Universal Journal of Plant Science 2(6): 108-113, 2014
DOI: 10.13189/ujps.2014.020603 http://www.hrpub.org

Effect of Nitrogen Fertilization, Sowing Methods and Sowing Dates on Yield and Yield Attributes of Wheat (*Triticum aestivum* L)

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Abstract A field experiments were conducted at the College of Agricultural Studies, Sudan University of Science and Technology at Shambat, Khartoum, during winter season in 07/2008 and 08/2009, to investigate the effect of nitrogen fertilization, sowing methods and sowing dates on yield and yield attributes of wheat (Triticum aestivum L.), local variety (Wadi Elneel). Nitrogen fertilizer was applied in the form of urea at the rate of 0, 40, 80 and 120 kg N/ha. Four sowing methods viz. planting on flat, mastaba, ridge and ridge with line were tested. Three sowing dates namely; early November, mid November and early December were chosen and applied. The results of the study showed that nitrogen application displayed significant effect on plant height, total dry matter, 1000-seed weight and grain yield in both seasons but nitrogen fertilizer had no significant effect on harvest index for season 08/2009. Generally , planting on ridge and ridge with line achieved higher 1000-seed weight and grain yield for both seasons. Harvest index was superior for season 07/2008, whereas plant height and total dry matter had higher values for season 08/2009. Generally, crop sown at mid November produced higher grain yield, total dry matter and tallest plant for season 07/2008. Also higher plant height and harvest index were recorded for season 08/2009. The early sown (early November) obtained greater 1000-seed weight and harvest index for season 07/2008 and higher amount of 1000-seed weight and total dry matter for season 08/2009. The late sown (early December) produced higher grain yield for season 08/2009. It can be concluded neglecting the differences between the two seasons for yield and their components that Wheat can be grown at early and mid November on ridge and ridge with line with 120 kgN/ha fertilizer.

Keywords Fertilization, Sowing methods, Sowing date, Yield

1. Introduction

Wheat, (Triticum aestivum L) is a cereal crop originally from the Levant region of the near East and Ethiopian High lands, but now cultivated worldwide. In 2010 world production of wheat was 651 million tons, making it the third most produced cereal after maize (844 million tons) and rice (672 million tons). In 2009 world production of wheat was 682 million tons making it the second most produced cereal after maize (817 million tons) and with rice as close third (679 million tons) (FAO,2012).

Sudan has known wheat production since time immemorial. Production, till the Second World War was confined to a total area of 12 thousand hectares along the narrow stretch of the rich Nile-alluvial soils north of Khartoum. Yield was high enough to cover the needs of the northern region and the major cities and towns across the country (Mohamed,2000). The rest of the population was dependent on sorghum in central and eastern Sudan and on cassava in southern Sudan. However, increased urbanization and associated changes in food traditions have increased the demand for wheat from less than 100 thousand tons per annum to over one million tons. The gap between production and consumption was used to be bridged through international aids, loans and by direct purchase (Ibrahim et al 2007) However, due to social, economic, political changes and the current international food crises together with soaring wheat prices bridging the food gap through international co-operation and/or direct purchase is rather difficult and makes interventions, leading to increased local production to attain self-sufficiency an unequivocal necessity Traditionally, the crop is produced in the River Nile and the Northern states, where temperature is moderately suitable (Mahgoub and Ibrahim,2012) However, unavailability of land, the high cost of irrigation and competition with high value crops such as vegetables, fruit trees and beans limited the area allocated to wheat. Population pressure and the attendant increase in the demand for food together with availability of land, established irrigation systems, infrastructure and absence of major pests and diseases foster introduction of the crop into the harsh

environments south of Khartoum, where climatic criteria, especially high temperature, and short season, deny high yield potentials Ibrahim et al.,2008).

