Effect of Molybdenum, Phosphorus and Sulfur on Yield and Elements Content in Leaves of Wheat Grown in Saline Soil

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ABSTRACT: The objective of this work was to investigate the effect of molybdenum, phosphorus and sulfur on the growth and elements content in wheat (*Triticum aestivum L*) grown under saline soil conditions. To achieve this work, a field experiment was conducted at the experimental research station of Faculty of Agriculture, Saba Basha, Alexandria University. Four rates of molybdenum (0, 50, 100, and 200 g Mo /fed.), four phosphorus rates (0, 7.5, 15 and 22.5 kg P/fed.) and four sulphur rates (0, 50, 100 and 200 kg S/fed) were applied in a split split plot design with three replicates. Molybdenum, phosphorus and sulphur significantly improved grain yield of wheat. The highest grain yield (1.91 ton/ fed) was obtained with application of 200 kg S/ fed, 22.5 kg P/fed and 100 g Mo/fed rates. The contents of N, P, K, and S in wheat leaves were also increased due to phosphorus and sulphur application rates, but Mo concentration in the leaves was depressed due to sulphur application and increased with phosphorus and molybdenum applications.
Key words: salinity, sulphur, phosphorus, molybdenum, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L) is the main food crop in Egypt. Because of the great gap between the consumption and production, Egypt imports above five million tons of wheat grains (USDA, 2013). Salinity is the major abiotic stress that reduces plant growth and crop productivity worldwide (Tiwari *et al.,* 2010). Salinity has inhibitory effect on wheat phonological aspects such as leaf number, leaf rate expansion and total dry matter yield (El-hendawy *et al*., 2005).

Sulphur is one of the essential nutrients for plant growth (Ali *et al*., 2008). It is a building block of protein and a key ingredient in the formation of chlorophyll (Jamal *et al.,* 2009). The grain protein in wheat being low when S is deficient, the vegetative symptoms of S deficiency are stunting, yellowing of the whole plant and severe yellowing of the younger leaves when S deficiency is persistent (Wurst *et al.,* 2010). Sulfur deficient plants have also less resistance under stress conditions (Doberman and Fairhurst, 2000). Its fertilization is a feasible technique to suppress the uptake of excess Na and Cl because of the antagonistic relationship (Zhang *et at*., 1999).

Phosphorus is the second most important macronutrient next to nitrogen in limiting crop growth, this nutrient is involved in an array of process in plants such as photosynthesis, energy generation (ATP) , nucleic acid biosynthesis and as an integral component of several plant structures such as phospholipids (Vance *et al*., 2003). It is suggested that proper P fertilization under saline condition would be useful to increase yield of some plant species by minimizing the adverse effect of salinity (Aslam and Qureshi, 1998).

Molybdenum is essential for most organisms and occurs in more than 60 enzymes catalyzing diverse oxidation-reduction reactions in plant metabolism (Zimmer and Mendel, 1999). Because of its involvement in the nitrate assimilation, nitrogen fixation process, and transport of nitrogen compounds in plants, molybdenum plays a crucial role in nitrogen metabolism in plants (Li *et al*., 2013). Wu *et al*. (2014) indicated that Mo application significantly enhanced chlorophyll, dry matter, and grain yield in wheat. Availability of Mo to plants is influenced by soil parameters like pH, organic matter, and clay content. (Behera *et al*., 2011).

The present study was undertaken to investigate the effect of sulphur, phosphorus and molybdenum on the growth and elements contents in leaves of wheat grown in saline soil.

MATRIAL AND METHODS

A field experiment was conducted at the Experimental Research Station, Faculty of agriculture, Saba Basha, Alexandria University during the season of 2014/2015 (18 /11/2014). Wheat cultivar (Triticum aestivum, L), Giza 89 was used in this study as a test crop. Treatments were arranged using the split split plot design with three replicates. The experimental plot area was 2 x 3 meters and the experiment included 64 treatments. The main plot contained sulphur (0, 50, 100 and 200 kg/fed) which added before planting.

The sub plots contained phosphorus (0, 7.5, 15 and 22.5 kg P/fed) which added also before planting as calcium superphosphate fertilizer 15.5% P_2O_5. The sub sub plots contained molybdenum (0, 50, 100 and 200 g Mo/fad) which added after planting and before expulsion of spikes as ammonium molybdate.

