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Effects of Urea and Goat Organic Manure on Growth and Yield of Sorghum (*Sorghum bicolor* L.) Under Rain Fed Sandy Soil of North Kordofan State, Sudan

Noudar A. Abdelrahman[1], Makeen A. Makeen[1], Elgailani A. Abdalla[2], Feisal M. Ismaeil[1], Salah Eldeen E. Ahmed[1] and Aisha A. Adam[1]
[1]Department of Crop Sciences, Faculty of Natural Resources and Environmental Studies, University of Kordofan, P. O. Box 160, Elobied, Sudan
[2]Agricultural Research Corporation, Elobied Research Station, Sudan
*Corresponding author: nuodar106@gmail.com

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Abstract: *This study was carried out at the premises of Faculty of Natural Resources and Environmental Studies, demonstration farm, in Sheikan locality, North Kordofan state during two consecutive rainy seasons 2021- 2022, 2022-2023. The study was aimed at evaluating the effects of urea and goat organic manure fertilizers on growth and yield of sorghum (Sorghum bicolor L.) and some soil physical properties. The experiment consisted of four treatments (Control, 2 ton goat organic manure \ feddan, 2 ton goat organic manure / feddan + 40 kg urea / feddan and 2 ton goat organic manure / feddan + 80 kg urea / feddan). Treatments were laid out in a Randomized Complete Block Design (RCBD) with four replications. Growth characters studied were (days to 50% flowering, plant height (cm), number of leaf per plant and stem diameter (cm).Yield and yield attributes were straw dry yield (ton/ha), 1000 seeds weight (g), grain yield (ton/ha) and harvest Index%. Soil physical properties studied were (soil moisture content %, soil bulk density and soil porosity. Data were statistically analyzed using GEN STAT. Results showed that fertilizers significantly ($P \leq 0.05$) increased sorghum plant growth, yield attributes and grain yield compared to the control in both seasons. Goat organic manure and urea fertilizer had significantly ($P \leq 0.05$) decreased days to 50% flowering and increased plant height, straw dry yield (ton/ha), 1000 seeds weight (g), grain yield (ton/ha) and Harvest Index% for sorghum crop. While, there was no significant effect amongst treatments on number of leaf per plant and stem diameter (cm). The highest grain yield (2.6 ton/ha) was obtained when 2 ton goat organic manure \ feddan combined with 80 kg urea /feddan as compared with the control (1.7 ton/ha). The application of goat organic manure combined with urea fertilizer increased Soil moisture content, soil bulk density and soil porosity. It can be recommended to improve sorghum productivity and soil fertility in the marginal sandy rain fed soils of North Kordofan State and similar environments.*
Key word: Sorghum, Urea, Goat organic manure, sandy soil, North kordofan.

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INTRODUCTION

Agriculture is the most important activity in Sudan. Arable agricultural land is 97.5 million hectares (FAO, 2013). Kordofan region is situated in the mid-west of Sudan between latitudes 9.50 and 16.40 N and longitudes 27 to 32 E. It covers an area of about 380,000 km2, representing 24% of the total area of the country. Administratively, the region is divided into three states North, South and West Kordofan states. The production and productivity described as very low of most crops compared to international production average. The production and productivity is described as very low for most crops compared to other parts of the country (Yasir *et al.*, 2016). Rain-fed areas where rainfall is either characterized by long intermittent periods of dry spells or short rainy seasons inflicting water stress leading to decrease in yield of many crops, particularly sorghum crop. Crop production in the sandy rain-fed areas of North Kordofan State in Sudan is mainly practiced by smallholder, resource-limited farmers who constitute 75–80% of the population. The environment is characterized by low and erratic seasonal rainfalls, short growing season and poor soil conditions with low extractable phosphorus (4mg/ 100 g), low carbon (0.056%) and low nitrogen (0.03%) due to continuous cultivation (Elgailani *et al*., 2018) in the rain-fed areas where sorghum significantly contributes to the food security status of people in Sudan. However, its production remains low due to its cultivation in such rain-fed areas where negative changes in the soil related factors contributed by dominant use of chemical fertilizers. Goat organic manure is readily available in most farms. Nonetheless, farmers are using the manure in its raw form. Encouraging use of organic and inorganic fertilizer to increase the yield of sorghum cost effective production providing balanced nutrients in available forms for sorghum plant growth. The current study is an attempt to evaluate the effect of urea and goat organic manure fertilizer on growth and yield of sorghum crop in Sheikan locality, North Kordofan State.

