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EFFECT OF INORGANIC NITROGEN SOURCES WITH FOLIAR APPLICATION OF ZN AND B ON WHEAT (*Triticum aestivum* L.) CULTIVATED IN ALLUVIAL SOIL

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ABSTRACT

Feeding millions of poor people depend on wheat for both diet and livelihood, two field experiments were carried out at Abo-Zaher, Sherbin, Dakahlia Governorate, Egypt during the two successive winter seasons of 2013/2014 and 2014/2015 under alluvial soil conditions. Different sources of inorganic nitrogen fertilizers at recommended dose including urea (U), ammonium nitrate (AN), ammonium sulfate (AS) and calcium nitrate (CN) were applied to soil with foliar application of zinc (Zn) and/or boron (B). Several parameters of yield and yield components were recorded including vegetative growth, grain yield, total N, P and K content in grain and straw, total Zn and B content in grain and straw as well as quality parameters in grain and straw of wheat plant. The experiments were conducted in split plot design which consisted of the main plot (inorganic sources of nitrogen including U, AN, AS and CN as well as control) and sub plots (four treatments of micronutrient compounds including control, Zn, B, and Zn + B). The results revealed that Zn and/or B as foliar application of wheat plant under different sources of inorganic nitrogen fertilizers cause highly significant increases in all studied parameters of wheat grain and straw yields. Most of these parameters gave the highest values treated with ammonium sulfate as a soil application followed by urea. Foliar application of Zn or B as an individual effect caused high significantly increases for all studied parameters of wheat grain and straw in compared with the control (untreated). Combine foliar application of zinc + boron gave the highest values of all studied parameters of wheat grain and straw followed by individual Zn foliar application. Foliar application of Zn +B in addition to ammonium sulfate or urea results recorded the uppermost all studied parameters of wheat grain and straw. Therefore, it could be recommended that, under these experimental conditions, foliar application of both Zn and B in addition to ammonium sulfate followed by urea as soil application at recommended dose for wheat recorded the uppermost of vegetative growth (plant height and tillering height), yield components (weight of 100 grain and grain yield), N, P and K content in grain and straw, Zn and B content in grain and straw, chlorophyll a, b, protein content in grain and straw of wheat plant.

Keywords: Urea, Ammonium Nitrate, Ammonium Sulfate, Calcium Nitrate (CN), Zinc, Boron, Wheat, Soil addition, Foliar application, Alluvial soil

INTRODUCTION

Among the staple food crops, wheat is the most important food crop in a number of developing countries with respect to its contribution to the daily calorie intake (Cakmak 2008). Therefore, increasing its productivity as well as cultivated area is highly recommended. Wheat is very sensitive to insufficient soil nitrogen and very responsive to nitrogen fertilization. The most important role of N in the plant is its presence in the structure of protein. Therefore, the nitrogen supply to the plant influences the amount of protein, protoplasm and chlorophyll formed. In turn, this influences cell size and leaf area, and photosynthetic activity. Therefore, nitrogen (N) fertilizer is important for improving grain yields of cereal crops. However, excessive amounts and inappropriate application methods lead to de-nitrification, and volatilization (Kirda et al. 2001). It is stated that, all inorganic nitrogen fertilizers (urea, ammonium nitrate, ammonium sulfate… etc.) control the dry weight of wheat at all stages of plant growth (Abdel-Mottalb 2003). Furthermore, it is found that, N fertilization increases micronutrient accumulation in wheat grain as well as the proper management of N fertilization has the potential to enhance the nutritional of this important food (Shi et al. 2010).

Use of micronutrient enriched fertilizers result in significant economic benefit to farmers. Several reports indicated that either soil or foliar application of micronutrient have positive correlation with wheat yield (Abbas et al. 2009; Khan et al. 2009; El-Fouly et al. 2011; Ali 2012; Rawashdeh and Sala 2014, 2015). It is reported that, foliar application of micronutrients improves the growth parameters, nutrients uptake and yield of wheat (El-Fouly et al. 2011). Among micronutrients, Zinc and Boron play a key role in pollination and seed set processes resulting in decrease in seed formation and subsequently yield reduction due to their deficiency. It has been clearly proved that Zn is essential in wheat production (Moghadam et al. 2012). It is reported that, an increase of 31.6% in wheat grain yield over control by the addition of 5 kg Zn ha-1 (Khan et al. 2009). The foliar application of mixture micronutrients (Zn + Fe) gave the highest grain and yield components and of wheat grain (Gomaa et al. 2015).

Boron is essential in the formation of plant cells, sugar transportation, indole acetic acid (IAA), formation and germination. Therefore, cell wall formation, leaves chlorophyll concentration and IAA increased due to micronutrient foliar application (like Zn, Fe and B), which in turn, leads to an increase in plant height and production (Abbas et al. 2009; Ali 2012; Rawashdeh and Sala 2013a, b; Mekkei and El Haggan 2014). Seed and grain production are reduced with low boron supply still in the absence of any observable indication of deficiency symptoms and so the requirement of B for reproductive increase appears to be more for reproductive development than for vegetative growth (Pandey and Gupta 2013). It is reported that, foliar application of B was significant affected on grain yield, number of grains per spike and 1000-grain weight (Raza et al. 2014). On the other hand, combination of the foliar applications of iron and boron significantly increases some growth characteristics like plant height, number of leaves/plant, and number of tillers and root depth of wheat plant (Rawashdeh and Sala 2013a, b). Concerning foliar application of B and Zn, it had positive effect on yield and its components of wheat (Ali et al. 2009; Moghadam et al. 2012).

