Middle East Journal of Agriculture Research
Volume: 11 | Issue: 04| Oct. – Dec.| 2022

EISSN: 2706-7955 ISSN: 2077-4605
DOI: 10.36632/mejar/2022.11.4.80
Journal homepage: www.curresweb.com
Pages: 1201-1208

Effect of Irrigation Interval, Nitrogen Fertilizer and Farmyard Manure on Wheat (*Triticum aestivum* L.) Yield in Elmultaga Soil Series Northern State, Sudan

Ali Abdalla Mohammed

National Institute of Desert Studies, University of Gezira, Sudan.

Received: 29 August 2022 **Accepted:** 20 Nov. 2022 **Published:**15 Dec. 2022

ABSTRACT

A field study was conducted for two cons successive winter seasons; 2016/17 and 2017/18, at the Research Farm of the National Institute of Desert Studies, New Hamdab Scheme, Northern State of Sudan. The objective was to investigate the effect of treatments interactions of irrigation interval (7, 10 and 15 days), application of Nitrogen fertilizer (43 and 86 Kg fed^{-1}) and farmyard manure (zero and 10ton ha^{-1}) on wheat (*Triticum aestivum* L.) growth and yield in the area. The experimental design was a split-split-plot design with four replicates. The results showed no significant differences ($P \leq 0.05$) on plant per meter square in both seasons and harvest index in the second season to significant differences ($P \leq 0.05$) on plant height, spike length, number of seeds/spike, biological yield, straw yield in both seasons and harvest index season one. and highly significant differences ($P \leq 0.01$) due to the interaction effect of these three factors on the number of spikes/m^2, number of tillers/ m^2, 1000 seeds weight and grain yield. The combination of 7 or 10 days irrigation interval, application of 86 Kg fed^{-1} nitrogen fertilizer and 10 ton ha^{-1} farmyard manure produced the highest means values of growth, yield and yield components of wheat in both seasons.

Keywords: *Triticum aestivum* L., Aridisols, Soil reclamation, New Hamdab scheme.

1. Introduction

Wheat (*Triticum aestivum* L.) is mainly grown in 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.

Increasing wheat productivity is a national target in Sudan to fill the gap between wheat consumption and production. However, the lack of yield stability over seasons and location has remained a great challenge to both research and production management (Babiker and Faki, 1994). Wheat production under the semi-arid conditions of Sudan is now a success. Grain yield of over five tonne ha^{-1} were obtained with high irrigation, either from river flows or lifted from the River Nile and wells using diesel pumps (Farah *et al.,* 1994).

Ageeb (1994) stated that, irrigation water and irrigation practices are factors which have always limited wheat productivity. Detection of crop water stress is critical for efficient irrigation water management, especially in the semi-arid regions. On the other hand, irrigation water is becoming increasingly scares; this highlights the

The high terrace soils of the Northern State are characterized by light texture, low chemical fertility (low N, P and O.C) (LWRC, 1999).

Irrigation is an expensive input, therefore, farmers, agronomists, economists and engineers need to know the response of growth and yield of wheat to irrigation. Several investigations from different

Corresponding Author: Ali Abdalla Mohammed, National Institute of Desert Studies, University of Gezira, Sudan. E-mail: linids72@yahoo.com

parts of the world reported that growth and yield attributes of wheat; plant height; number of tillers/m^2, number of spike/m^2, spike length, number of seeds/spike, 1000-seeds weight, biological yield, grain yield, straw yield and harvest index, increased with more frequent irrigation and decrease with less frequent irrigation (Hussain *et al.,* , 2004; Zeidan *et al.,* , 2009; Akram, 2011; El Hwary and Yagoub, 2011; Seleiman *et al.,* , 2011; Ali and Ahmed, 2012; Ngwako and Mashiqa, 2013; Rahman, 2014; Shrief and Abdel-Mohsen, 2015).

Nitrogen is an integral component of 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. 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 decrease 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.

Manures are natural sources of organic matter. The sources of organic matter in soil are animal and plant residues, plant roots, and 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).

