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OPTIMIZED POTENTIAL OF UTILIZATION EFFICIENCY AND PRODUCTIVITY IN WHEAT BY INTEGRATED CHEMICAL NITROGEN FERTILIZATION AND STIMULATIVE COMPOUNDS

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ABSTRACT. Foliar sprays application is an important crop management strategy, which could help to maximize yield and other beneficial substances. Therefore, a field experiment was conducted at Kafrelsheikh University research farm, Egypt, to study the effect of stimulating compounds (control, salicylic acid and ascobien) and nitrogen levels (0, 57.5, 115, 172.5 and 230 kg N ha^{-1}) on yield and nitrogen utilization efficiency of wheat. Results indicated that spraying of ascobien and increasing nitrogen level had significant effect on yield traits. Interaction between stimulating compounds and nitrogen were achieved progressive increases in all yield traits, furthermore, the magnitude of increments was much more pronounced in response to salicylic acid and control treatments in both seasons. It was observed no statistically significant difference between 172.5 and 230 kg N ha^{-1} in both seasons. A significant interactive effect were observed on grain N uptake, whole plant N uptake, nitrogen harvest index (NHI), nitrogen utilization efficiency (NU$_t$E) and nitrogen use efficiency (NUE) by using foliar spraying combined with N fertilizer. Grain N uptake and whole plant N uptake were closely correlated with nitrogen under stimulating compounds, whereas ascobien with 172.5 kg N ha^{-1} was more effective than salicylic acid in both seasons. Interestingly, foliar spraying of ascobien and N level of 172.5 kg ha^{-1} was the optimal and could be a useful to improve the efficiency of N-fertilizer and it can be saved 57.5 kg N ha^{-1}. Consequently, could be the key to reduce the need for chemical fertilizers and decrease the cost of production.

Keywords: wheat; ascobien; salicylic acid; grain N uptake; nitrogen utilization efficiency.

INTRODUCTION

Wheat (*Triticum aestivum L.*) is one of the most widely grown and most consumed food crops all over

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the world. Moreover, it is one of the significant crops, playing important role in terms of economy, production, food, nourishment in the world (Varga *et al.,* 2002; Bayaner, 2002). Wheat is a major staple food crop for more than one third of the world population. Wheat is the major cereal cultivated in the Mediterranean region and represent strategic crops for food security across the whole area and the main staple food in Egypt (Ibrahim *et al.*, 2014). Wheat crop is considered the first strategic food crop in Egypt, since it constitutes the major part of the Egyptian diet. It has maintained its position as the basic staple food in urban areas and mixed with maize in rural areas for bread making. In addition, wheat straw is an important fodder (Gomma,1999; Gaballah and Mandour, 2000). Wheat has a special importance in Egypt because the local production is not sufficient to meet the annual demands. The total cultivated area of wheat reached about 8.0 mha and the total production exceeded 8.8 million tons (FAO, 2012).

Salicylic acid (SA) is water-soluble antioxidant compound, that can also regulate plant growth (Amin *et al.,* 2008). Salicylic acid (SA) positively influenced on plant growth and yield by regulating physiological processes in plant (Kowalczyk and Zielony, 2008). It is reported that SA participates in the regulation of several physiological processes, such as stomatal closure, nutrient uptake, chlorophyll synthesis, protein synthesis, transpiration and photosynthesis of wheat (Khan *et al.,* 2003; Shakirova *et al.* 2003). Sanjari *et al.* (2008) showed that sprayed SA on plants increased vegetative growth and yield components of wheat.

Ascobien is a foliar nutrient, contain 13% citric acid, 25% ascobien plus 62% organic materials, acts as a primary substrate and a potential growth-regulating factor, which influences many biological processes (Podh, 1990). Ascobien had a promotion effect on growth and active constituent’s compounds on various plants (Sheteaw, 2007). Ascobien has a synergistic effect on crops that functions as an antioxidant and also play an important role in vital processes in plants growth, such as cell growth and division, differentiation, and metabolism in plants (Pignocchi and Foyer, 2003) and minimizing the damage caused by oxidative stress (Smirnoff and Wheeler, 2000).

Thus salicylic acid and ascobien might be enhanced the growth and yield components in wheat. N fertilization is the most effective nutrient element for the growth, yield and quality of wheat. Applications of nitrogen at early growth stages ensure sufficient canopy growth, containing high levels of stem carbohydrate, which is translocated to the developing grain during maturation resulting increased grain size and weight. This is particularly important in drought areas, where 60% of the grain yield could come from this store. Therefore, it is important to monitor plant nitrogen levels ensuring sufficient canopy growth at early and curtail the grain filling period of wheat plants. Nitrogen use efficiency in wheat may be low owing to losses of N by volatilization, denitrification, and leaching (Ercoli *et al.*, 2012). Thus, N application may be the latest compatible approaches, in order to reduce losses of unused N, as well as to improve efficiency of N fertilizer use and to obtain higher productivity (Raun *et al.*, 2008). Presently, Egypt is being faced by a problem arising from the shortage in local production of wheat in comparison with the increased level of their consumption. Therefore, using suitable agricultural practices, such as foliar spraying with using appropriate N fertilization level, may affect wheat productivity. Moreover, this can reduce input costs. Therefore, with keeping the above points in view, the present study was planned to improve and maximizing the productivity of wheat, under the environmental conditions of delta region, Egypt, by elucidating the role of spraying some antioxidants and different nitrogen levels on yield, yield component, nitrogen use efficiency and nitrogen utilization efficiency of wheat (Sakha 94 var.)