Therefore, the objectives of this study were to evaluate the inorganic nitrogen sources with foliar application of zinc and boron either individual or in a combination on yield and yield components for wheat cultivated in alluvial soil.

MATERIALS AND METHODS

Experimental design

Two field experiments were carried out at Abo-Zaher, Sherbin, Dakahlia Governorate, Egypt during the two successive winter seasons of 2013/2014 and 2014/2015 under alluvial soil conditions cultivated with wheat plant (*Triticum aestivum* L., cv. seeds 12). The studied soil has clayey texture, its salinity about 3.86 dS m^{-1} and soil pH about 7.85 (Table 1). The experiments were conducted in split plot design including the main plot (inorganic nitrogen sources) and sub plot (the micronutrient treatments of Zn or/and B). Each treatment was replicated 3 times, the total number of studied plots were 60 plots and the area of each plot 12 m^2.

Table 1: Some physical and chemical properties of the two experimental sites before wheat planting during the two growth seasons

Soil characteristics	1st Season	2nd Season
Physical soil analyses		
Sand (%)	24.2	24.2
Silt (%)	24.1	23.8
Clay (%)	51.7	52.0
Soil texture class	clay	clay
Saturation percentage (%)	70	72
Soluble cations (m mole L^{-1})		
Ca^{++}	12.3	12.5
Mg^{++}	11.5	12.0
Na^{+}	13.0	13.2
K^{+}	1.7	1.7
Soluble anions (m mole L^{-1})		
SO_4^{--}	19.8	16.7
CO_3^{--}	0	0
HCO_3^{-}	13.0	16.0
Cl^{-1}	5.7	6.7
Chemical and nutritional analyses		
Soil pH (1:2.5 suspension)	7.86	7.90
EC (soil paste, dS m^{-1})	3.86	3.90
$CaCO_3$ (%)	1.89	2.00
OM (g kg^{-1})	16.5	16.0
Soil CEC (mol_c kg^{-1})	32.00	30.00
Available N (mg kg^{-1})	31.00	28.20
Available P (mg kg^{-1})	16.0	18.0
Available K (mg kg^{-1})	224.00	200.00
Available Zn (mg kg^{-1})	0.60	0.62

Soil and plant sampling:

Soil samples were taken before the cultivation and then dried, grinded and passed through 2 mm sieve and stored in bags for soil chemical analyses. Plant samples were taken at tillering and booting stages from each plot and the vegetative growth parameters were recorded (fresh weight, dry weight, and chlorophyll reading), chemical composition was determined and nutrients-uptake were calculated. At harvest grain and straw samples were separated and weighed and stored for analyses, yield components; grain yield (ardb fed^{-1}) and straw yield (ton fed^{-1}), nutrients (%) and nutrients-uptake and N-use efficiency were determined. Plant parts were taken, weighed and dried at 60 ºC and the dry weight was recorded and grinded to fine powder and wet digested.

Soil pH value, electrical conductivity (EC), particle size distribution, saturation percentage (%), soluble ions, were determined according to (Jakson 1976). Available nitrogen was extracted using 1 % (K_2SO_4) and determined by micro-kjeldahl apparatus according to (Hesse 1971). Available phosphorus was extracted using 0.5 N ($NaHCO_3$) solution (pH 8.5) and determined using spectrophotometer after treating with ammonium molybdate and hydroquinone and sodium sulphite at a wave length of 660 nm (Jakson 1976). Available potassium was extracted using 1.0 N ammonium acetate (pH 7), and determined by flam photometer according to (Hesse, 1971). Available micronutrients were extracted using DTPA solution according to (Lindsay and Norvall, 1978) and determined using atomic absorption spectrophotometer. Calcium carbonate was determined using Collins calcemeter according to Jakson, (1976). Organic matter content was determined using Anne method (modified Walkely's Black method) according to Mathieu and

Pieltain (2003). Chlorophyll was measured by a Minolta SPAD Chlorophyll meter (Yadova 1986). Mechanical analysis was determined according to Piper, (1950)

Statistical analysis:

All data were statistically analyzed according to the technique of analysis variance (ANOVA) and the least significant difference (L.S.D) method was used to compare the deference between the means of treatment values to the methods described by Gomez and Gomez (1984). All statistical analyses were performed using analysis of variance technique by means of CoSTATE Computer Software.

RESULTS AND DISCUSSION

Vegetative growth and yield of wheat plant:

Significant effect resulted from different inorganic N sources and micronutrients (Zn and/or B) either individual or in combination effects on vegetative growth (plant height and tillering height) and yield (weight of 100 grain and grain yield) of wheat plant during 2013/2014 and 2014/2015 seasons (Table 2). Micronutrient (Zn, B and Zn + B) as foliar application of wheat plant under different inorganic nitrogen fertilizer sources (urea, ammonium nitrate, ammonium sulfate and calcium nitrate) revealed that there is a high significant increases in all vegetative growth and grain yield of wheat plant in both seasons.

