Azarian J. Agric. VOL (5) ISSUE 5, 2018: 142-150

Azarian Journal of Agriculture

www.azarianjournals.ir

Azarian Journals

Research article **ISSN:2383-4420**

Pivotal impact of sources and rates of nitrogen fertilizers on yield, nitrogen use efficiency in bread wheat cultivars

Emad Hafez[1*], Amgad El-Gammaal[2], Emad Rashwan[2]

Article Info

Accepted:
20 Oct. 2018

Keywords:
Cultivars, grain N uptake, N fertilizer sources, N fertilizer rates, wheat

ABSTRACT

Wheat is considered as one of the main agricultural cereals worldwide, used in human and animal feed. The goal of this research was to investigate the pivotal impact of using different sources and rates of nitrogen fertilizer on the productivity of wheat cultivars in two growing seasons 2015/2016 and 2016/2017 to find out alternatives for wheat farmers. A strip-split plot experimental design was used with three rates of nitrogen fertilization (119, 166 and 240 kg ha^{-1}), three nitrogen sources (ammonium sulphate, ammonium nitrate and urea) and three wheat cultivars (Giza 168, Sakha 93 and Sakha 94). A number of variables such as number of grains spike^{-1}, 1000-grain weight, number of spikes m^{-2}, grain yield, harvest index, percentage of apparent recovery N of fertilizer and agronomic NUE were assessed. Results showed that Sakha 94 was superior than Giza168 and Sakha 93 in all yield-related traits. N fertilizer rate had a more consistent effect on yield-related traits. Applied 240 kg N ha^{-1} resulted in increased number of grains spike^{-1}, 1000-grain weight as well as number of spikes m^{-2} in both seasons furthermore grain yield and harvest index, % apparent recovery N of fertilizer and agronomic NUE declined with increment of N rates. The application of sources of N fertilizer seems to play a pivotal role. Application of ammonium sulphate resulted in positive impact on all traits than other sources of nitrogen. It was concluded that grain yield enhanced by Sakha94 cultivar with 240 kg N ha^{-1} of ammonium sulphate.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop in world and is the staple food for humans, and considered to be the first strategic food crop in Egypt. Wheat is the fundamental food crop for more than one-fifth of human populace around the globe especially in Egypt (FAO 2014). By the end of year 2050, it is expected that the world population will increment to reach about 10 billion (Abou El-Hassan et al. 2014). Otherwise, wheat yield is diminishing owing to the influence of different abiotic stresses which resulting in loss millions of dollars annually (Hafez et al. 2014). Therefore, it is pivotal to reduce these losses to face the increasing food requirements (Abou Khadrah et al. 2014). Therefore, selection of cultivars with high yield related traits appears to be a successful strategy for higher grain yield. Wheat crop yield is connected to biotic and abiotic factors, especially to cultivars and soil fertility. Regarding fertility, managing N inputs in wheat production systems is a vital issue so as to attain maximum profitable production. Nitrogen (N), is an essential element of the biochemical processes that drives crop production, many times restricts grain yield in wheat grown under field conditions. This is mainly due to a reduction in available N when soil N mineralization is not enough to fulfill the crop demand. Under these circumstances, N fertilization plays a central role for achieving the highest yield in wheat in each particular environment such as Egypt. Hafez et al. (2015) reported that spikes m^{-2}, plant height, spike length, number of spikelet, grains/spike and grain of wheat were increased with increasing N level. Hafez and Gharib (2016) reported a beneficial effect of nitrogen application on wheat. They reported that numbers of tillers and spikes/m^2, plant height, spike length, number of spikelets, grains spike^{-1}, grain and straw yields of wheat increased with increasing N level. Nitrogen (N) constantly cycles among different forms in the environment. Nitrogen sources application increase

[1]Department of Agronomy, Faculty of Agriculture, Kafrelsheikh University, 33516, Kafr-Elsheikh, Egypt
[2]Department of Agronomy, Faculty of Agriculture, Tanta University, Egypt
* E-mail: emadhafez2014@gmail.com

plant absorption efficiency and reduce losses by volatilization and leaching, resulting in higher grain yield (Abedi et al. 2011). However, an excessive external supply of N causes major problems in agriculture and the environment, polluting underground waters, increasing N losses related to NH_3^{+} volatilisation, denitrification and NO_3^{-} leaching. Hafez and Abou El Hassan (2015) stated that NUE decreased with increasing N rates. Nitrogen addition as ammonium showed a favorable significant effect in improving most studied traits. Significant interaction between varieties and N rates was detected for number of grains/spike and grain yield/fed in both season and significant interaction between N rates and N sources was detected for grain yield and NUE. Thus, the goal of this study is to investigate the effect of nitrogen rates and nitrogen sources under different three Egyptian cultivars on wheat yield, its attributes and N-uptake together with nitrogen recovery, nitrogen use efficiency in grains of wheat.