MATERIAL AND METHODS

Experimental setup, climate, soil growing conditions

This research was undertaken at Kafrelsheikh University research farm, Egypt (31°05'54.3"N, 30°57'19.4"E), during two consecutive winter growing seasons in 2012-2013 and 2013-2014. Climatic data were collected from Sakha agro-meteorological station, located 1 km from the experimental site, as given in *Table 1*. Soil samples were taken from the 0 to 30 cm soil depth, using a soil Auger to analyze N content by Kjeldahl method (Bremner, 1960). The soil was clayey and an average bulk density of 1.22 g cm^{-3} in upper 30 cm depth. This layer also contained 1.37% total organic matter, 0.15 % total nitrogen (N), 35 mg kg^{-1} available phosphorus (P) and 255.3 mg kg^{-1} exchangeable potassium (K), 1.25 EC, ds m^{-1},1:5), 8.1 pH (1:2.5) and 1.38 cm annual precipitation, as average in both seasons.

Experimental design and treatments

The experiment was laid out as a randomized complete block design with a split plot with three replicates. Five N fertilizer rates (0, 57.5, 115, 172.5 and 230 kg N ha^{-1}) were allocated to the main plots. Subplots were three foliar spraying applications ("tap water" control, salicylic acid and ascobien). Wheat plants were sprayed twice with salicylic acid and ascobien at the rates of 200 mg L^{-1}. The plants were sprayed after 30 and 45 days from sowing. The net experimental unit size (plot) was 10.5 m^2 (3 m width x 3.5 m long)

Plant materials

Wheat (Cv. Sakha 94) was planted on November 25th during 2012/2013 and November 28th during 2013/2014 with arrow spacing of 12.5 cm and a seeding rate 140 kg ha^{-1}. N fertilizer was applied as ammonium sulphate (20.6% N) to each plot at three splits (20% as basal dose at sowing stage, 40% at the beginning of tillering stage and the remaining 40% at end of stem elongation stage). Super phosphate fertilizer (70 kg P_2O_5ha^{-1}) was added during seedbed preparation.

Table 1 - Monthly relative humidity (RH, %), wind speed (km), mean minimum and maximum air temperatures (Tmax and Tmin, respectively), during the two growing seasons

Month	Season							
	2012				2013			
	Temperature (°C)		Wind speed (km)	RH (%)	Temperature (°C)		Wind speed (km)	RH (%)
	Tmax	Tmin			Tmax	Tmin		
Dec	17.7	11.6	155.5	37.8	16.9	11.4	156.0	30.7
Jan	22.6	11.0	158.7	41.4	23.5	9.4	142.0	41.4
Feb	23.3	11.9	167.9	45.5	22.0	11.0	152.1	45.1
Mar	22.5	14.7	129.3	49.2	24.0	16.2	123.5	47.9
April	29.1	17.0	89.1	52.5	27.4	17.2	88.2	55.4
May	33.8	18.2	111.7	61.1	31.9	17.8	96.3	64.1

max = maximum, min = minimum, RH = relative humidity

Harvesting

Wheat grain yield (14% moisture), 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. Plant samples collected at harvest were separated into grain and straw and electric oven-dried at 70°C for 72 h till constant dry weight, then were grounded in a mill to produce a fine powder, which is needed for the N analysis using the standard procedure of micro-Kjeldahl digestion with sulfuric acid. Wheat grain protein content was obtained by multiplying grain N content (%) by 5.75 (Halvorson *et al.,* 2004). The terminology of N efficiency indices is in accordance with Delogu *et al.* (1998), Lopez-Bellido and Lopez-Bellido (2001).

Measurements and calculations

Plants were sampled at harvesting stage. Plant height (cm), spike length (cm), number of spikelets /spike, number of grains per spike, 1000-grain weight, grain yield and straw yield, were counted in both seasons and grain yield was corrected to 14% moisture. Chlorophyll content (SPAD) of flag leaves was determined with a portable chlorophyll meter (SPAD-502, Minolta Camera, Osaka, Japan) (Castelli *et al.*, 1996) at 120 days after sowing (DAS).

Then, N harvest index (NHI, %) at maturity was calculated (Jones *et al.*, 1990) and also N uptake (kg N ha^{-1}) in the straw or grains was calculated (Michael, 1978) as follows:

$$\text{N harvest } \textit{Index} = \frac{\text{Grain N uptake (kg ha}^{-1}\text{)}}{\text{Total N uptake (kg ha}^{-1}\text{)}}$$

where, the total N uptake includes all N that accumulated in leaves, stem, shank, cobs, husk organs in addition to the grain N.

$$\text{Stovers } \textit{N uptake}\text{(kg ha}^{-1}\text{)} = \frac{\text{Straw N content (g kg}^{-1}\text{)} \times \text{Straw DM (kg ha}^{-1}\text{)}}{1000}$$

$$\text{Grains N } \textit{uptake} \text{ (kg ha}^{-1}\text{)} = \frac{\text{Grains N content (g kg}^{-1}\text{)} \times \text{Grains DM (kg ha}^{-1}\text{)}}{1000}$$

$$\text{Whole plant nitrogen uptake}\left(kg\ ha^{-1}\right) = \text{Stovers } N\ uptake\left(\text{kg ha}^{-1}\right) + \text{Grains N } uptake\left(kg\ ha^{-1}\right)$$

N use efficiency (NUE) was calculated as it is described by Azizian and Sepaskhah (2014). In addition, N utilization efficiency was calculated as described by Haegele (Xu, 2006).

$$\text{NUE}\left(kg\ \text{kg}_N{}^{-1}\right) = \frac{\text{GY}_t - \text{GY}_c\ (\text{kg ha}^{-1})}{\text{NF}_t \quad \text{NF}_c\ (\text{kg ha}^{-1})}$$

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.

$$\text{NUtE}\left(kg\ \text{kg}^{-1}{}_{\text{plantN}}\right) = \frac{\text{GY}_t - \text{GY}_c\ (\text{kg ha}^{-1})}{\text{N uptake}_t - \text{N uptake}_c\ (\text{kg ha}^{-1})}$$

where, GY_t and GY_c express the grain yield at different N treatments and control, respectively. While, N uptake_t and N uptake_c express the total N accumulation in whole plant biomass above ground (grains and stover) for different N treatments and control, respectively.