Concerning the mean values of vegetative growth parameters and yield, it was noticed that urea treatment gave the highest values of plant height (105.21 and 105.01 cm), while ammonium sulfate (AS) achieved the highest values of tillering height (9.84 and 11.57 cm), weight of 100 grains (7.32 and 7.75 g), and grain yield (16.73 and 19.08 ardab fed^{-1}), respectively in both seasons. These increases may be taken place due to the efficient utilization of nutrients in the soil which restricted the production number of vegetative growth of wheat (Saeed et al. 2012 and Nadim et al. 2013). On the other hand, the lowest mean values for yield and its components were recorded as follows: for plant height with AN (93.85and 94.42 cm), tillering height with CN (9.41 and 10.96 cm), weight of 100 grain with CN (7.13 and 7.56 g), and yield with U (14.96 and 17.31 ardab fed^{-1}) in both seasons, respectively. Therefore, the descending order was as follows:

Plant height: (U) > (AS) > (CN) > (AN)
Tillering height: (AS) > (U) > (AN) > (CN)
Weight 100 grain: (AS) > (U) > (AN) > (CN)
Grain yield: (AS) > (CN) > (AN) > (U)

It is also observed that, the foliar application of Zn or B as well as combination of Zn + B were high significantly increased all vegetative growth (plant height and tillering height) and yield (weight of 100 grain and yield) of wheat plant in both seasons (Table 2). Moreover, it is also illustrated that, by foliar application of zinc + boron, the vegetative growth and yield were recorded the superiority values of plant height (91.46 and 91.26 cm), tillering height (9.43 and 11.01 cm), weight of 100 grain (7.35 and 7.78 g), and grain yield (16.04 and 18.39 ardab fed^{-1}), respectively in both seasons. While, the lowest values observed with B foliar application where, plant height (88.13 and 87.93 cm), tillering height (9.06 and 10.46 cm), weight of 100 grain (6.94 and 7.36 g), and grain yield (14.20 and 16.55 ardab fed^{-1}), respectively in both seasons as well as the descending order was Zn + B > Zn > B. It is also noticed that, foliar application of Zn + B in addition to urea recorded the uppermost plant height, while foliar application of Zn + B in addition to ammonium sulfate also recorded the uppermost of tillering height, weight of 100 grain, and highest value of grain yield (Table 2).

Concerning the role of Zn in improving grain of wheat, it is reported that, the soil addition or foliar Zn application recorded significant increases in plant growth and grain yield in various locations in Central Anatolia (Cakmak et al. 1996). Whereas, under Zn-deficient in soils, plants show a high susceptibility to environmental stress factors such as drought stress and pathogenic infections as well as develop severe symptoms such leaf necrosis and stunting growth. Consequently, Zn deficiency results in significant decreases in plant performance to grow and yield better, as shown in various countries such as India, Pakistan, Australia and China (Alloway 2007). In India, Zn-enriched urea fertilizers are becoming an important source for Zn application to wheat and rice. Applying Zn-coated urea fertilizers (up to 3 % Zn) increased both grain yield and grain Zn concentration in rice (Shivay et al. 2008). Furthermore, it is advocated that foliar application of nutrient solution at tillering, jointing and boot stages along with half of the recommended dose of N and P can be performed to increase yield and yield components of wheat (Arif et al. 2006). The results of this study are in harmony with results obtained by Khan et al. (2009). They found an increase of 31.6% in wheat grain yield over control by the addition of 5 kg Zn ha^{-1}. Similarly, the yield parameters like number of spike per plant, spike length, plant height, biological yield and 1000- grain weight were increased over control.

Regarding to inorganic nitrogen fertilizer sources, several studies involved which nitrogen source is suitable for wheat plant production. For example, it is reported that, ammonium sulfate as a nitrogen source was more efficient with an average yield compared to urea (Boukef et al. 2013). The foliar application with some micronutrients like Zn and B can increase the production of wheat in presence of some inorganic nitrogen fertilizer sources (Table 2). Furthermore, it is indicated that, foliar application of boron gave significantly higher wheat seedling length, root length, shoot fresh weight, root fresh and dry weight compared to the control (Rawashdeh and Sala 2013a, b); due to the importance of boron, it is required for plant growth and yield (Soomro et al. 2011). These results are in agreement with results from Rawashdeh and Sala (2014)

Table (2): Effect of inorganic N sources and micronutrients (Zn and/or B) on vegetative growth and grain yield of wheat plant