Because nitrogen is a primary constituent of grain protein, wheat of a high percentage protein is produced only where the crop is provided with an adequate nitrogen supply. So high fertile soil is an essential ingredient for producing high quality wheat (Balikai, 2001 and Ibrahim and Kittani,2009a). Wheat is most sensitive to temperature and water stress during the flowering and heading stages. Sowing at the wrong time exposes the crop to temperature and moisture extremes. There is an optimum time for sowing for every location determined primarily by weather and availability of the field and irrigation water, but also by the variety that is being used and likely timing of serious disease in the area. The best sowing time gives the highest yield within the local limitation and it is usually decided by working backward from the date that been determined. Delays in sowing can reduced yield and this loss will generally be greater in hotter regions (Ibrahim and Kittani, 2009b). Wheat can be sown on ridges, mustaba or flat depending on the location, cultivar and soil conditions. Ibrahim 1999 found that the best results were obtained when wheat was planted on ridges at Khartoum State. The method of sowing is significant as it determines the proper crop stand establishment and the production of individual plant depends on balancing plant to plant competition (Sulieman 2010). The present study was conducted to investigate the effects of various nitrogen (Urea) fertilizer rates, sowing methods and sowing dates on the growth and yield of bread wheat.

2. Materials and Methods

The experiment was carried out during the period from November to April (2007/08and2008/09) at the Demonstration Farm of the College of Agricultural Studies, Sudan University of Science and Technology, Shambat (latitude 1 5:10 N longitude 3 2: 32 E) .The climate of the location is described as tropical semi arid with only three months of rain fall during July, August and September. Maximum temperature is above 40˚C in summer and minimum is around 20˚C in winter season. The relative humidity ranges between 14 -27% during dry season and 31-51%during wet season. The soil is a typical clay soil characterized by a deep cracking, moderately alkaline and low permeability, nitrogen content and PH ranging between 7,5 - 8 (Addelhafeez, 2001). . Experiment was a factorial trial with three factors in a Randomized Complete Block Design (RCBD). Four levels of nitrogen fertilizer, No = (control) with no nitrogen, N1 (40 kg N/ha), N2 (80 kg N/ha) and N3 (120 kg N/ha). Nitrogen dose was applied in the form of urea (46%N).Four methods of planting were : F = (planting on flat), M= (planting on mastaba) , R = (planning on ridge, R1 (planting on ridge with line).Three dates of sowing (I = early November, II = mid November, III = early December) .Yield and its components (plant height,1000-seed weight , total dry shoot, grain yield and harvest index) were measured. Randomly samples were taken from the middle rows of the plot. After data collection different statistical analysis including ANOVA were done using Microsoft excel .SAS software.

3. Results and Discussions

Non significant differences were detected for nitrogen , planting methods and sowing dates for all parameter under study. However, significant differences were observed for nitrogen × planting date for all parameters measured. Planting method × planting date present significant differences for grain yield, plant height and harvest index and non significant differences for 1000 seed weight and total dry matter. The interaction of nitrogen x sowing date revealed significant differences for all except the harvest index which showed highly significant difference in season 2007/08 The overall interaction of the three factors resembled significant differences for all measure parameters. Table 1.

All treatments interaction (N x P x D) displayed non significant differences for all parameters in the second season (2008/09) Table 2. Moreover nitrogen x, planting methods , nitrogen x sowing dates and planting methods x sowing dates interactions showed significant differences for all measured parameters. Planting methods x sowing dates had no significant effects. on plant height.

Generally, the results in Tables (3,4) showed that, there was no significant difference between most interactions applying 40 kg nitrogen fertilizer x planting date x sowing method for season 2007and 2008. Moreover, the same result obtained from early sown crop of early November for season 2008, lower results of total dry matter was recorded for late sown crop for season 2007. But was recorded at mid November for season 2008 (Tables 3,4). Generally, lower amount of total dry matter obtained from delaying sowing of early December with different planting methods and different levels of nitrogen fertilizers for the two seasons. But higher amount of total dry matter appear at early season crop for season 2008 (Tables 3,4). For both seasons 2007 and 2008 in this study, the influence of nitrogen fertilizer on total dry matter was positive. The above ground biomass significantly increased with increasing of nitrogen fertilizer up to 120 kg N/ha. Nitrogen fertilizer encourages vegetative growth and hence increase total dry matter. The results were strongly supported by (Ashrafi et al. 2010) who found that adding nitrogen fertilizer increased wheat biomass significantly. For season 2007, the results of this study indicated that biological yield was affected by planting methods. Planting on flat recorded higher amount of total dry matter compared to the other three planting methods.