MATERIALS AND METHODS

Experimental Design and Treatments

Four sorghum (Variety Boutana) treatments assigned in a Randomized Complete Block Design (RCBD) with four replications for two consecutive rainy seasons 2021- 2022, 2022-2023. The experiment was carried out at the premises of Faculty of Natural Resources and Environmental Studies, demonstration farm, in Sheikan locality, North Kordofan state. The plot area (2×5m), the spacing for sorghum (50 × 50cm) and (1m) kept between plot to plot. Planting was done after prevail sufficient moisture availability in the soil and the goat organic manure was incorporated in the soil before planting. Urea doses applied into two split doses. The first half dose applied after three weeks from sowing, the second one after a month from the first half dose. Crop was sown at middle July for two rainy seasons 2021- 2022 and 2022-2023. The sowing depth of seeds was 2cm. Manual weeding was practiced two times during both seasons the first one after three weeks from sowing and the second weeding after a month from the first. Soil sample were taken before planting and after harvesting. The experiment consisted of four treatments as follows: Control, 2 ton goat organic manure/ feddan (M), 2 ton goat organic manure/ feddan + 40 kg/ feddan urea (MN_1) and 2 ton goat organic manure/ feddan + 80 kg/ feddan urea (M N_2).

When sorghum plant was at 50% flowering, the data were recorded. Plant growth parameters: days to 50% flowering (days), plant height (cm), number of leaf per plant and stem diameter (cm). Yield attributes and grain yield straw dry yield (ton/ ha), 1000 - grain weight (g), grain yield (ton/ ha) and harvest index (%).

Soil Samples
Six soil subsamples were collected from the 0–30 cm depth of each treatment using a bucket auger. Some Soil Physical analysis was soil moisture content, soil bulk density and soil porosity

Data Analysis
Data was analyzed using GEN STAT program with treatment and replications as the traits on which data was collected. Significant means were separated using Least Significance Difference (LSD) at 5% probability level. Based on the means, the percent change in each trait as compared to the control was determined. Results are provided for those traits or components that were statistically significant.

RESULTS

Days to 50% flowering
Results showed that there were significant differences ($P \leq 0.05$) in days to reach 50% flowering in both seasons and the combined analysis of variance over two seasons revealed that the effect of cropping season was highly significant ($p \leq 0.05$) on flowering date (Figure 1). All treatments showed significant effect in contrast to the control The extended retention of moisture and availability of moisture secured sustainable uptake of nutrient for proper growth and development of plants, resulting in faster growth of plant, as compared to control. The application of goat manure and nitrogen fertilizer increased the sorghum growth, which might have been due to the balance availability of nutrients to the plants that resulted in a favorable soil environment. This result in line with (Muhammad Arif *et al*., 2014) he reported that all the growth and yield parameters of rice significantly affected by organic manures in combination with inorganic fertilizers. The positive effect of the fertilization may be due to the role of organic manure with chemical fertilizers in providing the essential nutrient elements necessary for plant growth especially nitrogen which result in the improvement of plant growth parameters (Amanolahi- Baharvand *et al*., 2014).