Treatment		First season (2013/2014)				Second season (2014/2015)			
		Plant high (cm)	Tillering height (cm)	w. 100 grain (g)	Yield (ardab fed^{-1})	Plant high (cm)	Tillering height (cm)	w. 100 grain (g)	Yield (ardab fed^{-1})
Individual effect of inorganic N sources									
(0) N		54.14	6.83	5.33	9.28	53.94	7.49	5.65	11.63
U		105.21	9.72	7.24	14.76	105.01	11.42	7.67	17.11
AN		93.85	9.48	7.17	15.78	93.65	11.02	7.59	18.13
CN		94.62	9.41	7.13	15.71	94.42	10.96	7.56	18.06
AS		97.48	9.84	7.32	16.73	97.28	11.57	7.75	19.08
Significance		**	**	**	**	**	**	**	**
LSD 5%		0.7412	0.0601	0.0518	0.5435	0.7412	0.0895	0.0589	0.5419
Individual and combination effects of zinc and boron									
Control		85.92	8.53	6.05	12.33	85.72	9.91	6.41	14.68
Zn		90.71	9.19	7.01	15.22	90.51	10.59	7.42	17.57
B		88.13	9.06	6.94	14.21	87.93	10.46	7.36	16.56
Zn + B		91.46	9.43	7.35	16.04	91.26	11.01	7.78	18.39
Significance		**	**	**	**	**	**	**	**
LSD 5%		0.6533	0.0393	0.0399	0.316	0.6533	0.0807	0.0426	0.3161
Interaction effect of inorganic N sources and micronutrients (Zn and/or B)									
Control	(0) N	51.07	6.57	5.05	7.76	50.87	7.07	5.35	10.11
	U	101.13	9.10	6.33	12.33	100.93	10.80	6.71	14.68
	AN	90.47	8.93	6.27	13.14	90.27	10.43	6.64	15.49
	CN	92.33	8.87	6.23	14.34	92.13	10.37	6.60	16.69
	AS	94.60	9.20	6.38	14.08	94.40	10.87	6.76	16.43
Zn	(0) N	55.47	6.90	5.35	10.05	55.27	7.40	5.67	12.40
	U	107.57	9.87	7.45	15.58	107.37	11.57	7.89	17.93
	AN	96.00	9.60	7.38	16.94	95.80	11.10	7.81	19.29
	CN	96.33	9.53	7.34	15.66	96.13	11.07	7.77	18.01
	AS	98.20	10.07	7.51	17.85	98.00	11.80	7.96	20.21
B	(0) N	52.53	6.73	5.27	8.99	52.33	7.40	5.58	11.34
	U	102.93	9.77	7.39	14.54	102.73	11.47	7.83	16.89
	AN	91.80	9.50	7.31	15.35	91.60	10.97	7.74	17.70
	CN	95.87	9.43	7.29	16.22	95.67	10.90	7.73	18.57
	AS	97.53	9.87	7.46	15.93	97.33	11.57	7.90	18.28
Zn + B	(0) N	57.47	7.10	5.65	10.30	57.27	8.10	5.98	12.65
	U	109.20	10.13	7.79	16.57	109.00	11.83	8.25	18.92
	AN	97.13	9.87	7.70	17.68	96.93	11.57	8.16	20.03
	CN	93.93	9.80	7.67	16.60	93.73	11.50	8.12	18.95
	AS	99.57	10.23	7.94	19.05	99.37	12.03	8.39	21.40
Significance		**	**	**	**	**	**	**	**
LSD 5%		0.9839	0.1719	0.1245	0.7465	0.9839	0.1711	0.134	0.746

(0) N= Control, U= urea, AN=ammonium nitrate, CN=calcium nitrate, AS=ammonium sulfate

N, P and K content in grain and straw of wheat plant:

It is well documented that, N fertilization increased wheat biomass (Golik et al. 2005), yield (Fallahi et al. 2008) and protein content (Saint Pierre et al. 2008). In fact, nitrogen is a constitutive component of chlorophyll and proteins affecting thus photosynthesis process (Tranavičienė et al. 2007). In fact, plants are capable of assimilating nitrate (NO_3^-) and ammonium (NH_4^+) into amino acid (Xu et al. 2011). Besides, plants could capture urea throw passive and/or active pathways (Kojima et al. 2007). In addition, concomitant sulfate (S) and N application enhanced durum wheat grain parameters (Lerner et al. 2006).

The total N, P and K content in grain and straw of wheat plant at booting stage have been determined (Table 3). The effect of different inorganic N sources and micronutrients (Zn and/or B) and their combination effects on during 2013/2014 and 2014/2015 seasons, respectively are presented in Table 3. It is illustrate that, there is a high significant increases in total N, P, and K% of wheat grain and straw in 1st and 2nd seasons under foliar and soil application of different sources of inorganic nitrogen fertilizers and micronutrients including Zn and B, respectively. The mean values of N, P, and K (%) of wheat grain and straw which resulted from different inorganic N fertilizers sources were listed in Table 3. It could be noticed, that ammonium sulfate treatment gave the highest values except N (%) of wheat straw, which noticed that urea followed ammonium sulfate in both seasons.

The descending order was as follows:

N in grain: (AS) > (U) > (AN) > (CN)

N in straw: (U) > (CN)1st > (AS) > (AN)

P in grain: (AS) > (U) > (CN) > (AN)

P in straw: (AS) > (U) > (AN) > (CN)

K in grain: (AS) > (U) > (AN) > (CN)
K in straw: (AS) > (AN) > (U) > (CN)

It is also observed that, foliar application of Zn and/or B as individual effect caused high significant increases for total N, P, and K (%) of wheat grain and straw in both seasons compared with the control (Table 3). It is also illustrated that, the combine foliar addition of zinc + boron gave the highest mean values of total N, P, and K (%) of wheat grain and straw in both seasons. Whereas, the individual Zn foliar application recorded the lowest mean values of N and K as percent (in both grain and straw) recorded with individual B foliar application. It is recorded that, the mean values of N, P, and K content were higher in case of foliar B application than Zn foliar application, in both seasons. The descending order were (Zn + B) > (Zn) > (B) in case of N and K content (%), while in case of P content (%) was followed by (Zn + B) > (B) > (Zn), either grain or straw of wheat, in both seasons. It could be also noticed that, foliar application of Zn + B along with ammonium sulfate involved the uppermost total N, P, and K content (%) of wheat grain and straw.

