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SOME BIO-CHEMICAL NITROGEN AND PHOSPHORUS FERTILIZATION REGIMES IMPACTS ON WHEAT (*Triticum aestivum* L.) PRODUCTIVITY

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ABSTRACT

On- farm field experiments were conducted to assess the impacts of some nitrogen (N) and phosphorus (P) bio-chemical fertilization regimes on wheat grain yield and its components and harvest index of wheat cultivar Misr-1. Experiments were conducted in a farmer's field, El-Sheikh Essa Viallage, Zagazig District, Sharkia Governorate, Egypt, during the two successive winter seasons of 2012-2013 and 2013-2014. The five nitrogen fertilization regimes (NFR) studied were (control ; 100 kg N/fad.; 75 kg N/fad. + cerealine; 50 kg N/fad.+ cerealine; cerealine) as well, the seven phosphorus fertilization regimes (PFR) studied were (control; 15 kg P_2O_5/fad.; phosphorien; mycorrhiza; 7.5 kg P_2O_5/fad. + phosphorien ; 7.5 kg P_2O_5/fad. + mycorrhiza ; phosphorien + mycorrhiza). Regarding the impact of (NFR), results show that, whatever the NFR applied, it caused significant increase over the control in each of spike No./m^2, grain weight/spike, grain No./spike, 1000-grain weight, grain yield/fad., and harvest index. The appliance of the dual bio-chemical fertilizers *i.e.*, (75 kg N/fad.+ cerealine) ranked at the top in grain yield/fad., and the main components *i.e.* spike number/m^2, grain weight/spike, 1000-grain weight. As for PFR, results revealed that availability of phosphorus *via* the application of any PFR surpassed the control in each of spike No./m^2, 1000-grain weight, harvest index and grain yield/fad. The PFR which included both chemical and bio-fertilizers *i.e.* (7.5 kg P_2O_5/ fad. + phosphorien) outyielded other PFR, and was excellency in each of spike No./m^2, grain weight/spike, grain number/spike and harvest index.

Key words: Bio-chemical fertilization, nitrogen, phosphorus, fertilization regimes, wheat productivity.

INTROCUTION

Wheat is an important large-acre crop which is grown on more acers globally than any other and provides a major share of nutritional requirements for the growing world population (Shapiro *et al.*, 2009). Global per capita food use of wheat in 2013/2014 amounts to roughly 80.5 kg/ year (FAO, 2015). Cultivated area with wheat in Egypt raised from 2.6 million fad., in 2004 to about 3.2 million fad., in 2013/2014 and then to 3.5 million fad., in 2014/2015 season (FAO, 2014b). Egypt, the world's largest wheat importer, buys around 10 million tons of wheat a year (FAO, 2014a), Egypt per capita food use of wheat in 2013/2014 amounts to roughly 196.8 kg/year (FAO, 2014b). Large amounts of chemical fertilizers are generally used to improve growth and yield of crops. But, with the steadily increasing prices of chemical fertilizers, especially nitrogenous fertilizers, and sever negative environmental impacts on soil and water, have led to the development of alternative strategies. The use of biofertilizers could reduce amount of chemical fertilizer input by increasing the efficiency of nutrient availability and other plant growth promoting activities. Biofertilizers hold a promise to balance many drawbacks of the conventional chemical based technology and could recuperate healthy farming practices and bio-farming (Sabry *et al.*, 2000; Zaki *et al.*, 2012; Minaxi *et al.*, 2013).

Nitrogen is one of the essential nutrients for plants and its practical management as the major element for intensive plant production is an important aspect. Many investigators reported

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the meliorating effect of N-fertilizers on wheat yield and its components, No. of spikes/m^2, grain yield/fad., and harvest index (Abdul Galil *et al.,* 2003); grain number/spike, spike number/ m^2, 1000-grain weight and grain yield/fad., (Hafez, 2007); spike number/m^2, grain number/ spike, grain weight/spike, 1000-grain weight and grain yield/fad. (Abdul Galil *et al.,* 2008; Mowafy, 2008; Zeidan *et al.*, 2009; Amin *et al.*, 2011; Farag and El-Khawaga, 2013).

Esaad *et al.* (1997) found that biofertilization can compensate about 30-40% of the recommended N level. Bio-fertilizers can play a significant role in fixing atmospheric N and production of plant growth promoting substances. Cerealine which was used in this study is a commercial product of nitrogen biofertilizer contains free living N_2-fixing bacteria (*Azospirillum brasilense* and *Bacillus polymyxa*). Subba Rao (1982) in India and Sharief *et al.* (1998) in Egypt detected that inoculation wheat grains with Azospirillum and Azotobacter (free living N_2-fixing bacteria), increased grain weight/ spike, number of grains/ spike, 1000-grain weight and grain yield/fad., Zaki *et al.* (2012) proved that No. of spikes/m^2, No. of grains/spike, weight of grains/ spike, 1000-grain weight and grain yield/fad., as well as harvest index were, significantly increased by inoculation wheat grains with N_2-fixing bacteria.

Phosphorus is the second most essential element of crop production and it is deficient in most soils around the world to achieve maximum yields (Brady and Weil, 2002). Large amount of P applied as fertilizers enters into the immobile pools through precipitation reaction with highly reactive Al^{3+} and Fe^{3+} in acidic, and Ca^{2+} in calcareous or normal soils. (Gyaneshwar *et al.,* 2002; Hao *et al.,* 2002) efficiency of P fertilizer throughout the world is around 10-25% (Isherword, 1998). Kabir *et al.* (2014) asseverated that the highest value for each of grain yield, harvest index and 1000-grain weight, was recorded when plants were fertilized with 100 kg phosphorus.

Conversion of the insoluble forms of phosphorus to an accessible form by plants (orth-phosphate) is an important traits of phosphate-solubilizing bacteria (PSB) and arbuscular mycorrhizal fungi (AMF). An Egyptian PSB (*Bacillus megatherium* var phosphaticum) which commercially named (phosphorien) was used as phosphorus biofertilizers, also an Egyptian phosphate dissolving fungi *(Glomus* sp, *Gigzspora* sp., *Acaulespora* sp) which commercially named (Multi VAM) or (mycorrhiza) was used. Hussein and Radwan (2001) detected that, inoculated wheat seeds with phosphorus biofertilizers, significantly increased grain yield/ fad., harvest index, 1000-grain weight and spike grain weight.

