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INFLUENCE OF CHELATED IRON AND MANGANESE WITH SULPHER ON PRODUCTIVITY AND QUALITY OF SUGAR BEET

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ABSTRACT

Two field experiments were carried out at Sakha Research Station, Kafr El-Sheikh Governorate during two growing seasons of 2010/2011 and 2011/2012 to study the effect of the combinations between foliar application of three Fe levels (0, 1 , and 2g/L as Fe- EDTA), three Mn levels (0, 0.5 and 1 g/L as Mn-EDTA) and two sulpher levels (0 and 8 cm S/L as calcium poly sulphide 30 %) on yield and quality of sugar beet.

The obtained results proved that:

- The increase of Fe level up to 2 g / L, Mn up to 1g/L and 8 cm S/L individually as foliar application significantly increased root length and diameter as well as sucrose%, extractable sugar %, purity % , yields of top, root and sugar (ton / fed), whereas Juice impurities content (K, Na and α-amino N) and sugar losses to molasses were decreased in both seasons.
- Foliar spray beet plants at the rate of 2g Fe/L+1g Mn / L+8 cm S/L achieved the highest root yield (29.32 and 33.82) in the 1st and 2nd seasons, respectively.

Therefore, it could be recommended that, spraying beet plants by 2g Fe / L +1g Mn / L + 8 cm S/L as foliar application to maximize root yield.

INTRODUCTION

In the recent years, sugar beet became the second crop after sugar cane to produce sugar yield. In Egypt, sugar production is still insufficient for local consumption therefore, many attempts devoted to improve sucrose quality and quantity of sugar beet plants. These may achievable via plant fertilization, so , nutrients as foliar application are one of the most important methods to substitute for mineral fertilizers.

Micronutrients play a very important role in vital processes of plants . It is increase leaves chlorophyll content , improve photosynthesis which intensively the assimilating activity of the hole plants (Marschners , 1995).Therefore, application of Fe and /or Mn or combined with trace elements has a positive effect on beet root performance (average root weight , root length and root diameter) yields of top , root and sugar , most root quality characteristics and nutrient uptake but on the contrary has a negative effect on some juice impurities , Moustafa, Shafika and El-Masry (2006), Safaa and El-Geddawy (2007), Yarnia *et al.* (2008), Selim *et al.* (2009) , Moustafa, Zeinab *et al.* (2011) and Safaa (2012) .

Sulpher is increasingly being recognized as the fourth major plant nutrient after nitrogen , phosphorus and potassium . Sulphur is a constituent element of three essential amino acids viz . cystine , cysteine and methionine. It is involved in synthesis of chlorophyll and play an important role in the synthesis of certain vitamins and carbohydrates. It is important to mention that beneficial effect of elemental sulphur on sugar beet in terms of its fungicidal effect on powdery mildew disease. (Drycott , 1972). El-Kammah and Ali (1996) and Hashem *et al* . (1997) indicted that yields of roots and sugar were significantly increased with increasing levels of applied sulphur. El-Adl(2002) found that increasing sulpher level increased fresh and dry weights of beet leaves and roots , root and sugar yields , sucrose and purity % and sugar lose to molasses ,while Na content was decreased. Wassif *et al.* (2002) indicated that the application of S increased the availability of Fe , Mn ,and Zn as well as significantly increased yields of sugar beet. Moustafa, Shafika *et al* .(2005) indicated that the applied level of sulphur up to 8 cm/L led to additional increase in fresh and dry weights / plant , yields of top , root and sugar (ton/fed), sucrose% , juice purity % , extractable sugar % and photosynthetic pigments content, whereas juice impurities % and sugar lose to molasses % were decreased. Osman and Shehata,Mona (2010) reported that foliar spray with sulpher solution twice or three times significantly increased root diameter , root fresh weight , root yield while root quality were significantly decreased. Ferweez *et al.* (2011) indicated that sulpher application had a significant effect on root diameter , Na content , α - amino nitrogen , and sugar yield ton/ fed.

Therefore , the present work was carried out to study the effect of iron , manganese and sulpher and their combinations on sugar beet productivity and quality .

MATERIALS AND METHODS

Two field experiments were carried out at Sakha Research Station , Kafr El- Sheikh Governorate during the two growing seasons of 2010 /2011 and 2011 /2012 to study the effect of foliar application of iron, manganese and sulpher and their combinations on some physiological properties , yield and quality of sugar beet.

The present work included 18 treatments , which were the combinations between three iron levels (0 , 1 and 2g /L as Fe-EDTA) , three manganese levels (0 , 0.5 and 1g/L as Mn-EDTA) and two sulpher levels (0 and 8 cm/L as calcium poly sulphide 30 %) .

