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IMPACT OF CULTIVARS, BIO-FERTILIZER AND N FERTILIZER LEVELS ON NITROGEN USE EFFICIENCY (NUE) AND YIELD OF WHEAT (*Triticum aestivum* L.)

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ABSTRACT: Two field experiments were carried out at the Experimental Farm (Ghazala Village), Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt, during 2015/2016 and 2016/2017 seasons to study the influence of the bio-fertilizer *Azotobacter* (without and with inoculation) and four N levels (0, 40, 80 and 120 kg N/fad.) on nitrogen use efficiency (NUE), yield and its attributes of two bread wheat cultivars (Gemmeiza11 and Misr2). Results of combined analysis revealed that Misr2 cultivar produced the highest number of spikes per square meter, grain and biological yields compared to Gemmeiza11 which was superior in plant height, spike length, spike grain weight, thousand grain weight and harvest index, as well it was higher in NUE. Inoculating wheat grains with *Azotobacter chroococcun* (in commercial form Biogein) before sowing significantly increased studied traits *i.e.* Plant height, spike length, spike number/m^2, grain weight/spike, 1000-grain weight, grain and biological yields/fad., and harvest index, but in contrary NUE decreased by *Azotobacter* inoculation during the two seasons and their combined analysis. Results of combined analysis also indicated that increasing N application level up to 120 kg N/fad., significantly increased each of plant height, spike length, spike number/m^2, grain weight/ spike, grain and biological yields/ fad., and decreased NUE that responded to N addition up to 80 kg N/fad. Significant interactions between the studied factors indicated that the addition of *Azotobacter* increased the response of wheat cultivars to the increase of N level particularly. According to the results of the interactions between cultivars and *Azotobacter*, cultivars and N-fertilizer levels and between *Azotobacter* and N levels, wheat cultivar Misr2 should be fertilized with *Azotobacter* and 120 kg N/fad., to produce the highest yield. Moreover, the results showed the significant interaction effect between bio and N fertilizer levels on NUE where the efficiency of N use was higher with *Azotobacter* inoculation and 80 kg N/fad., in comparison to control and 120 kg N/fad.

Key words: Wheat, cultivars, *Azotobacter*, nitrogen levels, NUE.

INTRODUCTION

Wheat (*Triticum aestivum* L.) used as a source of both food and income and considered as the most important strategic cereal crop not only in Egypt but also in the world and is the staple food for about one-third of the world's population **(Abd Allah and El-Gammaal, 2009)**. The gap between production and consumption in Egypt remains wide in spite of the exerted efforts for increasing wheat production **(Attia and Barsoum, 2013)**. To minimize this gap, it is necessary to enhance both of the productivity of unit area and the total cultivated area by choosing the highly yielding cultivars and suitable fertilization amount **(Atia and Ragab, 2013)**.

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Many researchers had indicated that there were significant differences between cultivars in their response to studied factors in terms of growth and yield **(Ahmed *et al*., 2011; Hafez *et al*., 2012; Fadl, 2016; Zaki *et al*., 2016)**. As well, **Gaju *et al*. (2014)** indicated that using wheat cultivars with higher NUE can participate in decreasing N fertilizer amount without affecting grain yield. **Sadras and Lemaire (2014)** recorded that cultivars that more effective in N use is one of the main wheat breeding programs goals.

Utilization of bio-fertilizers considered as a key part of organic farming, it is minimizing the harmful effects of excessive use of chemical fertilizers through its ability to facilitate elements to plants **(Rana *et al*., 2012)**. *Azotobacter* bio-fertilizer has an important role in fixing atmospheric nitrogen in rhizosphere zone of wheat and many other crops, and also contributes to maintenance of soil fertility **(Venkatashwarlu, 2008; Rehman *et al*., 2017)**. Moreover, it has a positive effect on wheat plants by promoting plant growth and increasing yield and yield components **(Badr *et al*., 2009; Bahrani *et al*., 2010; Esmailpour *et al*. 2013; Singh *et al*. 2016; Hassanein *et al*. 2018; Mahato and Kafle, 2018)** reported that wheat grains inoculated before sowing with *Azotobacter* led to a significant increment in yield and yield components *i.e.* plant height, number of spikes per square meter, thousand grain weight, grain and biological yields.

