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EFFECT OF COBALT APPLICATIONS ON YIELD AND YIELD COMPONENTS OF WHEAT GROWN UNDER TWO INTERVALS OF IRRIGATION

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ABSTRACT: *A field experiment was carried out on a clayey soil at El-Gemeiza Agricultural Research Station, El-Gharbia Governorate, Middle Nile Delta region, Egypt during two successive growing winter seasons of 2012 / 2013 and 2013 / 2014 to study the effect of different rates and doses of cobalt and its temporal foliar application on growth, yield and some chemical compositions of wheat plant (Triticum aestivum L.) variety Gemeiza 11 under two intervals of irrigation; 25 and 40 days. Cobalt was added as Co- acetate {$(CH_3COO)_2$ Co} at four rates namely 81, 162, 324 and 648 mg Co / L in addition to control treatment with Co-free water on two techniques; the first was three equal doses at seedling, tillering and heading stages and the second was one dose only at tillering stage. The volume of the spray solution for each application was 400 l / fed. The experiment was carried out in a split split plot design with three replicates. The obtained results showed that:-*

Plant height (cm), spike length (cm), number of spikes / m^2, weight of 1000 grains (g), grains and straw yields as (kg/plot and kg/fed.) as well as biological yield (kg/fed.) were significantly increased with the increase of added Co rate. Foliar application of Co on three equal doses efficiently enhanced these parameters more than those sprayed on one dose. Also, the values of the previous parameters were markedly higher when wheat plants irrigated every 25 days than those irrigated every 40 days. The best results were accompanied with the foliar application of Co at a rate of 648 mg Co / L, applied on three equal doses, under 25-day irrigation interval treatment.

Interaction effects among all the applied treatments were insignificant on the studied parameters of plant growth, grains and straw yields and yield quality. Also, most of the dual interactions exerted significant effect on growth characters. However, the interaction between the techniques of Co application rates and doses was significant effect on grain and straw yields.

Nitrogen, P and K concentration (%) and uptake (kg / fed.) by grains and straw as well as crude protein (%) were increased by elevating Co rates especially in the first technique of Co application and at 25-day irrigation interval. Nitrogen and P concentration (%) and uptake (kg / fed.) by grains were higher than those by straw, while K appeared reverse this trend.

Except Fe, both concentrations (mg kg^{-1}) and uptake (g / fed.) of Mn, Zn, Cu and Co by grains and straw were increased with the increase of added Co rates, especially in the first technique of Co application and at irrigation every 25 days. The obtained data exhibited existence of an antagonistic relationship between the added Co and Fe. These microelements could be arranged, according to their contents of both grains and straw, in the following orders: Fe > Zn > Mn > Cu > Co. Except Zn, the content of the microelements, under study, in grains were higher than those found in straw.

Key words: *Clayey soil, Irrigation intervals, Cobalt, Foliar application, Rates and doses and Wheat productivity and quality.*

INTRODUCTION

The scarcity of water makes it difficult and expensive to expand the cultivated lands or even protect soils with natural cover. In Egypt, there is growing concern about the very limited water resource. Abu-Zeid (1999) indicated that, the country reached the so-called line in water resources with a per capita water share of almost 1000 m^3 / person / year. This is expected to fall to less than 500 m^3 by 2030, when the population reaches an estimated 100 million. Because of increasing population, demand for irrigation water will continue to increase. Irrigation uses more than 85 % of the total renewable water in Egypt. So, efficient and effective water management is necessary.

From other wise, wheat plant (*Triticum aestivum L*.) is considered one of the most important cereal crops in the world. The mass production of wheat in Egypt (8 million ton) is about 50 % lower than the consumption (14.5 million ton / year at 2010). Therefore, more than six million tons must be imported annually. One or more of various manners should be followed. The first is by increasing the cultivated area of wheat in both old and newly reclaimed soils. The second is by growing resistant cultivars (plant certified must-free seed) which is considered the most economical and effective way of controlling diseases. The third is by improving agriculture practices among which are the time, irrigation and amount of chemical fertilization (Elbaalawy, 2010).

Through the role of producing healthy wheat plants, cobalt is considered a beneficial element in spite of the absence of evidence for direct role in plant metabolism. It is essential for the synthesis of vitamin B., which is required for human and animal nutrition (Smith, 1991). The daily cobalt requirement for human nutrition could reach 8 ppm depending on cobalt levels in the local supply of drinking water without health hazard (Gad *et al.,* 2013). WenHua *et al*. (2004) showed that cobalt application at rates of 0.75 and 1.05 kg Co / ha increased grain yield of wheat by 7.4 – 20.3 % as compared with the no-Co control, respectively. The greatest yield increase was obtained with the treatment of 1.05 kg Co / ha. Also, Cobalt treatment of 0.75 kg Co / ha increased the different extents; protein content and protein yield of the grain. Elbaalawy (2010) found that application of cobalt to alluvial soil at rate of 2 mg L^{-1} enhanced both air and oven dry weights of straw and grains yield of wheat plants. Also, Gad and Kandil (2011) indicated that increasing cobalt levels in the wheat plants cultural media up to 15.0 mg Co kg^{-1} soil stimulated their growth, dry matter content, yield and its quality. Cobalt at application rate of 15.0 mg kg^{-1} soil gave a significant increase of wheat growth; yield and nutritional status except Fe. Also, they found that iron content was decreased with increasing cobalt doses and suggested the existence of certain antagonistic relationships between the two elements (Co and Fe). In addition, Aziz (2012) indicated that the application of different levels of cobalt (10-50 mg kg^{-1} soil) led to an increase in biomass accumulation and yield responses to cobalt and such increase was always accompanied by increasing nitrogen, phosphorous and potassium concentrations in both shoots and roots as well as protein content of alfalfa.

This work was carried out to study the effect of different rates and doses of cobalt and its temporal foliar applications on wheat growth, yield and some nutrient contents in grains and straw under two intervals of irrigation.

MATERIALS AND METHODS

A field experiment was carried out on alluvial clayey soil at El-Gemeiza Agricultural Research Station, El-Gharbia Governorate, Middle Nile Delta region, Egypt during the two successive growing winter seasons of 2012 / 2013 and 2013 / 2014 to study the effect of foliar application of different rates of Co, numbers of doses and its temporal application, under two intervals of irrigation on wheat plant (*Triticum aestivum L.*) variety (Gemeiza 11). These characters of wheat plant were appraised according to the previous treatments; growth parameters, grain and straw yields, some nutrient contents and its tolerance for drought stress under the circumstance of these treatments. Representative surface soil samples (0 - 30 cm) were taken from the used soil before performance of the experiment. Soil samples were air - dried, ground, mixed well, sieved through a 2 mm sieve. The samples then were analyzed for determination of some physical and chemical properties, also, the content of some available macro- and micronutrients and Co according to the methods described by Cottenie *et al*. (1982); Page *et al.* (1982) and Klute (1986). The obtained data were recorded in Table (1).

