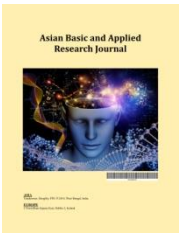

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Effect of Urea Fertilizer Rate on Growth and Yield Components of Sorghum (*Sorghum bicolor L.*) under Rain – fed Conditions, in North Kordofan, Sudan

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Low soil fertility is one of the main factors for low productivity of crops in North Kordofan State. The effects of urea fertilizer on growth and yield of sorghum (*Sorghum bicolor* L.) variety *Botana* was studied at the experimental field of Faculty of Natural Resources and Environmental Studies, in Sheikan locality, North Kordofan State during two consecutive rainy seasons 2021/2022 and

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2022/2023. The experiment consisted of three treatments (Control, 40kg urea/feddan and 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, leaf area index and stem diameter (cm). Yield and yield attributes were straw dry yield (ton/ha), full head dry weight (g) 1000 seeds weight (g), grain yield (ton/ha) and harvest Index (%). Data were analyzed using GEN STAT program. Means were separated using Least Significance Difference (LSD) at 5% probability level. Results showed that urea fertilizer significantly ($P \leq 0.05$) increased sorghum plant growth, yield attributes and grain yield compared to control in both seasons. Urea fertilizer significantly ($P \leq 0.05$) decreased days to 50% flowering and increased plant height (cm), straw dry yield (6.5 ton/ha) compared to control (4.7 ton/ha), 1000 seeds weight (g), grain yield (2.3 ton/ha) compared to control (1.9 ton/ha) and Harvest Index% for sorghum crop. Whereas there was no significant effect amongst treatments on number of leaf per plant and stem diameter (cm). It was concluded that application of urea had a significant effect in most studied attributes in addition to shortening the maturity period. Therefore, to increase yield and yield components of Sorghum, namely cultivar *Botana*, in the study area during rainy season's application of urea is recommended.

Keywords: Urea fertilizer; sorghum; rain-fed; North Kordofan State.

1. INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is the staple food crop of most people in the Sudan. In Sudan; sorghum is the most important cereal crop in terms of total acreage, production and consumption. Sorghum (Dura) is the main grain crop used by Sudanese in their daily diet (Mohammed *et al*., 2020). It is mainly produced traditionally in rain fed areas and in modern agriculture in central clay plain Gezira. Soil fertility is a major barrier affecting all aspects of crop production (Mbah and Mbagwu, 2006). Also Naba *et.al* (2020) reported that, sorghum is primarly cultivated as rain-fed cereal crop in subtropical Africa in areas with low inconsistent extremely variable annual rainfall total ranging from 400 mm to 650 mm. Low soil fertility is one of the main factors responsible for low productivity of crops in North Kordofan State. Soil fertility can be presumably enhanced by organic and inorganic fertilizers application (Khalid and Fadni, 2013). Soils in North Kordofan are predominantly sandy; these soils are characterized by low nutrient and water holding capacity, especially during hot summer. This often results in stunted plant growth, poor bloom or crop production. However, sandy soil also offers benefits, including excellent drainage, good air circulation and less pest incidence. By properly preparing and maintaining sandy soils, farmers enjoy these advantages while manipulating possible negative production factors. Soil fertility is play important role in subsistence farming in North Kordofan state hence smallholder farms is almost entirely dependent on locally available resources to use different application of miss use fertilizers. Urea is a fertilizer material used for direct application to crops or in the preparation of blended fertilizers. Under most circumstances, it is equivalent to or superior than most other nitrogen sources. To understand the significance of urea, as opposed to other sources of nitrogen, one must examine the nature of commercial fertilizers. This study was conducted to evaluate the effect of urea nitrogen on growth and yield of Sorghum Cultivar (*Botana*) under rain-fed conditions in North Kordofan State.

2. MATERIALS AND METHODS

2.1 Study Area

The experiment was carried out at the premises of Faculty of Natural Resources and Environmental Studies, demonstration farm, in Sheikan locality, North Kordofan state. It covers an area of about 8312Km^2 (2 million acres), mostly useful for agriculture and grazing activities. Sheikan locality is located within the semi-desert zone where the average annual rainfall is between 250-450 mm/year during the rainy season (June to October). The total rainfall for season 2021/2022 was (338.4mm\year) and was (317.9mm\year) for the second season 2022/2023.Rainfall amount and distribution were fairly similar in both seasons as shown in Fig. 1.