Statistical analysis

Data obtained from the current investigation were subjected to an analysis of variance (ANOVA), procedures according to Gomez and Gomez (1984), using the MSTAT-C statistical software package. Different means were compared using Duncan's multiple range tests (1955), when the ANOVA showed significant differences ($p < 0.05$).

RESULTS AND DISCUSSION

Effect of foliar spraying application and nitrogen fertilizer rates on wheat yield components in both of winter 2012 and 2013 seasons

As it can be seen from *Tabs. 2 and 3* foliar spraying of SA and Ascobien and different levels of nitrogen caused significant effects on wheat growth and yield attributes in both seasons (*Tabs. 2 and 3*). Ascobien and salicylic acid treatment significantly increased wheat growth characters and yield attributes, as compared with control treatments in both growing seasons. Applying of 172.5 or 230 kg N ha^{-1} significantly increased wheat growth characters and yield attributes.

In this study, we observed that foliar spraying application by ascobien was produced the highest value from dry weight (410.8 and 427 g m^{-2}), chlorophyll content (42.86 and 43.70), plant height (96.02 and 99.12 cm) (*Table 2*) in the same way yield attributes i.e., number of spike m^{-2} (309.67 and 311.00), spike length, (10.43 and 10.59 cm), number of grains $spike^{-1}$ (48.13 and 53.95) and 1000-grain weight (44.43 and 44.42 g) were highly significantly influenced by foliar spraying application by ascobien both 2012 and 2013 seasons, respectively, has produced in *Table 3*. On the other hand, it was observed that no significant difference between foliar spraying application by ascobien and salicylic acid in number of grains spike^{-1} in winter 2012 season. Similarly, chlorophyll content and plant height in 2013 season. These findings are in good agreement with those obtained by Amin *et al.*, 2008; Sadak *et al.*, 2013; Abo-Youssef *et al.*, 2015; Anis *et al.,* 2015). The importance of ascobien may be attributed to that its roles in biosynthetic pathways, detoxification, antioxidant biochemistry and redox homeostasis.

Table 2 - Dry weight (g m^{-2}), chlorophyll content and plant height of wheat as influenced by nitrogen levels and salicylic and ascobien application in 2012 and 2013 seasons

Treatments	Dry weight (g m^{-2})		Chlorophyll content		Plant height (cm)	
	2012	2013	2012	2013	2012	2013
N. fertilizer (kg ha^{-1})						
0	189.22e	205.0d	33.39e	34.8d	88.53c	84.27d
57.5	331.67d	296.0c	40.04d	38.66c	90.96bc	92.78c
115	426.44c	395.0b	43.17c	41.91b	94.44b	97.33b
172.5	511.78b	546.0a	46.24b	47.24a	100.13a	102.89a
230	544.67a	562.0a	47.89a	48.6a	102.67a	105.93a
Foliar spraying (S)						
Control	393.13b	376.0c	41.68b	40.55b	94.95	93.33b
Salicylic	398.33b	400.0b	41.90b	42.48a	95.07	97.48a
Ascobien	410.8a	427.0a	42.86a	43.7a	96.02	99.12a
ANOVA						
N	**	**	**	**	**	**
S	**	*	**	*	N.S.	*
N × S	*	*	*	*	N.S.	*

*,** and N.S. indicate $p < 0.05$, $p < 0.01$ and not significant, respectively. Means of each factor designated by the same latter are not significantly different at 5% level using Duncan's Multiple Range Test.

The results has presented in *Tabs. 2 and 3* implied that the effect of nitrogen fertilizer levels on growth and yield attributes were significant effects in the two growing seasons. It can be stated that all studied growth and yield attributes were significantly increased, as a result of increasing nitrogen fertilizer levels from 0 to 172.5 and 230 kg N ha^{-1} and the differences between them were obvious in both seasons. The highest values were recorded at 230 kg N ha^{-1}, but most of the cases there was no significant difference with the 172.5 kg N ha^{-1} in both seasons, except dry weight, chlorophyll content and number of spike m^{-2} in 2012 season. In this connection, Abou El-Hassan *et al.* (2014) and Hafez *et al.* (2014) pointed out that N fertilizer application significantly increased grain yield and its components, but the N effect depended on the availability of water before anthesis. The improvement of plant growth, this might be due to the well utilization of the supplied N in the metabolism and the meristemic activity, which, consequently improve growth and yield components, which contributed to the significant increase in wheat grain yield. These findings are in good agreement with those obtained by Hafez and Kobata (2012), Abd El-Wahed *et al.* (2015); EL Sabagh *et al.* (2016$_{a}$).

Table 3 - Number of spikes m^{-2}, Spike length (cm), No. of grains $spike^{-1}$ and 1000-grain weight (g) of wheat as influenced by nitrogen levels and salicylic and ascobien application in 2012 and 2013 seasons

Treatments	No. of spikes, m^{-2}		Spike length, cm		No. of grains, $spike^{-1}$		1000-grain weight, g	
	2012	2013	2012	2013	2012	2013	2012	2013
N. fertilizer (Kg ha^{-1}								
0	224.44e	220.0d	9.5d	9.43d	38.56d	39.05d	40.68	40.45
57.5	267.33d	259.0c	9.99c	9.89cd	43.11c	45.59c	41.63	41.18
115	299.56c	299.0b	10.56b	10.38bc	46.22b	54.29b	41.84	42.02
172.5	346.56b	360.0a	10.86a	10.98ab	53.44a	58.51a	42.11	42.75
230	367.78a	368.0a	10.93a	11.29a	54.89a	59.86a	42.22	43.57
Foliar spraying (s)								
Control	293.53c	291.0b	10.28b	10.18b	46.0b	48.72b	43.64b	43.56b
Salicylic	300.2b	301.0ab	10.39ab	10.41ab	47.6a	51.7b	44.22ab	44.00ab
Ascobien	309.67a	311.0a	10.43a	10.59a	48.13a	53.95a	44.43a	44.42a
ANOVA								
N	**	**	**	**	**	**	N.S	N.S
S	**	**	**	**	**	**	**	**
N × S	*	*	*	*	N.S.	N.S.	N.S.	N.S.