The present experiment includes 60 experimental units (plots). The area of each plot was 10.5m^2 (3.5 m length × 3 m width; 1/400 fed.). The experiment was carried out in a split split plot design with three replicates. The main plots were assigned to two intervals of irrigation; at 25 and 40 days. The subplots received the different rates of cobalt namely 0, 81, 162, 324 and 648 mg Co / L and the sub subplots were denoted for the number of Co application doses (one or three doses).

Cobalt was added as foliar applications in the form of Co- acetate {$(CH_3COO)_2$ Co} on two different techniques. In the first technique, Co was applied on three equal doses (each was of 27, 54, 108 and 216 mg Co / L) for different growth periods, i.e., seedling stage (with the first irrigation), tillering and heading stages. While in the second technique, Co was applied on one dose at tillering stage, only. The volume of the spray solution for each foliar spraying was 400 l / fed.

All agricultural practices beginning from sowing to harvesting were performed as recommended by Egyptian Ministry of Agriculture. Before sowing, all plots were fertilized with 100 kg /fed. of ordinary super phosphate (15.5 % P_2O_5), during the final soil preparation. Wheat grains were planted on 15th and 18th of November 2012 and 2013 and harvested on 4th and 8th of May 2013 and 2014 at the first and second season, respectively.

Table (1): Some Physical and chemical properties of the used soil.

Physical properties	Particles size distribution (%)				Textural grade	Bulk density (Mg / m^3)	Total porosity (%)	Water field capacity (%)
	Coarse sand	Fine sand	Silt	Clay				
	6.62	14.22	28.50	50.66	Clayey	1.33	49.81	34.5

Chemical properties	pH 1:2.5 soil : water susp.	EC (soil paste) dS m^{-1}	Soluble cations (meq / l)				Soluble anions (meq / l)			OM (%)	CEC (cmol / kg)	Ca CO_3 (%)
			Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	HCO_3^-	SO_4^{2-}			
	7.81	3.8	21.10	0.75	7.01	9.14	20.12	5.22	12.66	2.05	34.20	3.22

Available elements	Macronutrients (mg / kg)			Microelements (mg / kg)				
	N	P	K	Fe	Mn	Zn	Cu	Co
	45.00	7.21	354	10.42	4.11	3.23	2.96	0.26

* $SO4^{2-}$ were calculated as the difference between the content of soluble cation (Na^+ , K^+ , Ca^{2+} and Mg^{2+}) and soluble anions (Cl^- and $HCO3^-$) .

Just before harvesting, ten plants were taken randomly from each plot. Some growth parameters, i.e., height of whole plant (cm), spike length (cm) and number of spikes / m^2 were measured. At harvesting time, the plants of each plot were harvested separately. The grains were separated from straw to measure: weight of 1000 grains (g), grains and straw yield as kg / plot and kg /fed. and were recorded. Biological yield (kg /fed.), harvest index (%), relative change of wheat yield (grains and straw) and agronomical efficiency were calculated. Grain and straw samples were air-dried then, oven-dried at 70 ^{o}C for 48 hrs., weighed , ground and digested for chemical determination according to the method described by Chapman and Pratt (1961). Nitrogen, P and K content in the digests were determined according to the methods described by Cottenie *et al.* (1982). Crude protein percentage was estimated in the different parts by multiplying N % values by 5.75 as described by A.O.A.C. (1990). The atomic absorption spectrophotometer was used to determine Fe, Zn, Mn, Cu and Co concentrations in the prior parts according to the methods recommended by A. O. A. C. (1990).

The relative change (RC) of wheat yield (grains and straw) was calculated as follows:-

RC = {(dry matter yield of treated plants) - (dry matter yield of untreated plants) / (dry matter yield of untreated plants)}x 100.

The agronomical efficiency (AE) was calculated according to Sisworo *et al.* (1990) as follows:-

AE = {(dry matter yield of treated plants) - (dry matter yield of untreated plants)}/ added Co (mg L^{-1}).

The data were exposed to statistical analysis according to Gomez and Gomez (1984). The significant differences among means were tested using the least significant differences (L.S.D.) at 5 % level of significant error.

RESULTS AND DISCUSSION

Growth Parameters.

The presented data in Tables (2 and 3) showed the effect of foliar application cobalt rates and two techniques of application (rates, number of applied doses and its temporal application) under two intervals of irrigation on some growth parameters of wheat plants. These data showed that all plant growth parameters under study; plant height, spike length, number of spikes / m^2, spike weight and 1000 - grain weight were increased significantly with the increase rates of added Co. At the same interval of irrigation, the values of all growth parameters of plants treated by Co, in three doses, were higher than those treated in one dose. The greatest effect of cobalt on dry matter accumulation of different plant parts was observed with Co rate of 648 mg Co L^{-1}, applied in three doses treatment. This trend was found under the two intervals of irrigation. These increases indicated that the enhanced effect of Co on plant growth may be resulted due to its important role on some biochemical processes and enzymes activity within plant tissues (Marschner, 2003). These data are in harmony with those obtained by Elbaalawy (2010) and Gad and Kandil (2011). Also, data clarified that performed application of Co in doses was preferred among the beneficial effects of Co to be exist at different growth periods. These findings may be supported by the calculated values of relative changes (RC) as a per cent of the found values of the control treatment for all growth parameters under study (Table, 3). The results revealed that all RC values at different application rates of Co were positive with different growth parameters. These percentage of increases were elevated by increasing the added Co rates, especially in three doses. At the same application rate of Co, the percentage of increases values of each growth parameter in the plants treated by Co, in three doses, were higher than those found in the plants treated by Co, in one dose. In the two techniques of Co application, the highest values of RC were found with spike weight followed by spike length, while the lowest values were found with RC of plant height. This trend reflects the differences among these growth parameters to response for Co application.

Table (2) : Effect of cobalt foliar applications, at different rates and doses under two irrigation intervals on some growth parameters of wheat plants as mean values of two seasons.