The recommended dose of nitrogen (73.6 kg N/fad) was applied as urea fertilizer (46% N) after planting to the soil. The wheat grain yield was recorded at the time of harvesting (30/4/2015) and samples of plant leaves were collected at stage of expulsion of spikes.

Table (1). Some physical and chemical properties of the experimental soil

Soil properties	Results
Particle size distribution	
Clay %	43.40
Silt %	42.30
Sand %	14.30
Soil texture	Clay loam soil
Chemical properties:	
pH (1:2.5)	8.32
EC (1:1water extract), dS/m	3.65
Organic matter %	0.60
1) Soluble cations (1: 1) (meq/L):	
Ca^{++}	8.60
Mg^{++}	6.50
Na^{++}	18.88
K^{+}	1.70
Soluble anions (1: 1) (meq/L):	
HCO_3^{-}	7.60
Cl^{-}	23.20
SO_4^{--}	7.42
SAR	6.87
Available nutrients(mg/kg soil) :	
Available N	150
Available P	12.5
Available K	275
Available Mo	0.35
Available S	44.9

The plant samples (leaves) were washed by tap water then by distilled water and oven dried at 65℃ for 48 hours and grinded using a stainless steel mill. Ground plant samples powder divided into two portions, the first portion was wet digested with H_2SO_4- H_2O_2 digest (Lowther, 1980) for measuring potassium by flame photometer (Jackson, 1973), nitrogen, phosphorus by spectrophotometry (Jackson, 1973) and molybdenum using thiocyanate and thioglycollic acid (Mir *et al.*, 2012) The second portion was digested with HNO_3-H_2O_2 (Zheljazkov and Nielson, 1996) to determine sulphur as described by Jackson (1973).The main physical and chemical properties of the experimental soil are presented in Table (1) and the soil was saline in nature. The analysis of soil was carried out according to the methods outlined by Black (1965), The obtained results were statistically analyzed according to the analysis of variance technique and the multiple regression equations were calculated using costat software (CoHort softwere 1995).

RESULTS AND DISCUSSION

Grain yield

Data in Table (2) showed that the grain yield (ton/fed) was significantly affected by S, P and Mo application rates. Table (3) revealed that increasing S rates from 0 to 200 kg/fed significantly and progressively increased the grain yield as compared with the control treatment. The highest grain yield (1.82 ton fed) was obtained with the application of 200 kg S/fed which is 14.5 % higher than the control treatment. Similar results have been reported by El-Badawy *et al*. (2011). This is most probably due to healthy soil environment for plant growth (Ali *et al*., 2012). The main action of S is minimizing the soil pH and this will minimize the possibility of NH_3 loss by volatilization or the accumulation of nitrite and consequently the gaseous loss of N due to its presence (Nasseem and Nasrallah, 1981).Table (3) showed that grain yield of wheat increased gradually as the application of P increased. It is increased by 1.17, 1.75 and 1.34% for rated of 7.5, 15 and 22.5 kg P/fed, respectively, relative to the control treatment. The positive effect of P most probably due to modification of root architecture, development of large root system, longer root hairs and thinner roots and improved the ability of plant to produce higher dry matter yield (Balemi and Negisho, 2012; Haling *et al*., 2013 and Paez-Garcia *et al*., 2015). Addition of P not only helped for overcoming P deficiently but also improved the restricted root growth under saline condition (Feigin, 1985).

Table (2). Wheat yield (ton/fed) as affected by sulphur, phosphorus, and molybdenum application rates

Treatments		**Molybdenum, g/fed**			
Sulphur kg/fed	**Phosphorus kg/fed**	**0**	**50**	**100**	**200**
0	0	1.57	1.58	1.61	1.59
	7.5	1.57	1.59	1.61	1.59
	15.0	1.57	1.59	1.62	1.60
	22.5	1.57	1.59	1.62	1.60
50	0	1.69	1.71	1.73	1.70
	7.5	1.70	1.71	1.74	1.71
	15.0	1.69	1.71	1.74	1.71
	22.5	1.70	1.71	1.74	1.72
100	0	1.75	1.76	1.78	1.75
	7.5	1.75	1.76	1.79	1.76
	15.0	1.75	1.77	1.79	1.77
	22.5	1.75	1.76	1.79	1.76
200	0	1.81	1.82	1.84	1.80
	7.5	1.81	1.83	1.85	1.82
	15.0	1.81	1.83	1.85	1.82
	22.5	1.81	1.83	1.91	1.81
LSD (0.05)					
Sulphur		0.005			
Phosphorus		0.004			
Molybdenum		0.004			
sulphur* phosphorus		0.007			
sulphur* molybdenum		0.008			
phosphorus * molybdenum		0.009			
Sulphur* phosphorus* molybdenum		0.017			