For both seasons, the results of application different rates of nitrogen fertilizer showed that increasing of nitrogen fertilizer rates increased plant height. 120 kg N/ha produced

tallest plant, because nitrogen as a main constituent of protein and protoplasm, stimulates and increase cell division and elongation. This result was in agreement with work of (Seadh and Badawi., 2009) who stated that increasing of nitrogen fertilizer levels gradually increased plant height the influence of sowing methods on plant height was not significant as was reported by (Kakar and Khair., 2003) who concluded that plant height was statistically non significantly affected by planting method.

,High 1000-seeds weight was observed for early sown crop of early November for season 2007 and season 2008. Lighter 1000-seeds weight was recorded for delayed sown crop of early December for season 2007 and at mid November for season 2008. (Table 3,4).

In both seasons (2007 and 2008) progressively increasing rates of nitrogen fertilizer up to 120 kg nitrogen fertilizer increased grain yield over control. 80 and 120kg N/ha produced higher amount of grain yield caused by nitrogen addition due to increase in the number of spikelets and number of grain per spikelets. Similar results were found by (Igbal et al. 2010) who revealed that, maximum grain yield was recorded with application of 120 kg N/ha but in contrast, (Njuguna et al. 2010) concluded that nitrogen rate of 46 kg/ha gave the highest grain yield.

Table 1. Mean squares of plant height, total dry matter, 1000-seed weight , grain yield and harvest index - season (2007/08)

Source of variation	d.f	Harvest index	Total dry matter matter	1000-seed weight	Plant height	Grain yield
Replications	2	408.223	7.447	96.167	115.032	1.46
Nitrogen (N)	3	183.365 ns	60.744 ns	193.984 ns	210.464 ns	4.49 ns
Planting mehod (P)	3	1215.208 ns	42.117 ns	4.538 ns	140.949 ns	2.553 ns
N×P	9	1143.330*	19.304*	242.62ns	167.938ns	3.584*
Planting date(D)	2	2467.046	427.933 ns	2708.832 ns	837.358 ns	45.799
N x D	6	777.319**	29.229*	226.064*	314.530*	3.587*
P x D	6	1279.020*	20.624ns	47.831ns	198.373*	2.568*
N x P x D	1	2090.653*	31.9*	870.838*	325.282*	6.384*
Error	94	15517.825 ns	243.699 ns	3287.326 ns	2838.728 ns	44.26 ns
cv		17.44%	18.44%	29.47%	13.5%	14.53%

ns = Not significant

* = Significant at (P≤0.05).

** = Highly significant at (P≤0.01)

Table 2. Mean squares of plant height, total dry matter, 1000-seed weight , grain yield and harvest index - season (2008/09)

Source of variation	d.f	Harvest index	Total dry matter (t/ha)	1000-seed weight (gm)	Plant height (cm)	Grain yield (t/ha)
Replications	2	25.597	0.983	27.231	4.885	0.168
Nitrogen (N)	3	289.795	23.259	9.996	858.4	1.276
Planting method (P)	3	124.962	14.988	0.925	83.938	0.679
N x P	9	1414.661*	6.192*	85.441*	195.686*	1.882*
Planting date (D)	2	3868.459	10.538	278.429	100.581	2.126
N x D	6	853.367*	12.686*	21.551*	289.627*	1.405*
P x D	6	348.378*	11.509*	15.458*	140.821ns	1.482*
N x P x D	1	1193.423	6.838	39.633	379.029	0.988
Error	94	7733.789*	73.815*	414.942*	2668.113*	9.095*
CV		33.05%	26.56%	5.91%	8.47%	33.88%

Lns = Not significant

* = Significant at (P≤0.05)

** = Highly significant at (P≤0.01)'

Table 3. Interaction of nitrogen, planting method and sowing date (N x P x D) on plant height, total dry matter, 1000-seed weight , grain yield and harvest index - season (2007/08)