MATERIALS AND METHODS

The present study was carried out in the Experimental Farm of the Faculty of Agriculture, Kafr El-Sheikh University, Egypt (31°05'N& 30°57'E). This investigation was performed during the two successive growing seasons 2015/2016 and 2016/2017. The goal of this study is to investigate the effect of nitrogen rates (119, 166, 240 kg N ha^{-1}) and nitrogen sources (urea, ammonium nitrate and ammonium sulphate) under different three Egyptian cultivars (Sakha 94, Sakha 93 and Giza168) on bread wheat yield, its attributes and N-uptake together with nitrogen recovery, nitrogen use efficiency in grains of wheat.

The weather conditions (Table 1) were collected from an agro-meteorological Sakha Station, Kafrelsheikh Governorate, Egypt located at 2 km from the Experimental Farm. Soil samples were collected from 0-20 cm depth before sowing date in each season using a soil Auger, then were stored at -20 °C for further analysis. The soil was clay and the bulk densities were 1.25 and 1.28 g cm^{-3} for first and second seasons, respectively. The soil contained; total organic matter:1.50 and 1.44%, Nitrogen (N): 1.5 and 1.7 g kg^{-1} , available phosphorus (P): 35.0 and 36.5 Kg kg^{-1}, exchangeable potassium (K): 0.31 and 0.30 g kg^{-1}, EC: 1.02 and 1.09 ds m^{-1} (1:5), pH 8.0 and 8.1 (1:2.5) , annual precipitation: 1.41 and 1.42 cm in seasons of 2015–2016 and 2016–2017, respectively.

The experiments were carried out using A strip split plot in four replicates. The horizontal plots were devoted the three cultivars as above mentioned. The vertical plots were allocated with three sources of nitrogen as above mentioned. Rates of nitrogen occupied the sub plots. The area of sub-plot was 10.5 m^2 (3 m wide and 3.5 m long), each plot contained 20 rows with 15 cm apart. Plots were separated by 1 m allays. The preceding crops were rice in both seasons. In this experiment the sowing was done by using hand drill machine on 1 of December in first season and 8 December in the second season. Calcium superphosphate (15.5% P_2O_5) was added at the rate of 250 kg ha^{-1} during seedbed preparation, N fertilizer was applied at rate of 170 kg N ha^{-1} to each plot before irrigation at two splits; 60% at jointing stage and the remaining 40% at booting stage. Weeds were controlled by Topik 15% WP herbicide. Wheat grain yield obtained by harvesting the center (2 m x 2 m) of the experimental unit, but yield components were determined from two outer rows within each plot.

Yield and related traits measurement

Total number of spikes m^{-2} from each plot were carefully counted and averaged to determine number of spikes m^{-2}. Total number of spikelet's $spike^{-1}$ and number of grains $spike^{-1}$ from ten randomly selected spikes were counted carefully and averaged to record number of spikelet's and grains per spike. Five random samples each of 1000 grains were taken, weighed and averaged to measure 1000-grain weight. At harvest maturity, each plot was harvested manually, sun dried for three days and tied into bundles. These bundles were then threshed manually and grains were separated and weighed to record grain yield (<14% moisture content). Left over straw was again

Table 1. Meteorological data for El-Karada Station during growing seasons

Year	2015/2016				2016/2017			
Month	Temperature (°C)		Precipitation (mm)	RH (%)	Temperature (°C)		Precipitation (mm)	RH (%)
	max	min			max	min		
Dec	25.8	11.3	0.80	30.5	24.9	10.9	0.60	32.2
Jan	24.4	9.2	3.50	41.4	22.2	9.7	3.30	43.8
Feb	21.1	11.1	7.00	45.3	20.6	12.7	7.60	44.6
Mar	23.1	16.2	0.00	47.7	22.5	14.7	0.50	45.5
April	26.2	17.4	0.00	55.4	25.4	16.1	0.00	53.4
May	30.7	17.5	0.00	64.1	30.3	15.4	0.00	65.5

max = maximum, min = minimum, RH = relative humidity weighed to record straw yield. Grain and straw yields were converted into kg ha^{-1}. Harvest index (HI) was determined as ratio between grain and biological yield and was expressed in percentage

Nitrogen efficiencies measurement

N use efficiency (NUE) and apparent N fertilizer recovery (ANR) were calculated as it is described by (Azizian and Sepaskhah 2014). In addition, grain N uptake was calculated as described by (Haegele 2012).

$$NUE\ (kg\ kg_N{}^{-1}) = \frac{GY_t - GY_c\ (kg\ ha^{-1})}{NF_t - NF_c (kg\ ha^{-1})}$$

Where, GY_t and GY_c express the grain yield at different N treatments and control, respectively. While, NF_t and NF_c express the N applications for different N treatments and control, respectively.

$$\text{Grains nitrogen uptake}\ (kg\ ha^{-1}) = \frac{\text{Grains nitrogen content}\ (g\ kg^{-1}) \times \text{Grains dry matter}\ (kg\ ha^{-1})}{1000}$$

$$ANR\ (kg\ kg^{-1}) = \frac{\text{Total N accumulation}_t - \text{Total N accumulation}_c\ (kg\ ha^{-1})}{NF_t - NF_c (kg\ ha^{-1})}$$

Where, total N accumulation either for different treatments or for the control expresses the total N accumulation in both of grain and stover.

