expense of grain production (Gardner and Jackson, 1976). Generally, heavy rates of nitrogen are used with higher seed rates particularly when there is abundant moisture in the soil. AwadElkarim and Babiker (2005) studied the response of wheat to farmyard manure and nitrogen fertilization in the high terrace soils in Northern State, Sudan. Their study showed that farmyard manure very highly significantly influenced the length of spike, number of seeds per head and grain yield. The aim of this study was to determine the effect of nitrogen and chicken manure application on agronomic traits of wheat and some soil physical properties.

2. Materials and Methods

Description of the Experimental Site

Field experiments were carried out during two consecutive winter seasons (2009/10 and 2010/11) at the National Institute of Desert Studies Research Farm, New Hamdab Scheme, Northern State of Sudan (latitude 17°55' N and longitude 31°10' E). The climatic zone of the area is described as desert, which is characterized by high temperature in summer, low temperature in winter and low rainfall (Habiballa and Ali, 2010). The soil of the study area belongs to El Multaga soil series which classified as vertichaplocambids, fine loamy, mixed, supper active and hyperthermic. The soil structure is moderate sub angular blocky. It is non-saline and non-sodic (Table 1) (LWRC, 1999). Generally, the soil chemical fertility is low and mostly these soils deficient in nitrogen, phosphorus and organic carbon for optimum yield production of different cultivated crops. The physical and chemical properties of the soil are shown in Table1

Table1. Some Soil Properties of the Experimental Site

Soil properties	Soil depth (cm)				
	0 – 23	23 – 65	65 – 80	80 – 105	105 – 125
FS (%)	40	23	22	21	24
CS (%)	37	33	43	42	40
Silt (%)	15	25	11	19	8
Clay (%)	8	19	24	18	28
Texture	LS	SL	SL	SL	SCL
pH (paste)	7.5	7.3	8.1	7.8	7.5
Ece	0.35	0.37	0.42	1.1	3.2
ESP	3.0	3.0	4.0	5.0	8.0
CaCO3 (%)	0.8	2.6	10.4	0.2	27.5
O.C (%)	0.05	0.07	0.08	0.06	0.05
C/N ratio	4	4	5	5	5

LS = loamy Sand, SL = Sandy Loam, SCL= Sandy Clay Loam

Treatments and Experimental Design

The treatments were arranged in completely randomized a split-plot design with four replicates. The area of each sub- sub plot was 42 m^2 (6 × 7 m). The experimental units were two meter apart from each other. The main plots were assigned to nitrogen fertilizer application with two (43 and 86Kg ha^{-1}) rates and sub - plots were assigned to chicken manure with two rates (0 and 4ton ha^{-1}). The experimental procedures were the same for both seasons. Treatments and their abbreviations are illustrated in Table 2

Table 2.Treatments Application and their Abbreviations.

Treatment	Operation	Abbreviation
Nitrogen Fertilizer	43 Kg fed^{-1}	N_1
(N)	86 Kg fed^{-1}	N_2
Chicken Manure	0 ton ha^{-1}	CM_1
(CM)	10 ton ha^{-1}	CM_2

N_1C_1= as the control.
fed= Feddan (= 0.42 ha).

Soil Physical Analyses:

The soil dry bulk density (ρd) was determined by the core sample method as described by Black (1965) and Landon (1984) . Soil core was obtained from 0 -15 cm soil depth for each of experimental units at 80 days after sowing (DAS). The soil was oven dried at 105º C for 24 hours, and weighed. The soil dry bulk density (ρd) for all soil samples were calculated in the lab using the equation below:

$$\rho d = \frac{Ms}{VT}$$

Where:

Ms is a dry soil mass and Vt is the total soil volume or the core volume. Measurements of the soil moisture were done at 0 - 30 and 30 - 60 cm soil depth. Soil samples were taken by using an auger. Readings were taken at the field, two days after irrigation at 80 DAS. Gravimetric method was used to determine the soil moisture percentage (Θ) as described below:

$$\Theta = \frac{(Mm - Md)}{Md}$$

Where Mm is the moist soil mass Md is the dry soil mass.

Soil Amendment

Chicken manure was manually broadcasted six weeks before planting on the designated experimental units at the rates of 0 and 4 ton ha^{-1}. The manure was incorporated into the soil using disk plow. Then the soil was watered and the subsequent watering was carried out at ten- day interval for six weeks before sowing of wheat crop.

Cultural Practices

Wheat (*Triticumaestivum*L.) variety WadiElneel was used in this study. Sowing was done manually by digging on 20th of November for both seasons, with seed rate of 120 kg ha^{-1}, at 0.2 m inter-row spacing. The crop was harvested on 20st of March in both seasons. Irrigation

was applied according to (Erneo, 2007) who concluded that, wheat water requirements per season was 635mm.