Parameters															Treatment
Harvest index			Total dry matter			1000-seed weight			Plant height			Grain yield			
Sowing date															
III	II	I	III	II	I	III	II	I	III	II	I	III	II	I	
28.58^{bcd}	34.23^{a-d}	34.25^{a-d}	3.9^{h-p}	5.15^{f-p}	4.62^{h-p}	35.87^{hij}	42.07^{a-j}	45.20^{a-j}	67.83^{a-g}	64.93^{a-g}	65.97^{a-g}	1.10^{f-m}	1.76^{b-m}	1.58^{b-m}	**N_0F**
31.35^{bcd}	34.23^{a-d}	29.17^{bcd}	2.71^{nop}	4.97^{g-p}	4.17^{i-p}	35.13^{ij}	46.40^{a-i}	54.80^{a}	62.33^{b-g}	67.30^{a-g}	66.63^{a-g}	0.89^{h-l}	1.67^{b-m}	1.25^{e-m}	**N_0M**
30.04^{bcd}	32.52^{a-d}	45.24^{abc}	3.37^{l-p}	6.31^{d-l}	4.00^{i-p}	40.33^{b-j}	47.40^{a-h}	46.67^{a-i}	61.27^{c-g}	66.20^{a-g}	65.33^{a-g}	0.82^{ijkl}	2.25^{a-h}	1.77^{a-m}	**N_0R**
31.55^{bcd}	43.62^{a-d}	35.22^{a-d}	3.15^{l-p}	6.84^{c-j}	5.07^{f-p}	36.07^{f-j}	46.33^{a-i}	43.87^{a-j}	63.27^{b-g}	67.23^{a-g}	65.83^{a-g}	1.03^{g-m}	2.60^{abcd}	1.60^{b-m}	**N_0R_1**
26.62^{bcd}	18.76^{d}	30.22^{bcd}	3.86^{i-p}	9.64^{abc}	5.64^{e-o}	41.60^{b-j}	44.73^{a-j}	49.80^{abcd}	66.63^{a-g}	71.50^{abcd}	59.83^{efg}	1.04^{g-m}	1.50^{b-m}	1.78^{a-m}	**N_1F**
21.59^{cd}	29.65^{bcd}	48.07^{ab}	4.09^{i-p}	6.22^{d-l}	4.40^{h-p}	40.53^{b-j}	41.53^{b-j}	48.07^{a-g}	64.37^{a-g}	68.70^{a-g}	59.23^{fg}	0.65^{m}	1.80^{a-m}	2.15^{a-j}	**N_1M**
29.44^{bcd}	33.63^{a-d}	34.19^{a-d}	2.40^{op}	8.26^{a-f}	4.40^{h-p}	35.67^{hij}	47.33^{a-h}	48.60^{a-e}	57.60^{g}	70.57^{a-e}	63.87^{a-g}	0.75^{klm}	2.74^{abcd}	1.49^{c-m}	**N_1R**
26.92^{bcd}	44.57^{a-d}	49.78^{ab}	2.84^{m-p}	6.84^{c-j}	4.60^{h-p}	36.00^{g-j}	50.07^{abc}	48.13^{a-f}	61.73^{b-g}	70.17^{a-f}	66.90^{a-g}	0.78^{j-m}	2.94^{ab}	1.96^{a-m}	**N_1R_1**