Plant height (cm)
Plant height was significantly increased due to application of fertilizers, as demonstrated in Figure 1, showed the effect of combined analysis of variance over two seasons in organic and inorganic fertilizer on plant height of sorghum. The result revealed that, 80 kg urea / feddan with 2 ton goat organic manure/ feddan was significantly ($P \leq 0.05$) higher in terms of plant height throughout the study period. The increase in height of plants obtained by the use of urea fertilizer might be due to the high stimulating effect of nitrogen on various physiological phases in cell division and cell elongation (Alim 2012). Ayoola and Adeniyan. (2008), reported earlier that application of cow organic manure alone or in combination with urea significantly increased the plant height of sorghum.

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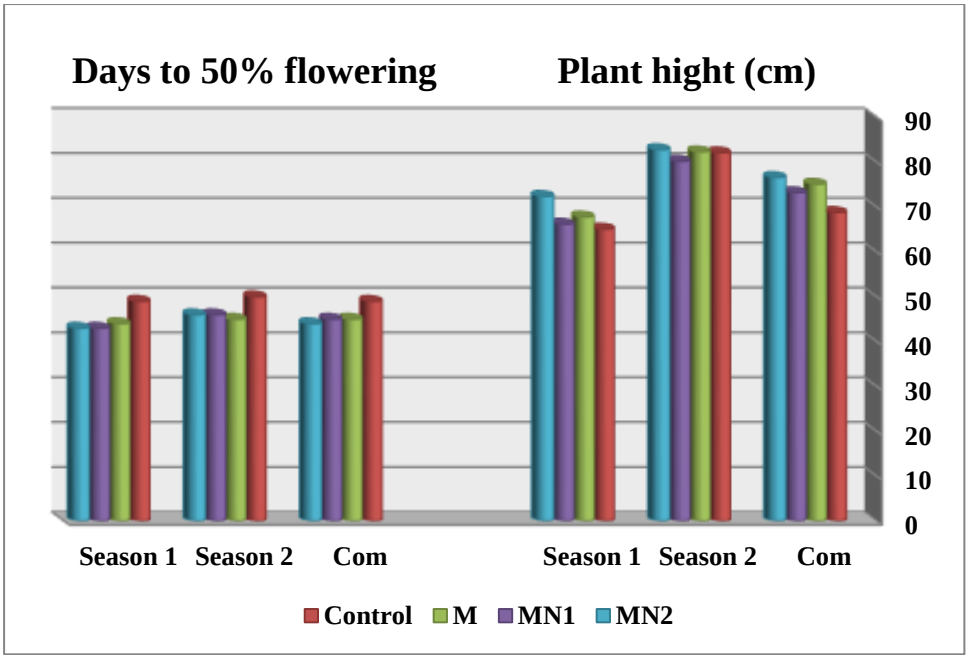

Figure 1. Effect of Urea and Goat organic Manure Fertilizer on Days to 50% flowering and Plant height (cm)

Number of leaf per plant

As illustrated in Figure 2, all treatments manifested no significant effect on number of leaf per plant. This result could be attributed to the length of the growth cycle of the cultivars which solely depends on their genetic makeup. It seems plausible that the number and size of leaf were genetically controlled traits. In fact, several reports (e.g. Meena and Mann. 2007) documented that the differential behavior of sorghum varieties in respect of growth parameters could be explained by the variation in the genetic constitution of the cultivars. This presumably was due to the fact that increasing vegetative growth rate leads to a reduction in nutrients in the leaf, in addition to increasing their movement from leaf to grains, resulting in a decreasing nutrients concentration in leaf with plant growth progress (Al-Fadlly, 2011 and Mohammed, 2013).

Stem diameter (cm)

No significant differences in stem diameter among treatments were observed at the treatments (Figure 2). As stem diameter is thought to be genetically controlled, significant increase in stem diameter are presumably dependent on conditions that favor stem diameter (e.g. temperature, sufficient moisture content, photoperiod and availability of nutrients). This result agreed with (Liman *et al*. 2018[) who reported that the treatment type and dose of manure was not significant on the proportion of stems and leaf of forage Sorghum. Conversely, Samanhudi *et al* 2021) who reported that the results showed that the treatment of the type of fertilizer had a very significant effect on the stem diameter on sorghum.