*,** and N.S. indicate $p< 0.05$, $p< 0.01$ and not significant, respectively. Means of each factor designated by the same latter are not significantly different at 5% level using Duncan's Multiple Range Test.

Effect of foliar spraying application and nitrogen fertilizer rates on some parameters in wheat (Sakha 94 cultivar) in both of winter 2012 and 2013 seasons

It was observed that foliar spraying of ascobien and salicylic acid with 172.5 or 230 kg N ha^{-1} promoted wheat grain yield, compared to control treatment with the same amount of N applied in 2012 and 2013 seasons. Moreover, it was found that increment by spraying treatment from ascobien was more effective than that sprayed from control or salicylic acid (*Fig. 1*). It is clear that the beneficial effect of ascobien on producing vigour plants, as well as improving yield components surly reflected on improving production of wheat plants. It has also been observed by Franceschi and Tarlyn (2002), Noctor *et al.* (2012), EL-Hosary *et al.* (2013) and confirmed our results, they concluded that ascobien and nitrogen fertilizer had promoting effects on grain yield, and it may be attributed to the enhancement of cell division and plant development.

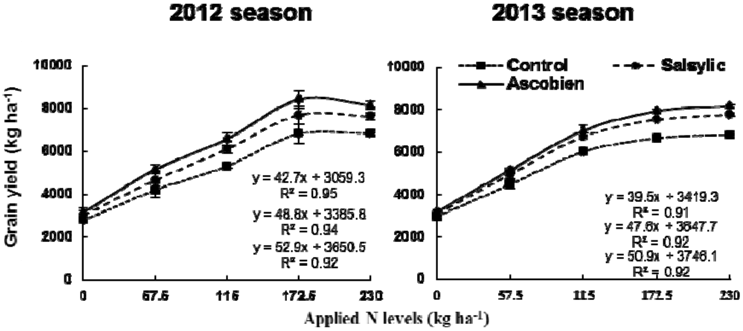

Figure 1 - Grain yield (kg ha^{-1}) in the wheat supplied with foliar spraying of control (■), salicylic acid (•) and ascobien (▲) and different levels of nitrogen fertilizer (0, 57.5 ,115, 172.5 and 230 kg N ha^{-1}) in 2012/2013 and 2013/2014 seasons. The data are the mean ± standard error of three replicates.

According to data in 2012 and 2013 seasons, grain N uptake and whole plant N uptake was highly influenced by increased N application rates. The rate of increase decreased with the increase in the amounts of applied N, and the increase by foliar spraying from ascobien was greater than that by salicylic acid and control treatment (*Fig. 2*). The grain N uptake and whole plant N uptake was recorded the maximum value by application 172.5 kgN ha^{-1} with foliar spraying of ascobien estimated from the regression in *Fig. 2* and the value was 122.21 and 182.20 kgN ha^{-1} in 2012, and 116.35 and 163.14 kgN ha^{-1} in 2013, but in salicylic acid was 109.81 and 165.57 kgN ha^{-1} in 2012 and 109.54 and 155.11 kg N ha^{-1} in 2013, respectively (*Fig. 2*). Thus, the response of N uptake in grain and whole to foliar spraying was much lower in control treatment. Nitrogen uptake reflects the efficiency of the plant in obtaining N from the soil. Increased N uptake has been noticed as a strategy to increase NUE and NU$_t$E by Raun and Johnson (1999). Moll *et al.* (1982) confirmed that variation in N uptake by plants significantly influenced grain yield. Lopez-Bellido and Lopez-Bellido (2001) also observed the similar results in wheat. Lee *et al.* (2004) showed that N uptake was positively correlated with dry weight and straw nitrogen content. In this connection, there was a positive correlation between N uptake and grain yield

(*Fig. 2*). The increases in N uptake in grains and whole plant due to foliar spraying of ascobien probably ascribed to its the role in cell division and enlargement, protein and nucleic acid synthesis and chlorophyll formation (Castelfranco and Beale, 1983), as well as the ability of ascobien in induction of endogenous hormones, like GA3 and IAA (Amin *et al.*, 2008; Abo-Youssef *et al.*,2015). The ameliorative effect of ascobien (ascobien + citric acid) on N uptake comes from the fact that they act as an antioxidant. Antioxidants ameliorate the damaging effect of water stress through interaction of antioxidant response and protection of membranes (Ekmekçi and Karaman, 2012; EL Sabagh *et al.,*2016$_b$).