28.05^{bcd}	31.32^{bcd}	31.20^{bcd}	2.89^{m-p}	10.09^{ab}	6.80^{c-k}	39.47^{c-j}	50.73^{abc}	46.13^{a-g}	67.30^{a-g}	74.90^{a}	62.57^{b-g}	0.86^{h-m}	3.15^{a}	2.12^{a-k}	**N_2F**
31.53^{bcd}	40.96^{a-d}	38.82^{a-d}	2.35^{p}	7.60^{a-h}	6.01^{d-m}	40.93^{b-j}	47.40^{a-h}	47.27^{a-h}	63.87^{a-g}	71.73^{abc}	63.07^{b-g}	0.75^{klm}	2.92^{ab}	2.19^{a-i}	**N_2M**
33.19^{a-d}	28.65^{bcd}	58.19^{a}	4.22^{i-p}	7.95^{a-g}	4.04^{i-p}	41.00^{b-j}	46.73^{a-i}	51.73^{ab}	66.90^{a-g}	68.23^{a-g}	65.20^{a-g}	1.40^{d-m}	2.36^{a-g}	2.25^{a-h}	**N_2R**
31.91^{bcd}	29.90^{bcd}	34.53^{a-d}	2.89^{m_p}	8.49^{a-e}	6.20^{d-l}	36.67^{e-j}	44.00^{a-j}	52.20^{ab}	66.40^{a-g}	67.73^{a-g}	59.60^{efg}	0.82^{i-m}	2.49^{a-f}	2.05^{a-l}	**N_2R_1**
33.70^{a-d}	19.29^{cd}	33.09^{a-d}	5.77^{e-n}	10.49^{a}	7.13^{b-i}	34.20^{i}	46.80^{a-j}	50.73^{abc}	69.73^{a-f}	74.63^{a}	67.03^{a-g}	1.96^{a-m}	2.05^{a-l}	2.42^{a-g}	**N_3F**
19.20^{cd}	30.02b^{cd}	37.04^{a-d}	3.95^{i-p}	6.31^{d-l}	5.44^{e-p}	35.13^{ij}	51.67^{ab}	39.27^{c-j}	60.27^{defg}	69.23^{a-}f	63.90^{a-g}	0.66^{lm}	1.70^{b-m}	1.83^{a-m}	**N_3M**
38.41^{a-d}	25.83^{bcd}	51.55^{ab}	3.60^{i-p}	9.15^{a-d}	5.61^{e-p}	36.60^{e-j}	46.33^{a-i}	36.67^{e-j}	65.73^{a-g}	70.40^{a-f}	68.13^{a-g}	1.37^{d-m}	2.$^{48a-f}$	2.86^{abc}	**N_3R**
29.64^{bcd}	30.00^{bcd}	35.97^{a-d}	3.55^{k-p}	8.53^{a-e}	5.73e-^{n}	37.87^{d-j}	46.00^{a-j}	45.47^{a-j}	64.77^{a-g}	71.20^{abcd}	72.87^{ab}	1.05^{g-m}	2.62^{a-e}	2.06^{a-l}	**N_3R_1**
18.42%			29.47%			13.50%			8.29%			38.92%			**C.V%**
20.83*			2.611*			9.587*			8.909*			1.113*			**$Lsd_{0.05}$**
7.418			0.9297			3.414			3.173			0.3962			**SE**