Obviously, the main method to preserve the soil or to restore its nutrients and also to increase crop yields is the application of mineral fertilizers such as nitrogen **(Hirel *et al*., 2011)**. Substantially, nitrogen is the most limiting nutrient for wheat production; it affecting plant growth, yield and NUE. Likewise **(Noureldin *et al*., 2013; Haileselassie *et al*., 2014; Daba, 2017; Harfe, 2017)** stated that applying N fertilizer led to an increment in each of plant height, spike length, 1000 grain weight, grain and biological yields but decreased NUE with excessive levels of N. In this respect, the commercial nitrogen fertilizers are used for its particular solubility and easy uptake by plants, but unfortunately they represent a significant cost in wheat production **(Cui *et al*., 2014)**.

Based on the facts discussed above, this investigation carried out to study the effect of bio-fertilizing by *Azotobacter* inoculation and N fertilizer application on yield, yield attributes and nitrogen use efficiency (NUE) of two wheat cultivars.

MATERIALS AND METHODS

Site Description and Soil Analysis

Two field experiments were conducted at the Experimental Farm (Ghazala Village), Fac. Agric., Zagazig Univ., Sharkia Governorate, Egypt, (30.11_N, 31.41_E) during two winter successive seasons 2015/2016 and 2016/2017 to find out the effect of cultivar differences, bio-fertilizer (*Azotobacter chroococcum*) inoculation and four nitrogen fertilizer levels on NUE and yield of wheat.

The preceding crop was maize (*Zea mayes* L.) in both seasons, and the soil was clay in texture; it has a particle size distribution of 22.63, 30.67 and 46.70% for sand, silt and clay, respectively. The soil had an average pH value of 7.99, EC 1.88 dSm^{-1} (soil paste extract) and organic matter content of 1.04%. The available N, P and K contents were 58.91, 8.95 and 148.10 mg kg^{-1}, respectively (averaged over the two seasons for the upper 30 cm of soil depth). Mechanical and chemical analysis was carried out in Central Laboratory of Faculty of Agriculture, Zagazig University, Egypt.

Studied Factors and Experimental Design

This experiment included 16 treatments *viz*. two bread wheat cultivars (Gemmeiza11 and Misr2), two bio-fertilizer levels [without inoculation (control) and *Azotobacter* inoculation], and four nitrogen levels (0, 40, 80 and 120 kg N/fad.)

Split-split plots design was applied with three replicates and each plot area was 12 m^2 (3× 4). The two cultivars were assigned to main plots, the two bio-fertilizer treatments were occupied in sub plots and the four N fertilizer levels were randomly allocated in the sub-sub plots.

Experimental Procedures

The recommended grain rate for each cultivar was 60 kg/fad., sown on 22 and 19

November 2015/2016 and 2016/2017, respectively. As recommended, wheat grains were inoculated before sowing with a free-living Nitrogen-fixing bacteria (*Azotobacter*) under the commercial name (Biogein) that contains a specific clone of *Azotobacter chroococcum* bacteria, conc.106 cells/ml. Biogein is produced by Bio-fertilizers Unit, General Organization of Agriculture Equalization Fund, Agricultural Research Centre, Giza, Egypt. Urea (46.5%) was used as a source of nitrogen which was added in three equal doses at: sowing, first and second irrigation. The basal doses of P and K, corresponding to 15 kg P_2O_5 as super phosphate (15.5% P_2O_5) was broadcasted at the time of soil preparation and 50 kg K_2O as potassium sulfate (50% K_2O) was added with the first irrigation.

Data Measurement

At harvest, 0.5 m^2 was taken randomly from each plot to determine yield and yield attributes *i.e.* plant height (cm), spike length (cm), number of spikes/m^2, grain weight/spike (g), thousand grain weight (g), grain yield (ardab/fad.), biological yield (ton/fad.), harvest index HI: as a ratio of grain yield to biological yield **(Abdel-Gawad *et al*., 1987)** and also nitrogen use efficiency (NUE) which was calculated according to **Moll *et al*. (1982), Ortiz-Monasterio *et al*. (1997) and Daba (2017)**.

$$NUE_{(\text{grain yield})} = \frac{GDW_f\left(\frac{kg}{fad.}\right) - GDW_C\left(\frac{kg}{fad.}\right)}{N_S\left(\frac{kg}{fad.}\right)}$$

Where

GDW_f = grain dry weight of fertilized treatment,

GDW_C = grain dry weight of control treatment

Ns = N supplied

Statistical Analysis

The obtained data were analyzed with the appropriate method of statistical analysis of variance (ANOVA) as described by **Gomez and Gomez (1984)** by using MSTAT-C software, and the means were compared using least significant differences (LSD test) at 0.05 level of probability **(Waller and Duncan, 1969)**. The error mean squares of split-split plot design were homogenous (Bartlet's test), the combined analysis were calculated for all studied traits in both seasons.