El-Gizawy (2009) in Egypt and Saber *et al.* (2012) in Iran assured that phosphate dissolving bacteria, significantly increased wheat number of spikes/m^2, 1000-grain weight, grain number/ spike, harvest index and grain yield.

MATERIALS AND METHODS

On farm field experiments were conducted to assess the impacts of some nitrogen (N) and phosphorus (P) bio-chemical fertilization regimes on wheat grain yield and its components as well as harvest index of wheat cultivar Misr-1. Experiments were conducted in a farmer's field, El-Sheikh Essa Viallage, Zagazig District, Sharkia Governorate, Egypt. Factors studied included five nitrogen fertilization regimes (NFR) *i.e.,* (unfertilized control; 100 kg N/fad.; 75 kg N/fad. + cerealine; 50 kg N/fad. + cerealine; cerealine), as well, included seven phosphorus fertilization regimes (PFR) i.*e.* (unfertilized control; 15 kg P_2O_5/fad.; phosphorien; mycorrhiza; 7.5 kg P_2O_5/fad.+ phosphorien; 7.5 kg P_2O_5/fad. + mycorrhiza; phosphorien + mycorrhiza).

Chemical and Biological Fertilizers Used

Urea (46.5% N) as chemical N fertilizer was used, N-fertilizer was splited into two doses, the first was applied 35 days after sowing (DAS), just before the 1st irrigation, the second dose was applied 48 DAS. The amounts of the commercial fertilizer were calculated according to each nitrogen level in different NFR. With regard to the biological fertilizer, (cerealine) as a free living nitrogen fixing bacteria (*Azotobacter* Sp.+ *Azospirillum* Sp.) at the rate of 700 g/ seeds/ fad., was used. Inoculation with cerealine was performed by coating wheat grains using sticking substance (Arabic gum 5%) just before sowing. As for PFR, calcium superphosphate (15.5% P_2O_5) was added at sowing. The amounts of the commercial fertilizer were calculated according to each phosphorus level in different PFR. An Egyptian phosphate dissolving bacteria (PDB) (*Bacillus megatherium* var phsophaticum), which commercially named (phosphorien) was used at the rate of 600g / seeds/fad., also, an Egyptian phosphate dissolving fungi (*Glomus* sp.; *Gigzspora* sp.; *Acaulospora* sp.) which commercially named (Multi VAM or Mycorrhiza) was used at the rate of 46 kg/seeds/ fad.

The used biofertilizer *i.e.* cerealine and phsphorien are commercially produced by General Organiztion for Agricultural Equilzation fund (GOAFE), Ministry of Agric., Egypt. Miycorrhiza was obtained from plant pathology research institute, Agric. Res. Cen., Ministry of Agric. and land reclamation.

Experimental Design, Cultural Practices and Data Recorded

A split-plot design with three replicates was used in both seasons, NFR were assigned to the main plots. The sub-plots were devoted to PFR, each sub-plot area was 6.25m^2 (2.5 × 2.5m), included 20 rows, 12.5 cm apart.

The preceding crop was maize in both seasons, wheat grains were hand drilled in rows at the rate of 400 seeds/m^2, harvest was done 165 DAS, in both seasons. The data recorded at harvest included spike number/m^2, grain weight (g/spike), grain number/spike, 1000-grain weight and grain yield (ton/fad.). The economic yield was divided by the biological yield and the relationship was worked out expressed as percentage as below (Donald and Humblin, 1976).

$$\text{Harvest index} = \frac{\text{Eonomical yield (ton/fad.)}}{\text{Biological yield (ton/fad.)}} \times 100$$

Statistical Analysis

Data was subjected to the analysis of variance of split plot design using computer program MSTAT-C as described by Snedecor and Cochran (1967). The differences among treatments had the different letters are statistically significant, in the interaction tables, capital and small letters were used to compare between means in rows and columns, respectively.

RESULTS AND DISCUSSION

Spike Number/m^2

Results of NFR disclosed that supplimention any of the following regimes, mineral nitrogen fertilization (100 kg N/fad.), N_2-free fixing biofertilizer (cerealine) and their combinations (75 kg N/fad. + cerealine or 50 kg N/fad. + cerealine), significantly elevated wheat spike number/ m^2 over the control treatment. Copiousness of spikes/m^2 (380.33, 389.05 and 384.69) in first, second seasons and combined analysis were obtained from the applicant of bio-chemical nitrogen fertilization regime (75 kg N/fad.+ cerealine) Based on the combined analysis results, the abovementioned bio-chemical regime casud relative increase in spike number /m^2 valued as much as 61.69% over the control. The meliorate role of nitrogen on number of spikes /m^2 was also avouched by Saleh (2000), Mohamed *et al.* (2001), Ali *et al.* (2004), El-Guibali *et al.* (2005), Mowafy (2008), Badran (2009), El-Gizawy (2009), Farag and El-Khawaga (2013) and Liu and Shi (2013).

Wheat spike number/m^2 was significantly influenced by phosphorus fertilization regimes in both seasons and their combined analysis. It is worth to mention that singly supplement any of the following regimes, 15kg P_2O_5/fad., phosphorien (phosphate-solubilizing bacteria PSB) and arbuscular mycorrhial fungi (AMF, mycorrhiza), suppressed to some ertent spike number/m^2 comparing with the combined application of the former mentioned phosphorus fertilization regimes. Duality of 50% chemical phosphores fertilizer and the bio-fertilizer (phosphorien) produced the uppermost number of spikes /m^2, which valued as much as 359.33 and 355.80 in first season and the combined analysis, while both of the phosphorus fertilization regimes (mycorrhiza +7.5 kg P_2O_5/ fad.) and (phosphorien+ mycorrhiza) ranked second in first season and the combined analysis. The melorating effect of chemical phosphorus fertilizers was obvious in the results reported by Abdul Galil *et al.* (2003), Alam *et al.* (2003), Jelic *et al.* (2004), Khan *et al.* (2010), Rahim *et al.* (2010) as well as Sisie and Mirshekari (2011).