Cobalt treatments		Plant height (cm)			Spike length (cm)			No. of spikes / m^2			Spike weight (g)			1000-grain weight (g)		
		Irrigation intervals (days)														
Added rate (mg/L)	Added doses No.	25	40	Mean	25	40	Mean	25	40	Mean	25	40	Mean	25	40	Mean
0	On three doses	101.1	99.1	100.1	18.9	17.8	18.4	615	594	605	2.50	2.05	2.28	31.0	29.0	30.0
81		103.2	102.5	102.9	20.7	18.5	19.6	693	658	676	2.93	2.58	2.76	35.0	33.0	34.0
162		105.6	104.1	104.9	24.4	20.3	22.4	749	689	719	3.74	2.80	3.27	37.0	36.0	36.5
324		108.8	106.2	107.5	27.3	24.1	25.7	785	737	761	3.85	3.18	3.52	37.8	36.5	37.2
648		112.5	109.1	110.8	29.5	26.5	28.0	818	756	787	4.50	3.80	4.15	38.5	37.3	37.9
Mean		106.2	104.2	105.2	24.2	21.5	22.8	732	687	710	3.50	2.88	3.19	35.8	34.4	35.1
0	On one dose	101.1	99.1	100.1	18.9	17.8	18.4	615	594	605	2.50	2.05	2.28	31.0	29.0	30.0
81		102.5	101.4	101.9	19.5	18.1	18.8	678	611	645	2.65	2.53	2.59	33.5	31.0	32.3
162		103.8	102.5	103.2	22.8	21.5	22.2	685	665	675	2.93	2.73	2.83	35.8	32.5	34.2
324		106.8	104.8	105.8	25.1	23.1	24.1	701	677	689	3.31	2.95	3.13	36.6	35.5	36.1
648		108.3	106.1	107.2	27.1	24.9	26.0	749	701	725	3.82	3.41	3.62	37.5	37.0	37.3
Mean		104.5	102.8	103.6	22.7	21.1	21.9	686	650	668	3.04	2.73	2.88	34.9	33.0	33.9
General mean		105.4	103.5	104.4	23.4	21.3	22.4	709	668	689	3.27	2.81	3.04	35.4	33.7	34.5
L.S.D. at level 0.05	Irrigation	1.1			0.3			10			0.12			1.40		
	Rates	0.5			0.5			8			0.11			0.44		
	Doses	1.0			0.3			5			0.09			0.43		
	Irr. x Rates	0.7			0.8			11			0.15			0.81		
	Irr. x Doses	ns			0.5			ns			0.13			ns		
	RatesxDoses	0.7			0.8			11			0.15			0.81		
	Irr. x Ra.xDo.	ns			ns			16			ns			ns		

Table (3): Relative change (RC, %) of some growth parameters of wheat plants as affected by different cobalt foliar applications rates and doses under two irrigation intervals (mean values of two seasons).

Cobalt treatments		Irrigation intervals (days)									
		25					40				
Added rate ($mg\ L^{-1}$)	Added doses No.	Plant height (cm)	Spike length (cm)	No. of spikes / m^2	Spike weight (g)	1000 grain weight (g)	Plant height (cm)	Spike length (cm)	No. of spikes / m^2	Spike weight (g)	1000-grain weight (g)
81	On three doses	2.077	9.524	12.683	17.20	12.903	3.431	3.933	10.774	25.854	13.793
162		4.451	29.101	21.789	29.60	19.355	5.045	14.045	15.993	36.585	24.138
324		7.616	44.444	27.642	54.00	21.935	7.164	35.393	24.074	55.122	25.862
648		11.177	56.085	33.008	80.00	24.194	10.091	48.876	27.273	85.366	28.621
81	On one dose	1.385	3.175	10.244	6.00	8.065	2.321	1.685	2.862	23.415	6.897
162		2.671	20.635	11.382	17.20	15.484	3.431	9.551	11.953	32.195	12.069
324		5.638	32.804	13.984	32.40	18.065	5.752	29.775	13.973	43.902	22.414
648		7.122	43.386	21.789	52.80	20.968	7.064	39.888	18.013	66.341	27.586

In this respect, WenHua *et al.* (2004); Hussain *et al*. (2005) and Elbaalawy (2010) obtained similar results.

Concerning to the effect of irrigation intervals on all studied plant growth parameters, data in Table (2) showed that their were significant differences between 25 days and 40 days intervals. The results in Table (2) illustrated that all studied plant growth parameters were higher at 25 days irrigation intervals than that at 40 days. The enhanced findings, under 25-day interval, may be resulted from the higher amounts of available or soluble nutrients and its uptake by plants associated the high content of available water under 25 days of irrigation interval compared with that of the another one. Also, the high content of available water might be resulted in a decrease of salinity and/or drought stress (Marschener, 2003). These results are in accordance with those obtained by Mahgoub and El-Sayed (2001); Nassar *et al.* (2004) and El-Ashry and El-Kholy (2005).

The listed RC (%) values in Table (3) for the spike weights and 1000- grain weights revealed that, with the same application rate of Co, RC values for the plants irrigated every 40 day were higher than those in the plants irrigated every 25 day. These findings could be explained due to higher efficiency of Co applications under 40 days irrigation interval. Also, it means that Co applications raised plants tolerance for drought stress. In this concern, Li *et al.* (2005) noticed that treatment of potato seedlings with Co alleviated the decline of polyamines content which are bound to cell membrane, under stress, and exert protective effect on leaves from stress damage. Another reason for such results was reported by El-Sheekh *et al.* (2003) who found that Co application was associated by an increase of photosynthetic electron transport. Finally it could be concluded that, Co fertilization may be used to overcome the deficient of available water, where these fertilizer applications were resulted in increasing water use efficiency.

Grain and Straw Yields.

The presented data in Tables (4 and 5) showed the yields of grain and straw of wheat plants and their statistical analysis as affected by different treatments of Co (rates and techniques) and intervals of irrigation. The data showed that both grains and straw yields (kg / plot and kg / fed.) were significantly increased with the increase rate of added Co. The obtained increases in wheat yield treated by Co applied in three doses were markedly higher than that in one dose, where splitting the rates of Co into three doses during the different stages allows the enhancement effect of Co on plant growth to be excised for longer periods. A significant interaction effect between the numbers of applied doses and the rates of Co application was detected. This finding may be clarified from the calculated RC (%) values for both grains and straw yield (Table, 5). These values show that all RC values were positively increased with the increase rates of added Co. And the obtained percentage of grain and straw yield increases with the plants treated by 3-doses Co application were higher than those sprayed by 1-dose only. From these results, it could be concluded that Co fertilization rates should be added in splitted portions. The enhanced effect of Co application, on plant growth and yield productivity may be attributed to its effect on some enzymes activity, nutrients uptake and photosynthetic electron transport (El-Sheekh *et al.,* 2003; Gad, 2006; Kandil, 2007 and Elbaalawy, 2010).

The data of grains and straw yield of wheat plants and their statistical analysis presented in Tables (4 and 5) detected the obtained yields of both grains and straw wheat plants irrigated every 25 days were significantly higher than those produced by the plants irrigated every 40 days. These findings were found with all applied Co rates at the two application techniques. On the other hand, the results showed that, RC (%) values of grain and straw yields of wheat plants irrigated every 25 days were higher than those in the plants irrigated every 40 days. This could be explained due to the differences between the increases percentages of both yields of Co rates of the two intervals did not reach the significance where the highest difference was 2.89 for

Table (4): Effect of cobalt foliar applications, at different rates and doses under two irrigation intervals, on grains and straw yields of wheat plants as well as their relative change (RC,%) (mean of two seasons).