Table (3): Effect of inorganic N sources and micronutrients (Zn and/or B) on N, P and K content in grain and straw of wheat plant

Treatment		First season (2013/2014)						Second season (2014/2015)					
		N (%)		P (%)		K (%)		N (%)		P (%)		K (%)	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Individual effect of inorganic N sources													
(0) N		0.66	0.51	0.211	0.156	4.25	1.93	1.04	0.69	0.343	0.199	3.77	2.68
U		1.68	1.19	0.334	0.191	5.90	3.79	2.05	1.28	0.466	0.234	5.42	4.54
AN		1.56	0.99	0.322	0.183	5.83	4.10	1.91	1.07	0.454	0.226	5.35	4.85
CN		1.44	1.12	0.323	0.182	5.69	2.67	1.82	1.00	0.455	0.225	5.21	3.42
AS		1.76	1.10	0.349	0.202	6.02	4.77	2.12	1.09	0.481	0.245	5.54	5.52
Significance		**	**	**	**	**	**	**	**	**	**	**	**
LSD 5%		0.135	0.077	.003	0.004	0.183	0.156	0.137	0.052	0.006	0.005	0.183	0.156
Individual and combination effect of zinc and boron													
Control		1.06	0.77	0.227	0.122	4.78	2.83	1.43	0.96	0.359	0.165	4.30	3.58
Zn		1.54	0.94	0.262	0.146	5.64	3.54	1.90	1.01	0.394	0.189	5.16	4.29
B		1.34	0.86	0.352	0.233	5.53	3.40	1.72	1.06	0.484	0.276	5.05	4.15
Zn + B		1.73	1.36	0.390	0.229	6.20	4.03	2.09	1.08	0.522	0.272	5.72	4.78
Significance		**	*	**	**	**	**	**	**	**	**	**	**
LSD 5%		0.134	0.079	0.002	.004	0.1257	0.266	0.131	0.043	0.003	0.003	0.126	0.270
Interaction effect of inorganic N sources and micronutrients (Zn and/or B)													
Control	(0) N	0.55	0.35	0.205	0.101	4.00	1.26	0.93	0.51	0.337	0.144	3.52	2.01
	U	1.23	0.91	0.234	0.126	5.01	3.02	1.60	1.17	0.366	0.169	4.53	3.77
	AN	1.13	0.83	0.224	0.125	4.97	2.96	1.49	1.00	0.356	0.168	4.49	3.71
	CN	1.07	0.83	0.227	0.124	4.82	2.11	1.45	1.00	0.359	0.167	4.34	2.86
	AS	1.33	0.93	0.243	0.134	5.11	4.79	1.68	1.10	0.375	0.177	4.63	5.54
Zn	(0) N	0.73	0.57	0.214	0.135	4.31	2.16	1.10	0.73	0.346	0.178	3.83	2.91
	U	1.87	1.05	0.277	0.152	6.05	3.91	2.23	1.21	0.409	0.195	5.57	4.66
	AN	1.73	0.99	0.264	0.139	5.91	4.38	2.04	1.10	0.396	0.182	5.43	5.13
	CN	1.50	0.95	0.258	0.140	5.83	2.73	1.88	0.96	0.390	0.183	5.35	3.48
	AS	1.89	1.13	0.297	0.162	6.11	4.54	2.27	1.03	0.429	0.205	5.63	5.29
B	(0) N	0.55	0.44	0.213	0.183	4.16	1.92	0.93	0.70	0.345	0.226	3.68	2.67
	U	1.60	0.94	0.386	0.247	5.89	3.71	1.98	1.36	0.518	0.290	5.41	4.46
	AN	1.50	0.94	0.376	0.237	5.87	4.21	1.88	1.03	0.508	0.280	5.39	4.96
	CN	1.33	0.94	0.383	0.237	5.62	2.64	1.71	1.03	0.515	0.280	5.14	3.39
	AS	1.73	1.03	0.404	0.261	6.09	4.54	2.10	1.20	0.536	0.304	5.61	5.29
Zn + B	(0) N	0.80	0.67	0.212	0.204	4.52	2.36	1.18	0.83	0.344	0.247	4.04	3.11
	U	2.03	1.86	0.438	0.237	6.63	4.52	2.38	1.36	0.570	0.280	6.15	5.27
	AN	1.87	1.21	0.422	0.229	6.58	4.85	2.22	1.16	0.554	0.272	6.10	5.60
	CN	1.87	1.75	0.424	0.227	6.50	3.20	2.23	1.00	0.556	0.270	6.02	3.95
	AS	2.07	1.30	0.453	0.249	6.75	5.21	2.42	1.03	0.585	0.292	6.27	5.96
Significance		**	**	**	**	**	**	**	**	**	**	**	**
LSD 5%		0.162	0.132	0.003	0.007	0.253	0.325	0.174	0.113	0.006	0.010	0.253	0.325

(0) N= Control, U= urea, AN=ammonium nitrate, CN=calcium nitrate, AS=ammonium sulfate

It is well known that, the main function of boron in plants can be included cell wall formation, nucleic acid, nitrogen fixation, sugar transportation, phenol, membrane stability carbohydrate and indole acetic acid (IAA) metabolism as well as flower retention and pollen formation and germination also are affected by boron (Rawashdeh and Sala 2013a, b). Therefore, boron deficiency affects the reproductive more than biomass yield. Seed and grain production are reduced with low boron supply still in the absence of any observable indication of deficiency symptoms and so the requirement of boron for reproductive increase appears to be more for reproductive development than for vegetative growth (Pandey and Gupta 2013).

Total Zn and B content in grain and straw of wheat plant:

Concerning the importance of Zn in improving wheat production, it could be concluded that, Zn is an essential micronutrient for biological systems. Moreover, one of the critical physiological roles of Zn in biological systems is its role in protein synthesis and metabolism. Almost 40% of the Zn-binding proteins are transcription factors needed for gene regulation and the 60% enzymes and proteins involved in ion transport (Andreini et al. 2006). Zinc is also a critical micronutrient required for structural and functional integrity of biological membranes and for detoxification of highly aggressive free radicals (Cakmak 2000).