Statistical analysis

Data were analyzed with analysis of variance (ANOVA) procedures according to Gomez and Gomez (1984) using the MSTAT-C Statistical Software package. Where the F-test showed significant differences among means Duncan's multiple range test (1955) was performed at the 0.05 level of probability to compare between means.

RESULTS AND DISCUSSION

Number of spikes m^{-2}

The results revealed that number of spikes m^{-2} differed significantly among cultivars in both seasons (Table 2). Sakha 94 produced the highest number of spikes m^{-2} in the first season and in the second season. Number of spikes m^{-2} was positively and significantly affected by increasing nitrogen rates up to 240 kg N ha^{-1} in both seasons. Sources of nitrogen caused positively significant effects on number of spikes m^{-2} for both seasons. Number of spikes m^{-2} increased by source of nitrate. The interaction between cultivars and sources of nitrogen led to significant effect on number of spikes m^{-2} for both seasons. Also, Sakha 94 produced the highest number of spikes m^{-2} with source of nitrate. This supports the findings of (Hafez 2016), who identified significant correlations between number of spikes m^{-2} and rates and sources of N for wheat crops. In the current study, the higher number of spikes m^{-2} can be attributed to the adequate N availability (Asif et al. 2014) leading to increased photosynthetic activities (Benin et al. 2012), vigorous plant growth (Dilip et al. 2016) and thus lastly increased the productive tillers. Our data are in agreement with results of (Mauricio et al. 2016) who stated that higher number of spikes m^{-2} in fertilized plots than controled and were proved by (Dilip et al. 2016). Applied N source of ammonium sulphate at vegetative stage ameliorated the plant growth (Federico et al. 2016) and therefore increased number of spikes m^{-2}. The N application could have fulfilled the plant N requirement owing to higher availability of N for prolonged time (Fox et al. 1986) and thus could have increased the number of spikes m^{-2}.

Number of grains $spike^{-1}$

Sakha 94 wheat cultivar gave the highest number of grains $spike^{-1}$ in both seasons (Table 2). Increasing nitrogen rates led to a significant increase in number of grains $spike^{-1}$ in both seasons. The highest number of grains $spike^{-1}$ was obtained by 240 kg N ha^{-1} in both seasons. Sources of nitrogen did significantly on affect number of grains $spike^{-1}$ in both seasons. It gave the highest value by source of sulphate. The interaction between cultivars and sources of nitrogen led to significant effect on number of grains $spike^{-1}$ for both seasons. Also, Sakha 94 produced the highest number of grains $spike^{-1}$ with source of sulphate. The interaction between cultivars and rates of nitrogen led to significant effect on number of grains $spike^{-1}$ for both seasons. Also, Sakha 94 produced the highest number of grains $spike^{-1}$ with 240 kg N ha^{-1}, in both seasons. The interaction between cultivars, rates of nitrogen and sources of nitrogen led to significant effect on number of grain $spike^{-1}$ for both seasons. Also, Sakha 94 produced the highest number of grains $spike^{-1}$ with 240 kg N $ha^{-1}$and source of sulphate, in both seasons. These results support those obtained by (Gernica et al. 2010) who noted that increasing N rates resulted in increase in number of grains. Increasing number of grains $spike^{-1}$ owing ammonia N could be attributed the higher availability of N owing to NH_4-N in contrast to NO_3-N in grains. Our findings are in line with results of (Garrido-lestache et al. 2004). Increment number of grains $spike^{-1}$ owing N applied may be attributed to improved crop growth in treated plots (Gheith et al. 2013), or greater nutrient availability (Giambalvo et al. 2010) as compared to unfertilized. Improved number of grains $spike^{-1}$ owing to applied of NH_4-N could be regard with higher and prolonged N availability (Guelser 2005), which could have synchronized the plant support and demand and thus increment number of grains $spike^{-1}$. Applied of N had increased the available N (Habtegebrial et al. 2007) especially at sowing that promoted the plant

Table 2. Yield attributes of three wheat cultivars as affected by different nitrogen rates and sources in 2015/2016 and 2016/2017 seasons.