Cobalt treatments		Irrigation intervals (days)															
		25								40							
Added rate (mg L^{-1})	Added doses No.	Grains yield (kg / plot)	Grains yield (kg/ fed.)	Grains yield RC (%)	Straw yield (kg / plot)	Straw yield (kg/ fed.)	Straw yield RC (%)	Biological yield (kg/fed.)	Harvest index (%)	Grains yield (kg / plot)	Grains yield (kg/ fed.)	Grains yield RC (%)	Straw yield (kg / plot)	Straw yield (kg/ fed.)	Straw yield RC (%)	Biological yield (kg/fed.)	Harvest index (%)
Control		6.69	2676	-	8.39	3356	-	6032	44.36	6.54	2616	-	8.19	3276	-	5892	44.40
81	On three doses	7.05	2820	5.38	8.86	3544	5.60	6364	44.31	6.81	2724	4.13	8.50	3400	3.79	6124	44.48
162		7.35	2940	9.87	9.36	3744	11.56	6684	43.99	7.02	2808	7.34	8.97	3588	9.52	6396	43.90
324		7.62	3048	13.90	9.67	3868	15.26	6916	44.07	7.26	2904	11.01	9.28	3712	13.31	6616	43.89
648		7.77	3108	16.14	9.87	3948	17.64	7056	44.05	7.58	3032	15.90	9.56	3824	16.73	6856	44.22
Mean		7.30	2918	11.32	9.23	3692	12.52	6610	44.11	7.04	2816	9.60	8.90	3560	10.84	6376	44.12
81	On one dose	6.87	2748	2.69	8.58	3432	2.26	6180	44.47	6.66	2664	1.83	8.42	3368	2.81	6032	44.16
162		7.11	2844	6.28	8.97	3588	6.91	6432	44.22	6.87	2748	5.05	8.78	3512	7.20	6260	43.90
324		7.31	2924	9.27	9.40	3760	12.04	6684	43.75	7.11	2844	8.72	9.01	3604	10.01	6448	44.11
648		7.53	3012	12.56	9.56	3824	13.95	6836	44.06	7.23	2892	10.55	9.36	3744	14.29	6636	43.58
Mean		7.10	2840	7.70	8.98	3592	8.79	6432	44.13	6.88	2752	6.54	8.75	3500	8.58	6253	43.94
General mean		7.20	2879	9.51	9.11	3642	10.66	6521	44.12	6.96	2784	8.07	8.83	3530	9.71	6314	44.03

Table (5) : L.S.D. at level 0.05 of wheat plants (grains and straw yields) as affected by different cobalt foliar applications rates and doses under two irrigation intervals.

The studied treatments	Grains yield		Straw yield	
	kg / plot	kg / fed.	kg / plot	kg / fed.
Irrigation	0.100	40.0	0.160	64.0
Rates	0.133	53.2	0.070	28.0
Doses	0.123	49.2	0.090	36.0
Irrigation x Rates	ns	ns	ns	ns
Irrigation x Doses	ns	ns	ns	ns
Rates x Doses	0.16	65.0	0.100	40.0
Irrigation x Rates x Doses	ns	ns	ns	ns

ns = not significant

grains and 2.04 for straw. This might be revealed that treatment of wheat plants with Co enabled the plants to tolerate the wider interval of irrigation. In this regard, Hu and Schmidhalter (2005) demonstrated that decreasing soil water content decreases the availability of K the element of an important role in stomatal closure during abiotic stress; like drought and salinity. Cabanero and Carvajal (2007) reported that K starvation in plants favors stimulation of stomatal conductance and promotion of transpiration as well as synthesis of ethylene that counteracts and delays stomatal closure. Benlloch-Gonalez *et al.* (2010) found that treatment of K-starved sunflower plants with 5 μ M $CoSO_4$ inhibited stomatal conductance as those of plants with an adequate K and inhibited synthesis of ethylene. Data of RC (%) in Table (4) revealed that, under all treatments of Co, the increasing percentages of straw yield were higher than those of grain yield. So, it may be concluded that straw of wheat plants have higher responses to Co application than grains. Also, RC values of straw under the two intervals of irrigation were higher than those of grains (Table, 4). This means that, straw yield less affected by the availability of soil water content than grains. In this concern, Ghazanavi and Abdolshahi (2012) indicated that drought stress had the highest impact on grain yield out of the studied traits. These results could be related to the limited translocation of photosynthetase and nutrients to the developing grains as affected by limited availability of water. These results agree with these obtained by Aery and Jagetiya (2000); Elbaalawy (2010) and Aziz (2012).

Data shown in Table (6) illustrated the agronomical efficiency (AE) which indicated the effect of each unit of added Co at the two techniques and, under two intervals of irrigation on plant growth, dry matter accumulation and yield productivity. AE values were varied widely according to plant part and added Co concentrations. The obtained values of AE in the first technique of Co application were higher than those in the second technique, under the two intervals of irrigation. The higher increases of AE were found with plants irrigated every 25 days. Also, these results were in harmony with the tabulated value of RC of dry matter. The results are in a good accordance with those of Tantawy (2004); WenHua *et al.* (2004) and Gad and Kandil (2011).

Table (6): Agronomical efficiency (AE), per mg cobalt, of wheat yield (grains and straw) as affected by different cobalt foliar applications rates and doses under two irrigation intervals.

Cobalt treatments		Irrigation intervals (days)											
		25						40					
Added rate	Added doses	Grains yield		Straw yield		Biological yield	1000 grain weigh	Grains yield		Straw yield		Biological yield	1000 grain weigh
(mg L^{-1})	No.	(g/plot)	(g/fed.)	(g/plot)	(g/fed.)	(g/fed.)	(g)	(g/plot)	(g/fed.)	(g/plot)	(g/fed.)	(g/fed.)	(g)
81	On three doses	4.44	1777.8	5.80	2321.0	4098.8	0.049	3.33	1333.3	3.83	1530.9	2864.2	0.049
162		4.07	1629.6	5.99	2395.1	4024.7	0.037	2.96	1185.2	4.81	1925.9	3111.1	0.043
324		2.87	1148.1	3.95	1580.2	2728.3	0.021	2.22	888.9	3.36	1345.7	2234.6	0.023
648		1.67	666.7	2.28	913.6	1580.3	0.012	1.60	642.0	2.11	845.7	1487.7	0.013
Mean		3.26	1305.6	4.51	1802.5	3108.0	0.030	2.53	1012.4	3.53	1412.1	2424.4	0.032
81	On one dose	2.22	888.9	2.35	938.3	1827.2	0.031	1.48	592.6	2.84	1135.8	1728.4	0.025
162		2.59	1037.0	3.58	1432.1	2469.1	0.030	2.04	814.8	3.64	1456.8	2270.6	0.022
324		1.91	765.4	3.12	1246.9	2012.3	0.017	1.76	703.7	2.53	1012.3	1716.0	0.020
648		1.30	518.5	1.81	722.2	1240.7	0.010	1.06	425.9	1.81	722.2	1148.1	0.012
Mean		2.01	802.5	2.72	1084.9	1887.3	0.022	1.59	634.3	2.71	1081.8	1715.8	0.020
General mean		2.64	1054.1	3.62	1443.7	2497.7	0.026	2.06	823.4	3.12	1247.0	2070.1	0.026

Macronutrients Content of Grain and Straw.