Mean(s) followed by the same superscript(s) in columns and rows (for each parameter) are not significantly different at the 5% level of significance according to the DMRT. N0 = zero, N1 = 40 kg, N2 = 80 kg and N3 = 120 kg nitrogen fertilizer; F = flat, (M) = mastaba, , (R) = ridge and (R1) = ridge with line; I =early November, II = mid November and III = early December

Table 4. Interaction of nitrogen, planting method and sowing date (Nx P x D) on plant height, total dry matter, 1000-seed weight , grain yield and harvest index - season (2008/09)

Harvest index			Total dry matter			1000-seed weight			Plant height			Grain yield			
Sowing date															
III	II	I	III	II	I	III	II	I	III	II	I	III	II	I	
34.63^{a-f}	a-d 37.30	e-i 16.70	b-g 3.15	fg 2.35	e-g 2.44	a-g 35.00	e-h 33.13	a-g 36.13	a-f 62.37	ef 54.87	a-f 61.37	a-f 1.17	b-i 0.87	hi 0.49	**N_0F**
40.62^{ab}	a-e 35.13	c-i 21.67	c-g 2.89	g 2.17	e-g 2.42	a-g 35.87	a-g 36.00	a-e 37.13	a-e 64.10	b-f 58.13	c-f 56.60	a-g 1.19	c-i 0.76	f-i 0.54	**N_0M**
33.$^{33a-h}$	a-i 31.79	d-i 19.30	c-g 2.84	g 2.00	b-g 3.20	b-h 34.07	b 30.60	a-g 35.73	a-f 61.37	d-f 55.83	b-f 59.17	a-i 1.03	d-i 0.69	i 0.42	**N_0R**
22.58^{b-i}	a 41.70	d-i 20.00	b-g 3.59	g 2.18	b-g 3.51	a-g 35.53	b-h 34.20	ab 38.00	b-f 58.50	a-f 60.40	f 51.77	d-i 0.68	a-i 1.01	e-i 0.59	**N_0R_1**
40.54^{ab}	a-g 34.04	c-i 20.91	b-g 3.24	b-g 3.28	c-g 2.88	a-g 36.00	a-h 34.60	a-f 36.80	a-e 64.97	a-e 63.10	b-i 57.50	a-i 1.03	a-g 1.14	d-i 0.63	**N_1F**
23.05^{b-i}	a-e 35.01	52a-i 28.	g 2.08	b-g 3.42	d-g 2.62	a-g 35.33	d-h 33.40	a-g 35.50	a-e 64.40	a-e 63.97	a-f 62.30	ghi 0.52	a-f 1.17	d-i 0.70	**N_1M**
21.21^{c-i}	a-i 24.07	d-i 18.95	b-g 3.15	b-g 3.33	a-d 4.40	a-g 35.33	b-h 34.13	a-d 37.53	a-e 62.60	a-d 66.23	a-e 64.43	e-i 0.73	b-i 0.84	b-i 0.85	**N_1R**
26.25^{a-i}	b-i 23.16	f-i 16.27	fg 2.35	a-d 4.35	a-f 4.04	a-d 37.60	b-h 33.77	a-f 36.93	a-e 64.90	a-c 67.10	a-f 62.20	b-i 0.87	a-c 1.35	d-i 0.65	**N_1R_1**
24.16^{a-i}	d-i 19.23	hi 15.44	b-g 3.77	a-g 3.42	ab 4.71	a-g 34.93	b-h 33.87	a-c 37.80	a-c 67.23	a-e 63.17	a-e 64.53	a-h 1.06	d-i 0.67	c-i 0.80	**N_2F**
26.62^{a-i}	65a-i 30.	a-i 25.44	c-g 2.89	b-g 3.51	b-g 3.46	a-h 34.47	e-h 33.20	a-g 36.40	b-f 59.60	ab 67.17	a-f 60.80	b-i 0.93	a-i 1.05	b-i 0.87	**N_2M**
33.57^{a-g}	a-d 36.11	a-i 23.71	a-d 4.26	b-g 3.28	ab 4.75	a-g 35.80	a-g 36.00	a 38.53	a-c 67.10	a-c 62.27	a-e 62.90	ab 1.44	a-e 1.20	a-h 1.12	**N_2R**
29.11^{a-i}	a-i 29.32	b-i 22.78	b-f 3.42	b-g 3.73	a-c 4.61	a-g 35.47	c-h 33.67	a-e 37.40	a-d 66.13	a-d 64.17	a-d 66.10	a-h 1.00	a-h 1.08	a-i 1.05	**N_2R_1**
35.21^{a-e}	a-i 27.65	g-i 16.06	b-f 3.60	a-g 2.84	b-g 3.46	a-g 36.60	f-h 32.73	a-e 37.40	b-f 59.83	a-f 61.23	a-e 64.13	a-d 1.25	b-i 0.87	d-i 0.62	**N_3F**
38.81^{a-c}	a-i 29.16	i 14.03	g 2.09	b-g 3.33	b-g 3.29	a 38.60	b-h 33.80	a-g 36.63	a-f 60.70	a-d 66.53	a-e 63.13	e-i 0.80	a-i 0.98	f-i 0.55	**N_3M**
35.90^{a-d}	a i 26.10 -	c i 21.99 -	a-f 4.13	b-g 3.55	a 5.51	a-g 36.27	a-h 34.50	a 38.53	a-e 63.87	a 70.80	a-d 66.65	a 1.59	a-g 1.13	a-d 1.23	**N_3R**
34.49^{a-g}	a-d 35.64	c-i 20.40	b-g 3.29	b-g 3.15	a-e 4.17	a-h 34.67	gh 32.47	a-c 37.87	a-e 63.50	ab 68.23	a-e 64.10	b-i 0.86	a-f 1.18	b-i 0.84	**N_3R_1**
33.05%			26.56%			5.91%			8.47%			33.88%			**C.V%**
14.70*			* 1.436			* 3.406			* 8.637			* 0.5049			**$Lsd_{0.05}$**
5.237			0.5115			1.213			3.076			0.1798			**SE**

Mean(s) followed by the same superscript(s) in columns and rows (for each parameter) are not significantly different at the 5% level of significance according to the DMRT

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