2.2 Plant Material Used

The plant material was used in this study include Botana variety which is charactrisized by high

yield stability during all Sudanese soils and environment and previous studies recorded that, physiological efficiency of this variety was almost equal and minerals utilization was balanced between all yield components and productivity.

2.3 Experimental Design and Treatments

Treatments assigned in a Randomized Complete Block Design (RCBD) with four replications for two consecutive seasons 2021/ 2022 and 2022/2023. The plot area (2×5^{m}), the spacing for sorghum (50 × 50^{cm}) and the spacing between plot to plot (1^{m}). The first half dose was applied after three weeks from sowing, and the second one after a month from the first one. Seeds were sown at the depth of 2 cm at the middle of July for the two rainy seasons. The experiment consisted of three treatments control (TR1), 40 kg/urea/feddan (TR2) and 80 kg/urea/feddan (TR3).

2.4 Data Collection

Plant growth parameters include: days to 50% flowering, plant height (cm), number of leaf per plant, leaf area index and stem diameter (cm). While the yield attributes include full head dry weight (g), straw dry yield (ton/ ha), grain yield (ton/ ha), 1000 – grain weight (g) and harvest index (%).

2.5 Data Analysis

Data was analyzed using GEN STAT program. 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.

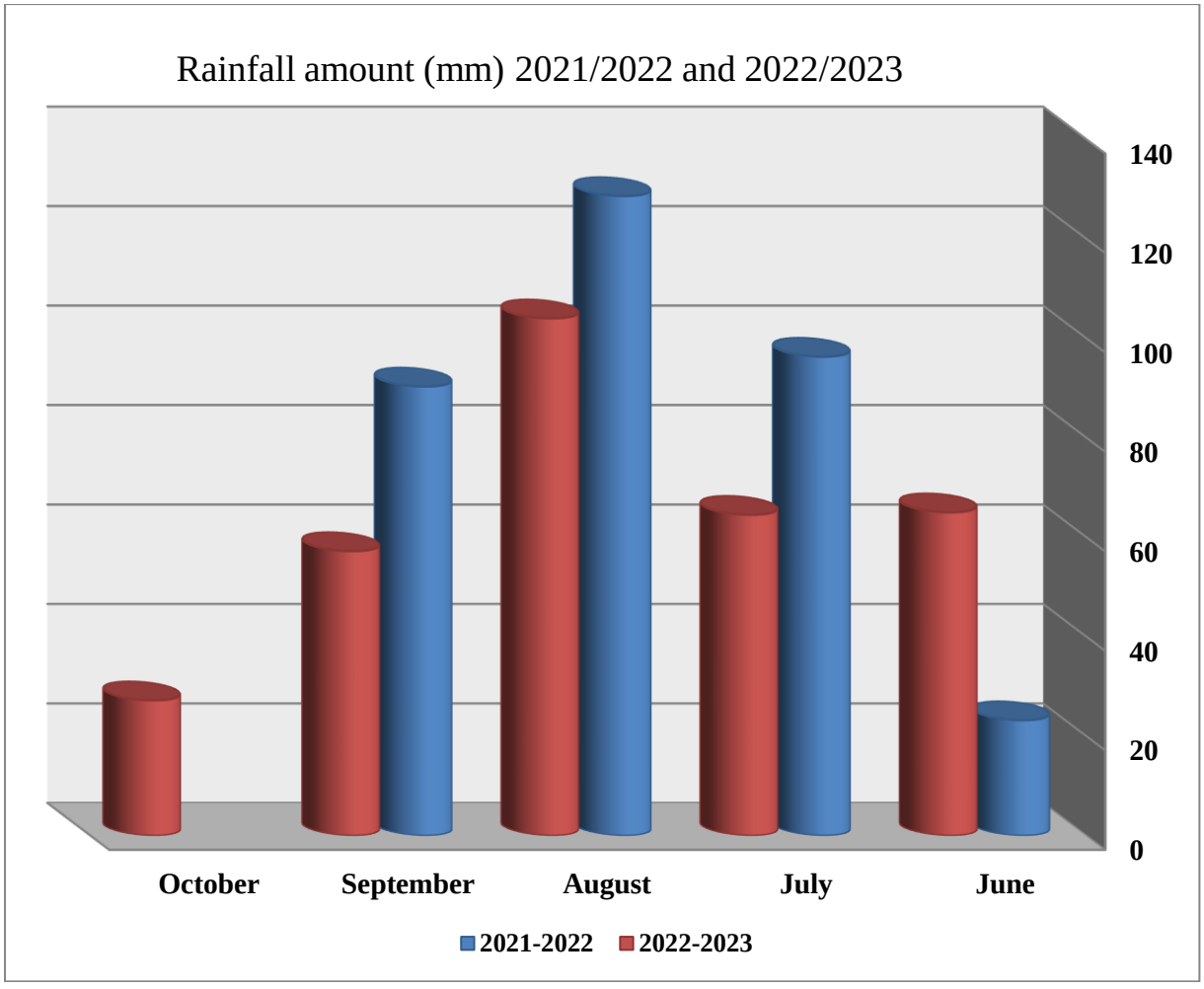

Fig. 1. Rainfall amount (mm\year) during rainy seasons 2021/2022 and 2022/2023.Source: Elobeid Research Station

3. RESULTS AND DISCUSSION

3.1 Sorghum Growth and Yield Parameters

Days to 50% flowering: Results showed that days to 50% flowering response decreased linearly (Table 1). All treatments showed significant ($P \leq 0.05$) early flowering effect in contrast to the control which displayed delayed flowering in both seasons. This observation suggests that the application of fertilizers decrease the number of days to the flowering stage implying earliness in maturity especially in such short rainy season. This could be attributed to the immediate accessibility of available nitrogen in the soil for plants, which plays a key role in cell division and enlargement (Muhammad *et al*. 2003).