The presented data in Tables (7 to 9) showed concentrations (%) and uptake (kg / fed.) of N, P and K by grains and straw of wheat plants as affected by Co application rates and doses under two intervals of irrigation. These data showed that the contents of N, P and K were increased with the increase of added Co in the two techniques. In grains and straw, contents of N, P and K with Co application rate as three doses were higher than those of one dose. This finding may be attributed to covering almost the different growth periods, in the first technique. In the two techniques of Co application, N and P concentration and uptake by grains were higher than those found with straw, while K appeared reverse this trend. This trend was found with different application rates of Co, under the two intervals of irrigation. At the same application rate of Co under the two irrigation intervals, the content of N, P and K in the grains takes the order of N > K > P, while in the straw this order was: K > N > P. These results are in agreement with these obtained by Basak (2006); Elbaalawy (2010) and El- Dardiry *et al*. (2010). The data in Table (7) also, showed that grain and straw contents of protein (%) takes the same trend of N concentration (%), where it's obtained by multiple the content of N (%) by 5.75 (A.O.A.C., 1990). The increase effect of Co applications on N, P and K uptake could be clear by the calculated values of RC (%) for these macronutrients under the two irrigation intervals as listed in Tables (7 to 9). These tables show that all RC values for N, P and K uptake by both grain and straw were increased with the increase of added Co. The values of RC with Co application in 3-doses technique were higher than those of sole dose. This trend was found with different application rates of Co under the two irrigation intervals. With the same treatment of Co and irrigation period, RC (%) of N and P uptake by straw were higher than those of grains, while K appeared reverse this trend.

Regarding the effect of irrigation intervals on wheat plant (grain and straw) content of N, P and K (% and kg / fed.) as presented in Tables (7 to 9) , it was showed that with the two techniques of Co applications at all application rates, N, P and K concentration and uptake by both grains and straw of wheat plants irrigated every 25 days were higher than those irrigated every 40 days. These findings were resulted from the higher soil content of available water under 25 days treatment compared with that under 40 days one. The increases were varied between grains and straw. These differences may be clear from the calculated values RC (%) for N, P and K uptake by either of grains or straw as recorded in Tables (7 to 9). The RC values of these nutrients uptake by wheat plants with 25 and 40 days intervals of irrigation were positive, but these values were higher with 25-day irrigation treatment compared with the another interval treatment. These findings were in good harmony with those obtained by El-Ashry and El- Kholy (2005); Arif *et al*. (2006) and El- Dardiry *et al.* (2010).

Microelements Content of Grain and Straw.

The presented data in Tables (10 to 14) pointed out that except Fe, both concentration (mg kg^{-1}) and uptake (g / fed.) of Zn, Mn, Cu and Co by grains and straw of wheat plants were increased with the increase of added Co under the two intervals of irrigation. In both grains and straw, the found increases of Zn, Mn, Cu and Co content in wheat plants treated by Co as three doses were higher than those treated by Co as one dose. Also, at the same rate of added Co under the two intervals of irrigation, the concentration (mg kg^{-1}) and uptake (g / fed.) of microelements, under study, in the grains were higher than those in the straw, except Zn where it was reverse this trend. These results are in agreement with those obtained by Arif *et al.* (2006); Basak (2006) and Gad and Kandil (2011). At the same studied treatment, the values of concentration (mg kg^{-1}) and uptake (g/fed.) of microelements, under study, by grains and straw were varied from element to another where these elements may be arranged according to their content of both grains and straw in the following order: Fe > Zn > Mn > Cu > Co.

Table (7) : Nitrogen concentration (%) and uptake (kg/fed.) and their relative changes (RC,%) and protein (%) of wheat plants (grains and straw) as affected by different cobalt foliar applications rates and doses under two irrigation intervals (mean values of two seasons, 2012/2013 and 2013/2014).

Cobalt treatments		Irrigation intervals (days)															
		25								40							
		Grains yield				Straw yield				Grains yield				Straw yield			
Added rate (mg L^{-1})	Added doses No.	Nitrogen			Protein (%)	Nitrogen			Protein (%)	Nitrogen			Protein (%)	Nitrogen			Protein (%)
		Conc. (%)	Uptake (kg/fed.)	RC (%)		Conc. (%)	Uptake (kg/fed.)	RC (%)		Conc. (%)	Uptake (kg/fed.)	RC (%)		Conc. (%)	Uptake (kg/fed.)	RC (%)	
Control		1.28	34.25	--	7.36	0.196	6.58	-	1.13	1.23	32.18	-	7.07	0.190	6.22	-	1.09
81	On three doses	1.42	40.04	16.91	8.17	0.224	7.94	20.67	1.29	1.35	36.77	14.26	7.76	0.215	7.31	17.52	1.24
162		1.50	44.10	28.76	8.63	0.252	9.43	43.31	1.45	1.40	39.31	22.16	8.05	0.240	8.61	38.42	1.38
324		1.56	47.55	38.83	8.97	0.308	11.91	81.00	1.77	1.48	42.98	33.56	8.51	0.272	10.10	62.38	1.56
648		1.60	49.73	45.20	9.20	0.336	13.27	101.67	1.93	1.57	47.60	47.92	9.03	0.298	11.40	83.28	1.71
Mean		1.47	43.14	32.43	8.46	0.263	9.83	61.66	1.51	1.41	39.77	29.48	8.09	0.243	8.73	50.40	1.39
81	On one dose	1.32	36.27	5.90	7.59	0.204	7.00	6.38	1.17	1.28	34.10	5.97	7.36	0.198	6.67	7.23	1.14
162		1.37	38.96	13.75	7.88	0.240	8.61	30.85	1.38	1.36	37.37	16.13	7.82	0.225	7.90	27.01	1.29
324		1.45	42.40	23.80	8.34	0.280	10.53	60.03	1.61	1.40	39.82	23.74	8.05	0.258	9.30	49.52	1.48
648		1.53	46.08	34.54	8.80	0.315	10.05	83.13	1.81	1.46	42.22	31.20	8.40	0.280	10.48	68.49	1.61
Mean		1.39	39.59	19.50	7.99	0.247	8.96	45.10	1.42	1.35	37.14	19.26	7.74	0.230	8.12	38.06	1.32
General mean		1.43	41.37	-	8.23	0.255	9.40	-	1.47	1.38	38.46	-	7.92	0.237	8.43	-	1.36

Table (8) : Phosphorus concentration (%) and uptake (kg / fed.) and their relative changes (RC, %) of wheat plants (grains and straw) as affected by different cobalt foliar applications rates and doses under two Intervals of irrigation (mean values of two seasons, 2012/2013 and 2013/2014).