The total zinc and boron content can be illustrated in grain and straw of wheat plant at booting stage during 2013/2014 and 2014/2015 seasons (Table 4). It is illustrated that, the soil application of different inorganic N sources and foliar addition of micronutrients (Zn and/or B) have high significant increases on Zn and B content in grain and straw of wheat.

Table 4: Effect of inorganic N sources and micronutrients (Zn and/or B) on Zn and B contents in grain and straw of wheat plant

Treatment		First season (2013/2014)				Second season (2014/2015)			
		Zn (mg kg^{-1})		B (mg kg^{-1})		Zn (mg kg^{-1})		B (mg kg^{-1})	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Individual effect of inorganic N sources									
(0) N		39.00	50.25	7.36	4.01	38.00	49.25	7.78	4.36
U		50.83	66.25	8.61	5.88	49.83	65.25	9.03	6.23
AN		57.50	57.83	8.39	5.83	56.50	56.83	8.81	6.18
CN		55.75	56.75	8.14	5.46	54.75	55.75	8.56	5.81
AS		69.75	58.42	8.94	6.04	67.50	57.42	9.36	6.39
Significance		**	**	**	**	**	**	**	**
LSD 5%		3.319	3.904	0.0857	0.1519	2.268	3.905	0.0767	0.1519
Individual and combination effect of zinc and boron									
Control		42.73	44.13	6.53	4.09	41.73	43.13	6.95	4.44
Zn		64.13	73.13	7.51	4.50	62.20	72.13	7.93	4.85
B		49.33	47.00	8.54	6.13	48.27	46.00	8.96	6.48
Zn + B		62.07	67.33	10.56	7.06	61.07	66.33	10.98	7.41
Significance		**	**	**	**	**	**	**	**
LSD 5%		6.068	4.186	0.162	0.081	5.538	4.186	0.167	0.081
Interaction effect of inorganic N sources and micronutrients (Zn and/or B)									
Control	(0) N	35.33	38.00	5.90	2.99	34.33	37.00	6.32	3.34
	U	42.33	50.00	6.83	4.37	41.33	49.00	7.25	4.72
	AN	43.67	47.33	6.44	4.34	42.67	46.33	6.86	4.69
	CN	44.67	44.67	6.76	4.19	43.67	43.67	7.18	4.54
	AS	47.67	40.67	6.72	4.57	46.67	39.67	7.14	4.92
Zn	(0) N	39.33	63.00	7.26	3.45	38.33	62.00	7.68	3.80
	U	59.67	95.00	7.43	4.65	58.67	94.00	7.85	5.00
	AN	69.00	68.67	7.63	4.81	68.00	67.67	8.05	5.16
	CN	65.33	67.33	7.47	4.41	64.33	66.33	7.89	4.76
	AS	87.33	71.67	7.75	5.16	81.67	70.67	8.17	5.51
B	(0) N	40.00	43.33	7.18	4.45	39.00	42.33	7.60	4.80
	U	41.00	48.33	8.92	6.73	40.00	47.33	9.34	7.08
	AN	49.33	47.33	8.75	6.68	48.33	46.33	9.17	7.03
	CN	47.33	50.00	8.20	5.88	46.33	49.00	8.62	6.23
	AS	69.00	46.00	9.66	6.91	67.67	45.00	10.08	7.26
Zn + B	(0) N	41.33	56.67	9.10	5.15	40.33	55.67	9.52	5.50
	U	60.33	71.67	11.25	7.78	59.33	70.67	11.67	8.13
	AN	68.00	68.00	10.74	7.47	67.00	67.00	11.16	7.82
	CN	65.67	65.00	10.11	7.36	64.67	64.00	10.53	7.71
	AS	75.00	75.33	11.61	7.53	74.00	74.33	12.03	7.88
Significance		**	**	**	**	**	**	**	**
LSD 5%		9.906	6.361	0.128	0.209	9.079	6.291	0.108	0.209

(0) N= Control, U= urea, AN=ammonium nitrate, CN=calcium nitrate, AS=ammonium sulfate

The mean values of Zn and B content of wheat grain and straw is related to both different inorganic N fertilizers sources and added micronutrient (Zn and B). It is noticed that, ammonium sulfate treatment gave the highest mean values except Zn content of wheat straw, which observed with urea followed ammonium sulfate in both seasons (Table 4). The descending order was as follows:

Zn in grain: (AS) > (AN) > (CN) > (U)
Zn in straw: (U) > (AS) > (AN) > (CN)
B in grain: (AS) > (U) > (AN) > (CN)
B in straw: (AS) > (U) > (AN) > (CN)

It is also observed that, foliar application Zn and/or B as individual effect (without soil application of inorganic N sources) caused high significant increases for both Zn and B contents of wheat grain and straw in both seasons compared with the control (Table 4). It is also illustrated that, foliar application of Zn recorded the highest mean values of Zn contents in both grain and straw of wheat plants, followed by combined treatment of Zn + B as foliar addition. While, the combined treatment of Zn + B as foliar addition gave the highest mean values of Zn content in both of grain or straw of wheat plants in both seasons followed by individual B foliar application. The descending order were (Zn) > (Zn + B) > (B) with Zn content, while with B content were (Zn + B) > (B) > (Zn), either grain or straw of wheat, in both seasons. It could be noticed that, foliar application of Zn + B in addition to ammonium sulfate resulted the superiority of values of Zn content in grain and straw, whereas, B content in straw wheat have the highest values with foliar application of (Zn + B) in addition to urea.