Plant height (cm): Table 1 illustrated that, the difference in values of plant height between urea and control was found to be significant at ($P \leq 0.05$) level at two seasons. The increase in height of plants obtained by the use of fertilizers might be due to the high stimulating effect of nitrogen on various physiological phases in cell division and cell elongation (Alim, 2012). Urea Fertilizer provides adequate nitrogen levels during reproductive stage and support the formation of panicles and the filling of grains. This in turn was reflected in increasing plant growth parameters such as plant height and leaf area index. Fertilizer application in beans was also reported to improve soil conditions and supported better aeration to the plant roots and absorption of water and nutrients which was reflected in increasing plant growth parameters such as plant height (Manivannan *et al*., 2009).

Number of leaf per plant: Effects of nitrogen application on the number of leaf per plant exhibited no significant differences amongst treatments in both seasons (Table 1). This could be due to that leaf number is dictated by the genetic setup of the plant (Meena and Mann. 2007). In other words, these results could be attributed to the length of the growth cycle of the cultivars which solely depends on the genetic makeup of the cultivar plants. However, increasing vegetative growth rate may lead to a reduction in nutrients in the leaf, by increasing their remobilization from leaf to grains, resulting in decreasing nutrients concentration in leaf with progress in plant growth (Al-Fadlly, 2011 and Mohammed, 2013).

Leaf area index (LAI): Leaf area index was significantly ($P \leq 0.05$) increased due to urea fertilizer compared to control, in two seasons (Table 2). These nutrients triggered the vigorous growth of plant leaves, thereby achieving higher LAI and further boosted the dry matter production and hastened the flowering and maturity period. Moreover, Aflakpulet *al.,*(2005), reported that N.P.K application increased growth and yield of sorghum. Similar results were stated by (Darwin *et al* 2018) who reported that the response of plants to the application of urea fertilizer gave a significant effect on leaf area index in sweet corn.

Stem diameter (cm): The results of stem diameter showed that there were no significant differences ($P \leq 0.05$) between treatments at two seasons Table 2. At stem diameter in sorghum is thought to be genetically controlled. The nitrogen content also serves to spur the process of formation of the plant growth, because nitrogen is a nutrient-forming amino acid and proteins as raw material in the preparation of plant growth as explained by (Djunaed, 2009) in long beans. Stem diameter is dependent on the number of internodes for their length and this represents the genotypic characteristics of a variety (Abdul-Basit 2019).