In a study at New Hamdab, Awad Elkarim and Younis (2008) evaluated the effect of FYM, nitrogen and phosphorus on wheat growth and productivity for three consecutive seasons (2005/06, 2006/07 and 2007/08). They used three rates of FYM (0, 5 and 10 ton ha-1) in combination with two rates of nitrogen (0 and 86 kg ha-1) and two rates of phosphorus (0 and 43 kg P2 O5 ha-1). They revealed that farmyard manure and nitrogen had very high significant ($p \leq 0.001$) effects on the yield and all the studied yield components of wheat in the three seasons.

Adam and Ali (2001) studied the effect of farmyard manure (FYM), filtermud (FM) and bagasse (B) on yield of wheat at Khashmelgirba soil series in Eastern Sudan. Their study showed that the application of each of the tested manures resulted in highly significant ($P \leq 0.01$) increases in grain yield.

Ali *et al.,* (1993) studied the effect of organic manures on soil properties and wheat yield at Gezira, Hudeiba and New Halfa. The result of their study showed that in the Gezira scheme plots that received organic manures gave higher grain yield as compared to those that received no organic manures. The increase in grain yield was due to the improvement of soil physical properties rather than chemical properties. At high terrace soil "Karu soil" which is a cracking soil of Hudeiba there was no significant effect of organic manures in yield or yield components. At New Halfa a considerable increase in yield was only obtained when the rate of both organic manures and inorganic fertilizer increased.

Awad Elkarim and Babiker (2005) studied the response of wheat to farmyard manure and nitrogen fertilization in the high terrace soils. Their study showed that farmyard manure very highly significantly ($P \leq 0.001$) influenced the length of the spike, number of seeds per head and grain yield.

Awad Elkarim (2003) studied the response of wheat to organic and inorganic fertilizers in high terrace soils, at Hudeiba Research Farm. His study showed that organic manure highly significantly ($P \leq 0.01$) affected the plant height and very highly significantly affected the length of the spike ($P \leq 0.001$), number of seeds/head and grain yield.

2. Material and Methods

2.1. Description of the experimental site

Field experiments were carried out during two consecutive winter seasons (2016/17 and 2017/18) 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 temperatures in summer, low temperatures in winter and low rainfall (Habiballa and Ali, 2010).

The soil of the study area belongs to El Multaga soil series which is classified as Vertic Haplocambids, fine loamy, mixed, supper active, hyperthermic. The soil structure is moderate subangular blocky. It is non-saline and non-sodic (see Table 1 below) (LWRC, 1999). Generally, the soil chemical fertility is low and mostly these soil 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 Table 1.

Table 1: 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 (%)	0.052	0.066	0.078	0.061	0.052
C/N ratio	4	4	5	5	5

L S = loamy sand, SL = sandy loam, SCL= sandy clay loam

2.2. Experimental design and treatments

The treatments were arranged in a split-split-plot design that completely randomized within four replicates. The area of each sub- sub plot was 42 m^2 (6 × 7 m). The experimental units were two meters apart from each other. The main plots were assigned to irrigation interval with three levels, the sub-plots were assigned to nitrogen fertilizer application with two rates and sub- sub plots were assigned to farmyard manure with two rates. 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
Irrigation interval (I)	7 days	I_1
	10days	I_2
	15 days	I_3
Nitrogen Fertilizer (N)	43 Kg fed^{-1}	N_1
	86 Kg fed^{-1}	N_2
Farmyard Manure (FM)	0 ton ha $^{-1}$	F_1
	10 ton ha $^{-1}$	F_2

$I_2N_1F_1$= as the control. fed= Feddan (= 0.42 ha).

2.3. Cultural practices

Wheat variety Wadi Elneel 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. According to Erneo (2007) who concluded that, wheat water requirements per season was 635 mm. The source of water supply for the farm irrigation system was Artesian Well.

2.4. Collection of data

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 the maturity stage, each season. Plant height as expressed in cm was measured from the tip of the spike to the soil surface, 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 the 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 the 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 (kg ha^{-1}) (dry matter plus grain) was determined.