A split –split plot design with three replicates was used, Iron levels were arranged randomly in the main plots , Mn levels in the sub plots and S levels in sub- sub plots.

A multigerm sugar beet variety Margbil was sown on 20 and 27 October in the 1^{st} and 2^{nd} season respectively. The plot area was 14 m^2. Foliar application of Fe , Mn and S were applied after thinning .

Nitrogen fertilizer was added at the rate of 90 kg N / fed in the form of urea (46% N) in two equal doses , the first was applied after thinning (at 4 – leaf stage), while the second ones was added one month later. Phosphorus fertilizer was applied at the level of 30 Kg P_2O_5 as calcium super phosphate (15.5% P_2O_5) at seedbed preparation. Potassium fertilizer was added with the first dose of nitrogen at the level of 48 Kg K_2O /fed as potassium sulphate

(48% K_2O). The normal agronomic practices in sugar beet fields were carried out as recommended by sugar crops Res. Inst., A.R.C. Mechanical and chemical properties of the experimental site (Table 1) were determined according to **Jackson (1973).**

Table1:Soil mechanical and chemical analysis of experimental sites in Kafr El - Sheikh in both seasons.

Seasons	Mechanical analysis				
	Coarse sand %	Fine sand %	Silt %	Clay %	Soil texture
2010/2011	1.50	23.00	20.20	55.30	Clay
2011/2012	1.46	23.50	20.00	55.04	Clay

Chemical analysis

Seasons	Available nutrients (ppm)					pH 1:2.5	EC (ds/m)	Soluble anions (meq/l)				Soluble cations (meq/l)			
	N	P	K	Fe	Mn			Co3	Hco3	Cl^-	$So4^-$	Na^+	K^+	Ca^{++}	Mg^{++}
2010/2011	27.85	9.20	280.0	9.50	12.4	8.00	4.30	-	2.09	20.10	20.81	24.50	0.42	9.55	8.53
2011/2012	25.30	8.35	282.5	10.6	13.5	8.10	4.25	-	2.00	20.50	20.0	24.59	0.50	9.60	7.81

Recorded data:

At harvest time (210 days after sowing) a sample of ten guarded sugar beet plants were taken from each plot to determine the following growth and juice characteristics :

1- Growth characters :

a – Root length (cm).

b – Root diameter (cm).

c – Root fresh weight (kg).

2- Juice quality and some technological parameters :

a – Sucrose % .

b– Impurities (Na , K and α- amino N meq/ 100 g beet).

Sucrose % and impurities contents were determind in Delta Sugar Company Limeted Laboratories at El Hamoul Kafr El –Sheikh Governorate according to the method of McGinnus (1971).

c-Sugar loss to molasses (SLM %) was calculated according to Devillers (1988).

SLM % = 0.14 (Na +K) + 0.25 (α- amino N) + 0.5.

d- Extractable sugar (EXS%) .

e-Purity%.

Extractable sugar (EXS %) and Purity % were calculated as proposed by Dexter *et al* .(1967).

Extractable sugar=sucrose% - (sugarloss to molasses%+0.6).

Purity %= 99.36 -(14. 27 (Na +K + α amino N)/sucrose%).

3- yield :

At harvest time, sugar beet plants in three ridges of each experimental unit were collected and cleaned ,then after roots and tops were separated and each were weighted in kg then after it was converted to estimate:

a – Top yield (ton / fed).
b – Root yield (ton / fed).
c– Sugar yield (ton/fed) was calculated according the following equation :

Sugar yield (ton/fed) = root yield (ton/fed) x extractable sugar % .

Statistical analysis :

The collected data were subjected to statistical analysis for the two seasons according to Snedecor and Cochran (1981). Treatment means were compared using LSD at 5% level of probability.

RESULTS AND DISCUSSION

1- Root characteristics:

Data obtained in Table 2 indicated that increasing Fe levels up to 2 g/L significantly increased root length and diameter in both seasons as well as root fresh weight/plant in the 2nd season only. Also, increasing Mn levels up to 1g/L significantly affected root parameters in terms of length , diameter and fresh weight/plant in both seasons .The pronounced effect of micronutrients may be due to their effect on growth hormone production which has a direct effect on plant growth, throughout their influence on the production of plant growth promoting substances and increase in various availability soil nutrients. (Sandman and Bogger 1983). These results are in accordance with those obtained by Selim *et al* .(2009), Osman (2011) and Safaa (2012).