Table 1. Effect of nitrogen and phosphorus fertilization regimes on wheat spike number /m² in 2012-2013 and 2013-2014 seasons

Main treatments and interaction	2012-2013	2013-2014	Combined	Relative increase
Nitrogen fertilization regimes (A)				
Control	234.38c	241.43d	237.91d	-
100kgN/fad.	351.38b	357.57b	354.48b	48.99
75 kg N/fad. +Cerealine	380.33a	389.05a	384.69a	61.69
50 kgN/fad. +Cerealine	332.48 c	332.76c	332.62c	39.80
Cerealine	335.29 c	332.91c	334.09c	40.42
F.test	**	**	**	
Phosphorus fertilization regimes(B)				
Control	285.73f	295.13e	290.43f	-
15 kg P_2O_5 /fad.	300.87 e	306.73d	303.80e	4.60
Phosphorien	314.80d	319.93c	317.37d	9.27
Mycorrhiza	333.93c	335.67b	334.80c	15.27
7.5 kg P_2O_5/fad. + Phosphorien	359.33a	352.27a	355.80a	20.82
7.5 kg P_2O_5/fad. + Mycorrhiza	348.07 b	353.73a	350.90b	20.51
Phosphorien+ Mycorrhiza	344.67 b	351.73a	348.20b	19.89
F. test	**	**	**	
Interaction(AB)	**	**	**	

** Means followed by different letters are significantly different at P≤ 0.1 level.

Significant increase in wheat spike number /m^2 due to phosphorus biofertilization was observed by Afzal *et al.* (2005), Tawfik and Gomaa (2005), Abbasdokht (2008), Badr *et al.* (2009), Metin *et al.* (2010) and Radwan *et al.* (2013).

The interaction between the two main factors studied was significant in both seasons and the combined analysis. The results are presented in Table (1-a). marked and significant increase in spike number /m^2 was observed when bio-chemical nitrogen fertilizer regime was applied whatever phosphorus fertilization regime used. The most effective interaction between nitrogen and phosphorus fertilization regimes on wheat spike number/m^2, was that between (75 kg N/ fad. + cerealien) and (phosphorien + mycorrhiza), which produced 422.00 spikes/m^2, followed by the interaction between (75 kg N/ fad. + cerealine) and (7.5 kg P_2O_5/fad.+ phosphorine). The lowest spike number/fad., (188.50) was observed under the control treatment for both nitrogen and phosphorus fertilization regimes.

Grain Weight /Spike (g)

Spike grain weight is usually a function of many attributes such as, spike and spikelet grain number, grain weight /spikelet and 1000-grain weight. Generally, appliance the NFR (75kg N/ fad. + cerealine) caused marked and significant increase in grain weight /spike in both seasons and the combined analysis (Table 2). The relative increase in spike grain weight valued 21.61% over the control treatment. Plants fertilized with that nitrogen regime (75 kg N/ fad. + cerealine), also were superior (combined data) in each of spike number /m^2 and 1000-grain weight.

Sawires (2000) mentioned that application of 100 kg N/fad., gave the highest weight of wheat grains /spike, also Sohail *et al.* (2002), Nassar *et al.* (2004), Abdul Galil *et al.* (2008), Zeidan *et*

Table 1-a. Interaction effect between both nitrogen and phosphorus fertilization regimes on wheat spike number/m² (combined data)

PFR / NFR	Control	15 kg P_2O_5/fad.	Phosphorien	Mycorrhiza	7.5 kg P_2O_5/fad. + Phosphorien	7.5 kg P_2O_5/fad. + Mycorrhiza	Phosphorien + Mycorrhiza
	E	D	B	C	A	B	B
Control	188.50c	194.17c	259.50e	220.50d	273.83e	265.00e	263.83e
	F	E	C	D	AB	A	B
100kgN/fad.	306.17b	321.33b	359.17b	341.33b	385.67b	390.17b	377.50b
	F	E	D	E	B	C	A
75 kg N/fad. + Cerealine	338.67a	363.33a	387.00a	370.50a	410.83a	400.50a	422.00a
	E	D		CD	A	B	C
50 kg N/ fad. + Cerealine	307.67b	320.00b	B 339.50c	325.17c	366.00c	340.33d	329.67d
	E	D	CD	C	B	A	B
Cerealine	311.18b	320.18b	328.83d	329.33 c	342.67d	358.50c	348.00c

NFR= Nitrogen fertilization regimes. PFR=Phosphorus fertilization regimes.

Table 2. Effect of nitrogen and phosphorus fertilization regimes on wheat grain weight/spike (g) in 2012-2013 and 2013-2014 seasons

Main treatments and interaction	2012-2013	2013-2014	Combined	Relative increase
Nitrogen fertilization regimes(A)				
Control	3.39 c	3.55 b	3.47 c	-
100kgN/fad.	3.85b	4.15 a	4.00 b	15.27
75 kg N/fad. +Cerealine	4.12a	4.31 a	4.22 a	21.61
50 kgN/fad. +Cerealine	3.92b	4.13a	4.02b	15.85
Cerealine	3.84 b	4.13 a	3.98b	14.69
F.test	**	**	**	
Phosphorus fertilization regimes (B)				
control	3.70 c	3.85c	3.78 d	-
15 kg P_2O_5/fad.	3.66c	3.88c	3.77 de	-0.08
Phosphorien	3.63c	3.78c	3.70ef	-2.12
Mycorrhiza	3.51d	3.85c	3.68f	-2.64
7.5 kg P_2O_5 /fad. + Phosphorien	4.12a	4.35 ab	4.23b	11.9
7.5 kg P_2O_5 /fad. + Mycorrhiza	4.18 a	4.43 a	4.31a	14.02
Phosphorien+ Mycorrhiza	3.96 b	4.24 b	4.10 c	8.46
F. test	**	**	**	

Interaction(AB)	**	**	**

** Means followed by different letters are significantly different at P≤ 0.1 level.

al. (2009) and Zaki *et al.* (2012) as well Farag and El-Khawaga (2013) manifested that increasing chemical nitrogen fertilizer, significantly increased wheat grain weight / spike. Regarding to the N_2-fixer biofertilizers, Kandil *et al.* (2011) reported that inoculated wheat plants produced higher grain weight compared to non-inoculated plants. The effective role of the dual application of N_2 – fixer biofertilizer and chemical N fertilizers was observed on increasing grain weight /spike as recorded by Hassanein and Gomaa (2001), Zaki *et al.* (2007) and Kabesh *et al.* (2009).