Quality parameters in grain and straw of wheat plant:

It is illustrated in Table 5 that, the soil application of different inorganic N sources and foliar addition of micronutrients (Zn and/or B) have effects on quality parameters (chlorophyll a, b at booting stage and protein content in grain and straw of wheat plant at harvest stage) during 2013/2014 and 2014/2015 seasons.

Table 5: Effect of inorganic N sources and micronutrients (Zn and/or B) on chlorophyll a, b and protein in grain and straw of wheat plant as a quality parameters

Treatment		First season (2013/2014)				Second season (2014/2015)			
		Chlorophyll		Protein (mg g^{-1} FW)		Chlorophyll		Protein (mg g^{-1} FW)	
		A	B	Grain	Straw	A	B	Grain	Straw
Individual effect of inorganic N sources									
(0) N		1.66	0.19	6.02	4.04	1.48	0.18	3.84	2.95
U		2.82	0.30	11.92	7.45	2.64	0.28	9.81	6.93
AN		2.64	0.26	11.12	6.25	2.46	0.25	9.09	5.79
CN		2.61	0.27	10.60	5.81	2.43	0.25	8.41	6.52
AS		2.91	0.28	12.36	6.34	2.73	0.26	10.23	6.40
Significance		**	**	**	**	**	**	**	**
LSD 5%		0.135	0.023	0.785	0.450	0.135	0.023	0.801	0.305
Individual and combination effect of zinc and boron									
Control		2.21	0.25	8.34	5.56	2.03	0.24	6.20	4.50
Zn		2.66	0.26	11.10	5.86	2.48	0.25	9.01	5.46
B		2.33	0.26	10.02	6.20	2.15	0.24	7.83	5.00
Zn + B		2.91	0.27	12.16	6.28	2.73	0.25	10.06	7.91
Significance		**	Ns	**	**	**	ns	**	**
LSD 5%		0.092	0.0134	0.795	0.459	0.092	0.0134	0.762	0.262
Interaction effect of inorganic N sources and micronutrients (Zn and/or B)									
Control	(0) N	1.49	0.19	5.39	2.99	1.31	0.174	3.21	2.04
	U	2.39	0.315	9.33	6.82	2.21	0.299	7.19	5.28
	AN	2.37	0.216	8.67	5.81	2.19	0.2	6.61	4.86
	CN	2.35	0.27	8.48	5.81	2.17	0.254	6.22	4.86
	AS	2.43	0.272	9.81	6.39	2.25	0.256	7.77	5.44
Zn	(0) N	1.72	0.20	6.43	4.25	1.54	0.184	4.28	3.30
	U	2.99	0.286	12.97	7.07	2.81	0.27	10.88	6.12
	AN	2.79	0.276	11.92	6.39	2.61	0.26	10.11	5.76
	CN	2.73	0.28	10.94	5.61	2.55	0.264	8.75	5.56
	AS	3.07	0.269	13.23	6.00	2.89	0.253	11.04	6.56
B	(0) N	1.65	0.19	5.39	4.06	1.47	0.174	3.20	2.55
	U	2.6	0.287	11.52	7.95	2.42	0.271	9.33	5.48
	AN	2.4	0.278	10.94	6.00	2.22	0.262	8.75	5.48
	CN	2.35	0.243	9.97	6.00	2.17	0.227	7.77	5.47
	AS	2.64	0.281	12.27	6.97	2.46	0.265	10.08	6.02
Zn + B	(0) N	1.77	0.185	6.86	4.84	1.59	0.169	4.66	3.89
	U	3.28	0.298	13.86	7.95	3.10	0.284	11.85	10.85
	AN	3.01	0.279	12.94	6.78	2.83	0.263	10.88	7.04
	CN	3.01	0.278	13.02	5.81	2.83	0.262	10.88	10.19
	AS	3.50	0.288	14.12	6.00	3.32	0.272	12.04	7.57
Significance		*	*	**	**	*	*	**	**
LSD 5%		0.251	0.036	1.010	0.661	0.251	0.036	0.941	0.765

(0) N= Control, U= urea, AN=ammonium nitrate, CN=calcium nitrate, AS=ammonium sulfate

Treatments of micronutrient (Zn and/or B) as foliar application of wheat plant under different sources of inorganic nitrogen fertilizers as soil application have been illustrated that, there is a high significant increases in quality parameters of wheat in both seasons. These quality parameters include chlorophyll a and b as well as protein content of wheat grain and straw which tabulated in Table 5. It could be noticed that, ammonium sulfate treatment recorded the highest mean values of chlorophyll a, and protein content in grain followed by urea while, urea gave the highest mean values of chlorophyll b and protein content in straw flowed by ammonium sulfate in both seasons. The descending order was as follows:

Chlorophyll a: (AS) > (U) > (AN) > (CN)
Chlorophyll b: (U) > (AS) > (CN) > (AN)
Protein in grain (AS) > (U) > (AN) > (CN)
Protein in straw (U) > (AS) > (AN) > (CN)

It is also observed that, foliar application Zn and/or B as individual effect caused high significant increases for quality parameters of wheat in 1^{st} and 2^{nd} seasons compared with control as presented in Table 5. It is also illustrated that, the combine application of zinc + boron as foliar addition gave the highest values of chlorophyll a and b as well as protein content of wheat grain and straw in 1^{st} and 2^{nd} seasons followed by individual Zn foliar application. Whereas, the lowest values of quality parameters recorded in case of the individual B foliar application. Generally, quality parameters have higher values with application Zn foliar application comparing with B foliar application in both seasons. The descending order were (Zn + B) > (Zn)> (B) for quality parameters in both seasons. Furthermore, it could be noticed that, foliar application of (Zn + B) in addition to ammonium sulfate or urea resulted the highest values of quality parameters, while the trend is not clear between (AS) or (U) application. These results are in harmony with results obtained by Rawashdeh and Sala (2013a, b). They have been indicated that foliar fertilizer application of boron gave significant higher wheat chlorophyll leaf contents compared to the control.