Application of molybdenum (Table 3) produced higher values of grain yield (2.35, 3.35 and 1.2%) at 50,100 and 200 g Mo/fed rates, respectively, as compared with control. The highest value of grain yield (1.84 ton/fed) was obtained at 100 g Mo/fed rate. Molybdenum occurs in several enzymes catalyzing diverse oxidation – reduction reaction in plants (Mengel and Kirkby, 2001). Because of its involvement in the nitrate assimilation, nitrogen fixation process, and transport of nitrogen compounds in wheat plants, molybdenum plays a crucial role in nitrogen metabolism in plants (Li *et al*., 2013). The effect of molybdenum on increasing plant yield is often related to increasing the ability of the plant to utilize nitrogen (Biscaro *et al*, 2011).

Table (3). The grain yield of wheat plants as affected by sulphur, phosphorus and molybdenum application rates

Treatments	Yield Ton / fed
Sulphur rate, kg / fed	
0	1.59
50	1.72
100	1.78
200	1.82
$LSD_{0.05}$	0.005
Phosphorus rate, kg/fed	
0	1.71
7.5	1.73
15.0	1.74
22.5	1.75
$LSD_{0.05}$	0.004
Molybdenum rate, g/fed	
0	1.70
50	1.74
100	1.76
200	1.73
$LSD_{0.05}$	0.004

Table 4 indicated a significant interaction effect between sulphur and phosphorus rates on grain yield. The highest value of grain yield was obtained with applying 200 kg S/fed and 22.5 kg P/fed rates. The synergistic effect of P and S may be due to utilization of high quantities of nutrients through the development of root system which resulted in better growth and grain yield. Similar results were reported by Yadav (2011) for wheat. Also, the interaction between sulphur and molybdenum had significant effect on grain yield of wheat. The highest yield was obtained at 200 kg S/fed with 100 g Mo/fed rates (Table 5). Application of S fertilizer is a feasible technique to suppress the uptake of Na and Cl due to the antagonistic relationship. Thus its application is useful to improve soil conditions for healthy crop growth (Zhang *et al*., 1999). The interaction effect between phosphorus and molybdenum on grain yield of wheat was significant and the highest value of grain yield was obtained with 22.5 kg P/fed and 100 g Mo /fed rates (Table 6). According to Modi (2002), both Mo and P increased seed protein content and seed yield in wheat. The second order interaction between sulphur, phosphorus and molybdenum rates had significant effect on grain yield of wheat. The highest value of grain yield of wheat was obtained with 200 kg S/fed and 22.5 kg P/fed and 100 g Mo/fed application rates.

Table (4). The interaction between sulphur and phosphorus application rates on wheat grain yield

Sulphur kg/fed	Phosphorus kg/fed	Grain Yield Ton/fed
0	0	1.58
	7.5	1.71
	15.0	1.76
	22.5	1.82
50	0	1.58
	7.5	1.72
	15.0	1.78
	22.5	1.84
100	0	1.59
	7.5	1.72
	15.0	1.79
	22.5	1.85
200	0	1.59
	7.5	1.73
	15.0	1.79
	22.5	1.87
$LSD_{0.05}$		0.029

Table (5). The interaction between sulphur and molybdenum application rates on wheat grain yield

Sulphur kg/fed	Molybdenum g/fed	Grain Yield Ton/fed
0	0	1.56
	50	1.58
	100	1.61
	200	1.59
50	0	1.70
	50	1.72
	100	1.74
	200	1.72
100	0	1.76
	50	1.78
	100	1.80
	200	1.77
200	0	1.83
	50	1.84
	100	1.88
	200	1.83
$LSD_{0.05}$		0.008

Table (6). The interaction between phosphorus and molybdenum application rates on wheat grain yield