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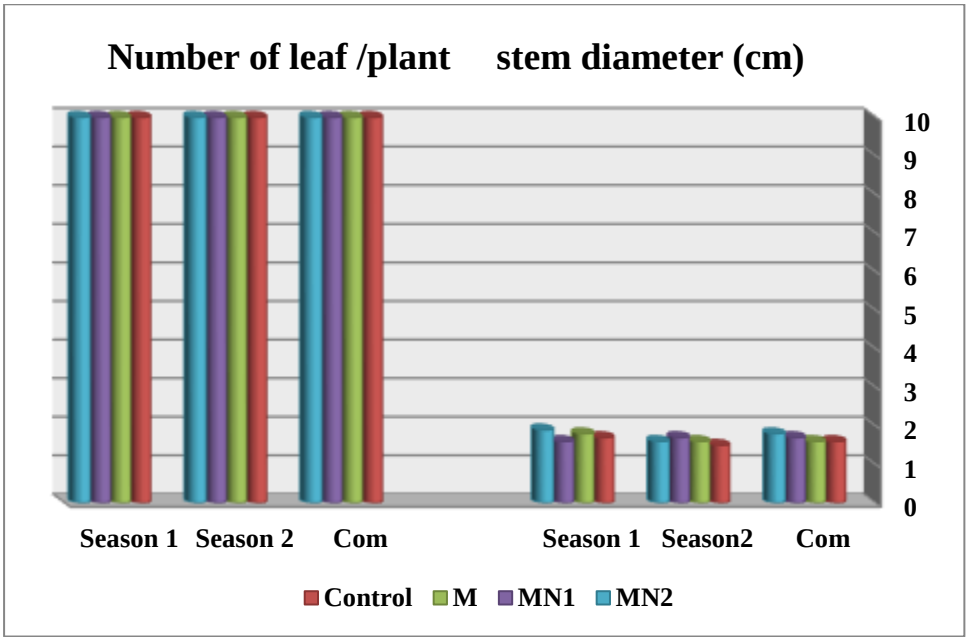

Figure 2. Effect of Urea and Goat organic Manure Fertilizers on Number of leaf per plant and Stem diameter (cm) of sorghum

Straw dry yield (ton/ ha)

The highest hay dry yield was obtained in the 2 ton/ feddan goat organic manure with 80 kg urea /feddan fertilizer treatments (Figure 3). It was pointed out that availability of nutrients which substantially increased vegetative growth and thereby increased rice straw yield.(Sci *et al*. 2018) also reported high straw biomass from combined application of organic and inorganic fertilizer compared to other treatments due to the presence of adequate amounts of both nitrogen and soil moisture that increase accessibility and uptake of NH^{4+}. Husein *et al*., (2016) noticed that the fresh and dry weight values affected by different rates, where 5 ton of organic manure with 25% of Nitrogen gave the highest values of both fresh and dry weight compared with other treatments of sorghum.

Grain yield (ton/ha)

Results indicated that fertilizer application significantly ($P \leq 0.05$) increased the grain yield of sorghum as compared to the control (Figure 3). The highest grain yield (2.6 ton/ha) was obtained when 2 ton goat organic manure/feddan combined with 80 kg urea /feddan was applied. The combined analysis of variance over two years (Figure 3) showed that grain yield values of sorghum plants were generally increased by different application rates of urea with goat organic manure fertilizer. Using both urea fertilizer and goat organic manure can exert a synergistic effect on plant growth, where immediate availability of nitrogen from fertilizers complements the slow-release nutrients from the raw organic manure. Both urea fertilizer and goat organic manure were presumably positively affect the grain yield of sorghum, especially when combined together. This integrated approach can improve soil properties and provide more sustainable nutrient supply for the crops. Similar earlier results were obtained by (Hassan *et al*, 2008) who stated that application of nitrogen to wheat resulted in higher yield and higher

1000-seed weight. Moreover, application of organic and inorganic fertilizers resulted in significant effects on above-ground biomass, grain yield, and straw yield of the maize plant (Sigaye *et al*., 2020), Muhammad *et al.*, (2014) found that total dry matter yield of sorghum significantly affected by the application of different composted organic materials. It seems plausible that application of urea and organic manure fertilizers in such rain fed sandy soils will probably enhance grain yield due to improvement of soil physical and chemical properties as compared to the low yield obtained by farmers in the same region.