Cobalt treatments		Irrigation intervals (days)											
		25						40					
Added rate (mg L^{-1})	Added doses	Grains			Straw			Grains			Straw		
		Conc. (%)	Uptake (kg/fed.)	RC (%)	Conc. (%)	Uptake (kg/fed.)	RC (%)	Conc. (%)	Uptake (kg/fed.)	RC (%)	Conc. (%)	Uptake (kg/fed.)	RC (%)
Control		0.325	8.70	-	0.235	7.89	-	0.319	8.35	-	0.227	7.44	-
81	On three doses	0.343	9.67	11.15	0.247	8.75	10.90	0.340	9.26	10.90	0.239	8.13	9.27
162		0.350	10.29	18.28	0.260	9.73	23.32	0.345	9.69	10.05	0.254	9.11	22.45
324		0.360	10.97	26.09	0.264	10.21	29.40	0.352	10.22	22.40	0.258	9.58	28.76
648		0.366	11.38	30.80	0.266	10.50	33.08	0.356	10.79	29.22	0.260	9.94	33.60
Mean		0.349	10.20	21.58	0.254	9.42	24.18	0.342	9.72	19.64	0.248	8.84	23.52
81	On one dose	0.339	9.32	7.13	0.241	8.27	4.82	0.337	8.98	7.54	0.237	7.98	7.26
162		0.344	9.78	12.41	0.250	8.97	13.69	0.340	9.34	11.86	0.247	8.67	16.53
324		0.351	10.26	17.93	0.255	9.59	21.55	0.346	9.84	17.84	0.250	9.01	21.10
648		0.355	10.69	22.87	0.258	9.87	25.10	0.349	10.09	20.84	0.254	9.51	27.82
Mean		0.343	9.75	15.09	0.248	8.92	16.29	0.338	9.32	14.52	0.243	8.52	18.18
General mean		0.346	9.98	-	0.251	9.17	-	0.340	9.52	-	0.246	8.68	-

Table (9): Potassium concentration (%) and uptake (kg / fed.) and their relative changes (RC, %) of wheat plants (grains and straw) as affected by different cobalt foliar applications rates and doses under two irrigation Intervals (mean values of two seasons, 2012/2013 and 2013/2014).

Cobalt treatments		Irrigation intervals (days)											
		25						40					
Added rate (mg L^{-1})	Added doses	Grains			Straw			Grains			Straw		
		Conc. (%)	Uptake (kg/fed.)	RC (%)	Conc. (%)	Uptake (kg/fed.)	RC (%)	Conc. (%)	Uptake (kg/fed.)	RC (%)	Conc. (%)	Uptake (kg/fed.)	RC (%)
Control		0.501	13.41	-	1.850	62.09	-	0.485	12.69	-	1.810	59.30	-
81	On three doses	0.540	15.23	13.57	1.872	66.34	6.84	0.525	14.30	12.69	1.860	63.24	6.64
162		0.570	16.76	24.98	1.885	70.57	13.66	0.558	15.67	23.48	1.872	67.17	13.27
324		0.594	18.11	35.05	1.894	73.26	17.99	0.580	16.84	32.70	1.883	69.90	17.88
648		0.610	18.96	41.39	2.010	79.35	27.80	0.596	18.07	42.40	1.890	72.27	21.87
Mean		0.563	16.50	28.75	1.902	70.32	16.57	0.549	15.51	27.82	1.863	66.38	14.92
81	On one dose	0.530	14.56	8.58	1.861	63.87	2.87	0.520	13.85	9.14	1.857	62.54	5.46
162		0.560	15.93	18.79	1.873	67.20	8.23	0.555	15.25	20.17	1.865	65.50	10.46
324		0.583	17.05	27.14	1.883	70.80	14.03	0.580	16.50	30.02	1.875	67.58	13.96
648		0.595	17.92	33.63	1.891	72.31	16.46	0.590	17.06	34.44	1.885	70.57	19.01
Mean		0.554	15.78	22.04	1.872	67.26	10.40	0.546	15.07	23.44	1.859	65.10	12.22
General mean		0.559	16.14	-	1.887	27.52	-	0.548	15.29	-	1.861	65.74	-

Table (10): Iron concentration (mg / kg) and uptake (g / fed.) and their relative changes (RC, %) of wheat plants (grains and straw) as affected by different cobalt foliar applications rates and doses under two irrigation intervals (mean values of two seasons, 2012/2013 and 2013/2014).

Cobalt treatments		Irrigation intervals (days)											
		25						40					
Added rate (mg L^{-1})	Added doses	Grains			Straw			Grains			Straw		
		Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)
Control		145	388.0	-	58.4	196.0	-	133	347.9	-	51.0	167.1	-
81	On three doses	141	397.6	2.47	52.5	186.1	-5.05	131	356.8	2.56	47.4	161.2	-3.53
162		135	396.9	2.29	41.0	153.5	-21.68	127	356.6	2.50	38.1	136.7	-18.19
324		122	371.9	-4.15	35.4	136.9	-30.15	119	345.6	-0.66	33.3	123.6	-26.03
648		119	369.9	-4.66	31.5	124.4	-36.53	108	327.5	-5.86	29.0	110.9	-33.63
Mean		132.4	384.9	-4.05	43.8	159.4	-23.35	123.6	346.9	-0.37	39.8	139.9	-20.35
81	On one dose	137	376.5	-2.96	45.5	156.2	-20.31	128	341.0	-1.98	44.2	148.9	-10.89
162		130	369.7	-4.72	38.0	136.3	-30.46	120	329.8	-5.20	36.7	128.9	-22.86
324		121	353.8	-8.81	32.5	122.2	-37.65	112	318.5	-8.45	30.5	109.9	-34.23
648		109	328.3	-15.39	30.7	117.4	-40.10	100	289.2	-16.87	27.5	103.0	-38.36
Mean		128.4	363.3	-7.97	41.0	145.6	-32.13	118.6	325.3	-8.13	38.0	131.6	-26.59
General mean		130.4	374.1	-	42.4	152.5	-	121.1	336.1	-	38.9	135.8	

Table (11) : Manganese concentration (mg / kg) and uptake (g / fed.) and their relative changes (RC, %) of wheat plants (grains and straw) as affected by different cobalt foliar applications rates and doses under two intervals of irrigation (mean values of two seasons, 2012/2013 and 2013/2014).