Treatments	No. of grains spike^{-1}		No. of spikes m^{-2}		1000-grain weight (g)	
Cultivars (C)	2015	2016	2015	2016	2015	2016
Giza 168	16.54c	16.85c	320.65c	325.76c	42.65c	43.65c
Sakha93	17.43b	17.76b	330.43b	335.23b	45.87b	47.32b
Sakha94	18.89a	18.78a	340.87a	345.22a	48.77a	49.54a
N rates (kg ha^{-1})						
0	15.55d	16.22d	305.33d	309.65d	45.44d	45.87d
80	16.89c	17.34c	314.45c	319.54c	44.88c	44.55c
160	17.45b	18.35b	326.43b	330.32b	43.56b	43.02b
240	18.54a	19.67a	337.23a	342.44a	42.78a	42.22a
N-sources (S)						
Urea	16.34c	16.44c	315.22c	320.44c	42.87c	42.98c
AN	17.87b	17.98b	327.66b	329.98b	43.89b	43.76b
AS	18.11a	18.22a	332.98a	339.44a	44.87a	45.67a
C	*	*	*	*	*	*
N	*	*	*	*	*	*
S	*	*	*	*	*	*
C × N	ns	ns	ns	ns	ns	ns
C × S	ns	ns	ns	ns	ns	ns
N × S	ns	ns	ns	ns	ns	ns
C ×N × S	ns	ns	ns	ns	ns	ns

Means designated by the same letter are not significantly different at 5 % level according to Duncan's Multiple Range Test.
- * , ** and ns indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.

vegetative stage, or at boot stage that is a responsible for ameliorating the reproductive stage and thus increased number of grains spike^{-1}.

1000 - grain weight (g)

1000-grain weight was significantly affected by cultivars in both seasons (Table 2). Sakha 94 accounted for the heaviest kernels whilst Giza 168 was the lightest. 1000-grain weight decreased with increasing nitrogen rates up to 240 kg N ha^{-1}. This may be attributed to that increasing nitrogen rates increased number of grains/plant by large rate than the rate of grain filling. The influence of source of nitrogen on 1000-grain weight was significant in both seasons with source of sulphate. This supports the findings of (Hafez and Geries 2018), who identified significant correlations between 1000-grain weight and rates and sources of N for wheat crops. Thus, it is proved that nitrogen application in vegetative growth stage affect 1000-grain weight, due to it decreases losses by volatilization and gives continuous support to the plant. Studies by (Hafez and Seleiman 2017) demonstrated that nitrogen application in wheat led to greater 1000-grain weight. It reinforces with findings by (Jan and Khan 2000), who stated that 1000-grain weight differed for nitrogen sources, and only the treatment with ammonium sulphate application differed from other fertilizer application periods. Studies conducted by (Khan et al. 2009), with the goal of assessing the effect of different nitrogen sources in the wheat crop, found that 1000-grain weight was affected by different nitrogen sources, highlighting ammonium sulfate, which are products of slow nitrogen release, making the element available for longer periods during the crop. The higher 1000-grain weight in plots treated ammonium sulphate might be closed with higher positive efficiency of wheat (Li et al. 2013). Improved 1000-grain weight in fertilized plots by ammonium sulphate might be associated with individual plant performance (Lopes-Bellido et al. 2008), improved plant photosynthetic capability (Mauricio et al. 2016) or improved leaf area (Raun and Johnson 1999). Our findings are in line with the result of (Sadur et al. 2010) who indiated that increased nitrogen application decreased 1000-grain weight of wheat. The ammonium sulphate application of N had improved the N uptake efficiency (Lopez-Bellido, 2008) or recovery efficiency (Somarin et al. 2010) and thus increased the grain weight.

Grain yield (Kg ha^{-1})

The influence of cultivars on grain yield was significant in both seasons. Sakha 94 was highest grain yield (Table 3). The highest grain yield of any crop is the result of all positive relationships of the yield components. Increasing N level, up to 240 kg N ha^{-1}, caused significant and consistent linear increase in grain yield of wheat for both seasons. Applied nitrogen rates significantly increased number of spikes m^{-2} and number of grains/spike in both seasons. Fertilizer (especially nitrogen) application enhances the grain yield of wheat varieties. Sources of nitrogen showed significant

Table 3. Grain, straw yields and harvest index of three wheat cultivars as affected by different nitrogen rates and sources in 2015/2016 and 2016/2017 seasons.

Treatments	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})		Harvest index (%)	
Cultivars (C)	2015	2016	2015	2016	2015	2016
Giza 168	6120.3c	6320.5c	12540.6c	12654.8c	32.5c	32.8c
Sakha93	6520.5b	6720.3b	12870.6b	12986.4b	34.5b	34.7b
Sakha94	6830.6a	6950.7a	13453.8a	13245.6a	35.6a	35.8a
N rates (kg ha^{-1})						
0	6080.5d	6120.5d	12470.5d	12570.6d	31.9d	32.2d
80	6287.4c	6290.7c	12680.4c	12679.5c	33.8c	34.1c
160	6420.3b	6490.4b	12870.7b	12958.7b	35.7b	35.9b
240	6590.2a	6630.3a	13280.7a	13320.5a	36.4a	36.7a
N-sources (S)						
Urea	6150.3c	6170.5c	12450.6c	12490.3c	32.8c	32.9c
AN	6570.7b	6595.4b	12790.5b	12840.4b	34.7b	34.8b
AS	6820.4a	6860.4a	13320.7a	13380.6a	36.1a	36.3a
C	*	*	*	*	*	*
N	*	*	*	*	*	*
S	*	*	*	*	*	*
C × N	ns	ns	ns	ns	ns	ns
C × S	ns	ns	ns	ns	ns	ns
N × S	ns	ns	ns	ns	ns	ns
C ×N × S	ns	ns	ns	ns	ns	ns