The biological yield samples were manually threshed, and the grain yield as expressed in kg ha^{-1} was obtained. Also, straw yield (kg ha^{-1}) was determined as follows:

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

The harvest index (%) was obtained using the following formula:

$$Harvest\ index = \frac{Total\ grain\ yield\ (kg\ ha^{-1})}{Total\ biological\ yield\ (kg\ ha^{-1})} \times 100$$

2.5. Statistical analysis and interpretation of data

Statistical analysis was carried out using a computer software package (MSTAT). The significance of differences among the various characters under study were compared using Duncan's Multiple Range Test (DMRT). Results were presented in tabular forms.

3. Results and Discussion

Tables 3a and 3b summarize the effect of treatments mean interactions on the examined parameters of wheat crop in both seasons.

Generally, the results showed greater values in the second season than that of the first season. This could be attributed to the variations in climatic conditions between the two seasons, i.e. the second season was characterized by lower temperature in December and January and higher relative humidity percent in all months compared to the first season, and the first season was characterized by higher temperature in February and March compared to the second season. High temperature is a major environmental constraint that limits wheat production in Sudan (Ageeb, 1994).

It was found that the interaction of the tested treatments showed insignificant differences on plant per meter square and harvest index season two.

The results of the statistical analysis indicated that the interaction of irrigation interval, Nitrogen fertilizer and farmyard manure had significant effects ($P \leq 0.05$) on plant height, spike length, number of seeds/spike, biological yield, straw yield in both seasons and harvest index season one.

The results of the statistical analysis indicated that the interaction of irrigation interval, Nitrogen fertilizer and farmyard manure had highly significant effects ($P \leq 0.01$) on the number of spikes/m^2, number of tillers/ m^2, 1000 seeds weight and grain yield, this result confirmed to that of Adam and Ali (2001) who showed that the application of farmyard manures resulted in highly significant effects ($P \leq 0.01$) on wheat yield at Kashmelgirba soil series in Eastern Sudan.

The results clarified that the application of 10 tons fed^{-1} of farmyard manure and addition of 86 kg fed^{-1} nitrogen fertilizer when wheat was irrigated every seven days recorded the highest means values of all examined growth and yield attributes in both seasons but the same result obtained especially wheat grain yield when irrigated every ten days using high levels of nitrogen fertilizer and farmyard manure.

Table 3a: The mean effect of interactions of the applied treatments on growth and yield of wheat in both seasons.

Parameters / Treatments	No. of plants/m²		Plant height (cm)		No. of spikes/m²		No. of tillers/m²		Spike length (cm)		No. of seeds/spike	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
$I_1N_1F_1$	247a	388a	55.0cd	57.6c	295cd	422bcd	24c	49bc	4.7e	5.3b	16d	22b
$I_1N_1F_2$	334a	409a	79.8ab	83.7a	463a	532abcd	123ab	99abc	7.5abc	8.0a	43ab	41a
$I_1N_2F_1$	312a	382a	71.4abc	79.9a	403abcd	491abcd	97b	67bc	6.8bc	7.9a	33bc	42a
$I_1N_2F_2$	289a	402a	84.8a	90.1a	492a	592a	170a	188a	8.6a	8.7a	50a	42a
$I_2N_1F_1$	282a	377a	60.7bcd	57.6c	320bcd	384d	27c	11c	5.2e	5.4b	17d	22b
$I_2N_1F_2$	296a	465a	82.6a	82.3a	418abcd	575ab	121ab	122abc	7.7abc	8.0a	44ab	41a
$I_2N_2F_1$	316a	376a	68.9a	76.1ab	412abcd	515abcd	95b	137abc	6.8bc	8.0a	35ab	39a
$I_2N_2F_2$	321a	405a	83.8a	82.4a	455ab	588a	140ab	150ab	8.2ab	8.5a	48ab	45a
$I_3N_1F_1$	270a	372a	52.4d	56.4c	285d	394cd	25c	38bc	4.6e	5.1b	16d	20b
$I_3N_1F_2$	336a	431a	80.0a	82.3a	445ab	539abcd	110b	98abc	7.6abc	8.1a	45ab	43a
$I_3N_2F_1$	332a	423a	68.4abc	76.1ab	420abcd	505abcd	107b	122abc	6.5cd	8.1a	36ab	43a
$I_3N_2F_2$	307a	423a	80.0a	82.4a	422abcd	546abc	132ab	140abc	8.2ab	8.2a	47ab	45a
SE±	18.02	22.24	3.11	2.68	10.09	26.59	8.94	22.44	0.24	0.27	2.62	1.39
CV(%)	10.26	9.5	12.6	6.03	23.55	9.08	17.8	38.02	5.94	6.19	12.62	6.43
DMRT	N.S	N.S	*	*	**	**	**	**	*	*	*	*