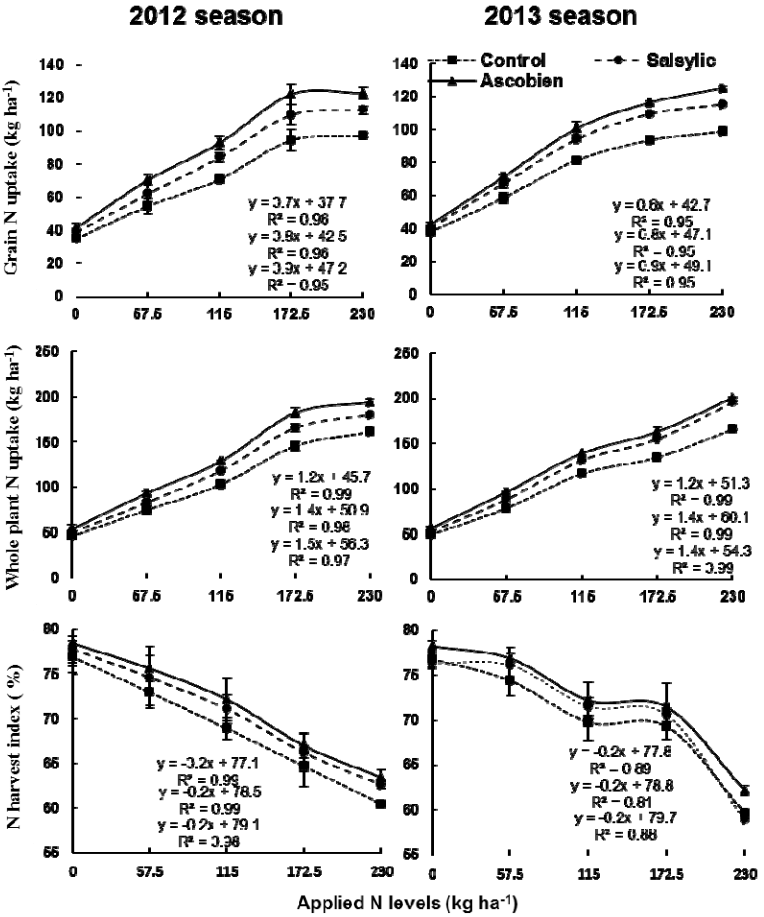

Figure 2 - Grain N uptake (kg ha^{-1}), whole plant N uptake (kg ha^{-1}) and N harvest index (%) in the wheat supplied with foliar spraying of control (■), salicylic acid (●) and ascobien (▲) and different levels of nitrogen in 2012/2013 and 2013/2014 seasons.

As it can be seen from the (*Fig. 1*), NHI of wheat varied significantly influenced by different nitrogen levels and foliar spraying treatments. NHI reflects the grain protein content and, thus, the grain nutritional quality (Hirel *et al.*, 2007). NHI decreased by increasing N levels, and also foliar spraying applications of ascobien and salicylic acid (*Fig. 2*). Montemurro *et al.* (2006) noticed that grain N uptake was positively correlated with yield, protein content and total N uptake and a significant positive correlation found in NHI, yield and total N uptake. The increase in NHI, without N fertilization, confirmed that N translocation to the grain is stimulated by low N availability in the soil, which is strongly associated with the report of Singh and Anderson (1973). Foliar spraying by ascobien improved both N uptake and N partitioning efficiency to the grain, compared to control treatment. Possibly the reason for an increase of the grain higher sink size induces higher N demand by the grain, stimulating remobilization and N translocation to the grain (Moll *et al.*, 1982). When N level in the soil is a limiting factor, vegetative plant parts could have enough N to satisfy gain demand leading to lower NHI and higher grain N uptake (Sarandon and Gianibelli, 1990).

Nitrogen utilization efficiency

Nitrogen utilization efficiency reflects the ability of the plant to transplant the N uptakes into grain (Delogu *et al.*, 1998). It was found that NUtE had significant differences in wheat among N fertilizer levels, as well as foliar spraying application. This result suggested that utilization efficiency and partitioning of N from vegetative plant parts to the grain respond to N fertilizer level applied in wheat. However, Delogu *et al.* (1998) showed that NUtE decreased with increasing N fertilizer rates. The highest NutE was obtained the application of 57.5 kg N ha^{-1} (*Fig. 3*). This was similar to Delogu *et al.* (1998), who reported that NUtE was highest with the lowest N application. NUtE was reduced from 51 to 36% with foliar spraying of ascobien, and from 49 to 35% with foliar spraying of salicylic acid in both seasons. Foliar spraying of ascobien was mor effective than salicylic acid. N utilization efficiency was decreased by increasing N fertilizer levels and foliar spraying with ascobien has the potentiality to exert a suppressive or stimulative impact on NUtE of wheat in both seasons. Foliar spraying with ascobien was more effective in increase of NUtE, it might be due to ascobien enhanced the biosynthesis of chlorophylls, photosynthetic activity and played an important role to enhance the activity of enzymes responsible for drought resistance (Cherki *et al.*, 2002). In this study, ascobien significantly increased the number of spikes and grain number (*Table 3*), with grain yield in (*Fig. 1*) and grain N uptake in (*Fig. 2*). According to the aforementioned results, it could be said that foliar spraying with ascobien significantly increased NUtE in both seasons, compared with salicylic acid and control treatments. These findings are in good agreement with those obtained by Kord and Hathout (1992).

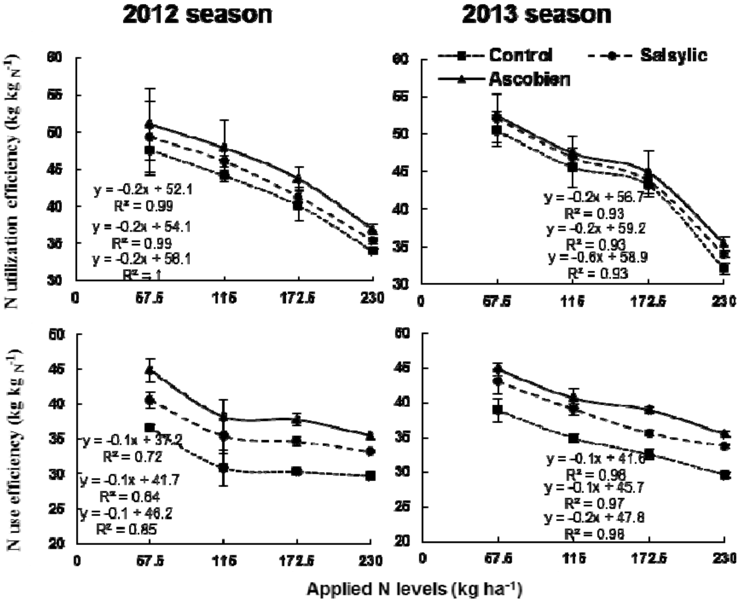

Figure 3 - N utilization efficiency (kg kg N^{-1}) and N use efficiency (kg kg N^{-1}) in the wheat supplied with foliar spraying application of control (■), salicylic acid (●) and ascobien (▲) and different levels of nitrogen fertilizer (0, 57.5 ,115, 172.5 and 230 kg N ha^{-1}) in 2012/2013 and 2013/2014 seasons.