- Means designated by the same letter are not significantly different at 5 % level according to Duncan's Multiple Range Test.
- * , ** and ns indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.

effect on grain yield (Kg ha^{-1}) for the two seasons, as grain yield/fed. was increased by source of sulphate. These results support those obtained by (Spratt and Gasser 1970) who noted that increasing N rates resulted in increase in yield. Consequently, applied N is necessary to achieve higher grain yield, whereas this element is required at higher concentrations. It has a substantial role in the structure of amino acid, protein, and pigment molecules, and is part of ion absorption, respiration and photosynthesis processes, which affect grain yield (Malavolta, 2006). Therefore, nitrogen fertilization directly affects this variable, and its use at single or split doses in tillering, booting and flowering stages leading to greater yield, when ammonium sulphate are applied (Tariq et al. 2011). Ammonium sulphate application may decrease losses by supplying nitrogen at lower doses, enabling better use by the plant throughout the cycle to develop its metabolic activities. The highest grain yield was found in the wheat fertilized with ammonium sulphate, followed by wheat fertilized with ammonium nitrate, and the lowest was found in the wheat fertilized with urea. The greater grain yield in wheat fertilized with ammonium sulphate was attributed to a higher yield related traits in both seasons. This result implies that there was a lower efficiency of urea on wheat yield compared to ammonium sulphate in well managed production systems (Tranaviciene et al. 2007).

Straw yield (Kg ha^{-1})

Straw yield was significantly different among cultivars (Table 3). The superiority of Sakha 94 cutivar in straw yield/ha in both seasons. Increasing nitrogen rates caused significant increases in straw yield of wheat. The highest straw yield/ha was recorded at 240 kg N ha^{-1} in both seasons. Sources of nitrogen showed significant effects on straw yield ha^{-1} in both seasons, where source of sulphate was the highest. The interaction between sources of nitrogen and cultivars showed positively significant effect on straw yield/ha up to Sakha 94 and source of sulphate in both seasons. Source of sulphate produced the highest straw yield (Kg ha^{-1}) at 240 kg N ha^{-1}. Similar results were obtained by (Xu et al. 2012). Tranaviciene et al. (2007) found that straw yield significantly increased with increasing N fertilization rates. Ammonium sulphate application may decrease losses by supplying nitrogen at lower doses, enabling better use by the plant throughout the cycle to develop its metabolic activities.

Table 4. Grain N uptake, apparent N recovery and NUE of three wheat cultivars as affected by different nitrogen rates and sources in 2015/2016 and 2016/2017 seasons.

Treatments	Grain N uptake (kg ha^{-1})		Apparent N recovery (%)		Nitrogen use efficiency (%)	
Cultivars (C)	2015	2016	2015	2016	2015	2016
Giza 168	116.6c	131.8c	61.2c	64.2c	29.7c	31.9c
Sakha93	128.7b	144.3b	66.4b	69.5b	31.7b	33.7b
Sakha94	134.2a	150.4a	68.7a	70.6a	34.3a	36.2a
N rates (kg ha^{-1})						
0	101.5d	112.8d	80.6a	84.8a	-	-
80	110.6c	121.4c	75.7b	80.2b	35.2a	37.3a
160	125.3b	142.3b	55.3c	60.3c	30.4b	33.6b
240	136.6a	152.9a	48.8d	50.2d	25.1c	28.8c
N-sources (S)						
Urea	118.7c	133.6c	55.6c	60.5c	35.7c	35.6c
AN	122.4b	138.3b	60.2b	64.2b	37.2b	40.8b
AS	138.2a	154.7a	70.3a	75.8a	40.6a	44.1a
C	*	*	*	*	*	*
N	*	*	*	*	*	*
S	*	*	*	*	*	*
C × N	ns	ns	ns	ns	ns	ns
C × S	ns	ns	ns	ns	ns	ns
N × S	ns	ns	ns	ns	ns	ns
C ×N × S	ns	ns	ns	ns	ns	ns

Means designated by the same letter are not significantly different at 5 % level according to Duncan's Multiple Range Test.
- * , ** and ns indicate $P < 0.05$, $P < 0.01$ and not significant, respectively.