CONCLUSION

It can be concluded that, Zn and/or B as foliar application under different sources of inorganic nitrogen fertilizers including U, AN, AS and CN caused highly significant increases in all studied parameters of wheat grain and straw. Most of these parameters gave the highest values treated with ammonium sulfate as a soil application followed by urea. Foliar application of Zn and/or B as individual effect caused high significant increases for all studied parameters of wheat grain and straw in compared with the control (untreated). Combine application of zinc + boron as foliar addition gave the highest values for all studied parameters of wheat grain and straw followed by individual Zn foliar application. Foliar application of both Zn + B in addition to ammonium sulfate or urea recorded the uppermost all studied parameters of wheat grain and straw. It could be recommended that, foliar application of Zn + B in addition to ammonium sulfate followed by urea as soil application at recommended dose of wheat gained the uppermost of vegetative growth, grain yield, total N, P and K content in grain and straw, total Zn and B content in grain and straw, quality parameters in grain and straw of wheat plant under alluvial soil conditions.

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تأثير مصادر مختلفة من النيتروجين المعدني مع إضافة الزنك والبورون رش ورقي على القمح المزروع في تربة رسوبية

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**** البحوث الزراعية – مركز تطوير الأسمدة المصرية، شركة الدلتا للسماد**

نظراً لأن حياة الملايين من الفقراء تعتمد على القمح لكل من النظام الغذائي ولذلك، فقد أجريت تجربتان حقليتان في أبو زاهر ، شربين بمحافظة الدقهلية ، مصر خلال موسمي الشتاء المتعاقبين من 2014/2013 - 2015/2014 وتحت ظروف التربة الرسوبية و ذلك بغرض تقييم المصادر المختلفة من الأسمدة النيتروجينية غير العضوية (و التى تم إضافتها بالجرعات الموصى بها) حيث تم إضافة سماد اليوريا (U) ، نترات الأمونيوم (AN) ، كبريتات الأمونيوم (AS) ونترات الكالسيوم (CN) مع الإضافة الورقية بالرش لكل من الزنك مع/أو البورون كمغذيات صغرى و تأثير ذلك على النمو الخضري ومحصول الحبوب و القش ، وكذلك محتوى حبوب وقش القمح من النيتروجين والفوسفور والبوتاسيوم ، و كذلك المحتوى الكلي من الزنك والبورون في الحبوب والقش ، وكذلك صفات الجودة في الحبوب والقش لنبات القمح.

قد أجريت التجربة في تصميم قطع منشقة حيث تكونت من القطعة المنشقة الرئيسية (والتى تحتوي على 5 معاملات هى: الكنترول وأربعة مصادر للأسمدة النيتروجينية هى يوريا U ، نترات آمونيوم AN ، سلفات آمونيا AS و نترات كالسيوم CN) ، بينما كانت القطع تحت المنشقة تحتوي على 4 معاملات للعناصر الصغرى تتمثل فى الكنترول والزنك Zn ، البورون B ، خليط من Z + B. و يمكن تلخيص أهم النتائج المتحصل عليها على النحو التالي:

أن إضافة الزنك مع/أو البورون رشاً على الأوراق على نبات القمح تحت مصادر مختلفة من الأسمدة النيتروجينية غير العضوية (U ، AN ، AS وCN) أدي إلى زيادات معنوية في جميع القياسات من حبوب وقش القمح. معظم القياسات تحت الدراسة أعطت أعلى القيم مع معاملة كبريتات الأمونيوم (AS) كإضافة أرضية تليها اليوريا (U) ، في حين أن الاتجاه غير واضح مع بعض القياسات الآخرى. أن الرش الورقي للزنك مع/أو البورون كإضافات فردية تسبب فى زيادة ملحوظة لجميع القياسات من حبوب وقش القمح مقارنة مع الكنترول. أن الإضافة الورقية لكل من الزنك + البورون معا أعطى أعلى القيم لجميع القياسات من حبوب وقش القمح مقارنة بالمعاملات الفردية لكل منهما. أن الرش الورقي لكل من الزنك + البورون ، مع الإضافة الأرضية لكبريتات الأمونيوم (AS) أو اليوريا (U) أعطت أفضل النتائج على الإطلاق لكل القياسات تحت الدراسة لحبوب وقش القمح.

وقد أوصت الدراسة بأنه تحت نفس الظروف التجريبية ، فإن الإضافة الورقية لكل من الزنك + البورون ، مع الإضافة الأرضية لكبريتات الأمونيوم (AS) ، يليها اليوريا (U) بالجرعة الموصى بها للقمح قد أعطى أعلى قيم من النمو الخضري (ارتفاع النبات وطول السنبلة) وقياسات المحصول (وزن 100 حبة ومحصول الحبوب بالإردب/فدان) ، والمحتوى العنصري لكل من N ، P و K في الحبوب والقش، والمحتوى العنصري للزنك و البورون في الحبوب والقش، والكلوروفيل أ ، ب ، ونسبة البروتين في الحبوب و القش لنبات القمح.