Grain N content in wheat depends on uptake of soil nitrate prior to flowering, continued uptake of nitrate during grain filling and remobilization of stored vegetative N. However, under condition of high N fertility and available soil moisture, post anthesis N uptake may increase substantially (Barbottin *et al.,* 2005; EL Sabagh *et al.,* 2015). Palta and Filery (1995) reported that N utilization efficiency decreased, when the amount of applied N increased, N remobilized efficiently when plants exposed to lower N. Knowles and Watkins (1993) found that most of the N taken up by the wheat plants was translocated to the grain either, directly or by mobilization from other plant parts. One explanation for different in utilization efficiency is that the plant retained an higher amount of N at anthesis essential for physiological functions, However, retained N depends on cultivars and prevailing growth conditions, although genetic variability in nitrogen utilization has been reported (Mickelson *et al.*, 2003).

Nitrogen use efficiency

Nitrogen use efficiency and its relationship with nitrogen fertilizer levels and foliar spraying treatments in wheat subjected to water-restricted conditions after anthesis are shown in

Fig. 3. NUE varied markedly, ranging from 45 kg kg_N^{-1} of foliar spraying ascobien plus the minimum fertilizer (57.5 kg N ha^{-1}) condition to 35 kg kg_N^{-1} by the maximum (230 kg N ha^{-1}) condition along with ascobien, respectively the NUE was slightly lower (40~33 kg kg $_N^{-1}$), supplied with salicylic acid treatment, but the lowest value (36~29 kg kg $_N^{-1}$) was recorded under control. Ju *et al.* (2006) reports that NUE and exudation rate were associated with root activity, and observed the association of root activity with NUE of a cultivar. It was reported that the decreased accumulation of nitrogen before flowering could be caused by nitrogen volatilization from plant tissues and death of partial leaf and organ at post-flowering stage (Jin and Mian, 2005). The negative effect, caused by volatilization and accumulation at flowering stage, was larger than the positive effect of post-flowering dry matter production and N redistribution at high N rate, so NUE decreased with increasing N rates. In addition, a high indigenous N supply of soil (INS) resulted in higher N concentration in rice straw and produce the phenomenon of luxury consumption of N (Feng *et al.*, 2006).

The lower N use efficiency and its utilization from higher N level might result from greater leakage of N. The water leaked with N should increase when the amount of supplied water is greater than the water capacity of soils (Barrows and Kilmer, 1963). The leaked N increased with the increasing N levels, but amount of leaked N from was lower with ascobien and salicylic acid, that means water enhanced the leakage of N. Hafez and Kobata (2012) reported that N leakage increased up to 50%, with lower N levels, but it increased only up to 10% at higher N fertilization. The strong inverse relationship was observed between NUE and both of N fertlizer levels, that is NUE decreased by increasing nitrogen application level (*Fig. 3*). Foliar spraying of ascobien and SA increased the NUE and nitrogen utilization efficiency, but inverse relationship was observed with increased N levels in wheat plants. Ascobien performed better than salicylic acid for the aforementioned parameters in both season. Nitrogen use efficiency is also affected by N metabolic processes in which N transporters and enzymes that synthesize N-transport amino acids play critical roles (Yamaya and Oaks, 2004). Recent advances in molecular approaches will facilitate better understanding of mechanisms regulating N uptake and N metabolism, leading to the identification of physiological traits responsible for superior NUE, although further studies are required to apply these approaches into practical breeding programs.

CONCLUSION

Considering the results of this study, both of nitrogen fertilizer and foliar spraying were significantly influenced yield, its components and

N use efficiencies. Application of 172.5 kg ha^{-1} of nitrogen and foliar spraying of ascobien was produced the highest value from yield, its components and N use efficiencies in wheat. Interestingly, for maximizing the productivity and promoting N use efficiencies could be using at 172.5 kgha^{-1} of nitrogen fertilizer with combined of 200 ml L^{-1} ascobien, during the vegetative growth of wheat. Consequently, these treatments (ascobien) could play an important role in improving plant growth and yield, as well as enhancing of N use efficiency and N utilization efficiency of wheat and could be the key to reduce the need for chemical fertilizers and decrease the cost of production.

REFERENCES

Abd El-Wahed M.H., EL Sabagh A., Zayed A., Ahmed S., Saneoka H., Barutçular C., 2015 - Improving yield and water productivity of maize grown under deficit-irrigated in dry area conditions. Azarian Journal of Agriculture, 2 (5): 123-132.

Abou El-Hassan W.H., Hafez E.M., Ghareib A.A.A., Freeg M.R., Seleiman M.F, 2014 - Impact of nitrogen fertilization and irrigation on water utilization efficiency, N accumulation, growth and yields of *Zea mays* L. J. Food Agric. Envi., 12 (3&4): 217-222.

Abo-Youssef M.I., Mohamed A.A.E., El Sabagh A., Abo-Gendy G.I. , 2015 - Effect of gibberellic acid and row ratio on morphological and seed yield characters of female line in hybrid rice. J. Agric. Res. Kafer El-Sheikh Univ., 41(2).

Amin A.A., Rashad E.S.M., Gharib F.A.E., 2008 - Changes in morphological, physiological and reproductive characters of wheat plants as affected by foliar spraying application with salicylic acid and ascorbic acid. AJBAS, 2 (2): 252-261.

Anis G., EL Sabagh A., Ghareb A., EL-Rewainy I., 2016 - Evaluation of promising lines in rice (*Oryza sativa* L.) to agronomic and genetic performance under Egyptian conditions. IJAAR, 8(3): 52-57.