Harvest index (%)

Harvest index was significantly different among cultivars (Table 3). Sakha 94 was the highest cultivar in harvest index. This may be attributed to the differences among the studied characteristics, i.e. grain yield and straw yield ha^{-1}. Increasing nitrogen rates caused significantly increment in harvest index whereas applied 240 kg N ha^{-1} led to highest harvest index. Sources of nitrogen showed significant effects on harvest index in both seasons. Where harvest index increased with source of nitrate and sulphate more than source urea. the vital role of nitrogen in stimulating the metabolic processes in wheat crop, then their grain yield, straw yield and harvest index, similar results were obtained by (Tariq et al. 2011). In the current research, sources of N had influenced the harvest index; the possible cause might be that ammonium sulphate fulfilled the crop requirements. Our findings are in agreement with (Spratt and Gasser 1970). Improved wheat harvest index over control might be closed with higher availability of N (Li et al. 2013), improved phenology (Khan *et al*. 2008), improved crop performance ((Jan and Khan 2000) or vigorous plant growth (Mauricio et al. 2016) in fertilized plots and thus might have increased the harvest index. Our findings are in agreement with the results of (Lopes-Bellido et al. 2008) who stated that N application increment harvest index of wheat over control and were proved by (Guelser 2005). The other possible cause for higher yield owing to N application could be the increased uptake of N (Gernica et al. 2010) and thus higher crop productivity (Federico et al. 2016) and ultimately harvest index.

Grain N uptake (Kg ha^{-1})

Grain N uptake shows that there were significant differences in the three wheat varieties tested in both seasons (Table 4). Sakha 94 was the highest grain N uptake in both seasons. Grain N uptake increased significantly and gradually by increasing nitrogen level up to 240 kg N ha^{-1}. Sources of nitrogen on grain N uptake were obtained for both seasons. Grain N uptake increased by source of sulphate in both seasons. This finding is in agreement with those stated by (Li et al. 2013) who observed that the wheat cultivars Sakha93 and Giza168 cleared significant difference in all characters studied. Higher N rates was positively associated with grain yield and grain N uptake but negatively connected with NUE and ANR in wheat in both seasons. These findings are in line with the notion that N is a key component in improving grain N uptake (Asif et al. 2014). Although, it stated that a higher N rates causes a decrease in NUE in wheat (Dilip et al. 2016). Grain N uptake positively associated with grain yield but negatively associated with NUE and ANR. Sources of nitrogen showed significant effects on grain N uptake in both seasons, where source of ammonium sulphate was the highest among the sources of N.

This proves that grain yield may be increased with increasing grain N uptake through increasing photosynthetic capacity in wheat. The findings suggest that grain yield and N use efficiency should be maximized for sustainable wheat production (Federico et al. 2016).

Apparent N fertilizer recovery (ANR)

Recovery N of fertilizer shows that there were significant differences in the three wheat varieties tested in both seasons (Table 4). Sakha 94 was the highest grain N uptake in both seasons. Recovery N of fertilizer increased significantly and gradually by increasing nitrogen level up to 240 kg N ha^{-1}. Sources of nitrogen on recovery N of fertilizer were obtained for both seasons. Recovery N of fertilizer increased by source of sulphate in both seasons. It might be a result of decreased N losses from volatilization in low temperature. This results may be illustrated by the fact that $(NH4)_2SO_4$ as N-form declined soil pH, which could favor elements availability and absorb by wheat (Giambalvo et al. 2010). Applied N source of ammonium sulphate had impact on recovery N of fertilizer in both seasons. These results are therefore in line with reports that demonstrated by (Gheith et al. 2013). Although plants were provided with the same amount of N from different fertilizer N sources, higher level of recovery N of fertilizer in wheat that received N from ammonium sulphate could have resulted from greater N uptake (Habtegebrial et al. 2007). The wheat fertilized with either ammonium sulphate displayed higher recovery N of fertilizer values than that with ammonium nitrate or urea. This was owing to higher levels of chlorophyll content in plants that received N from ammonium sulphate than those that received N from ammonium nitrate or urea (Federico et al. 2016).

Nitrogen use efficiency (Kg grains/kg N applied)

Nitrogen use efficiency shows that there were significant differences in the three wheat varieties tested in both seasons (Table 4). Sakha 94 was the highest grain N uptake in both seasons. Nitrogen use efficiency decreased significantly and gradually by increasing nitrogen level up to 240 kg N ha^{-1}. Significant effects for sources of nitrogen on nitrogen use efficiency were obtained for both seasons. Nitrogen use efficiency increased by source of sulphate in both seasons. The highest productivity for ammonium sulfate application could have been connected to higher N use efficiency (Somarin et al. 2010). NUE significantly increased with increase N fertilization level than in control. NUE was decreased in highest N level. This can be attributed to N loss in ecosystem. Li et al. (2013) stated that NUE significantly decreased in the highest N fertilizer rate. Khan et al. (2009) found that N fertilization increased NUE, but the highest N level reduced NUE. Dilip et al. (2016) reported that increased N level reduced NUE. Sources of nitrogen showed significant effects on NUE in both seasons, where source of ammonium sulphate was the highest among the sources of N. This can be further explained by higher NUE in wheat fertilized with ammonium sulphate compared with ammonium nitrate or urea in both growing season. Our results are in agreement with a recent report of (Giambalvo et al. 2010), which demonstrated that fertilizer N source effects on N_2O emission were significant. Due to an increment in nitrogen absorption which consider as building blocks in the synthesis of proteins.