In interaction Tables, capital and small letters were used to compare rows and columns means, respectively.

RESULTS AND DISCUSSION

Cultivar Variation

The obtained results in Tables 1 and 2 indicate the different performance between wheat cultivars (Gemmeiza11 and Misr2) in most of traits under study. These may be due to the genetic variances between cultivars and their responded to external conditions **(Zaki *et al*., 2012; Zaki *et al*., 2016)**. According to combined analysis, Gemmeiza11 surpassed in plant height, spike length, grain weight/ spike, 1000 grain weight and harvest index by 3.85, 14.53, 25.74, 3.50 and 4.38%, respectively in comparison to Misr2, this result is in quite line with **(Fadl, 2016)**. On the other hand, Misr2 was superior in No. of spikes/m^2, grain and biological yields/ fad., and NUE by 20.51, 5.73, 10.67 and 16.18%, respectively (combined data). However, there were no significant differences between cultivars in 1000 grain weight and NUE during the two seasons of the study. In this respect, same trend was supported by **Ahmed *et al*. (2011), Hafez *et al*. (2012), Abd El-Razek and El-Sheshtawy (2013), Atia and Ragab (2013) and Hassanein *et al*. (2018)**.

Bio-fertilizer Effect

Regarding to combined analysis, wheat grains that inoculated with *Azotobacter* significantly gave an increment in yield and yield attributes except nitrogen use efficiency NUE in comparison to control treatment (Tables 1 and 2). Similar findings were reported by **(Bahrani *et al*., 2010; Daneshmand *et al.,* 2012; Singh *et al*., 2013; Attia and Barsoum, 2013; Singh *et al*., 2016; Rehman *et al*., 2017; Mahato and Kafle, 2018)**. This explained the role of free-living Nitrogen-fixing bacteria that found not only for their ability to fix nitrogen but also for the ability to release Phytohormones, *i.e.* Cytokinins (CKs), Indoleacetic acid (IAA) and Gibberellic acid (GA) which stimulate plant

Table 1. Plant height, spike length, No. of spikes/m^2, grain weight/ spike and 1000-grain weight of wheat as affected by cultivar differences, bio-fertilizer and N fertilizer levels during 2015/2016 - 2016/2017 seasons and their combined analysis.

Main effect and interaction	Plant height (cm)			Spike length (cm)			No. of spikes/ m^2			Grain weight/ spike (g)			1000-grain weight (g)		
	2015/ 2016	2016/ 2017	Com.	2015/ 2016	2016/ 2017	Com.	2015/ 2016	2016/ 2017	Com.	2015/ 2016	2016/ 2017	Com.	2015/ 2016	2016/ 2017	Com.
Cultivar (C)															
Gemmeiza11	107.72	108.88	108.30	12.20	12.37	12.29	325.67	307.04	316.35	3.44	3.31	3.37	43.45	44.15	43.79
Misr2	103.95	104.06	104.28	10.40	11.05	10.73	398.17	364.33	381.25	2.61	2.72	2.68	41.61	43.00	42.31
F-test	NS	**	*	*	*	**	*	*	**	**	**	**	NS	NS	*
Bio- fertilizer (B)															
Control	104.60	105.43	105.02	10.93	11.32	11.12	342.00	314.79	328.39	2.93	2.85	2.89	41.36	42.41	41.88
Azotobacter	107.06	108.05	107.56	11.68	12.09	11.89	381.83	356.58	369.21	3.13	3.19	3.16	43.69	44.75	44.22
F-test	**	**	**	NS	NS	*	*	*	**	NS	NS	*	**	**	**
N- fertilizer levels kg N/fad. (N)															
0	99.55d	101.72d	100.63d	10.32d	10.68d	10.50d	273.33d	247.67d	260.50d	2.61d	2.63c	2.62d	38.02d	39.34d	38.68d
40	105.42c	105.65c	105.53c	10.98c	11.39c	11.18c	347.00c	315.33c	331.17c	2.92c	2.81c	2.87c	41.30c	42.83c	42.06c
80	108.03b	108.67b	108.35b	11.72b	11.98b	11.85b	383.67b	356.67b	370.17b	3.12b	3.13b	3.13b	46.22a	46.97a	46.59a
120	110.34a	110.93a	110.64a	12.21a	12.78a	12.49a	43.67a	423.08a	433.38a	3.46a	3.51a	3.48a	44.57b	45.18b	44.88b
F-test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
Interaction															
C × B	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C × N	**	NS	*	**	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS
B × N	NS	**	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

*,** and NS indicate significant at 0.05, 0.01 and insignificant, respectively.