Phosphorus fertilization regimes influenced significantly wheat grain weight /spike in both seasons and their combined (Table 2). It is worth to note that sole appliance of any of 15kg P_2O_5/ fad., phosphate-solubilizing bacteria (Phosphorien) or arbuscular mycorrhizal fungi (mycorrhiza), failed to improve the weight of grains/spike, but the meliorate impact of any of the chemical phosphorus fertilizer, phosphorien or mycorrhiza was observed in the dual application of bio-chemical phosphorus fertilization regimes, *i.e.* either (7.5 kg P_2O_5/fad.+ phosphorien) or (7.5 kg P_2O_5/fad.+ mycorrhiza), which increased the weight of grains/spike by 11.9 and 14.02% over the control in respective order (combined data).

Combined data reveal the significant interaction effect between nitrogen fertilization regimes and phosphorus fertilization regimes (Table 2-a) on wheat grain weight /spike. Phosphorine; 7.5 kg P_2O_5/fad.+ mycorrhiza; phosphorien + mycorrhiza caused significant increase in grain weight/spike under the application of nitrogen fertilization regime (75 kg N/fad.+ cerealine). The highest grain weight /spike (4.74g) was observed under the interaction effect of NFR (100kg N/fad.) and PFR (control), while the lowest grain weight /spike (2.71 g) was shown under the interaction effect of NFR (control) and PFR (mycorrhiza).

Grain Number/Spike

Grain number/spike as impacted by both nitrogen and phosphorus fertilization regimes is listed in Table 3.

Promotion role of nitrogen in raising number of grains/spike, obviously affirmed in both seasons and their combined, wherein nitrogen availability *via* any fertilization regime enhanced significantly grain number /spike comparing with nitrogen deficiency in control treatment. Moreover, singly application of either chemical fertilization regime (100 kg N/fad.) or the bio-N_2 fixer fertilization regime (cerealine), conduced to more grains /spike. The relative increase over the control, due to the past two fertilization regimes, valued 19.22 and 21.75%, respectively. The increase in number of grains / spike with nitrogen fertilization may be due to the role of nitrogen in building new merestemic cells, cell elongation and increasing photosynthesis activity which cause more flower fertility and setting per spike. The effective influence of chemical nitrogen application on grain number/ spike was noticed by several investigators such as, Sawires (2000), Mohamed *et al.* (2001), Abd-El-Hameed (2002), Zeidan *et al.* (2005), Hafez (2007), Abdul Galil *et al.* (2008), Amin *et al.* (2011), Farag and El-Khawaga (2013).

Inoculation wheat grains with N_2-fixer biofertilizers increased number of grains /spike as reported by Subba Rao (1982), Sharief *et al.* (1998), Abd-El-Hameed (2002), Tawfik and Gomaa (2005), Zaki *et al.* (2007), Abbasdokht (2008), Metin *et al.* (2010) and Radwan *et al.* (2013). Sharief *et al.* (2000) confirmed that, applying the biofertilizer (cerealine) in addition of 50 or 70 kg chemical N/fad., produced the heighest grain number/spike, analogous results were recorded by Zaki *et al.* (2007) and Zaki *et al.* (2012).

Effect of phosphorus fertilization regimes on grain number/spike was significant as shown in both seasons and the combined analysis. Marked supereminence of bio-chemical phosphorus fertilization regimes over other regimes in number of grains/spike, was avered in both seasons and their combined analysis. The relative increases in grain number /spike valued as much as 8.96 and 9.35% due to application of PFR (7.5 kg P_2O_5/fad.+ phosphorien) and (7.5kg P_2O_5/ fad.+ mycorrhiza).

The present results resemble with those noticed by Jelic *et al.* (2004), Kaleem *et al.* (2009), Rahim *et al.* (2010), Sisie and Mirshekari (2011) and Saber *et al.* (2012).

Table 2-a. Interaction effect between both of nitrogen and phosphorus fertilization regimes on wheat grain weight/spike (g) (combined data)

PFR / NFR	Control	15 kg P_2O_5 / fad.	Phosphorien	Mycorrhiza	7.5 kg P_2O_5 /fad. + Phosphorien	7.5 kg P_2O_5/ fad. + Mycorrhiza	Phosphorien + Mycorrhiza
	C	C	A	D	A	A	B
Control	2.95e	2.93e	3.94b	2.71d	4.06cd	4.00c	3.73b
	A	BC	E	CD	CD	B	D
100kgN/fad.	4.73a	4.09b	3.15c	4.01b	3.95d	4.19b	3.87b
	D	E	BC	CD	A	B	BC
75 kg N/fad. + Cerealine	3.93b	3.68d	4.34a	4.19a	4.64a	4.45a	4.29a
	E	C	C	C	B	A	AB
50 kg N/ fad. + Cerealine	3.51d	3.84c	3.99b	3.86bc	4.21bc	4.45a	4.30a
	B	A	C	B	A	A	A
Cerealine	3.75c	4.30a	2.99c	3.75c	4.31b	4.47a	4.30a

NFR= Nitrogen fertilization regimes. PFR=Phosphorus fertilization regimes.