Azizian A., Sepaskhah A.R., 2014 - Maize response to different water, salinity and nitrogen levels: agronomic behavior. Int. J. Plant Prod., 8:107-130.

Barrows H.L., Kilmer V.J.,1963 - Plant nutrient losses from soils by water erosion. Adv. Agron., 15: 303-316.

Barbottin A., Lecomte C., Bouchard C., Jeuffroy M.H., 2005 - Nitrogen remobilization during grain filling in wheat: genotypic and environmental effects. Crop Sci., 45: 1141-1150

Bayaner A., 2002 - Wheat sector in Turkey, final report. Ministry of Agriculture and Rural Affairs, Research Planning and Coordination Council.

Bremner J.M. 1960 - Determination of nitrogen in soil by the Kjeldahl method. J. Agric., Sci. 55: 11-37.

Castelfranco P.A., Beale S.I., 1983 - Chlorophyll biosynthesis: recent advances and areas of current interest. Annu. Rev. Plant Physiol. 34: 241-278.

Castelli F., Contillo R, Miceli F., 1996 - Non-destructive determination of leaf chlorophyll content in four crop species. J. Agron. Crop Sci., 177: 275-283.

Cherki G., Ahmed F., Khalid F., 2002 - Effects of salt stress on growth, inorganic ions and proline accumulation in relation to osmotic adjustment in five sugar beet cultivars. Environ. Exp. Bot., 47: 39-50

Delogu G., Cattivelli L., Pecchioni N., Defalcis D., Maggiore T., Stanca A.M., 1998 - Uptake and agronomic efficiency of nitrogen in winter barley and winter wheat. Eur. J. Agron., 9: 11-20.

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

Ekmekçi B.A., Karaman M., 2012 - Exogenous ascorbic acid increases resistance to salt of *Silybum marianum* (L.). African J. Biotech. 11(42): 9932-9940.

El-Hosary A.A., Hammam G.Y., EL-Morsi A., Hassan E.A., EL-Awadi M.E., Abdel-Baky Y.R., 2013 - Effect of some bio-regulators on growth and yield of some wheat varieties under newly cultivated land conditions. New York Sci. J., 6(6):1-11.

EL Sabagh A., Omar A., Saneoka H., Barutçular C., 2015 - Evaluation agronomic traits of canola (*Brassica napus* L.) under organic, bio- and chemical fertilizers. DUFED, 4(2):59-67.

EL Sabagh A., Abd El-Rasool S., Islam M.S., Barutçular C., Omar A., 2016$_a$ - Improving growth of canola (*Brassica napus* L.) plants by seed inoculation and inorganic - organic nitrogen fertilization.Asian Journal of Science and Technology, 7(1):2283 -2288.

EL Sabagh A., Sorour S., Morsi A., Islam M.S., Ueda A., Barutçular C., Arioglu A., Saneoka H., 2016$_b$ - Role of osmoprotectants and compost application in improving water stress tolerance in soybean (*Glycine max* L.). Int. J. Curr. Res., 8, (2), 25949-25954.

Ercoli L., Arduini I., Mariotti M., Lulli L., Masoni A., 2012 - Management of sulphur fertilizer to improve durum wheat production and minimize S leaching. Eur. J. Agron., 38: 74-82.

FAOSTAT, 2012 - Fertilizers.FAO Statistical Databases & Data-sets. http://faostat.fao.org/

Feng T., Yang J.P., Shi H.X., Zheng H.F, Sun J.H., 2006 - Effect of N fertilizer and N use efficiency under different N levels of application in high-fertility paddy field. J. Zhejiang Univ., Agric. Life Sci., 32(1): 60-64.

Franceschi V.R., Tarlyn N.M., 2002 - L-ascorbic acid is accumulated in source leaf phloem and transported to sink tissues in plants. Plant Physiol., 130(2): 649-656.

Gaballah M.S., Mandour M.S., 2000 - Increasing drought resistance of wheat plants during grain filling by using chemical desiccants. J. Sci. Mansoura Univ., 25(2): 833-841.

Gomma A.S.A., 1999 - Wheat improvement in Egypt: history and future prospects. Egypt. J. Plant Breeding, 3: 1-14.

Gomez K.A., Gomez A.A., 1984 - Statistical procedures for agricultural research. Wiley-Interscience, New York.

Hafez E.M., Kobata T., 2012 - The effect of different nitrogen sources from urea and ammonium sulfate on the spikelet number in Egyptian spring wheat cultivars on well watered pot soils. Plant Prod. Sci., 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. Intl. J. Plant Soil Sci., 3(10): 1302-1316.

Halvorson A.D., Nielsen D.C., Reule C.A., 2004 - Nitrogen fertilization and rotation effects on no- till dryland wheat production. Agron. J., 96: 1196-1201.

Hirel B., Le Gouis J., Ney B., Gallais A., 2007 - The challenge of improving nitrogen use efficiency in crop plants: toward a more central role for genetic variability and quantitative genetics within integrated approaches. J. Exp. Bot., 58(9): 2369-2387.

Ibrahim O.M., Bakry A.B., Thalooth A.T., El-Karamany M.F., 2014 - Influence of nitrogen fertilizer and foliar application of salicylic acid on wheat. Agric. Sci., 5:1316-1321.

Mickelson S., See D., Meyer F.D., Garner J.P., Foster C.R., Blake T.K., Fischer A.M.. 2003 - Mapping of QTL associated with nitrogen storage and remobilization in barley (*Hordeum vulgare* L.) leaves. J. Exp. Bot., 54:801-812.

Jin J., Mian S.P., 2005 - Review of losses pathways of fertilizer N from paddy field and the measurements for its reduction. J. Agric. Sci., 26(2): 76-98.