Table 2: Effect of iron, manganese and sulpher on root characters of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Characters / Treatments	Root length (cm)		Root diameter (cm)		Root fresh weight (kg)	
	2010/2011	2011/2012	2010/2011	2011/2012	2010/2011	2011/2012
A: Fe-.levels						
control	26.80	30.10	11.20	12.10	0.953	1.130
1.0 g/L	28.63	31.20	11.90	12.90	1.041	1.192
2.0 g/L	29.53	32.50	12.30	13.60	1.090	1.247
F.test	*	*	*	*	NS	*
LSD at 5%	0.25	0.39	0.29	0.23	NS	0.041
B: Mn- levels						
control	27.60	30.80	11.20	12.50	0.968	1.168
0.5 g/L	28.20	31.30	12.00	12.90	1.037	1.187
1.0 g/L	29.20	31.70	12.30	13.20	1.079	1.215
F.test	*	*	*	*	*	*
LSD at 5%	0.24	0.31	0.21	0.20	0.077	0.026
C: S- levels						
control	27.40	30.70	11.40	12.50	0.944	1.140
8 cm/L	29.30	31.80	12.20	13.20	1.112	1.239
F.test	*	*	*	*	*	*
Interactions						
Ax B	NS	NS	NS	NS	NS	NS
Ax C	*	NS	NS	NS	NS	*
Bx C	*	NS	*	NS	NS	NS
Ax Bx C	NS	NS	NS	NS	NS	NS

As for the influence of sulpher (S). Data in Table 2 showed that treating beet plants at the level of 8 cm S /L as foliar application significantly improved the above traits as compared with control. Such effects may be attributed to the important role of S in reducing soil pH and thus increase the availability of phosphorus and micronutrients. (Mc Cready and Krause, 1982). These results are in line with those obtained by Moustafa,Shafika *et al* .(2005), El-Adl (2002) Osman and Shehata,Mona (2010) and Ferweez *et al.* (2011).

Interactions effect :

Results indicated that the interaction between Fe x S levels significantly affected root length in the 1st season and root fresh weight in the 2nd season (Table 2a). Also, the interaction between Mn x S levels significantly affected root length and diameter in the 1st season only (Table 2b).

Table 2a : Significant interaction between iron and sulpher on root length and root fresh weight of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Interactions		2010/2011	2011/2012
Fe (A)	S (C)	Root length (cm)	Root fresh weight (Kg)
Control	Control	26.10	1.102
	8 cm/L	27.60	1.158
1 g/L	Control	27.6	1.134
	8 cm/L	29.7	1.251
2 g/L	Control	28.5	1.185
	8 cm/L	30.6	1.309
LSD at 5%		0.22	0.034

Table 2b : Significant interaction between manganese and sulpher on root length and root diameter of sugar beet at harvest during 2010/2011 season.

Interactions		2010/2011	
Mn (B)	S (C)	Root length (cm)	Root diameter (cm)
Control	Control	26.8	11.00
	8 cm/L	28.3	11.40
0.5 g/L	Control	27.3	11.40
	8 cm/L	29.2	12.50
1 g/L	Control	28.0	11.80
	8 cm/L	30.4	12.70
LSD at 5%		0.22	0.25

2- Juice impurities content:

Juice impurities comprises potassium, sodium and α - amino N were gradually and significantly decreased by individually Fe, Mn and S foliar application in both seasons (Table 3).

Regarding the influence of Fe and Mn. It worth to mention that the highest level of Fe (2g/L) or Mn (1g/L) exhibited the lowest values of juice impurities content. These results are in line with those obtained by Moustafa, Shafika and El-Masry (2006), Safaa and El-Geddawy (2007) and Moustafa,Zeinab *et al.* (2011).

With respect to the effect of sulpher. It could be noticed that treating beet plants at the level of 8 cm S/L as foliar application significantly decreased juice impurities as compared with control. In this connection Sexton (1996) reported that S deficiency resulted in higher proportion of assimilated N being sequestered into storage pools in the form of ∝ - amino

N and amides, while, in the presence of sufficient S decrease ∝ - amino N. These results are in coincide with those obtained by El-Adl (2002), Moustafa, Zeinab *et al.* (2006) and Ferweez *et al.* (2011).