Phosphorus kg/fed	Molybdenum g/fed	Grain Yield Ton/fed
0	0	1.70
	50	1.72
	100	1.74
	200	1.71
7.5	0	1.72
	50	1.73
	100	1.76
	200	1.73
15.0	0	1.72
	50	1.73
	100	1.76
	200	1.73
22.5	0	1.72
	50	1.74
	100	1.77
	200	1.74
$LSD_{0.05}$		0.009

Considering the three variables (S, P and Mo), the grain yield (Y) was regressed against sulphur rate (X_1), phosphorus rate (X_2) and molybdenum rate (X_3). The regression equation for this relationship was:

$$\mathbf{Y= 1.61+1.1\times10^{-3}X_1 + 4.7\times10^{-4} X_2+ 6.6\times10^{-5}X_3}$$

$$\mathbf{R^2= 0.854 \qquad P< 0.01}$$

The comparison of slopes of each variable in the equation (1.1×10^{-3}: 4.7×10^{-4}: 6.6×10^{-5}) gives a quantitative estimate for the efficiency of one variable to the other. Thus the efficiency of sulphur, phosphorus and molybdenum levels would be equal to (1:0.42:0.06). The comparison of the b values of S, P and Mo indicated that efficiency of S for increasing grain yields was the higher followed by the efficiency of the other two.

Elements content in leaves

Table (7) showed that increasing sulphur rates from 0 to 200 kg S/fed progressively and significantly increased N, P, K and S concentrations but decreased Mo concentration in wheat plant leaves. The main effect of sulphur (Table 8) showed increaseed nitrogen by about 1.15, 3.04 and 5.19% and phosphorus increased by about 1.09, 8.33 and 18.75%, respectively over the control (without sulphur) with the application of 50, 100 and 200 kg S/fed, respectively. The corresponding relative values for potassium and sulphur concentrations were 10.64, 14.48, 21.48 and 9.17, 36.69, 49.54 % respectively. On the other hand, the relative decrease in molybdenum concentration was 13.6, 24.82 and 31.20% with application of 50, 100 and 200 kg S /fed, respectively as compared with the control treatment. The addition of sulphur decreased the concentration of Mo, showing the antagonistic relationship.

The biochemical oxidation of S produces H_2SO_4 which acts for relatively lower decrease of soil pH. This improves soil conditions for more favorable plants growth due to increasing the availability of plant nutrients (Motior *et al.*, 2011). Xie *et al.* (2004) found that the sulphur fertilizer application increased N, P, K concentrations in plant and the requirements for sulphur are closely linked to nitrogen availability. Similar results were also reported by Kumar *et al.* (2012) for rice and wheat. On the other hand, plants take up molybdenum as the molybdate ion (MoO_4^{-2}) which causes antagonism with high levels of sulfate ions (Schulte and Kelling, 1992).

Table (8) showed increases relative values of 261.1, 694.4 and 983.3% for P; 1.87, 4.56 and 7.40 % for K; 3.84, 5.38 and 8.46 % for S, 1.63, 2.78 and 3.27 % for N; 11.29, 15.61 and 19.60 % for Mo with the application of 0, 7.5, 15 and 22.5 kg P/fed, respectively as compared with the control treatment. The highest values of N, P, K, S and Mo concentration were obtained with application of 22.5 kg P/fed. Haling *et al.* (2013) stated that increasing P levels significantly increased macronutrients and micronutrients in two common bean varieties. Similar results were observed by Sharma *et al.* (2012) who reported that increasing levels of phosphorus increased the uptake of N, P, and K in wheat plants. Barshad (1951) reported that a complex phosphomolybdate anion, more readily absorbed and translocated than the MoO_4^{-2} alone, the synergistic effects exist between Mo and P application, so that formation of anionic complexes between P and Mo (which are more likely to be absorbed by plant roots) could be accounted for such effects. Also, high availability of P and Mo ions can be due to ligand exchange mechanism (Zakikhani *et al.,* 2014). Similar results were reported by Modi (2002) in wheat.