Full head dry weight (g): Table 3 showed that, applying urea fertilizer resulted in significantly($P \leq 0.05$) higher full head dry weight as compared with control and the difference was, the highest weight was in season two (35.3 g) in contrast to control (21.4g) for the same season. The full head dry weight consistently increased at the two seasons. Increased in full head dry weight with an increased in nitrogen levels was obvious due to that fact, nitrogen promotes the plant growth manifesting positive effects on full head dry weight. It was obvious that the increase in head dry weight is an essential factor for panicle weight and hence, increase in number and weight of grains per head and consequently on grain yield. An increase in the full dry head weight at higher nitrogen levels might be attributed to the lower competition for nutrients allowing the plants to accumulate more biomass with a higher capacity to convert more photosynthesis products into sink resulting in more grains (Kripa *et al* 2021).

Straw dry yield (ton/ ha): Differences in straw dry weight between treatments were Significant ($P \leq 0.05$) in both seasons (Table 3). The highest weight of dry straw found when 80 kg urea\ feddan applied in season one (5.6 ton/ha). The weight of dry straw can be used as a reference for measuring the growth of a plant as the fresh

straw weight can rapidly change in a relatively short time due to loss of plant moisture content (Fitter and Hay 1994). Also, dry straw weight accumulates various food reserves, including protein, carbohydrates, and fats. According to (Moe *et al*. 2017) total dry matter accumulation in rice plants varied significantly under different levels of inorganic fertilizer. The effect of N fertilization on growth, yield and yield quality of two sorghum cultivars the high rate of N (80 IbN/feddan) significantly increased forage yield (fresh and dry) and crude fiber percent of *Abusabin* cultivar, (Zaid, 2004).

1000 seeds weight (g): The result showed that application of 80 kg urea\feddan significantly ($P \leq 0.05$) gave the highest 1000 grain weight than other treatments in both seasons (Table 4). These results are in agreement with findings of (Shuaibu Yunusa *et al* 2018) who reported that the combination of organic and inorganic fertilizers increases the weight of 1000 seeds in sorghum. Other studies revealed significant increase in 1000-grain weight due to the addition of nitrogen alone **(**Mafongoya, 2006 and Chaudhary and Mehdi 2003**)**. The effect of nitrogen fertilizer on 1000 grain yield of sorghum was reported to be significant only in the first sowing date (Azrag *et al* 2015).

Harvest index (%): Results in Table 4 depicted that harvest index values were affected by application of 80kg urea/feddan which recorded the highest values of harvest index compared with other treatments at two seasons. 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 and accumulation of assimilates during grain filling stage and assimilates remobilization after pollination. Previous results (Buah *et al.,* (2005) in pearl millet and the findings of (Muhammad Arif *et al*.,2014) in rice, and Aflakpul*et al*., (2005), in millet and rice crops were consistent with the findings of this study.

Grain yield (ton/ha): Table 3, shows the effect of urea on grain yield of sorghum and indicated that, the application of 80 kg urea\feddan was found to produce significantly ($P \leq 0.05$) higher yield than other treatments used at the two seasons. Application of 80 kg urea/feddan increased the yield up to (2.6 ton/ha) compared to control (1.9 ton/ha) in season two. The higher grain yield obtained could be due to balance in the proportion of nutrients in adequate amount. This is supported by the finding of **(**Ibrahim and Hashim 2002) they further reported that application of urea to the soil significantly increased total nitrogen content of the top 30 cm of the soil. This is in conformity with the report of **(**Conley and Dunn, 2005 and Lafarge and Hamma, 2002**)** who indicated that the grain sorghum responded to inorganic fertilizer by increasing grain yield. It seems plausible that the increase in grain yield attributes unequivocally will be reflected in the final grain yield. The subtle differences between the two seasons could be attributed to rainfall amount and distribution added to differences in cultural practices.