Table 2. Grain yield/fad., biological yield/fad., harvest index (HI) and nitrogen use efficiency (NUE) of wheat as affected by cultivar differences, bio-fertilizer and N fertilizer levels during 2015/2016 - 2016/2017 seasons and their combined analysis

Main effect and interaction	Grain yield (ardab/fad.)			Biological yield (ton/fad.)			Harvest index (HI)			Nitrogen use efficiency (NUE)		
	2015/ 2016	2016/ 2017	Com.	2015/ 2016	2016/ 2017	Com.	2015/ 2016	2016/ 2017	Com.	2015/ 2016	2016/ 2017	Com.
Cultivar (C)												
Gemmeiza11	16.46	17.04	16.75	6.07	6.13	6.09	40.58	41.72	41.15	6.32	4.81	5.56
Misr2	17.66	17.75	17.71	6.77	6.72	6.74	39.18	39.66	39.42	6.51	6.39	6.46
F-test	*	**	**	**	*	**	*	NS	**	NS	NS	*
Bio-fertilizer (B)												
Control	16.44	16.86	16.65	6.25	6.26	6.26	39.34	40.39	39.86	6.95	5.75	6.35
Azotobacter	17.68	17.94	17.81	6.58	6.58	6.58	40.42	41.00	40.71	5.88	5.46	5.67
F-test	**	**	**	**	*	**	NS	NS	*	*	NS	**
N-fertilizer levels kg N/fad. (N)												
0	13.70d	14.39d	14.05d	5.52d	5.54d	5.53d	37.21c	39.01c	38.11c	0	0	0
40	16.09c	16.29c	16.19c	5.92c	6.08c	6.00c	40.78ab	40.47bc	40.63b	8.98a	7.09b	8.04a
80	18.33b	18.69b	18.52b	6.68b	6.59b	6.64b	41.48a	42.74a	42.11a	8.68a	8.05a	8.37a
120	20.12a	20.21a	20.16a	7.54a	7.49a	7.51a	40.07b	40.55b	40.31b	7.99b	7.27b	7.63b
F-test	**	**	**	**	**	**	**	**	**	**	**	**
Interaction												
C × B	**	*	**	NS	NS	NS	*	NS	**	NS	NS	NS
C × N	*	**	**	**	NS	**	**	NS	**	NS	NS	**
B × N	NS	*	*	NS	NS	NS	NS	NS	NS	NS	NS	**

*,** and NS indicate significant at 0.05, 0.01 and insignificant, respectively. ardab= 120 kg

growth, cell division, nutrients absorption and photosynthesis **(Fayez *et al*., 1985; El-Gizawy, 2010; Zaki *et al*., 2012)**. The decrease in NUE because of *Azotobacter* inoculation can be attributed to the fact that NUE decreased by increasing available N in soil **(Giambalvo *et al*., 2010)**. Furthermore, the results reported that inoculation with *Azotobacter* significantly did not affect spike length, grain weight/spike and harvest index (HI) during the both seasons and also had no effect on NUE in 2[nd] season. Similar trend of results were obtained by **Abd El-Lattief (2013), Esmailpour *et al*. (2013) and Soleimanzadeh and Gooshchi (2013)**.