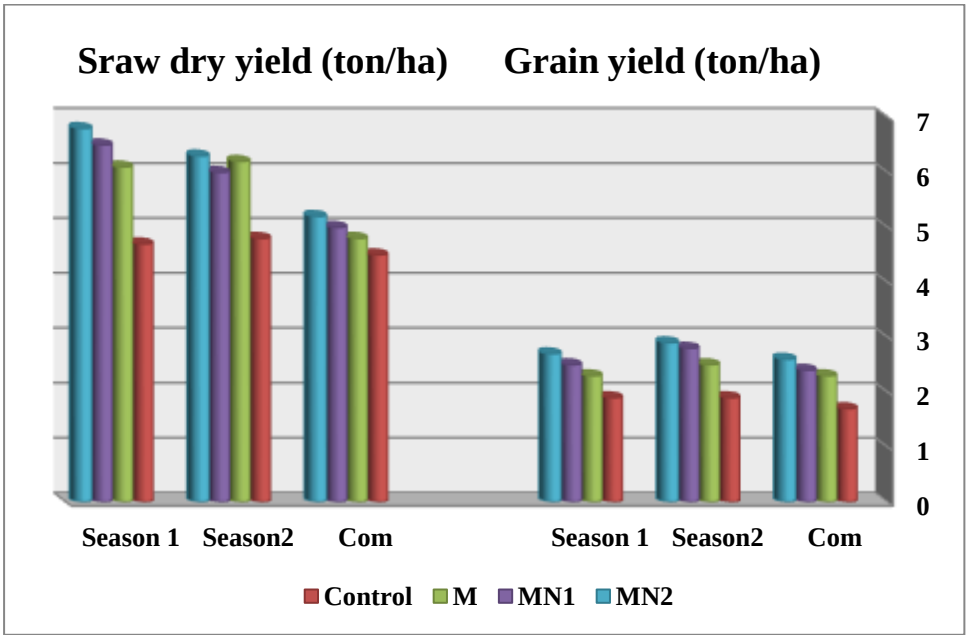

Figure 3. Effects of Urea and Goat organic Manure Fertilizers on Straw dry yield (ton/ ha) and Grain yield (ton/ha)

1000 seeds weight (g)

It was evident that results pertaining to 1000-grains weight in all the treatments differed significantly (P≤0.05) from the control as depicted in Figure 4. Organic and inorganic manures exerted significant effect on 1000 grain weight of rice (Muhammad Arif *et al*,2014), reconciled with (Madineh *et al* 2014) and (Shuaibu Yunusa *et al* 2018) who stated that the use of nitrogen increased 1000 seeds weight in grain sorghum.

Harvest Index%

Harvest index is the ratio of seed yield to total above ground plant yield (Figure 4). It was depicted that there were significant differences (P≤0.05) between treatments in harvest index. The highest ones (50.1%) were found under 2 ton/ feddan goat organic manure + 80 kg urea /feddan fertilizer. Results showed that there were significant differences (P≤0.05) amongst application of organic manures regarding harvest index for rice (Muhammad Arif *et al*., 2014). Madineh and his coworkers (2014) who found out that the use of nitrogen increased harvest index in grain sorghum. Since there is a strong relationship between harvest index and nitrogen

stock, the increase of harvest index in plants is due to increase of production of assimilates during grain filling stage and assimilates remobilization before pollination.