Table (8) showed that only Mo concentration in leaves of wheat plants was significantly affected by molybdenum application. The main effect of molybdenum rates showed increasing in Mo concentrations in leaves of wheat plants as compared with control treatment. The highest values of Mo were obtained at 200 g Mo/fed rate. According to the obtained results, Mo has no significant effect on P content in wheat leaves under the experimental conditions. This effect may be due to the presence of available S (Modi, 2002). In contrast, other researcher reported that application of Mo decreased P in mustard due to hindering P enzyme activity such as phosphatase (Chatterjee *et al.*, 1985). Table (9) showed that the highest concentration values of N, P, K and S were obtained at 200 kg S/fed and 22.5 kg P/fed application rates. Also, the highest Mo concentration was obtained without sulphur and 15 kg P/fed application rates. The lowest Mo concentration was obtained with 200 kg S/fed and 22.5 kg P/fed application rates (Table 9). Yadav, (2011) discussed the synergistic effect of phosphorus and sulphur on N, P and S concentration of cluster beam. The interaction effect between sulphur and molybdenum application rates on Mo concentrations showed that the highest molybdenum concentration was obtained without sulphur and 200 g Mo/fed and the lowest value of Mo was obtained at 200 kg S/fed without Mo application (Table 10).

The interaction effect between phosphorus and molybdenum rates showed that the highest value of molybdenum concentration was obtained with 22.5 P/fed and 200 g Mo/fed rates, while the lowest value was obtained without phosphorus and molybdenum applications (Table 11). The second order interaction between sulphur, phosphorus and molybdenum rates on molybdenum concentration (Table 7) showed that the highest value of molybdenum concentration was obtained without sulphur, 22.5 kg P/fed and 200 g Mo/fed rates, while the lowest value was obtained with 200 kg S/fed, 7.5 P/fed and without molybdenum application.

Table (7). Effect of sulphur, phosphorus and molybdenum application rates on elements contents in wheat leaves

Treatments			N	P	K	S	Mo mg/kg (d.m.)
Sulphur kg/fed	Phosphorus kg/fed	Mo g/fed	g/kg, (d.m.)				
0	0	0	12.05	0.16	19.33	1.04	0.70
		50	11.95	0.16	19.29	1.04	12.10
		100	11.91	0.16	19.57	1.04	4.10
		200	12.05	0.16	19.06	1.04	7.90
	7.5	0	12.07	0.60	18.93	1.03	0.77
		50	12.03	0.63	19.53	1.03	2.30
		100	12.10	0.59	18.99	1.03	4.43
		200	12.08	0.60	18.97	1.03	8.23
	15.0	0	12.23	1.26	19.27	1.13	0.89
		50	12.23	1.25	19.26	1.13	2.49
		100	12.22	1.25	19.24	1.13	4.66
		200	12.21	1.21	19.23	1.13	8.87
	22.5	0	12.31	1.79	19.42	1.15	0.92
		50	12.31	1.83	19.42	1.16	2.73
		100	12.31	1.92	19.43	1.26	5.07
		200	12.33	1.87	19.47	1.16	9.07
50	0	0	12.11	0.17	20.55	1.14	0.50
		50	12.13	0.17	20.67	1.14	1.77
		100	12.11	0.17	20.72	1.15	3.60
		200	12.09	0.17	20.59	1.14	7.10
	7.5	0	12.20	0.58	21.03	1.13	0.60
		50	12.20	0.63	21.07	1.13	2.00
		100	12.26	0.62	21.19	1.14	3.92
		200	12.27	0.60	21.07	1.13	7.13
	15.0	0	12.41	1.32	21.63	1.24	0.63
		50	12.40	1.25	21.72	1.24	1.99
		100	12.37	1.25	21.57	1.24	4.07
		200	12.42	1.25	21.69	1.24	7.20
	22.5	0	12.42	1.82	21.96	1.27	0.79
		50	12.44	1.83	22.00	1.27	2.11
		100	12.43	1.86	21.84	1.27	4.43
		200	12.45	1.89	21.94	1.28	8.33

Table (7). Continue.