1000 seeds weight (g): The result showed that application of 80 kg urea\ feddan was observed to have significantly ($P \leq 0.05$) the highest 1000 grain weight than other treatments in both seasons Table 4. These results are in agreement with findings of (Shuaibu Yunusa *et al* 2018) who reported that the combination of organic and inorganic fertilizers increases the weight of 1000 seeds in sorghum. Other studies revealed significant increase in 1000-grain weight due to the addition of nitrogen alone **(**Mafongoya, 2006 ; Chaudhary and Mehdi 2003**)**. The effect of nitrogen fertilizer on 1000 grain yield of sorghum was reported to be significant only in the first sowing date (Azrag *et. al*, 2015).

Harvest index (%): Result in Table 4 show that harvest index values of sorghum plants were affected by different application rates of urea fertilizer. It was noticed that the harvest index values were affected by 80kg urea/ feddan which recorded the highest values of harvest index compared with other treatments at two seasons. 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 and synthesis of assimilates during grain filling stage and assimilates remobilization before pollination. The results of this study were also consistent with the findings of (Buah *et al.,* (2005) in pearl millet and the findings of (Muhammad Arif *et al*.,2014) in rice. **(**Aflakpul 2005), also reported that manure alone or mixed with N.P.K result in an increase in growth and yield of sorghum. Other studies have also shown the influence of different nutrient management practices on the harvest index of pearl millet (Bhanu, 2014; Siavoshi M et al, 2011).

Table 1. Effects of urea fertilizer on days to 50 % flowering (days) plant height (cm), number of leaf per plant, on sorghum plants for rainy seasons 2021/2022-2022/2023

	Measurement parameters					
	50% flowering		Plant height(cm)		No. of leaf /plant	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Treatment						
TR1	49a	50a	65.1d	80.0b	10a	9a
TR2	44b	48a	69.4b	80.8b	9a	10a
TR3	44b	45b	60.8e	82.1a	9a	10a
Mean	45	48	65.1	80.9	9	10
LSD $_{(0.05)}$	1.4	3.4	7.9	7.3	1.1	0.6
SE±	0.43*	0.58*	1.52*	1.04ns	0.16ns	0.09ns
CV%	4.78	6.14	11.09	6.23	8.09	4.9

TR1: control, TR2: 40 kgurea / feddan, TR3: 80 kgurea/ feddan

Table 2. Effects of urea fertilizer on sorghum leaf area index and stem diameter for rainy seasons 2021/2022-2022/2023

	Measured parameters			
	Leaf area index		Stem diameter (cm)	
	Season 1	Season 2	Season 1	Season 2
Treatment				
TR1	237.7c	226.4c	1.7a	1.6a
TR2	246.5b	259.0b	1.7a	1.6a
TR3	274.2a	287.3a	1.7a	1.7a
Mean	252.8	257.6	1.7	1.6
LSD	6.4	5.5	0.9	1.2
SE±	9.9**	7.9**	0.05ns	0.02ns
CV%	18.5	15.2	13.26	7.5

TR1: control, TR2: 40 kg/urea / feddan, TR3: 80 kg/urea/ feddan

Table 3. Effects of urea fertilizer on full head dry weight (g), straw dry yield (ton/ ha) and grain yield (ton/ ha) for rainy seasons 2021/2022- 2022/2023

	Measured parameters					
	Head dry weight(g)		Straw dry yield (ton/ha)		Grain yield (ton/ha)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Treatment						
TR1	17.7c	21.4c	4.7b	4.8b	1.9b	1.9b
TR2	25.2ab	32.1ab	5.1a	5.1a	2.1a	2.5a
TR3	26.0a	35.3a	5.6a	5.3a	2.3a	2.6a
Mean	23	29.6	5.1	5.1	2.1	2.3
LSD	0.6	3.9	1.9	1.7	0.5	0.2
SE±	0.27*	1.9*	0.52*	0.3*	0.08*	0.14*
CV%	23.13	19.2	18.67	22.9	17.07	16.1

TR1: control, TR2: 40 kg/urea / feddan, TR3: 80 kg/urea/ feddan

Table 4. Effects of urea fertilizer on 1000 seeds weight (g) and harvest index (%) for rainy seasons 2021/2022- 2022/2023