Cobalt treatments		Irrigation intervals (days)											
		25						40					
Added rate ($mg\ L^{-1}$)	Added doses No.	Grains			Straw			Grains			Straw		
		Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)
Control		20.15	53.92	-	11.22	37.65	-	18.85	49.31	-	10.95	35.87	-
81	On three doses	21.65	61.05	13.22	12.50	44.30	17.66	20.95	57.07	15.74	11.45	38.93	8.53
162		25.30	74.38	37.95	14.65	54.85	45.68	23.65	66.41	34.68	12.85	46.11	28.55
324		28.50	86.87	61.11	15.83	61.23	62.63	26.50	76.96	56.07	14.10	52.34	45.92
648		30.75	95.57	77.24	16.50	65.14	73.01	27.92	84.65	71.67	15.63	59.77	66.63
Mean		25.27	74.36	47.38	14.14	52.63	49.75	23.58	66.88	44.54	13.00	46.61	37.41
81	On one dose	20.90	57.43	6.51	11.90	40.84	8.47	20.47	54.53	10.59	11.30	38.06	6.11
162		23.10	65.70	21.85	12.85	46.11	22.47	22.05	60.59	22.88	12.52	43.97	22.58
324		25.17	73.60	36.50	14.15	53.20	41.30	24.25	68.97	39.87	13.78	49.66	38.44
648		26.85	80.87	49.98	15.20	58.12	54.37	25.62	74.09	50.25	14.53	54.40	51.66
Mean		23.24	66.30	28.71	13.07	47.19	31.65	22.25	61.50	30.90	12.61	44.39	29.70
General mean		24.26	70.33	-	13.61	49.91	-	22.92	64.19	-	12.81	45.50	-

Table (12) : Zinc concentration (mg / kg) and uptake (g / fed.) and their relative changes (RC, %) of wheat plants (grains and straw) as affected by different cobalt foliar applications rates and doses under two irrigation intervals (mean values of two seasons, 2012/2013 and 2013/2014).

Cobalt treatments		Irrigation intervals (days)											
		25						40					
Added rate (mg L^{-1})	Added doses No.	Grains			Straw			Grains			Straw		
		Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)
Control		34.2	91.5	-	12.9	43.3	-	29.8	78.0	-	11.5	37.7	-
81	On three doses	38.7	109.2	19.3	42.7	151.3	249.4	38.3	104.3	33.7	45.9	156.1	314.1
162		51.4	151.1	65.1	68.9	258.0	495.8	46.9	131.7	68.8	59.1	212.1	462.6
324		56.0	170.7	86.6	72.7	281.2	549.4	51.7	150.1	92.4	74.5	276.5	633.4
648		68.9	214.1	134.0	99.4	392.4	806.2	60.4	183.1	134.7	93.1	356.0	844.3
Mean		49.8	147.3	76.3	59.3	225.2	525.2	45.2	129.4	82.4	56.8	207.7	563.6
81	On one dose	36.6	100.6	10.0	36.4	124.9	188.5	34.5	91.9	17.8	37.5	126.3	235.0
162		42.8	121.7	33.0	47.1	169.0	290.3	38.7	106.3	36.3	51.5	180.9	379.8
324		51.1	149.4	63.3	69.1	259.8	500.0	42.5	120.9	55.0	70.1	252.6	570.0
648		64.4	194.0	112.0	81.7	312.4	621.5	51.8	149.8	92.1	82.5	308.9	719.4
Mean		45.8	131.4	54.6	49.6	181.9	400.1	39.5	109.4	50.3	50.6	181.3	476.1
General mean		47.8	139.4	-	54.5	203.6	-	42.4	119.4	-	53.7	194.5	-

Table (13) : Copper concentration (mg / kg) and uptake (g / fed.) and their relative change (RC, %) of wheat plants (grains and straw) as affected by different cobalt foliar applications rates and doses under two Intervals of irrigation (mean values of two seasons, 2012/2013 and 2013/2014).

Cobalt treatments		Irrigation intervals (days)											
		25						40					
		Grains			Straw			Grains			Straw		
Added rate ($mg\ L^{-1}$)	Added doses No.	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)
Control		3.50	9.37	-	3.33	11.18	-	3.32	8.69	-	3.00	9.83	-
81	On three doses	8.60	24.25	158.8	7.66	27.15	142.8	6.40	17.43	100.6	4.00	13.60	38.4
162		17.66	51.92	454.1	10.12	37.89	238.9	11.33	31.81	266.1	6.33	22.71	131.0
324		23.66	72.12	669.7	18.33	70.90	534.2	18.67	54.22	523.9	8.33	30.92	214.5
648		30.33	94.27	906.1	27.66	109.20	876.7	23.11	70.07	706.3	14.67	56.10	470.7
Mean		16.75	50.39	547.2	13.42	51.27	448.2	12.57	36.44	399.2	7.26	26.63	213.7
81	On one dose	4.88	13.41	43.1	4.37	15.00	34.2	4.00	10.66	22.7	3.67	12.36	25.7
162		15.66	44.54	375.3	7.84	28.13	151.6	8.67	23.83	174.2	5.00	17.56	78.6
324		22.00	64.33	586.6	11.24	42.26	278.0	13.88	39.47	354.2	5.33	19.21	95.4
648		27.00	81.32	767.9	19.11	73.08	553.7	19.14	55.35	536.9	9.33	34.93	255.3
Mean		14.61	42.59	443.2	9.18	33.93	254.4	9.80	27.60	272.0	5.26	18.78	113.8
General mean		15.68	46.49	-	11.30	42.60	-	11.19	32.02	-	6.26	22.71	-

Table (14) : Cobalt concentration (mg / kg) and uptake (g / fed.) and their relative changes (RC, %) of wheat plants (grains and straw) as affected by different cobalt foliar applications rates and doses under two Intervals of irrigation (mean values of two seasons, 2012/2013 and 2013/2014).