N-fertilizer Effect

The obtained results of combined analysis in Tables 1 and 2 reveal that raising N fertilizer up to the highest level (120 kg N/fad.) increased yield and yield attributes *i.e.* plant height, spike length, No. of spikes/m^2, grain weight/spike, grain and biological yields/ fad., by 9.94, 18.95, 66.36, 32.82, 43.48, 35.80%, respectively compared with control (without N application). These results are supported by findings of **Mattas *et al*. (2011), Abd El-Razek and El-Sheshtawy (2013), Atia and Ragab (2013), Singh *et al*. (2013) and Hassanein *et al*. (2018)**. While, the highest value for each of 1000 grain weight and harvest index resulted from adding 80 kg N/fad., then decreased with increasing N level up to 120 kg, during the two seasons and their combined analysis 40 kg N/fad., was at par with 120 kg N/fad., in influencing HI. These results are in agreement with **Iqbal *et al*. (2010), Ali *et al*. (2011), Namvar and Khandan (2013), Shirazi *et al*. (2014), Mandic (2015) and Harfe (2017)**. Moreover, the results clarified that nitrogen use efficiency NUE increased with each increase in N unit over than control. But increasing N level up to 120 kg N/fad., decreased (NUE) which means that NUE increased up to optimum nitrogen application then reduced at the excessive N level as reported by **(Noureldin *et al*., 2013; Haileselassie *et al*., 2014; Daba, 2017; Harfe, 2017; Solomon and Anjulo, 2017 and Zemichael *et al*., 2017)**. Also, it was observed that NUE was significantly higher in 1[st] season compared to the 2[nd] one under all levels of N fertilizer.

Interaction Effect

The interaction effect between cultivars and bio-fertilizer

Significant interaction effect between cultivars and bio-fertilizer was found for each of grain yield and harvest index (Table 3). Generally, Misr2 cultivar surpassed Gemmeiza11 in grain yield/fad., with and without *Azotobacter* inoculation. As well, utilization of *Azotobacter* led to an increment in grain yield in both cultivars. On the other hand, Gemmeiza11 was superior in harvest index when wheat grains were inoculated with *Azotobacter*, while, under control treatment (without *Azotobacter* inoculation) there were no significant differences between cultivars in harvest index. These results are in line with those of **Ahmed *et al.* (2011), Zaki *et al.* (2012), Abd El-Razek and El-Sheshtawy (2013) and Hassanein *et al*. (2018)**.

The interaction effect between cultivars and N-fertilizer levels

There were significant interaction effects between cultivars and N-fertilizer levels on most of studied traits *i.e.* plant height, spike length, grain and biological yields/fad., harvest index and nitrogen use efficiency (NUE).

Results in Table 4 indicate that plant height and spike length of Gemmeiza11 were higher than Misr2 with each increase in N levels over control, and adding 120 kg N/fad., gave the highest values of both traits. Similar findings were reported by **Abd El-Razek and El-Sheshtawy (2013) and Hassanein *et al*. (2018)**.

In contrary, results obtained in Table 5 show that Misr2 cultivar was superior to Gemmeiza11 in grain and biological yields/fad., which increased by increasing N levels significantly up to 120 kg N/fad. This result is in close agreement with **Laghari *et al*. (2010), Atia and Ragab (2013), Shahzad *et al.* (2013) and Hassanein *et al*. (2018)**.

It is appear from Table 6 that under different levels of N fertilizer, Gemmeiza11 had no significant differences with Misr2 in HI, except the level 80 kg N/fad., where Gemmeiza11 significantly surpassed Misr2. Also, adding 40 kg N/fad., to Misr2 was at par with the other two levels (80 and 120 kg N/fad.) in affecting HI. This result was in accordance with those obtained by **Laghari *et al*. (2010) and Shahzad *et al*. (2013)**.

The results of NUE in Table 7 reveal that under the lowest level of N fertilizer there were no significant differences between Gemmeiza11

Table 3. Grain yield/fad., and harvest index of wheat as affected by cultivar differences and bio-fertilizer interaction (combined data)

Cultivar	Bio-fertilizer	
	Control	*Azotobacter*
	Grain yield (ardab/fad.)	
Gemmeiza11	B 15.92 b	A 17.58 b
Misr2	B 17.37 a	A 18.03 a
	Harvest index (HI)	
Gemmeiza11	B 39.89 a	A 42.40 a
Misr2	A 39.82 a	A 39.01 b

Table 4. Plant height and spike length of wheat as affected by cultivar differences and N fertilizer interaction (combined data)

Cultivar	N-fertilizer levels (kg/fad.)			
	0	40	80	120
	Plant height (cm)			
Gemmeiza11	D 103.40 a	C 107.55 a	B 109.95 a	A 112.30 a
Misrz2	D 97.86 b	C 103.51 b	B 106.74 b	A 108.97 b
	Spike length (cm)			
Gemmeiza 11	D 11.16 a	C 11.81 a	B 12.70 a	A 13.45 a
Misr2	D 9.83 b	C 10.55 b	B 10.99 b	A 11.53 b