CONCLUSIONS

Our goal was to investigate the impact of nitrogen (N) from ammonium sulfate, ammonium nitrate and urea split-applied at different rates before anthesis on yield traits and productivity as well as nitrogen use efficiency in the Egyptian cultivars Sakha93, Sakha94 and Giza 168. The response of all traits under study to applied N from ammonium sulfate was higher than that from ammonium nitrate and urea in all three cultivars used. 240 kg N ha^{-1} applied was the highest in Sakha94 among the three cultivars. These cultivar differences in yield productivity were owing to the difference in the number of grains spike^{-1}, number of spikes m^{-2} and 1000-grain weight. The findings indicated that the N from ammonium sulfate has a higher impact on productivity, grain nitrogen uptake and nitrogen use efficiency than that from ammonium nitrate and urea in the Egyptian cultivars. From the results it is clear that Sakha 94 showed superior performance among the cultivars with 240 kg N ha^{-1} of ammonium sulphate and increase grain yield and NUE.

ACKNOWLEDGMENTS

The authors are grateful to the faculty of agriculture, Kafrelsheikh University, Egypt for support and to assist in providing the appropriate means for conducting this study of this research.

REFERENCES

Abedi T. Alemzadeh A. Kazemeini S. (2011) Wheat yield and grain protein response to nitrogen amount and timing. Australian Journal of Crop Science, 5:330-336.

Abou El Hassan W.H. Hafez E.M. Ghareib A. Ragab A. Seleiman M. (2014) Impact of nitrogen fertilization and irrigation on N accumulation, growth and yields of *Zea mays* L. Journal of Food, Agriculture & Environment, 12 (3&4):217-222.

Abou-Khadrah S. Abo-Youssef M. Hafez E. Rehan A. (2014) Effect of planting methods and sowing dates on yield and yield attributes of rice varieties under D.U.S. experiment. Scientia Agriculturae, 8 (3): 133-139.

Asif M. Maqsood M. Ali A. Hassan S.W. Hussain A. Ahmad S. (2012) Growth yield components and harvest index of wheat (*Triticum aestivum* L.) affected by different irrigation regimes and nitrogen management strategy. Science International (Lahore), 24:215-218.

Azizian A. Sepaskhah A. R. (2014) Maize response to different water, salinity and nitrogen rates: Agronomic behavior. International Journal of Plant Production, 8:107-130.

Benin G. Bornhofen E. Beche E. Pagliosa E.S. Silva C.L. Pinnow C. (2012) Agronomic performance of wheat cultivars in response to nitrogen fertilization levels. Acta Scientiarum Agronomy journal, 34(3):275-283.

Dilip K. Biswas. Bao-Luo M. (2016) Effect of nitrogen rate and fertilizer nitrogen source on physiology, yield, grain quality, and nitrogen use efficiency in corn. Canadian Journal of Plant Science, 96: 392–403

Duncan B.D. (1955) Multiple range and multiple F.Test.Biometrics,11:1-42.

FAO (Food and Agriculture Organization of the United Nations). (2014) FAOSTAT database, [Online]. Available at: http://faostat.fao.org (Accessed April, 2015).

Federico M. Massimo B. Amedeo R. (2016) Effect of nitrogen fertilization on yield and quality of durum wheat cultivated in Northern Italy and their interaction with different soils and growing seasons, Journal of Plant Nutrition

Fox R.H. Kern J.M. Pickielek W.P. (1986) Nitrogen fertilizer source and method and time of application effects on no-till corn yields and nitrogen uptake. Agronomy Journal, 78: 741-746.

Garnica M. Houdusse F. Zamarre A. M. Garcia-Mina J. M. (2010) Nitrate modifies the assimilation pattern of ammonium and urea in wheat seedlings Journal of Science Food Agriculture, 90: 357–369.

Garrido-Lestache E. Lopez-Bellido R.J. Lopez-Bellido L. (2004) Effect of N rate, timing and splitting and N type on bread-making quality in hard red spring wheat under Mediterranean conditions. Field Crops Research, 85: 213-236.

Gheith E.M.S. El-Badry O.Z. Wahid S.A. (2013) Sowing dates and nitrogen fertilizer levels effect on grain yield and its components of different wheat genotypes. Research Journal of Agriculture and Biological Sciences, 9:176-181.

Giambalvo D. Ruisi P. Di Miceli G. Salvatore A. Amato G. (2010) Nitrogen use efficiency and nitrogen fertilizer recovery of durum wheat genotypes as affected by interspecific competition, American Society of Agronomy, 102(2), pp. 707-715.

Gomez K.A. Gomez A.A. (1984) Statistical procedures for agricultural research. Wiley Interscience, New York, 680 p.

Guelser F. (2005) Effects of ammonium sulfate and urea on NO_3^- and NO_2^- accumulation, nutrient contents and yield criteria in spinach. Scientia Horticulturae, 106:330–340.