Abbreviations of I, N and F and their operations as explained in Table 1.
Means followed by the different letter(s) in column are significantly different at $P \leq 0.05$.
N.S. = Not significantly different at $P \leq 0.05$.
** = Significantly different at $P \leq 0.01$.

Middle East J. Agric. Res., 11(4): 1201-1208, 2022
EISSN: 2706-7955 ISSN: 2077-4605 *DOI: 10.36632/mejar/2022.11.2.80*

Table 3b: The mean effect of interactions of the applied treatments on growth and yield of wheat in both seasons.

Parameters / Treatments	1000-seeds weight (g)		Grain yield (kg ha-1)		Biological yield (kg ha-1)		Straw yield (kg ha-1)		Harvest index (%)	
	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
$I_1N_1F_1$	37.5^{abcd}	20.4^{a}	2769^{cd}	3575^{abcd}	7354^{abc}	9833^{ab}	4585^{ab}	6910ab	38.67abc	36.89a
$I_1N_1F_2$	37.2^{abc}	20.3^{a}	4203^{ab}	3846^{abc}	9383^{ab}	10370^{ab}	4889^{ab}	8476a	47.50a	36.09a
$I_1N_2F_1$	38.7^{ab}	20.6^{a}	4659^{a}	3517^{abcd}	10545^{a}	9139^{ab}	5856^{ab}	8176a	45.07ab	38.55a
$I_1N_2F_2$	39.0^{a}	21.3^{a}	4812^{a}	5113^{a}	11387^{a}	13290^{a}	6574^{ab}	6958ab	42.43abc	38.44a
$I_2N_1F_1$	32.2^{cd}	10.9^{b}	1322^{e}	1948^{cd}	3779^{c}	6214^{b}	2457^{b}	4838ab	35.30bc	28.44a
$I_2N_1F_2$	36.6^{abc}	20.1^{a}	4790^{a}	4763^{ab}	11669^{a}	13240^{a}	6879^{a}	5016ab	41.27abc	35.88a
$I_2N_2F_1$	36.4^{abcd}	20.5^{a}	3099^{bc}	4093^{ab}	7896ab^{c}	11000^{ab}	4797^{ab}	5096ab	38.45abc	37.13a
$I_2N_2F_2$	38.1^{ab}	21.8^{a}	4655^{a}	4379^{ab}	11327^{a}	11340^{ab}	6673^{ab}	5622ab	41.10abc	38.13a
$I_3N_1F_1$	31.5^{cd}	10.6^{b}	1132^{e}	1856^{cd}	3536^{c}	6361^{ab}	2406^{b}	3250b	32.03c	31.76a
$I_3N_1F_2$	29.9^{d}	11.6^{b}	1770^{de}	1510^{d}	5033^{bc}	4767^{b}	3263^{ab}	5264ab	35.80abc	33.31a
$I_3N_2F_1$	35.9^{abcd}	19.5^{a}	3029^{bcd}	2918^{bcd}	7610^{abc}	8014^{ab}	5315^{ab}	6258ab	39.70abc	36.45a
$I_3N_2F_2$	37.3^{abc}	22.1^{a}	4466^{a}	3376^{abcd}	11346^{a}	8395^{ab}	6879^{a}	6526ab	39.70abc	37.13a
SE±	1.06	1.04	216.95	35.17	730.29	114.05	719.07	80.19	1.99	2.54
CV(%)	5.14	9.67	11.05	17.87	15.05	21.17	24.8	23.02	8.68	12.32
DMRT	**	**	**	**	*	*	*	*	*	N.S