Jones J.B., Case V.W., 1990 - Sampling, handling and analyzing plant tissue samples. *In:* R.L. Westerman (Ed.). Soil testing and plant analysis. Soil Sciences Society of American Inc.Wisconsin, 389-447.

Ju X.T., Kou C.L., Zhang F.S., Christie P., 2006 - Nitrogen balance and groundwater nitrate contamination: comparison among three intensive cropping systems on the North China Plain. Environ. Pollut., 143(1):117-125.

Khan W., Prithiviraj B., Smith D.L., 2003 - Photosynthetic response of corn and soybean to foliar application of salicylates. J. Plant Physiol., 160(5): 485-492.

Knowles R., J.E. Watkins., 1993 - The assimilation and translocation of plant nutrients in wheat during growth. J. Agric. Sci., 21: 612-637.

Kord M., Hathout T., 1992 - Changes on some growth criteria, metabolic activities and endogenous hormones in tomato plants consequent to spraying with different concentrations of salicylaldehyde. Egypt, J. Physiol. Sci., 16: 117.

Kowalczyk K., Zielony T., 2008 - Effect of aminoplant and asahi on yield and quality of lettuce grown on rockwool. Conf.of Biostimulators in Modern Agriculture, 7-8 Febuary, Warsaw, Poland.

Lee H.J., Lee S.H., Chung J.H., 2004 - Variation of nitrogen use efficiency and its relationships with growth characteristics in Korean rice cultivars. *In:* Proc. 4th International Crop Science Congress, Australia.

Michael M.L., 1978 - Irrigation - theory and practice, Vikas Pub. House, New Delhi.

Moll R.H., Kamprath E.J., Jackson W.A., 1982 - Analysis and interpretation of is factors which contribute to efficiency of nitrogen utilization. Agron. J. 74: 562-564.

Montemuro F., Maiorana M., Ferri D., Convertini G., 2006 - Nitrogen indicators, uptake and utilization efficiency in a maize and barley rotation cropped at different levels and source of N fertilization. Field Crop Res., 99: 114-124.

Noctor G., Mhamdi A., Chaouch S., Han Y., Neukermans J., Marquez-Garcia B., Queval G., Foyer C.H., 2012 - Glutathione in plants: an integrated overview. Plant Cell Environ. 35(2): 454-484.

Palta J.A., Filery I.R.P., 1995 - Application enhances remobilization and reduces losses of preanthesis N in wheat grown on duplex soil. CAB abstract.

Pignocchi C., Foyer C.H., 2003 - Apoplastic ascorbate metabolism and its role in the regulation of cell signaling. Curr. Opin. Plant Biol. 6(4): 379-389.

Podh H., 1990 - Cellular functions of ascorbic acid. Biochem. Cell. Biol., 68(10): 1166-1173.

Radmehr M., Ayeneh G.A., Mamghani R., 2003 - Responses of late, medium and early maturity bread wheat genotypes to different sowing date. I. Effect of sowing date on phonological, morphological, and grain yield of four breed wheat genotypes. Iran. J. Seed. Sapling, 21 (2), 175-189.

Raun W.R., Johnson G.V., 1999 - Improving nitrogen use efficiency for cereal production. Agron. J., 91(3): 357-363.

Raun W.R., Solie J.B., Taylor R.K., Arnall D.B., Mack C.J., Edmonds D.E., 2008 - Ramp calibration strip technology for determining midseason nitrogen rates in corn and wheat. Agron. J.,100: 1088-1093.

Sadak M. Sh., Abd Elhamid E. M. , Mostafa H.M., 2013 - Alleviation of adverse effects of salt stress in wheat cultivars by foliar treatment with antioxidants I. Changes in growth, some biochemical aspects and yield quantity and quality. American-Eurasian J. Agric. & Environ. Sci., 13 (11): 1476-1487.

Sanjari P.A., Yazdansepas A., 2008 - Evaluation of wheat (*Triticum aestivum* L.) genotypes under pre- and post-anthesis drought stress conditions. J. Agric. Sci. Technol., 10: 109-121.

Sarandón S.J., Gianibelli M.C., 1990 - Effect of foliar urea spraying and nitrogen application at sowing upon dry matter and nitrogen distribution in wheat (*Triticum aestivum* L.). Agronomie, 10(3):183-189.

Shah K.H., Saeed M., 1989 - Effect of combination of soil and foliar application of urea on three wheat genotypes. Pakistan J. Sci. Ind. Res., 32: 813-5.

Shakirova F.M., Sakhabutdinova, Bezrukova M.V., Fathkutdinova A.R., Fatkhutdinova D.R., 2003 - Changes in the hormonal status of wheat seedlings induced by salicylic acid and salinity. Plant Sci., 164(3): 317-322.

Sheteawi S.A., 2007 - Improving growth and yield of salt-stressed soybean by exogenous application of jasmonic acid and ascobin. Int. J. Agric. Biol., 9(3): 473-478.

Singh R. P., Anderson R.G., 1973 - Nitrogen and dry matter accumulation in dwarf wheat varieties as influenced by Nitrogen fertilization. Indian J. Agric. Sci., 43:570-579.

Smirnoff N., Wheeler G.L., 2000 - Ascorbic acid in plants: biosynthesis and function. Crit. Rev. Biochem. Mol. Biol., 35(4): 291-314.

Xu Z.Z., Yu Z.W., Wang D., 2006 - Nitrogen translocation in wheat plants under soil water deficit. Plant Soil., 280(1): 291-303.

Varga B., Svečnjak Z., Pospišil A., 2002 - Grain yield and yield components of winter wheat grown in two management systems. Die Bodenkultur, 51(3):145-150.

Yamaya T., Oaks A., 2004 - Metabolic regulation of ammonium uptake and assimilation. *In:* Amâcio S., Stulen I. (Eds.), Nitrogen acquisition and assimilation in higher plants. Kluwer, Dordrecht, 35-63.