Table 3. Effect of nitrogen and phosphorus fertilization regimes on wheat grain number /spike in 2012-2013 and 2013-2014 seasons

Main treatments and interation	2012-2013	2013-2014	Combined	Relative increase
Nitrogen fertilization regimes (A)				
Control	61.64b	62.88b	62.11c	-
100kgN/fad.	74.35a	74.05a	74.05a	19.22
75 kg N/fad. +Cerealine	71.72a	72.61a	72.04b	15.98
50 kgN/fad. +Cerealine	71.62a	72.42a	71.83b	15.64
Cerealine	75.33a	76.28a	75.62a	21.75
F. test	**	**	**	
Phosphorus fertilization regimes(B)				
Control	70.19 b	70.68bc	70.31bc	-
15 kg P_2O_5 /fad.	67.68cd	68.76cd	68.05d	-3.22
Phosphorien	70.41b	71.31b	70.73b	0.59
Mycorrhiza	66.01d	67.11d	66.39e	-5.58
7.5 kg P_2O_5 /fad. + Phosphorien	76.60a	77.09a	76.61a	8.96
7.5 kg P_2O_5 /fad. + Mycorrhiza	77.04a	77.13a	76.89a	9.35
Phosphorien + Mycorrhiza	68.60 bc	69.43bc	68.92cd	-1.98
F. test	**	**	**	
Interaction (AB)	**	**	**	

** Means followed by different letters are significantly different at P≤ 0.1 level.

As well Tawfik and Gomaa (2005), Abbasdokht (2008), Badr *et al.* (2009), Metin *et al.* (2010), Radwan *et al.* (2013) and Nooria *et al.* (2014) reported the meliorate role of phosphate-solubilizing bacteria and arbuscular mycorrhizal fungi on grain number /spike.

The interaction effect between both of nitrogen and phosphorus fertilization regimes on wheat grain number/spike was significant as shown in Table 3-a. The highest number of grains /spike was produced under the interaction effect of NFR (100kgN/fad.) and PFR (control). Deficiency of both nitrogen and phosphorus under the control treatment of both, depressed grain number /spike which valued 55.90.

1000- Grain Weight (g)

Table 4 expose the impact of both nitrogen and phosphorus fertilization regimes on 1000 – grain weight of wheat (seed index).

Statistical analysis reveal highly significant differences among nitrogen fertilization regimes in both seasons and their combined as well. Meanwhile, appliance of the dual bio-chemical fertilizers *i.e.* (75kg N/fad.+ cerealine) produced the heaviest weight of 1000 grains, followed by sole chemical nitrogen application *i.e.* (100 kg N/fad.). However, the lowest 1000- grain weight was obtained due to nitrogen deficincy strees in control treatment. Obtained results go along with those of Sawires (2000), Nassar *et al.* (2004), Hafez (2007), Abedi *et al.* (2010) and Zaki *et al.* (2012).

Regarding to the positive effect of N_2-fixer biofertilization on 1000-grain weight, Tawfik and Gomaa (2005), Abbasdokht (2008), Badr *et al.* (2009), Kabesh *et al.* (2009), Metin *et al.* (2010), Radwan *et al.* (2013) as well as Yousefi and Barzegar (2014), confirmed the meliorating role of biofertilization on 1000- grain weight.

In regard to phosphorus fertilization impact on wheat 1000- grain weight, results of both seasons and the combined analysis reflected significant and positive response of seed index to phosphorus application regardless the fertilization regime used compared with the control treatment.

Inoculation wheat grains with phosphorien (phosphate-solubilizing bacteria) singley, or in combination with 50% of the chemical phosphorus fertilizer *i.e.* (phosphorien + 7.5 kg $P_2\ O_5$/fad), produced the heaviest 1000- grain weight and outrivaled the other phosphorus fertilization regimes. The relative increase over the control in 1000-grain weight for account and risk of (phosphorien) and (7.5 kg P_2O_5/fad. + phosphorien) phosphorus fertilization regimes application amounted as much as 7.80 and 7.34%. The dual application of bio-chemical fertilizers (7.5 kg P_2O_5/fad. + phosphorien) also caused significant increase in each of spike number/m^2 and grain number/ spike.

Bakhsh *et al.* (2008), Rahim *et al.* (2010), Saber *et al.* (2012), Kabir *et al.* (2014) and Nooria *et al.* (2014) decided that, 1000-grain weight was significantly increased with chemical phosphorus application.

Phosphate dissolving bacteria inculation, significantly increased wheat 1000- grain weight as reported by Tawfik and Gomaa (2005), Abbasdokht (2008), Badr *et al.* (2009), El-Gizawy (2009), Metin *et al.* (2010), Saber *et al.* (2012) and Radwan *et al.* (2013).

The interaction impact between nitrogen fertilization regimes (NFR) and phosphorus fertilization regimes (PFR) was highly significant in both seasons and the combined analysis. As shown in Table 4-a the heaviest 1000- grain weight (50.22 g) was obtained when nitrogen fertilization regime (75 kg N/fad.+ cerealine) and phosphorus fertilization regimes (7.5 kg P_2O_5/fad. + phosphorien) were supplied. The lowest 1000-grain weight (38.32 g) was obtained when both nitrogen and phosphorus were deficit in control treatments.

Harvest Index

Harvest index of wheat cultivar Misr-1 as influenced by both nitrogen and phosphorus fertilization regimes is given in Table 5.

Harvest index is a measure to evaluate plant efficiency to produce grains relative to the biological yield. Plants efficiency to produce grains relative to their biological yield markedly increased with the availability of nitrogen throughtout any nitrogen fertilization regime in comparing with nitrogen deficiency in the control treatment (available N of the experimental site was 29.50 and 30.01 mg/kg) in

Table 3-a. Interaction effect between both of nitrogen and phosphorus fertilization regimes on wheat grain number /spike (combined data)

PFR / NFR	Control	15 kg P_2O_5 / fad.	Phosphorien	Mycorrhiza	7.5 kg P_2O_5 /fad. + Phosphorien.	7.5 kg P_2O_5 / fad. + Mycorrhiza	Phosphorien + Mycorrhiza
	CD	C	B	D	B	A	B
Control	55.90e	57.77e	64.17b	52.37d	66.10c	72.13c	66.30c
	A	D	F	C	CD	B	E
100kgN/fad.	85.33a	72.23b	58.50c	78.30a	75.60b	81.23a	67.13c
	C	D	B	B	A	CD	E
75 kg N/fad. + Cerealine	72.43c	68.47c	76.00a	76.33ab	80.03a	70.77c	60.23d
	D	D	AB	BC	A	AB	C
50 kg N/ fad. + Cerealine	60.80d	62.27d	77.47a	74.23bc	79.63a	77.53b	70.90b
	B	AB	D	C	A	A	AB
Cerealine	77.10b	79.50a	55.83c	72.43c	81.67a	82.80a	80.03a

NFR= Nitrogen fertilization regimes. PFR=Phosphorus fertilization regimes.