Abbreviations of I, N and F and their operations as explained in Table 1.
Means followed by the different letter(s) in column are significantly different at $P \leq 0.05$.
N.S. = Not significantly different at $P \leq 0.05$.
** = Significantly different at $P \leq 0.01$.

4. Conclusion

As far as irrigation interval, nitrogen fertilizer and farmyard manure combination are concerned, it can be concluded that higher values of growth and yield attributes of winter wheat cultivated in the El Multaga soil series (Northern State of Sudan) were obtained under 7 or 10 days irrigation interval, 86 Kg fed^{-1} nitrogen fertilizer and 10 ton ha^{-1} farmyard manure.

References

Ageeb, O.A.A. 1994. Agronomic Aspects of Wheat Production in Sudan. In: Wheat in Heat- Stressed Environments: Irrigated, Dry Areas and Rice-Wheat Farming Systems. Saunders, D.A. and G.P. Hettel, eds. Proceeding of the International Conference of Wheat in Hot, Dry, Irrigated Environments, Wad Medani, Sudan, 1- 4 February 1993. 67- 74.

Ageeb, O.A., A.B. Elahmadi, M.B. Solh, and M.C. Saxena, (Eds.) 1996. Wheat Production and Improvement in the Sudan. Proceedings of the National Research Review Workshop, 27- 30 August 1995, Wad Medani, Sudan.

Akram, M., 2011. Growth and Yield Components of Wheat under Water Stress of Different Growth Stages. Bangladesh J. Agric. Res., 36(3): 455- 468.

Ali, N.A., A.A. Salih, S.H. Ahmed, B.A. Ibrahim, B.A.A. Mohamed, M.G. Mansi, and O.A. Abelwahab, 1993. Effect of organic fertilization on wheat production under Sudan condition in Nile Valley Regional program for Cool- Season Food Legumes and wheat Annual Report 1992/93 ICARDA. NVRP. DOC. 031. ARC. Wad Medani, Sudan

Ali, Z.A., 2001. The effect of three organic manures on the properties of Khashmelgirba soil series and yield of wheat. PhD thesis, Department of Soil and Water Sciences, Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.

Ali, K.H., 2005. Soil properties and cotton yield as influenced by organic manures and urea under New Halfa environment. PhD thesis, Department of Soil and Water Sciences, Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan.

Ali, A.A. and S.H. Ahmed, 2012. Water Stress Effect on Yield and Water Use Efficiency of Two Wheat Varieties. Third RUFORUM Biennial Meeting 24- 28 September 2012, Entebbe, Uganda, 337-343.

Almeu, A. and A. Hazem, 2011. Government of Sudan and FAO/WFP Crop and Food Security Assessment Mission to the 15 Northern States of Sudan. Available at: http://www.documents.wfp.org/stellent/groups/public/documents/ena/wfp231348.pdf

Awad Elkarim, E.E., 2003. Response of wheat to organic and inorganic fertilizers in high terrace soils. Annual report of LWRC (2002/2003), ARC, Wad Medani, Sudan.

Awad Elkarim, E.E. and S. Babiker, 2005. Response of wheat to farmyard manure and nitrogen fertilization in high terrace soils. Annual report of LWRC (2004/2005), ARC, Wad Medani, Sudan.

Awad Elkarim, E.E. and I.D. Younis, 2008. Effects of Farmyard Manure, Nitrogen and Phosphorus Fertilization on Growth and Productivity of Wheat under New Hamdab Conditions. A paper submitted to the crop husbandry committee December 2008, LWRC, ARC, Wed Medani, Sudan.