Table 5. Grain yield (ardab/fad.) and biological yield (ton/fad.) of wheat as affected by cultivar differences and N fertilizer levels interaction (combined data)

Cultivar	N-fertilizer levels (kg/fad.)			
	0	40	80	120
	Grain yield (ardab/fad.)			
Gemmeiza11	D 13.83 b	C 15.90 b	B 17.84 b	A 19.43 b
Misr2	D 14.26 a	C 16.48 a	B 19.18 a	A 20.89 a
	Biological yield (ton/fad.)			
Gemmeiza11	D 5.40 b	C 5.79 b	B 6.07 b	A 7.11 b
Misr2	D 5.66 a	C 6.21 a	B 7.19 a	A 7.90 a

Table 6. Harvest index of wheat as affected by cultivar differences and N fertilizer levels interaction (combined data)

Cultivar	N-fertilizer levels (kg/fad.)			
	0	40	80	120
Gemmeiza 11	C 38.35 a	B 41.17 a	A 44.12 a	B 40.94 a
Misr 2	B 37.85 a	A 40.07 a	A 40.09 b	A 39.66 a

Table 7. Nitrogen use efficiency as affected by wheat cultivar differences and N fertilizer levels interaction (combined data)

Cultivar	N-fertilizer levels (kg/fad.)			
	0	40	80	120
Gemmeiza11	-	A 7.75 a	AB 7.49 b	B 7.00 b
Misr2	-	B 8.32 a	A 9.23 a	B 8.26 a

and Misr2, but increasing N levels showed a significant different performance of both cultivars, where NUE of Misr2 was higher than Gemmeiza11 under 80 and 120 kg N/fad. Clearly, previous results show that Gemmeiza11 more efficient than Misr2 in using nitrogen, as it gave its highest grain yield per nitrogen unit under the lowest N level.

The interaction effect between bio-fertilizer and N- fertilizer levels

Statistical analysis revealed significant interaction effects between bio-fertilizer and N-fertilizer levels on yield and nitrogen use efficiency which summarized in Tables 8 and 9.

The results regarded in Table 8 illustrate that plant height and grain yield/fad., increased significantly by increasing N levels from 0 up to 120 kg N/fad., whether it was with or without *Azotobacter* inoculation, as well as the inoculation with *Azotobacter* led to a significant increment in both traits. These results also corroborated with earlier findings of **El-Gizawy (2010), Abd El-Razek and El-Sheshtawy (2013), Namvar and Khandan (2013), Hassanein *et al.* (2018) and Mahato and Kafle (2018)**. As evidenced by the chemical analysis that the soil is poor in organic matter and nitrogen, this explains the positive effect of the interaction between bio-fertilizer and nitrogen because of their roles in improving soil and chemical properties, which was undoubtedly appeared in the increment of grain yield/fad.

The interaction effect of bio-fertilizer (*Azotobacter*) and nitrogen fertilizer levels on NUE (Table 9) recorded that *Azotobacter* inoculation with 80 kg N/fad., increased wheat plants efficiency in using nitrogen, but under control treatment (without *Azotobacter* inoculation) nitrogen use efficiency was superior with adding the lowest level of N fertilizer (40 kg N/fad.) this conformably to the fact that NUE reduced by increasing available N in soil. These results are in agreement with **Giambalvo *et al.* (2010)**.

Conclusion

The results obtained from this study summarized that NUE and wheat yield influenced strongly by cultivar differences, bio and N fertilization. Gemmeiza11 was superior in all traits except No. of spikes/m^2, grain yield and biological yields that were higher in Misr2. *Azotobacter* inoculation and the highest level of nitrogen (120 kg N/fad.), increased plant height, spike length, spikes number/m^2, grain weight/ spike, grain and biological yields/fad., and decreased NUE. Moreover the results showed that applying 80 kg N/fad., gave the highest value from 1000 grain weight and harvest index. Thus, it is recommended to use a combination of bio-fertilizer (*Azotobacter*) and moderate level of N-fertilization to get the highest yield and decrease adverse environmental effects.