Data Collection

Plant samples were collected randomly from each experimental unit (sub- sub plot) and then growth and yield parameters were determined. Number of plants/m^2 were counted for each season at 10 days after sowing in three different positions in each sub- sub plot using a steel frame of one meter square. Ten whole plant samples were selected randomly from each sub-sub plot at maturity stage, each season. Plant height as expressed in cm was measured from the tip of the spike to the soil surface, and then the mean was calculated. Using steel frame of one meter square, the number of spikes/m^2 was calculated at harvest time for each sub- sub plot as an average number of three readings. Number of tillers/m^2 was obtained by subtracting the number of plants/m^2 at 10 days after sowing from the number of spikes/m^2, each season. Ten spikes samples were selected randomly from each sub- sub plot at maturity stage and the spike length (cm) was measured, and then the mean spike length was obtained.
Samples of ten spikes were selected randomly from each sub- sub plot at maturity stage and seeds per spike were counted, and then the mean number of seeds/spike was obtained. A number of thousand seeds were picked randomly from each sub- sub plot. The seeds were weighed, and mean 1000-seeds weight (g) was obtained. Plants of the net area of one meter square (using steel frame of one meter square) were cut at the soil surface at harvest time in three different positions in each sub- sub plot, tied in bundles and left to dry by air. After drying, they were weighed, then the mean biological yield (ton ha^{-1}) (dry matter plus grain) was determined. The biological yield samples were manually threshed, and the grain yield as expressed in ton ha^{-1} was obtained. Also, straw yield (ton ha^{-1}) was determined as follows:

$$Straw\ yield\ (kg\ ha^{-1}) = Biological\ yield\ (kg\ ha^{-1}) - Grain\ yield\ (kg\ ha^{-1})$$

Harvest index (%) was obtained using the following formula:

$$Harvestindex = \frac{Totalgrainyield\ (kgha^{-1})}{Totalbiologicalyield\ (kgha^{-1})} \times 100$$

Statistical Analysis

Statistical analysis was carried out using a computer software package (MSTAT).

Significance of differences among the various characters under study were compared using

Duncan's Multiple Range Test (DMRT).

Results and Discussion

The interaction effects of nitrogen and chicken manure fertilization on wheat vegetative growth and yield during tow winter seasons are shown in Tables 3 and 4. The results indicated that chicken manure and nitrogen fertilization had significant effects ($P \leq 0.05$) on plant height, number of tillers/m^2, number of seeds/spike, 1000-seeds weight, harvest index and grain yield, highly significant differences ($P \leq 0.01$) on biological yield and straw yield for both seasons. But had not significant effect ($P \leq 0.05$) on number of plants/m2 in both seasons. The results indicated that the application of 4ton ha^{-1} of chicken manure with 86 Kg

nitrogen fertilizer recorded the highest means values of all examined growth and yield attributes in both seasons. Several investigations from different parts of the world reported that addition of chicken manure improved chemical properties of the soil and enhanced growth and yield of wheat (Agdede*et. al.*,, 2008: Adeleye*et. a.*,*l.* 2010 and Elhadi*et. al.*, 2016). The results of this study showed that the application of chicken manure improved growth and yield of wheat. As mentioned by Rasul*et al.*(2015), whom concluded that chicken manure increased wheat growth and yield significantly. Also, the results is in agreement with that of Ahmed (2010) who stated that, chicken manure improved the plant height, number of seeds per spike, number of spikes per square meter, number of tillers per square meter, 1000- seeds weight, straw yield, biological yield, grain yield and harvest index. The desert plain soils of the Northern State of Sudan are characterized by high amount of sand and low chemical soil fertility and mostly are deficient in nitrogen, phosphorus and organic carbon for optimum yield production of different cultivated crops (Land and Water Research Centre, 1999). Chicken manure and nitrogen fertilizer, is a good healthy and cheap solution for poor and infertile soil of the study area to improve wheat growth and yield. Table 4. Show the Interaction effects of nitrogen and chicken manure fertilization on soil bulk density and soil moisture percentage at 80 DAS during two Seasons. The results showed that the interaction of chicken manure of (4 ton ha-1) and nitrogen fertilizer of (86 Kg fed^{-1}) reduced the soil bulk density with very highly significant differences ($P \leq 0.001$) as compared to the control during the two seasons. Reduction in soil bulk density in response to manures application had already been mentioned by many researchers (AwadElkarim, 2007, Ali, 2001, Agdede*et. al*, 2008) and Adeleye et al.(2010) who found that organic manure significantly reduced the soil bulk density. The results showed that the interaction of chicken manure of (4 ton ha^{-1}) and nitrogen fertilizer of (86 Kg fed^{-1}) significantly increased soil moisture content compared with the control. This result is in conformity with that obtained by Ali (2001) and Adeleye*et. al.,*(2010) who found that moisture percentage increased significantly in response to organic manure application.