Habtegebrial K. Singh B.R. Haile M. (2007) Impact of tillage and nitrogen fertilization on yield, nitrogen use efficiency of *tef* (Eragrostis tef (Zucc.) Trotter) and soil properties. Soil and Tillage Research, 94: 55-63.

Haegele J. W. (2012) Genetic and Agronomic Approaches to Improving Nitrogen Use and Maize Productivity. PhD dissertation, University of Illinois, Urbana-Champaign, 187 p.

Hafez E.H. Abou El Hassan W.H. Freeg M.R. Seleiman M.F. (2015) Effect of gypsum and irrigation interval on yield and water use efficiency of rice grown on saline soil. Journal of Agricultural Science, 7 (12):208-219.

Hafez E.M. Gharib H. S. (2016) Effect of exogenous application of ascorbic acid on physiological and biochemical characteristics of wheat under water stress. International journal of plant production, 10(4) 579-596.

Hafez E.M. Abou El-Hassan W.H. (2015) Nitrogen and water utilization efficiency of barley subjected to desiccated conditions in moderately salt-affected soil. Egyptian Journal of Agronomy, 37(2):231 -249.

Hafez E.M. (2016) Influence of salicylic acid on ion distribution, enzymatic activity and some agromorphological characteristics of wheat under salt-affected soil. Egyptian journal of agronomy, 38 (3), 455- 469.

Hafez E.M. Geries L. (2018) Effect of N fertilization and biostimulative compounds on onion. Cercetari Agronomice in Moldova 1(173) 75-90.

Hafez E.M. Seleiman M.F. (2017) Response of barley quality traits, yield and antioxidant enzymes to water-stress and chemical inducers. International Journal of Plant Production, 11 (4) 477-490.

Hafez E.M. Kobata T. (2012) The Effect of Different Nitrogen Sources from Urea and Ammonia Sulfate on the Spikelet Number in Irrigated Egyptian Spring Wheat. Plant production Science, 15(4): 332―338.

Hafez E.M. Ragab A. Y. Kobata T. (2014) Water-Use Efficiency and Ammonium-N Source Applied of Wheat under Irrigated and Desiccated Conditions. International Journal of Plant and Soil Science, 3(10): 1302-1316.

Jan M.T. Khan S. (2000) Response of wheat yield components to type of N fertilizer, their levels and application time, Pakistan Journal of Biological Sciences, 3(8), pp. 1227-1230.

Khan P. Memon M.Y. Imtiaz M. Aslam M. (2009) Response of wheat to foliar and soil application of urea at different growth stages, Pakistan Journal of Botany,41(3), pp.1197-1204.

Li L. Hong J.P. Wang H.T. Xiu Y.H. Zhang L. (2013) Effects of watering and nitrogen fertilization on the growth, grain yield, and water- and nitrogen use efficiency of winter wheat. Chinese Journal of Applied Ecology, 24:1367-1373.

López-Bellido R.J. Castillo J. E. López-Bellido L. (2008) Comparative response of bread and durum wheat genotypes to nitrogen fertilizer in a rainfed Mediterranean environment: soil nitrate and N uptake and efficiency, Nutr Cycl Agroecosyst, 80, pp. 121-130.

Mauricio F. Vinícius J. Szareski M. N. Alan J. Ivan R. C. Velci Q. (2016) Effects of sources and split application of nitrogen fertilizer on wheat genotypes performance. Australian Journal of Crop Science, 10(12):1669-1674

Raun W.R. Johnson G.V. (1999) Improving nitrogen use efficiency for cereal production. Agronomy Journal, 91:357.

Sadur R. Khalil S. K. Muhammed F. Khalil I. H. (2010) Phenology, leaf area index and grain yield of rainfed wheat influenced by organic and inorganic. Pakistan Journal of Botany,42(5): 3671-3685.

Somarin S.J. Mahmoodabad R.Z. Yari A. Khayatnezhad M. Gholamin R. (2010) Study of agronomical nitrogen use efficiency of durum wheat affected by nitrogen fertilizer and plant density. World Applied Sciences Journal 11:674-681.

Spratt E.D. Gasser J.K.R. (1970) Effect of ammonium and nitrate forms of nitrogen and restricted water supply on growth and nitrogen uptake of wheat, Canadian Journal of Soil Science, 50, pp. 263-273.

Tariq J. M. Jamal Kh. M. Khan A. Arif M. Saeed D. Afridi M.Z. (2011) Improving wheat productivity through source and timing of nitrogen fertilization. Pakistan Journal of Botany,43(2), pp. 905-914.

Tranavicienė T. Siksnianiene J.B. Urbonaviciute A. Vaguseviciene I. Samuoliene G. Duchovskis P. Sliesaravicius A. (2007) Effects of nitrogen fertilizers on wheat photosynthetic pigment and carbohydrate contents, Biologija, 53(4), pp. 80–84.

Xu G. Fan X. Miller A.J. (2012) Plant nitrogen assimilation and use efficiency. Annual review of plant biology, 63(6):153-82.