Sulphur kg/fad	Phosphorus kg/fad	Mo g/fad	N	P	K	S	Mo mg/kg (d.m.)
			g/kg,(d.m.)				
100	0	0	12.27	0.18	21.04	1.38	0.40
		50	12.27	0.19	20.94	1.38	1.48
		100	12.28	0.19	20.99	1.39	2.90
		200	12.30	0.18	21.06	1.37	6.40
	7.5	0	12.57	0.65	21.95	1.60	0.45
		50	12.57	0.69	21.82	1.59	1.72
		100	12.54	0.66	21.84	1.59	3.63
		200	12.58	0.63	22.01	1.58	6.63
	15.0	0	12.65	1.32	22.40	1.49	0.46
		50	12.67	1.38	22.48	1.49	1.73
		100	12.66	1.32	22.49	1.50	3.83
		200	12.68	1.30	22.53	1.50	6.90
	22.5	0	12.57	2.03	22.78	1.53	0.55
		50	12.59	2.03	22.88	1.53	1.79
		100	12.60	2.03	23.00	1.53	3.49
		200	12.61	2.01	22.92	1.53	6.74
200	0	0	12.40	0.21	22.28	1.67	20.3
		50	12.38	0.20	22.28	1.67	1.35
		100	12.38	0.22	22.27	1.67	2.70
		200	12.40	0.19	22.19	1.67	4.86
	7.5	0	12.78	0.72	22.59	1.66	0.34
		50	12.77	0.76	22.74	1.65	1.56
		100	12.75	0.72	22.61	1.65	3.55
		200	12.80	0.72	22.73	1.66	6.47
	15.0	0	12.91	1.55	23.69	1.58	0.42
		50	12.89	1.51	23.65	1.59	1.68
		100	12.88	1.55	23.49	1.59	3.49
		200	12.95	1.53	23.70	1.59	6.44
	22.5	0	13.06	2.14	25.12	1.63	0.47
		50	13.08	2.10	25.07	1.62	1.63
		100	13.10	2.06	25.13	1.63	3.20
		200	13.09	2.08	25.15	1.63	6.38
LSD (0.05)							
Sulphur			0.09	0.04	0.24	0.011	0.09
Phosphorus			0.08	0.03	0.19	0.010	0.07
Molybdenum			NS	NS	NS	NS	0.09
sulphur* phosphorus			0.15	0.06	0.36	0.02	0.14
sulphur* molybdenum			NS	NS	NS	NS	0.18
phosphorus*molybdenum			NS	NS	NS	NS	0.19
Sulphur*phosphorus* molybdenum			NS	NS	NS	NS	0.37

Table (8). The main effects of sulphur, phosphorus and molybdenum application rates on elements contents in wheat leaves

Treatments	N	P	K	S	Mo
	g/kg, (d.m)				mg/kg,(d.m)
Sulphur rate, kg / fed					
0		0.96	19.27	1.09	4.07
50	12.29	0.97	21.32	1.19	3.51
100	12.52	1.04	22.06	1.49	3.06
200	12.78	1.14	23.41	1.63	2.80
LSD $_{0.05}$	0.09	0.04	0.24	0.01	0.09
Phosphorus rate, kg/fed					
0	12.20	0.18	20.80	1.30	3.01
7.5	12.40	0.65	21.19	1.35	3.35
15.0	12.54	1.43	21.75	1.37	3.48
22.5	12.60	1.95	22.34	1.41	3.60
LSD $_{0.05}$	0.08	0.03	0.19	0.010	0.07
Molybdenum rate, g/fed					
0	12.43	1.03	21.49	1.35	0.57
50	12.43	1.03	21.55	1.35	1.90
100	12.43	1.03	21.52	1.36	3.81
200	12.45	1.02	21.51	1.35	7.16
LSD $_{0.05}$	NS	NS	NS	NS	0.09

Table (9). The interaction between sulphur and phosphorus application rates on elements contents in wheat leaves

Sulphur, kg/fed	Phosphorus, Kg/fed	N	P	K	S	Mo
		g/kg,(d.m)				mg/kg,(d.m)
0	0	11.98	0.16	19.31	1.03	3.70
	7.5	12.06	0.6	19.11	1.04	3.93
	15.0	12.22	1.24	19.24	1.12	4.22
	22.5	12.31	1.85	12.43	1.18	4.44
50	0	12.11	0.16	20.63	1.13	3.24
	7.5	12.23	0.6	21.08	1.14	3.41
	15.0	12.39	1.26	21.65	1.24	3.47
	22.5	12.43	1.85	21.93	1.27	3.91
100	0	12.27	0.18	21.01	1.38	2.79
	7.5	12.56	0.65	21.91	1.49	3.10
	15.0	12.66	1.32	22.47	1.53	3.23
	22.5	12.59	2.02	22.89	1.59	3.14
200	0	12.39	0.2	22.25	1.59	2.30
	7.5	12.77	0.72	22.66	1.63	2.97
	15.0	12.91	1.5	23.63	1.65	3.00
	22.5	13.08	2.09	25.11	1.67	2.92
LSD $_{0.05}$		0.15	0.06	0.36	0.02	0.14