Table 3a **Interaction effects of nitrogen and chicken manure fertilization on wheat vegetative growth during Tow winter seasons**

Parameters	**No. of plants/m^2**		**Plant height (cm)**		**No. of tillers/m^2**		**No. of seeds/spike**	
Treatments	**1st Season**	**2nd Season**	**1st Season**	**2nd Season**	**1st Season**	**2nd Season**	**1st Season**	**2nd Season**
N_1C_1	182^b	201^c	67^c	73^c	54^c	59^d	32^c	32^c
N_1C_2	185^b	212^b	73^b	80^b	56c	63^c	33^c	34^b
N_2C_1	188^b	210^b	75^b	82^b	98^b	76^b	38^b	38^{ab}
N_2C_2	208^a	220^a	84^a	90^a	109^a	95^a	47^a	41^a
SE±	18.8	6.67	8.34	8.17	6.09	6.6	3.74	15.5
C.V (%)	16.3	9.2	20.6	18.2	13.6	17.3	17.1	16.9
Sig.	NS	NS	*	*	*	*	*	*

Means within columns followed by the same letter(s) are not significantly different at $P<0.05$ level according to Duncan's Multiple Range Test.
* and NS indicate significance at $P \leq 0.05$ and not significant, respectively.

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Table 3b.**Interaction effects of nitrogen and chicken manure fertilization on wheat yield during tow winter seasons**

Parameters	1000-seeds weight (g)		Biological yield (Ton ha^{-1})		Grain yield (Ton ha^{-1})		Straw yield (Ton ha^{-1})		Harvest index (%)	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
N_1C_1	30^{b}	33^{c}	7.6^{d}	7.2^{d}	2.3^{d}	2.3^{d}	5.2^{c}	4.9^{d}	31c	32^{c}
N_1C_2	35^{a}	35^{b}	9.4^{b}	8.4^{c}	3.1c	2.9^{c}	6.3^{a}	5.5^{b}	33^{b}	34^{b}
N_2C_1	36^{a}	37^{b}	8.8^{c}	8.5^{b}	3.3^{b}	3.1^{b}	5.1^{c}	5.4^{c}	38a	36^{ab}
N_2C_2	37^{a}	39^{a}	9.9^{a}	12.3^{a}	3.9^{a}	4.7^{a}	5.9^{b}	7.7^{a}	40a	38^{a}
SE±	4.8	1.99	0.44	0.22	0.31	0.37	3.1	3.6	1.67	1.11
C.V (%)	8.7	9.5	8.6	14.1	16.6	22.7	9.8	10.6	12.9	10.3
Sig.	*	*	**	**	*	*	**	**	*	*

Means within columns followed by the same letter(s) are not significantly different at P<0.05 level according to Duncan's Multiple Range Test.

Table 5.Interaction effects of nitrogen and chicken manure fertilization on soil bulk density and soil moisture percentage at 80 DAS during two Seasons.

Parameters	Bulk density (Kg cm^{-3})		Moisture Content (%)	
Treatments	1st Season	2nd Season	1st Season	2nd Season
N_1C_1	1.66^{a}	1.61^{a}	10.0^{b}	9.3^{b}
N_1C_2	1.33^{b}	1.39^{b}	19.0^{a}	17.7^{a}
N_2C_1	1.33^{b}	1.40^{b}	19.3^{a}	17.7^{a}
N_2C_2	1.31^{b}	1.38^{b}	20.0^{a}	19.0^{a}
SE±	1.40	1.44	17.1	15.92
C.V (%)	1.99	1.65	10.26	6.19
Sig.	***	***	***	***

Means within columns followed by the same letter(s) are not significantly different at P<0.05 level according to Duncan's Multiple Range Test.

*** indicate significance at P≤ 0.001 .

Means within columns followed by the same letter(s) are not significantly different at P<0.05 level according to Duncan's Multiple Range Test.

*** indicate significance at P≤ 0.001 .

Conclusion

It can be concluded that chicken manure (4 ton ha $^{-1}$) in addition to nitrogen fertilizer (86 Kg ha^{-1}) were a good, healthy and cheep solution to improve physical properties of infertile soil of Northern State of Sudan and enhanced wheat growth and yield.

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