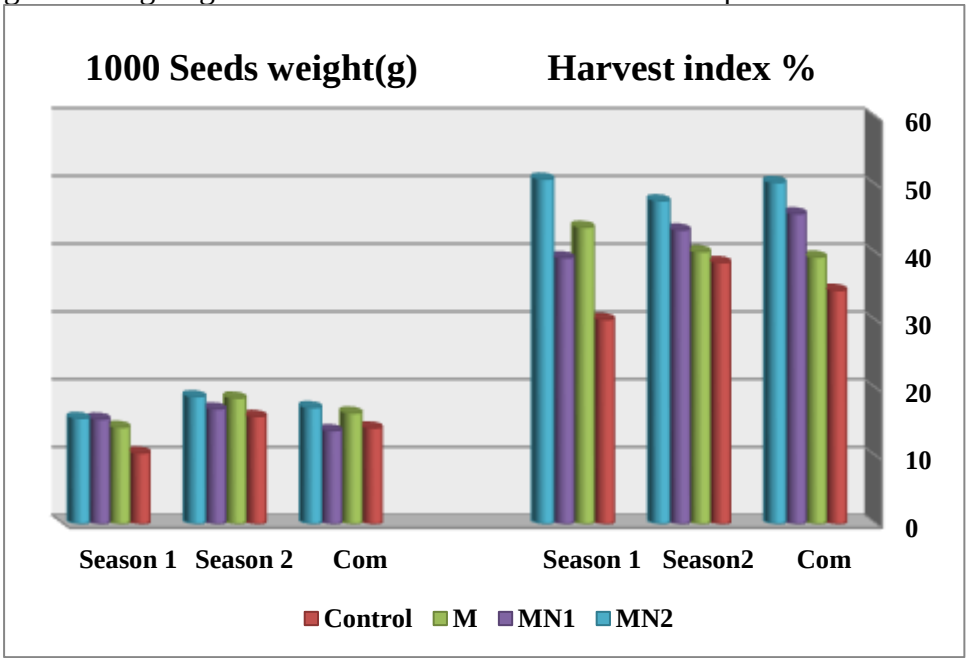

Figure 4. Effect of Urea and Goat organic manure Fertilizers on Harvest Index (%) and Yield (ton\ha).

Soil Physical Properties

Soil physical properties were presented in Figure 5.

Soil moisture content (%)

It was evident that soil moisture content significantly abundant ($P<0.05$) when organic and in organic fertilizers were applied. The highest percentage (11.6%) was found in treatment 40kg urea \feddan combined with 2 ton/ feddan goat organic manure (Figure 5). This result reconciled with (Khalid and Fadni, 2013) who found the highest value of moisture content given by compost treatment (9.57%) resembling an increase of (88.39%) in contrast to the untreated control. It was evident that organic matters increases water retention, especially, in dry land agriculture as practiced in sandy soil of North Kordofan and the likewise areas.

Soil Bulk density (g\cm^3)

The results revealed that the soil bulk density values were not significant with the control and 40 kg urea \ feddan, 80 kg urea \ feddan and 2 ton goat organic manure alone (Figure 5). However, significant differences were detected in soil bulk density when goat organic manure and urea fertilizer were combined together. This result agreed with (Sarkar *et al* 2003), who reported that application of organic fertilizers alone decreased the bulk density and in line with (Khalid and Fadni, 2013) who reported that highest value of bulk density was recorded in the compost treatment (1.62 g/cm3) while untreated control treatment gave the lowest value (1.46 g/cm3). It worth opting that upon the addition of organic and mineral fertilizers; there was a significant change in the soil physical properties.