Table 4. Effect of nitrogen and phosphorus fertilization regimes on wheat 1000 grain weight (g) in 2012-2013 and 2013-2014 seasons

Main treatments and interaction	2012-2013	2013-2014	Combined	Relative increase
Nitrogen fertilization regimes(A)				
Control	44.13d	44.59e	44.36e	-
100kgN/fad.	46.71b	47.09b	46.90b	5.72
75 kg N/fad. +Cerealine	47.39a	47.85a	47.61a	7.32
50 kgN/fad. +Cerealine	44.92c	45.35d	45.14d	1.75
Cerealine	46.36b	46.71c	46.54c	4.91
F. test	**	**	**	
Phosphorus fertilization regimes (B)				
Control	43.48e	43.89e	43.69e	
15 kg P_2O_5 /fad.	45.45d	45.83d	45.64d	4.46
Phosphorien	46.91a	47.28a	47.10a	7.80
Mycorrhiza	46.27bc	46.70bc	46.49c	6.40
7.5 kg P_2O_5/fad. + Phosphorien	46.75ab	47.20ab	46.90 ab	7.34
7.5 kg P_2O_5 /fad. + Mycorrhiza	46.07b	46.46c	46.27c	5.90
Phosphorien+ Mycorrhiza	46.37b	46.84abc	46.61bc	6.68
F. test	**	**	**	

Interaction(AB)	**	**	**	

** Means followed by different letters are significantly different at P≤ 0.1 level.

Table 4-a. Interaction effect between both of nitrogen and phosphorus fertilization regimes on wheat 1000-grain weight (g) (combined data)

PFR / NFR	Control	15 kg P_2O_5/ fad.	Phosphorien	Mycorrhiza	7.5 kg P_2O_5 /fad.+ Phosphorien	7.5 kg P_2O_5 /fad. + Mycorrhiza	Phosphorien + Mycorrhiza
	D	B	B	A	B	C	C
Control	38.32d	45.83 bc	45.73b	48.07b	44.97c	43.73c	43.87d
	E	E	AB	D	CD	B	A
100kgN/fad.	45.18b	45.47bc	47.97a	46.30c	47.10b	47.53a	48.73a
	B	D	B	A	A	C	D
75 kg N/fad. + Cerealine	47.89a	45.33bc	47.88a	50.02a	50.22a	47.03a	44.90c
	E	CD	D	AB	BC	C	A
50 kg N/ fad. + Cerealine	42.23c	44.97c	44.50c	46.22c	45.68c	45.38b	46.97b
	D	C	C	D	BC	B	A
Cerealine	44.80b	46.62a	46.35b	44.88d	46.90b	47.65a	48.57a

NFR= Nitrogen fertilization regimes. PFR=Phosphorus fertilization regimes.

Table 5. Effect of nitrogen and phosphorus fertilization regimes on wheat harvest index in 2012-2013 and 2013-2014 seasons

Main treatments and interaction	2012-2013	2013-2014	Combined	Relative increase
Nitrogen fertilization regimes (A)				
Control	38.33d	39.89d	39.11e	-
100kgN/fad.	41.66b	42.92b	42.29b	8.13
75 kg N/fad. +Cerealine	41.37b	42.56b	41.96c	7.28
50 kgN/fad. +Cerealine	43.83a	45.11a	44.47a	13.7
Cerealine	40.39c	41.17c	40.78d	4.27
F. test	**	**	**	
Phosphorus fertilization regimes (B)				
Control	39.09e	39.92c	39.51e	-
15 kg P_2O_5 /fad.	40.39d	42.27b	41.50cd	5.03
Phosphorien	41.39 c	42.25b	41.82bc	5.84
Mycorrhiza	41.04 c	42.15b	41.60cd	5.28
7.5 kg P_2O_5/fad. + Phosphorien	43.10a	45.44a	44.27a	12.04
7.5 kg P_2O_5/fad. + Mycorrhiza	42.14b	42.81b	42.48 b	7.51
Phosphorien+ Mycorrhiza	40.32d	41.47bc	40.89 d	3.49
F. test	**	**	**	

Interaction(AB)	**	**	**

** Means followed by different letters are significantly different at P≤ 0.1 level.

first and second seasons. In view of the combined data, maximum harvest index (44.47%) with relative increase over the control as much as 13.7% was detected when the dual application of bio-chemical fertilizers was used, *i.e.* (50kg N/ fad. + cerealine) NFR was applied. The results of Abd-El-Hameed (2002), Islam *et al.* (2002), Abdul Galil *et al.* (2003 and 2008), Iqbal *et al.* (2012) and Esmailpour *et al.* (2013), showed that harvest index of wheat was increased significantly as N-level was increased.

Phosphorus fertilization regimes exhibited significant impact on wheat harvest index in both seasons and the combined analysis as well. The highest harvest index, was attained due to applying the PFR (7.5kg P_2O_5 + Phosphorien) followed by the PFR (7.5kg P_2O_5 + mycorrhiza). That was assured in both seasons and their combined analysis. Meantime, the lowest harvest index was observed under phosphorus deficiency in the control treatment in both seasons and the combined analysis. Similar findings were found in each of spike number / m^2, grain weight/spike and grain number/ spike. Sisie and Mirshekari (2011), Piri (2012), Saber *et al.* (2012) and Kabir *et al.* (2014) asseverated that application of chemical phosphorus fertilizer, significantly increased harvest index.

Inoculation wheat grains with mycorrhiza fungi, significantly increased harvest index, that was the findings of Hasanpour *et al.* (2012) and Nooria *et al.* (2014).