Table (10). The interaction between sulphur and molybdenum application rates on molybdenum concentration in leaves of wheat leaves

Sulphur, kg/fed	Molybdenum, g/fed	Mo, mg/kg d.m.
0	0	0.81
	50	2.40
	100	4.56
	200	8.51
50	0	0.63
	50	1.96
	100	4.00
	200	7.44
100	0	0.46
	50	1.68
	100	3.46
	200	6.66
200	0	0.38
	50	1.55
	100	3.23
	200	6.03
$LSD_{0.05}$		0.18

Table (11). The interaction between phosphorus and molybdenum application rates on molybdenum concentration in leaves of wheat leaves

Phosphorus, kg/fed	Molybdenum, g/fed	Mo, mg/kg d.m.
0	0	0.47
	50	1.67
	100	3.32
	200	6.56
7.5	0	0.53
	50	1.89
	100	3.88
	200	7.11
15.0	0	0.60
	50	1.97
	100	4.01
	200	7.35
22.5	0	0.68
	50	2.06
	100	4.04
	200	7.63
$LSD_{0.05}$		0.19

The results showed highly significant positive correlation (0.01 probability) between grain yield and the content of nitrogen (r = 0.756), phosphorus (r =0.837), potassium (r =0.855), sulphur (0.837) and molybdenum (r = 0.755). This indicates that the presence of significantly higher potassium contents is due to sulphur application (Table 8) which helps plants to attain more potassium to avoid sodium uptake. This has been considered an added advantage to alleviate salinity apart from enhancing soil fertility and physical properties. The obtained results indicate that application of sulphur combats salinity by enhanced uptake of potassium.

CONCLUSIONS

Salinity is a major abiotic stress factor affecting plant growth and productivity worldwide. Plants develop several mechanisms to induce tolerance to overcome salinity effects. Of the several possible mechanisms to reduce the effect of salinity stress is management of mineral nutrients status of plant can be the efficient defense system. Sulphur, phosphorus and molybdenum applications caused increase in yield and N, P, K, S and Mo in wheat. Sulphur at 200 kg/fed, 22.5 kg P/fed and 100 g Mo/fed rates were efficient as compared to other treatments for grain yield of wheat under the saline soil condition. The application of sulphur helped in the utilization of added phosphorus, but appeared to depress molybdenum utilization showing and antagonistic relationship and when phosphorus was applied, however, the antagonistic effect of sulphur was overcome. Also, the application of phosphorus helped in the utilization of added and native soil sulphur.

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الملخص العربى

تأثير المولیبدنیم والفوسفور والكبریت على المحصول ومحتوى العناصر فى أوراق القمح النامى فى الارض الملحیه

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أقیمت تجربة حقلیة بمحطة التجارب الزراعیة بكلیة الزراعة سابا باشا جامعة الاسكندریة لاختبار تأثیر المولیبدنم والفسفور والكبریت على المحصول ومحتوى العناصر فى الاوراق للقمح النامى فى أرض متأثرة بالأملاح. وقد استخدمت اربعة مستویات الكبریت وھى (٠ ، ٥٠ ،١٠٠، ٢٠٠ كجم كبریت/ فدان) واربعة مستویات من الفسفور وھى (٠ ، ٧.٥ ،١٥، ٢٢.٥ كجم فسفور/ فدان) واربعة مستویات من المولیبدنم وھى (٠، ٥٠، ١٠٠، ٢٠٠ جم مولیبدنم/ فدان) فى تصمیم القطع المنشقة مرتین وبثلاث مكررات وقد اوضحت النتائج ان استخدام الكبریت والفسفور والمولیبدنم أدى الى زیادة معنویة فى محصول الحبوب لنبات القمح حیث كانت اعلى القیم (١.٩١ طن/فدان) عند مستوى ٢٠٠ كجم كبریت/ فدان و ٢٢.٥ كجم فسفور/فدان و ١٠٠ جم مولیبدنم/فدان. وقد زاد محتوي أوراق القمح من النیتروجین والفسفور والبوتاسیوم والكبریت عند استخدام التسمید بالكبریت والفسفور.بینما قل محتوى اوراق نبات القمح من المولیبدنم عند استخدام مستویات مختلفه من الكبریت ولكن زاد محتوى اوراق القمح من المولیبدنم عند استخدام الفسفور.