Cobalt treatments		Irrigation intervals (days)											
		25						40					
Added rate ($mg\ L^{-1}$)	Added doses No.	Grains			Straw			Grains			Straw		
		Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)	Conc. (mg / kg)	Uptake (g/fed.)	RC (%)
Control		0.94	2.52	-	0.71	2.38	-	0.78	2.04	-	0.59	1.93	-
81	On three doses	5.20	14.66	481.7	3.45	12.23	413.9	4.31	11.74	475.5	2.06	7.00	262.7
162		7.03	20.67	720.2	4.11	15.39	546.6	5.46	15.33	651.5	3.31	11.88	515.5
324		10.65	32.46	1188.1	5.82	22.51	845.8	7.11	20.65	912.3	4.33	16.07	732.6
648		12.33	38.32	1420.6	7.23	28.54	1099.2	9.89	29.99	1370.1	5.11	19.54	912.4
Mean		7.23	21.73	952.7	4.26	16.21	726.4	5.51	15.95	852.4	3.08	11.28	605.8
81	On one dose	2.88	7.91	213.9	2.33	8.00	236.1	1.78	4.74	132.4	1.05	3.54	83.4
162		5.88	16.72	563.5	3.35	12.02	405.0	3.50	9.62	371.6	2.50	8.78	354.9
324		7.71	22.54	794.4	4.45	16.73	602.9	5.41	15.39	654.4	3.13	11.28	484.5
648		9.12	27.47	990.1	5.96	22.79	857.6	6.02	17.41	753.4	4.10	15.35	695.3
Mean		5.31	15.43	640.5	3.36	12.39	525.4	3.53	9.84	478.0	2.27	8.18	404.5
General mean		6.27	18.58	-	3.81	14.30	-	4.52	12.90	-	2.68	9.73	-

Regarding the data of RC (%) of the determined microelements uptake by grains and straw of wheat plants as recorded in Tables (10 to 14) may be concluded that, except RC values of Fe uptake, all RC values for the other microelements uptake by either of grains and straw were increased with increasing of added Co in the two used application techniques under the two intervals of irrigation. At the same application rate of Co, RC (%) of microelements uptake by grains and straw of wheat plants treated by Co on three doses were higher than those on one dose; under the two irrigation intervals. The calculated RC (%) values were the highest with Co and the lowest with Fe.

The presented data in Tables (10 to 14) also, showed that Fe, Zn. Mn, Cu and Co concentration and uptake as well as the RC values of their uptake by grains and straw of wheat plants irrigated every 25 days were higher than those irrigated every 40 days. These findings were in harmony with the soil content of available water and its effect on nutrients solubility and uptake by plants.

Conclusion

From the previously obtained results it could be suggested that cobalt is considered a beneficial element for wheat. It stimulated the growth of plants, increased grains and straw yields and enhanced the quality of the grains by heightened their nutrients status; macronutrients N, P, and K and microelements Fe, Zn, Mn, Cu and Co. Also, it assisted wheat plant to tolerate drought condition.

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تأثير إضافات الكوبلت علي محصول و مكونات القمح النامي تحت فترتين من الري

زينب محمود خليل ، منال فتحي طنطاوي ، محمد عبد الفتاح حسن محمد
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الملخص العربي

أجريت تجربة حقلية علي أرض طينية بمحطة الجميزة للبحوث الزراعية - محافظة الغربية بمنطقة وسط دلتا النيل - مصر و ذلك خلال موسمي نمو شتويين متتاليين لعامي 2012 / 2013 و 2013 / 2014 م، لدراسة تأثير المستويات المختلفة لإضافة الكوبلت رشاً (صفر, 81, 162, 324 و 648 ملليجرام كوبلت / لتر) في صورة خلات كوبلت و توقيت إضافتها (علي ثلاث دفع متساوية عند أطوار البادرة و التفريع و طرد السنابل أو علي دفعة واحدة عند طور التفريع للنبات) علي النمو و المحصول و التركيب الكيميائي لنباتات القمح صنف جميزة 11 و ذلك تحت تأثير فترتيين من الري (25 و 40 يوماً). و كان حجم محلول الرش لكل معدل إضافة هو 400 لتر / فدان. و أجريت التجربة في تصميم قطع منشقة مرتين بثلاث مكررات.

و أوضحت النتائج ما يلي:

- وجود زيادة معنوية في كل مقاييس النمو و المتمثلة في : طول النبات (سم) - طول السنبلة (سم) - عدد السنابل لكل م^2 - وزن 1000 حبة (جم) - محصول الحبوب و القش علي مستوي الوحدة التجريبية أو الفدان و أيضاً المحصول الكلي (كجم / فدان) و ذلك بزيادة المضاف من الكوبلت، وكانت هذه الزيادة أكثر وضوحاً في معاملة إضافة الكوبلت علي ثلاثة دفعات متساوية و عند الري كل 25 يوماً.
- و قد بين التحليل الإحصائي للنتائج عدم وجود معنوية للتأثير المشترك للمعاملات تحت الدراسة و هي متحدة (فترات الري - مستويات إضافة الكوبلت - عدد دفعات الكوبلت و توقيت إضافتها) علي مقاييس النمو و محصولي الحبوب و القش. بينما أوضح أن معظم التفاعلات الثنائية لها تأثير معنوي علي صفات النمو , و أيضاً كان التفاعل بين المستويات المختلفة لإضافة الكوبلت و عدد دفعات إضافته ذو تأثير معنوي علي كل من محصولي الحبوب و القش.
- إزداد التركيز (٪) وكذلك الممتص (كجم/فدان) من عناصر النيتروجين و الفوسفور و البوتاسيوم و البروتين (٪) في كل من الحبوب و القش بزيادة المضاف من الكوبلت و كانت هذه الزيادة أكثر وضوحاً مع إضافة الكوبلت علي ثلاث دفعات متساوية و عند الري كل 25 يوماً. كما كان التركيز (٪) و الممتص (كجم / فدان) لكل من عنصري النيتروجين و الفوسفور في الحبوب أكبر من القش بينما أخذ عنصر البوتاسيوم عكس هذا الإتجاه.
- و بالنسبة للعناصر الصغري , فقد وجد زيادة في التركيز (ملليجم/كجم) و أيضاً الممتص (جم / فدان) لكل من عناصر المنجنيز- الزنك - النحاس - الكوبلت في كل من الحبوب و القش بزيادة المضاف من الكوبلت و خصوصاً عند إضافته علي ثلاث دفعات متساوية و الري كل 25 يوماً , بينما أخذ عنصر الحديد عكس هذا الإتجاه و هذا يوضح علاقة التضاد بين عنصري الحديد و الكوبلت. و قد أخذت العناصر الصغري التي تحت

الدراسة في كل من الحبوب و القش هذا الإتجاه: الحديد > الزنك > المنجنيز > النحاس > الكوبلت. كما إتضح أيضاً أن تركيز هذه العناصر الصغري كان في الحبوب أكبر من القش ما عدا عنصر الزنك الذي أخذ عكس هذا الإتجاه.

- و أخيراً أوضحت نتائج الدراسة التأثير الإيجابي لفترات الري و إضافات الكوبلت علي جميع قياسات نمو النباتات. و علي ضوء النتائج السابقة يمكن القول بأن ري نباتات القمح كل 25 يوماً مع إضافة الكوبلت رشاً بمعدل إضافة 648 ملليجرام كوبلت / لتر علي ثلاث دفعات متساوية (عند أطوار البادرة و التفريع و طرد السنابل) أدي إلي زيادة محصول القمح و تحسين قياسات الجودة و محتواه من العناصر الغذائية.