	Measured parameters			
	1000 seeds weight (g)		Harvest index	
	Season 1	Season 2	Season 1	Season 2
Treatment				
TR1	10.5b	15.9b	30.2c	38.6c
TR2	13.2ab	18.5a	42.6b	41.9b
TR3	14.6a	18.7a	48.8a	44.0a
Mean	12.8	17.7	40.5	41.5
LSD	3.9	1.7	1.9	3.4
SE±	0.63*	0.32*	0.28**	1.9*
CV%	22.31	8.8	16.66	17.2

TR1: control, TR2: 40 kg/urea / feddan, TR3: 80 kg/urea/ feddan

4. CONCLUSION AND RECOMMENDATIONS

The results indicated that, application of 80 kg urea/feddan showed significantly differences for all studied characters. Sorghum (*Botana* cultivar) gave the highest values of plant height, leaf area index, stem diameter, full head dry weight (g), straw dry yield (ton/ ha), 1000 seeds weight (g), grain yield (ton/ ha), and harvest index. To increase productivity of Sorghum (cultivar Botana) in north Kordofan State under rain-fed, urea fertilizer (80 kg/fed) is recommended. Further study needed it to cover a wide range of urea applications under rain-fed sector of North Kordofan.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Abdul-Rahman, A. I. (2019). *Combined effect of organic and inorganic fertilizers on growth of rice plants*. Unu Land Restoration Training Programme, Final Project 2019.

Adhikari, K., Bhandari, S., Aryal, K., Mahato, M., & Shrestha, J. (2021). Effect of different levels of nitrogen on growth and yield of hybrid maize (*Zea mays* L.) varieties. *Journal of Agriculture and Natural Resources, 4*(2), 48-62. https://doi.org/10.3126/janr.v4i2.33656

Aflakpul, G. S. K., Anchirinah, V. M., & Asumadu, H. (2005). Response of quality protein maize hybrid to N supply and plant density in the forest zone of Ghana. *Tropical Science, 45*, 3-7.

Al Fadlly, J. T. M. (2011). *Effect of organic and mineral fertilization on growth and yield of potato crop* (M.Sc. Thesis). Coll. Agric. Univ. Baghdad, Iraq. (in Arabic).

Alim, M. (2012). Effect of organic and inorganic sources and doses of nitrogen fertilizer on the yield of boro rice. *Journal of Environmental Science and Natural Resources, 5*, 273–282.

Arif, M., Tasneem, M., Bashir, F., Yaseen, G., & Iqbal, R. M. (2014). Effect of integrated use of organic manures and inorganic fertilizers on yield and yield components of rice. *Journal of Agricultural Research, 52*(2).

Azrag, A. A. D., Dagash, Y. M. I., & Yagoub, S. O. (2015). Effect of sowing date and nitrogen fertilizer rate on yield of sorghum (*Sorghum bicolor* L.) and nitrogen use efficiency. *Journal of Agricultural and Veterinary Sciences, 16*(1).

Buah, S., & Maranville, G. (2005). Response of nitrogen use efficient sorghum to nitrogen fertilizer. *Journal of Plant Nutrition, Zill*, 2303–2318.

Chaudhary, E. H., Ranjha, A. M., Gill, A. M., & Mehdi, S. M. (2003). Phosphorus requirement of maize in relation to soil characteristics. *International Journal of Agricultural Biology, 5*(4), 625-629.

Conley, S. P., Steven, W. G., & Dunn, D. D. (2005). Grain sorghum responds to row spacing, plant density, and planter skips. *Crop Management, 5*, 56-59.

Djunaed, A. (2009). Effect of Botashi fertilizer dose on growth and production of long bean (*Vigna sinensis* L.). *Agrovigor, 2*, 42-46.

Elsheikh, M. A., Abdalla, M. A., & El Tilib, A. M. A. (2020). Advances in soil fertility research in Sudan. *Sudan Journal of Desertification Research, 12*(1), 96-129.

Fitter, A. H., & Hay, R. K. M. (1994). *Plant environmental physiology* (Trans. Andani, S., & Purbayanti, E. D.). Gadjah Mada University Press.