Babiker, E.A. and H. Faki, 1994. Evaluation of Farmers' Attitudes and their Effect on Wheat Productivity and Input Use in Rahad Scheme. ICARDA/ ARC. Wad Medani, Sudan.

Bolland, M.O.A., J.W. Bowden, R.F. Brennan, J.W. Cartrol, M.G. Mason, and W.P. Proter, 1991. Wheat Nutrition in: Wheat book: Atechnical Manual for Wheat Producers Compiled by Michael Perry and Brain Hillman, 55-76.

El Hwary, E.B. and S.O. Yagoub, 2011. Effect of Different Irrigation Intervals on Wheat (*Triticum aestivum* L.) in Semi-arid Regions of Sudan. *Journal of Science and Technology*, 12(3): 75- 83.

Erneo, D.B., 2007. Impact of Irrigation Method and Variety on Water Requirement of Wheat (*Triticum aestivum* L.) in the Upper Terrace of Northern Sudan. Ph.D. Thesis. University of Juba, Sudan.

Farah, S.M., S.H. Ahmed, A.A. Salih, H.M. Ishag, and A.M. Badr Eldin, 1994. Effect of Skipping Irrigation at Different Developmental Stages of Wheat. Pages 1-5 in Nile Valley Regional Coordination Meeting, Cairo, Egypt.

Gardner, B.R. and E.P. Jackson, 1976. Fertilization nutrient composition and yield relationship in irrigated spring wheat. Agron. J. 68:75—78.

EISSN: 2706-7955 ISSN: 2077-4605 *DOI: 10.36632/mejar/2022.11.4.80*

Habiballa, A.M. and A.M. Ali, 2010. Classification of Climates Using Aridity Indices. Sudan J. Des. Res., 12: 62- 75.

Hussain, A., M.R. Chaudhry, A. Wajid, A. Ahmed, M. Rafiq, M. Ibrahim, and A.R. Goheer, 2004. Growth, Yield and Radiation Use Efficiency of Various Wheat Cultivars. Int. J. Agric. Biol., 6(6): 1074- 1079.

Kumar, S., R.S. Malik, and I.S. Dahiya, 1985. Influence of Different Organic Wastes Upon Water Retention, Transmission and Contact Characteristics of a Sandy Soil. Aust. J. Soil Res., 23(2): 131- 136.

Land and Water Research Centre. 1999. Detailed Soil Survey and Land Suitability Classification of El Multaga Scheme. Agricultural Research Corporation, Wad Medani, Sudan.

Ngwako, S. and P.K. Mashiqa, 2013. The Effect of Irrigation on Growth and Yield of Winter Wheat (*Triticum aestivum* L.) Cultivars. International Journal of Agriculture and Crop Sciences, 5(9): 976- 982.

Rahman, M., 2014. Effects of Different Levels of Irrigation on the Yield and Yield Contributing Characters of Wheat. M.Sc. Thesis. Bangladesh Agricultural University. Available at:

Seleiman, M., S. Abdel-aal, M. Ibrahim, and G. Zahran, 2011. Productivity, Grain and Dough Quality of Bread Wheat Grown with Different Water Regimes. Journal of AcroCrop Science, 2(1): 11- 17.

Shrief, S.A. and A.A. Abdel-Mohsen, 2015. Regression Models to Describe the Influence of Different Irrigation Regimes on Grain Yield and Water Use Efficiency in Bread Wheat. Adv. Agric. Biol., 4(1): 39- 49.

Tester, C.F., 1990. Organic Amendment Effects on Physical and Chemical Properties of a Sandy Soil. Soil Sci. Soc. Am. J., 54: 827- 831.

Zeidan, E.M., I.M. Abd El-Hameed, A.H. Bassiouny, and A.A. Waly, 2009. Effects of Irrigation Intervals, Nitrogen and Organic Fertilization on Yield, Yield Attributes and Crude Protein Content of some Wheat Cultivars under Newly Reclaimed Saline Soil. 4th Conference on Recent Technologies in Agriculture. `298- 307.
Available at: http://www.conf2009.agr.cu.edu.eg/volume2/33.pdf.