Table 5-a exhibit the significant impact of the interaction between nitrogen fertilization regimes and phosphorus fertilization regimes on wheat harvest index. In view of the combined results, the highest harvest index was obtained when NFR (50kg N/fad. + cerealine) and either (7.5 kg P_2O_5 fad. + phosphorine) or (7.5 kg P_2O_5 /fad. + mycorrhiza) PFR were added. The lowest harvest index of wheat was attained under the control treatments for both nitrogen and phosphorus *i.e.* under N and P deficiency, that stress hampered crop productivity (low harvest index)

Grain Yield (ton/fad.)

Nitrogen fertilization regimes had active impact on wheat productivity in both seasons and the combined analysis (Table 6). Such being the case, magnitude wheat grain yield (ton / fad.) was in favour of the dual application of both chemical and bio – fertilizers of nitrogen *i.e.* (75 kg N /fad. + cerealine). The sole application of chemical N fertilizer with 100 kg N/ fad., ranked second in wheat grain yield. The relative increase in grain yield over the control amounted as 68.13 and 62.08% due to the application of (75 Kg N/fad. + cerealine) and (100 kg N/fad.) NFR in respective order. The low productivity of wheat plants under the control treatment could be ascribed to the low available N (29.50 and 30.01 mg /kg in the experimental site). The superiority of wheat grain yield due to appliance of the dual bio-chemical fertilizers *i.e.* (75 kg N/ fad. + cerealine) was expected, since that fertilization regime ranked at the top in each of spike number/m^2, grain weight / spike and 1000-garin weight. Results, also indicated the possibility of partially replacement of the chemical N fertilizer (25%) with the bio-N_2 fixer fertilizer (cerealine) to protect the environment from chemical pollution and it’s harmful effect on human and animal health and nutrition, in the same time produced significantly higher wheat yield.

The positive response of wheat grain yield to chemical nitrogenous fertilization was reported by several investigators such as, Abdul Galil *et al.* (2003), Ibrahim *et al.* (2004), Zeidan *et al.* (2005), Hafez (2007), Mowafy (2008), Faizy *et al.* (2010), Amin *et al.* (2011), Zaki *et al.* (2012), Farag and El-Khawaga (2013) and El-Sanatawy *et al.* (2016). The increase in wheat grain yield due to inoculation with bio-N_2 fixer fertilizer was reported by Subba Rao (1982), Abd El-Maksoud (2002), Abd-El-Hameed (2002), Tawfik and Gomaa (2005), El-Garhi *et al.* (2007), Abbasdokht (2008), Badr *et al.* (2009), Metin *et al.* (2010), Zaki *et al.* (2012) and Esmailpour *et al.* (2013).

Phosphorus fertilization regimes acted significantly on wheat grain yield (ton/fad.) in both seasons and the combined analysis as recorded in Table (6). Relative increase over the control in wheat grain yield ranged between 16.66 and 34.25% (combined data). The PFR which included both chemical and biofertilizers *i.e.*, (7.5 Kg P_2O_5/fad.+ phosphorien) oulyielded other PFR in both seasons and their combined, with relative increase over the control amounted

Table 5-a. Interaction effect between both of nitrogen and phosphorus fertilization regimes on wheat harvest index (combined data)

NFR \ PFR	Control	15 kg P_2O_5/fad.	Phosphorien	Mycorrhiza	7.5 kg P_2O_5/fad.+ Phosphorien	7.5 kg P_2O_5/fad.+ Mycorrhiza	Phosphorien+ Mycorrhiza
	E	D	BC	BCD	A	CD	B
Control	35.13c	37.27c	39.43c	38.93c	45.38b	37.64c	39.98b
	B	A	AB	AB	A	A	AB
100kgN/fad.	40.62ab	43.58a	41.94ab	42.34ab	42.73c	42.57b	42.26a
	C	AB	AB	B	A	B	D
75 kg N/fad. + Cerealine	40.35ab	42.94ab	43.20a	42.59ab	44.60b	42.55b	37.53c
	C	BC	BC	B	A	A	BC
50 kg N/ fad. + Cerealine	41.62a	42.50ab	43.18a	43.68a	48.43a	48.89a	43.00a
	B	AB	AB	AB	AB	AB	A
Cerealine	39.81b	41.21b	40.24bc	41.54b	40.21d	40.76b	41.71ab

NFR= Nitrogen fertilization regimes. PFR=Phosphorus fertilization regimes.

Table 6. Effect of nitrogen and phosphorus fertilization regimes on wheat grain yield (ton/fad.) in 2012-2013 and 2013-2014 seasons

Main treatments and interaction	2012-2013	2013-2014	Combined	Relative increase
Nitrogen fertilization regimes(A)				
Control	1.81d	1.83e	1.82e	-
100kgN/fad.	2.91b	3.00b	2.95b	62.08
75 kg N/fad. +Cerealine	3.04a	3.09a	3.06a	68.13
50 kgN/fad. +Cerealine	2.82b	2.91c	2.87c	57.69
Cerealine	2.35c	2.41d	2.38d	30.76
F. test	**	**	**	
Phosphorus fertilization regimes(B)				
Control	2.11e	2.21f	2.16f	-
15 kg P_2O_5/fad.	2.48d	2.55e	2.52e	16.66
Phosphorien	2.64c	2.65d	2.64d	22.22
Mycorrhiza	2.64c	2.72c	2.68c	24.07
7.5 kg P_2O_5/fad. + Phosphorien	2.87a	2.93a	2.90a	34.25
7.5 kg P_2O_5/fad. + Mycorrhiza	2.74b	2.78b	2.76b	27.77
Phosphorien + Mycorrhiza	2.63c	2.71cd	2.67c	23.61
F. test	**	**	**	

Interaction(AB)	**	**	**

** Means followed by different letters are significantly different at P≤ 0.1 level.

34.25%. The other bio-chemical fertilization regime (7.5 Kg P_2O_5/fad. + mycorrhiza) ranked second in grain yield (ton/fad.) with relative increase over the control valued as much as 27.77%. Phosphorus deficiency in the control treatment hampered wheat productivity (available phosphorus in the experimental site amounted 9.20 and 9.59 mg/kg), so the lowest wheat grain yield was obtained under the control treatment conditions in both seasons and the combined analysis. Superiority of grain yield caused by the application of the beforenamed bio-chemical phosphorus fertilization regimes is consequent upon the excellency in each of spike number/m^2, grain weight/spike, grain number/spike and harvest index.