HabinsarandPangaribuan, D., Hendarto, K., Elzhivago, S. R., & Yulistiani, A. (2018). The effect of organic fertilizer and urea fertilizer on growth, yield, and quality of sweet corn and soil health. *Asian Journal of Agriculture & Biology, 6*(3), 335-344. https://www.researchgate.net/publication/343862739

Ibrahim, K. M., & Fadni, O. A. S. (2013). Effect of organic fertilizers application on growth, yield, and quality of tomatoes in North Kordofan (Sandy Soil), Western Sudan. *Greener Journal of Agricultural Sciences, 3*(4), 299-304.

Ibrahim, S. H., Moamed, A. B., Osman, H. N., & Hashim, A. A. (2002). Fertilizing with urea and FYM for higher cotton yields and better soil conditions in the Gezira. Paper presented at the National Crop Husbandry Committee Meeting, Agricultural Research Corporation (ARC), Wad Medani, Sudan.

Lafarge, T. A., & Hamma, G. A. (2002). Tillering in grain sorghum over a wide range of

population densities: Modeling dynamics of tiller density. *Botany Journal of Agronomy, 6*(9), 99-110.

Mafongoya, P. L., Bationo, A., Kihara, J., & Swaswa, B. (2006). Appropriate technologies to replenish soil fertility in Southern Africa. *Nutrient Cycling in Agroecosystems, 76*, 137-151.

Manivannan, S., Balamurugan, M., Parthasarathi, K., Gunasekharan, G., & Ranganathan, R. (2009). Effect of vermin compost on soil fertility and crop productivity of beans (*Phaseolus vulgaris*). *Journal of Environmental Science, 30*, 275-281.

Mbah, C. N., & Mbagwu, J. S. (2006). Effect of animal waste on physicochemical properties of a dystric leptosol and maize yield in Southeastern Nigeria. *Nigerian Journal of Soil Science, 1*, 290-305.

Meena, L., & Mann, J. (2007). Response of forage sorghum (*Sorghum bicolor*) varieties to different levels of nitrogen with and without farmyard manure in a semiarid region. *International Journal of Tropical Agriculture, 25*, 105-109.

Moe, K., Mg, K. W., Win, K. K., & Yamakawa, T. (2017). Combined effect of organic manures and inorganic fertilizers on the growth and yield of hybrid rice (*Palethwe-1*). *American Journal of Plant Sciences, 8*, 1022–1042.

Mohammed, E. J. (2013). Evaluation of the effect of organic and mineral fertilization on some soil properties, growth, and yield of snake cucumber (*Cucumis melo* var. *flexuosus*). (M.Sc. Thesis). Coll. Agric. Univ. Basrah, Iraq. (Arabic Thesis).

Muhammad, S. Y., Abdulmumini, B. R., Sani, K., & Zaharaddeen, S. (2018). Effect of organic and inorganic fertilizer on the growth and yield of sorghum (*Sorghum bicolor* (L.) Moench) in Bauchi State, Nigeria. *GSC Biological and Pharmaceutical Sciences*. https://www.gsconlinepress.com/journals/gscbps

Naba, W., Moges, A., & Gebremichael, A. (2020). Evaluating the effect of in-situ rainwater harvesting techniques on maize production in moisture-stressed areas of Humbo Woreda, Wolaita Zone, Southern Ethiopia. *International Journal of Agricultural Research, Innovation, and Technology, 10*(1), 71-79. https://doi.org/10.3329/ijarit.v10i1

Reddy, B. P. S. (2014). *Effect of nitrogen and potassium on yield and quality of pearl millet* (Master's thesis). Acharya N.G. Ranga Agricultural University.

Siavoshi, M., Nasiri, A., & Lawere, S. L. (2011). Effect of organic fertilizer on growth and yield components in rice (*Oryza sativa* L.). *Journal of Agricultural Science, 3*, 217-224.

U, M., Ehsan, U., Ejaz, A. W., & FAL, M. (2003). Effect of organic and inorganic manures on growth and yield of rice variety “Basmati–2000.” *International Journal of Agriculture & Biology, 4*, 481-483.

Zaid, G. A. A. (2004). Effect of nitrogen and sulfur fertilization on growth, yield, quality, nitrogen, and prussic acid content of two forage sorghum cultivars. (M.Sc. Thesis). University of Khartoum.

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