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Soil Porosity %

Result showed that total porosity values were increased by addition of organic goat manure, where the 40 kg urea \feddan with 2 ton\ feddan goat organic manure and 80 kg urea \feddan with 2 ton goat organic manure\ feddan gave highest values of total porosity compared with other treatments (Figure 5). Generally, the reduction in bulk density values led to increase of total porosity in soil. Such increase was probably an indication of soil aggregation in forms leading to improved soil structure and increased porosity. This result could be supported with results obtained by (Habtamu, 2015) who showed that integrated application of organic and inorganic fertilizers improved soil total porosity and decreased bulk density by 26.1% in 0 - 30 cm soil depth. The results indicated that the different fertilization treatments had significant effect ($p \leq 0.05$) on the soil porosity. The lowest porosity of the soil was in the control treatment which was 52.06% and significantly differs with the other treatments except at the urea treatment (52.57%) While, the highest soil porosity was found in the combined fertilizer treatments which was 57.57% which significantly differs from the other treatments (Muhsin 2018). Increasing of soil aggregate stability due to the addition of organic manure probably leads to increasing soil porosity (Rasoulzadeh and Yaghoubi, 2010).

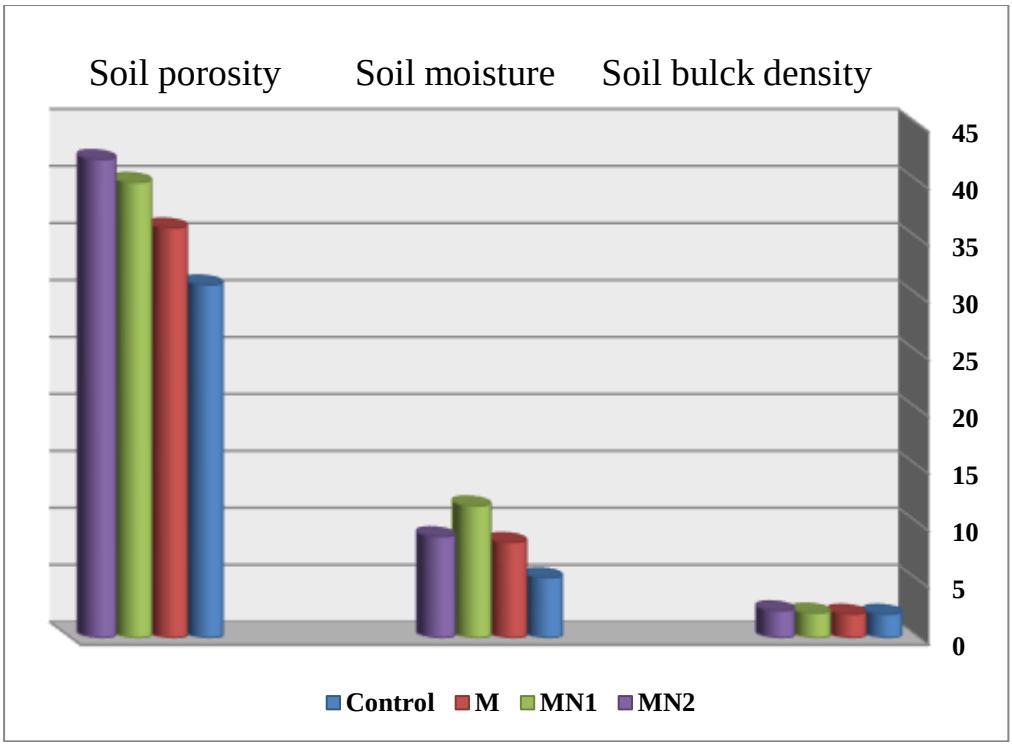

Figure 5: Effect of Urea and Goat Manure Fertilizer on Soil Porosity (%),Soil moisture content (%) and Soil bulk density (g\cm3)

CONCLUSION

Based on the objectives of the study, the results of the study showed that application of urea and goat organic manure significantly increased sorghum growth parameters, yield components and grain yield. Soil physical properties were also improved . It can be concluded

that using 2 ton goat organic manure /feddan with 80kg urea /feddan significantly increased vegetative growth, yield attributes, and grain yield of sorghum. soil physical properties of sandy soil were improved. Fertilizer combinations of goat organic manure and urea can be recommended to improve sorghum productivity and some soil physical properties in the marginal sandy rain fed soils of North Kordofan State and similar environments in Sudan.

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