In general, extra wheat grain yield could be obtained due to chemical phosphorus application as reported by Alam *et al.* (2003), Darwesh and Esmial (2008), Rahim *et al.* (2010), Sisie and Mirshekari (2011), Saber *et al.* (2012), and Kabir *et al.* (2014).

Inoculation wheat grain with phosphorus bio-fertilizers, significantly increased grain yield, that was the result reported by Afzal *et al.* (2005), Tawfik and Gomaa (2005), Abbasdokht (2008), Badr *et al.* (2009), El-Gizawy (2009), Faizy *et al.* (2010), Metin *et al.* (2010) and Saber *et al.* (2012).

The significant interaction between nitrogen fertilization regimes and phosphorus fertilization regimes on wheat grain yield is presented in (Table 6-a), which in general reveal the excelleny of the bio-chemical nitrogen fertilization regime (75 kg N/fad. + cerealine) under any phosphorus fertilization regime. On the other hand, irrespective of the nitrogen fertilization regimes, application of the phosphorus fertilization regime (7.5 kg P_2O_5/fad. + phosphorien) was accompanied by high grain yield. The uppermost grain yield value (3.33 tons/fad.) was obtained due to the application of NER (75 kg N/fad. + cerealine) and PFR (7.5 kg P_2O_5/fad. + phosphorien). While the lowermost grain yield value (1.21 ton/fad.) was achived under the deficit nutrition of nitrogen and phosphorus in the control treatment of both.

Table 6-a. Interaction effect between both of nitrogen and phosphorus fertilization regimes on wheat grain yield (ton/fad., combined data)

PFR / NFR	Control	15 kg P_2O_5 /fad.	Phosphorien	Mycorrhiza	7.5 kg P_2O_5 /fad. + Phosphorien	7.5 kg P_2O_5 /fad. + Mycorrhiza	Phosphorien+ Mycorrhiza
	E	D	C	C	A	B	B
Control	1.21c	1.50d	1.78d	1.75d	2.45c	1.97c	2.10d
	D	C	BC	C	AB	A	A
100kgN/fad.	2.48a	2.880b	2.97b	2.86b	3.10b	3.22a	3.16a
	E	BC	AB	ABC	A	CD	D
75 kg N/fad. + Cerealine	2.51a	3.12a	3.26a	3.20a	3.33a	3.09a	2.94b
	C	B	B	AB	A	A	B
50 kg N/ fad. + Cerealine	2.44a	2.82b	2.88b	2.97b	3.04b	3.10a	2.83b
	D	CD	A	AB	A	AB	BC
Cerealine	2.14b	2.26c	2.50c	2.44c	2.58c	2.43b	2.32c

NFR= Nitrogen fertilization regimes. PFR=Phosphorus fertilization regimes.

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تأثيرات بعض النظم السمادية البيوكيميائية للنتروجين والفوسفور على إنتاجية القمح

أميرة وفا محمود خطاب – عبدالستار عبدالقادر حسن الخواجة
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أجريت تجربتين حقليتين لدراسة تأثير بعض النظم البيوكيميائية للنيتروجين والفوسفور على محصول الحبوب للقمح ومكوناته الرئيسية بالإضافة إلى دليل الحصاد على الصنف مصر ١، أقيمت التجارب في حقل أحد المزارعين بقرية الشيخ عيسى – مركز الزقازيق – محافظة الشرقية – مصر، خلال الموسمين الشتويين المتعاقبين لعامي ٢٠١٢/٢٠١٣ ، ٢٠١٣/٢٠١٤ وكانت نظم التسميد النيتروجين تحت الدراسة هي (كنترول ، ١٠٠ كجم ن/فدان؛ ٧٥كجم ن/فدان + سيريالين ؛ ٥٠ كجم ن/فدان + سيريالين ؛ سيريالين) كما كانت نظم التسميد الفوسفاتي السبع كما يلى : (كنترول ؛ ١٥ كجم بو٢أ٥/فدان؛ فوسفورين ؛ ميكروهيزا؛ ٧.٥ كجم بو٢أ٥/فدان + فوسفورين؛ ٧.٥ كجم بو٢أ٥/فدان + ميكروهيزا ؛ فوسفورين + ميكروهيزا) فيما يتعلق بتأثير النظم السمادية للنيتروجين تؤكد النتائج أنه مهما كان النظام التسميدي المستخدم فقد تسبب في زيادة معنوية مقارنة بالكنترول في كل من (عدد السنابل/م٢؛ وزن الحبوب/ سنبلة؛ عدد الحبوب/سنبلة ؛ وزن الـ ١٠٠٠ حبة، محصول الحبوب/فدان) بالإضافة إلى معامل الحصاد؛ ظهر من النتائج أيضاً أن الإضافة الثنائية للأسمدة الحيوية والكيميائية (٧٥ كجم ن/فدان + سيريالين) احتلت القمة في محصول الحبوب للفدان ومكوناته الرئيسية وهي (عدد السنابل/م٢ ؛ وزن الحبوب/سنبلة ؛ وزن الـ ١٠٠٠ حبة)، وفيما يتعلق بالنظم السمادية للفوسفور فإن النتائج تعكس أن توافر الفوسفور عن طريق إضافة أي نظام تسميدي للفوسفور قد تفوق على الكنترول في كل من (عدد السنابل/م٢ ؛ وزن الـ ١٠٠٠ حبة؛ معامل الحصاد ؛ محصول الحبوب للفدان)، ولقد اتضح أن النظام التسميدي للفوسفور الذي يضم السماد المعدني والحيوي أي (٧.٥ كجم فو٢أ٥/فدان + فوسفورين) قد تفوق في المحصول على باقي النظم كما كان متفوقاً في كل من (عدد السنابل/م٢ ؛ وزن الحبوب/سنبلة؛ عدد الحبوب/سنبلة ؛ معامل الحصاد).

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