Table 8. Plant height and grain yield (ardab/fad.) of wheat as affected by bio-fertilizer and N-fertilizer levels interaction (combined data)

Bio- fertilizer	N-fertilizer levels (kg/fad.)			
	0	40	80	120
	Plant height (cm)			
Control	D 98.38 b	C 104.43 b	B 107.99 a	A 109.26 b
Azotobacter	D 102.88 a	C 106.63 a	B 108.70 a	A 112.01 a
	Grain yield (ardab/fad.)			
Control	D 13.33 b	C 15.78 b	B 17.83 b	A 19.64 b
Azotobacter	D 14.75 a	C 16.59 a	B 19.19 a	A 20.68 a

Table 9. Nitrogen use efficiency of wheat as affected by bio-fertilizer and N fertilizer levels interaction (combined data)

Bio-fertilizer	N-fertilizer levels (kg/fad.)			
	0	40	80	120
Control	-	A 9.15 a	B 8.39 a	B 7.85 a
Azotobacter	-	B 6.92 b	A 8.33 a	B 7.40 a

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تأثير الأصناف، السماد الحيوي ومستويات السماد النيتروجيني على كفاءة استخدام النيتروجين ومحصول القمح

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أقيمت تجربتان حقليتان بالمزرعة التجريبية (بقرية غزالة) التابعة لكلية الزراعة- جامعة الزقازيق- محافظة الشرقية، مصر خلال الموسمين ٢٠١٦/٢٠١٥ و ٢٠١٧/٢٠١٦ لدراسة تأثير اثنان من أصناف قمح الخبز (جميزة ١١ و مصر٢)، وإضافة التسميد الحيوي من خلال التلقيح ببكتريا الأزوتوباكتر (*Azotobacter chroococcum*) مقارنة بعدم الإضافة و٤ مستويات من السماد النيتروجيني (صفر، ٤٠، ٨٠ و١٢٠ كجم ن/الفدان) على كفاءة استخدام النيتروجين NUE ومحصول القمح ومساهماته، وقد أوضحت نتائج التحليل التجميعي للموسمين أن الصنف مصر٢ أنتج أعلى عدد سنابل في المتر المربع، محصول حبوب ومحصول بيولوجي/فدان بالمقارنة بالصنف جميزة ١١والذي تفوق بدوره في صفات ارتفاع النبات، طول السنبلة، وزن حبوب السنبلة ودليل الحصاد HI وكذلك كان أعلى كفاءة لاستخدام النيتروجين، أدى تلقيح حبوب القمح ببكتريا الأزوتوباكتر (في الشكل التجاري بيوجين) قبل الزراعة إلى زيادة معنوية في صفات: ارتفاع النبات، طول السنبلة، عدد السنابل/م^{٢}، وزن حبوب السنبلة، وزن ١٠٠٠ حبة، محصولي الحبوب والبيولوجي/فدان ودليل الحصاد، ولكن على النقيض انخفضت كفاءة استخدام النيتروجين مع التلقيح بالأزوتوباكتر خلال موسمي الزراعة والتحليل التجميعي لهما، أوضح التحليل التجميعي أن زيادة مستويات السماد النيتروجيني حتى ١٢٠ كجم ن/الفدان أدى إلى زيادة معنوية في كل من ارتفاع النبات، طول السنبلة، عدد السنابل/م^{٢}، وزن حبوب السنبلة، محصول الحبوب والمحصول البيولوجي/فدان؛ كما أدى لانخفاض كفاءة استخدام النيتروجين الذي استجاب للنيتروجين المضاف حتى ٨٠ كجم ن/فدان، لوحظ تداخل فعل معنوي بين عوامل الدراسة حيث أن اضافة الأزوتوباكتر زادت من استجابة أصناف القمح لزيادة مستويات النيتروجين. ووفقا لنتائج تداخل الفعل بين الأصناف والأزتوباكتر، الأصناف ومستويات السماد النيتروجيني وبين الأزوتوباكر والسماد النيتروجيني، فإن الصنف مصر٢ يوصى بتسميده بالأزوتوباكتر و١٢٠ كجم ن/فدان لإنتاج محصول أعلى، بالإضافة لذلك أظهرت النتائج التأثير المعنوي لتداخل الفعل بين التسميد الحيوي والنيتروجيني على كفاءة استخدام النيتروجين عند التلقيح بالأزوتوباكتر وتحت مستوى نيتروجين ٨٠ كجم ن/فدان مقارنة بمعاملة بدون تلقيح ومستوى ١٢٠ كجم ن/فدان.

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