Table 3 : Effect of iron, manganese and sulpher on juice impurities (meq/100g beet) of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Characters / Treatments	Potassium		Sodium		α- amino nitrogen	
	2010/2011	2011/2012	2010/2011	2011/2012	2010/2011	2011/2012
A: Fe-.levels						
control	3.52	3.91	1.84	1.90	1.27	1.71
1.0 g/L	3.39	3.66	1.68	1.70	1.24	1.59
2.0 g/L	3.25	3.53	1.50	1.58	1.20	1.44
F.test	*	*	*	*	*	*
LSD at 5%	0.115	0.048	0.012	0.029	0.014	0.037
B: Mn- levels						
control	3.43	3.76	1.72	1.77	1.28	1.65
0.5 g/L	3.39	3.70	1.68	1.73	1.23	1.59
1.0 g/L	3.33	3.63	1.62	1.68	1.20	1.52
F.test	*	*	*	*	*	*
LSD at 5%	0.022	0.015	0.021	0.013	0.010	0.019
C: S- levels						
control	3.42	3.77	1.70	1.79	1.26	1.65
8 cm/L	3.35	3.63	1.64	1.67	1.21	1.52
F.test	*	*	*	*	*	*
Interactions						
Ax B	NS	*	*	*	*	*
Ax C	NS	*	*	*	*	*
Bx C	*	*	*	*	NS	*
Ax Bx C	NS	NS	*	NS	NS	NS

Interactions effect :

Results cleared that the interaction between Fe levels x Mn levels and Fe x S levels significantly affected K content in the 2nd season as well as Na and α - amino N in both seasons (Tables 3 a and 3b). Also, the interaction between Mn levels x S levels significantly affected K and Na content in both seasons as well as α -amino N in the 2nd season only(Table 3 c). Moreover, the interaction among Fe x Mn x S significantly affected Na content in the 1st season only (Table 3 d).

Table 3a: Significant interaction between iron and manganese on juice impurities (meq/100 g beet) of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Interactions		2010/2011		2011/2012		
Fe(A)	Mn(B)	Sodium	α-amino nitrogen	Potassium	Sodium	α-amino nitrogen
Control	Control	1.87	1.31	3.97	1.94	1.76
	0.5 g/L	1.85	1.27	3.89	1.91	1.71
	1 g/L	1.81	1.23	3.86	1.87	1.67
1 g/L	Control	1.72	1.27	3.73	1.75	1.66
	0.5 g/L	1/78	1.24	3.66	1.71	1.60
	1 g/L	1.64	1.21	3.59	1.64	1.53
2 g/L	Control	1.25	1.25	3.6	1.64	1.52
	0.5g/L	1.53	1.19	3.55	1.58	1.46
	1 g/L	1.41	1.17	3.45	1.54	1.35
LSD at 5%		0.037	0.018	0.026	0.022	0.033

Table 3b : Significant interaction between iron and sulpher on juice impurities (meq/100 g beet) of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Interactions		2010/2011		2011/2012		
Fe(A)	S(C)	Sodium	α-amino nitrogen	Potassium	Sodium	α-amino nitrogen
Control	Control	1.85	1.28	3.95	1.92	1.74
	8 cm/L	1.83	1.25	3.86	1.89	1.69
1 g/L	Control	1.70	1.26	3.75	1.80	1.69
	8 cm/L	1.65	1.22	3.56	1.60	1.50
2 g/L	Control	1.55	1.25	3.60	1.66	1.51
	8 cm/L	1.45	1.16	3.45	1.51	1.37
LSD at 5%		0.024	0.014	0.031	0.031	0.034

Table 3c : Significant interaction between manganese and sulpher on juice impurities (meq/100 g beet) of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Interactions		2010/2011		2011/2012		
Mn(B)	S(C)	potassium	Sodium	Potassium	Sodium	α-amino nitrogen
Control	Control	3.45	1.73	3.82	1.82	1.68
	8 cm/L	3.42	1.71	3.71	1.72	1.61
0.5 g/L	Control	3.42	1.70	3.78	1.79	1.66
	8 cm/L	3.36	1.66	3.62	1.68	1.52
1 g/L	Control	3.38	1.67	3.71	1.76	1.60
	8 cm/L	3.28	1.56	3.55	1.60	1.43
LSD at 5%		0.029	0.024	0.031	0.031	0.034

Table 3d : Significant interaction among iron , manganese and sulpher on sodium content of sugar beet at harvest. during 2010/2011season.

2010 / 2011			
Interactions		Sodium (meq/100 beet)	
Fe (A)	Mn (B)	S (C)	
		Control	8 cm/L
Control	Control	1.87	1.86
	0.5 g/L	1.85	1.84
	1 g/L	1.82	1.79
1 g/L	Control	1.73	1.71
	0.5 g/L	1.70	1.65
	1 g/L	1.68	1.59
2 g/L	Control	1.58	1.56
	0.5 g/L	1.56	1.49
	1 g/L	1.51	1.30
LSD at 5%		0.042	

3- Juice quality and technological parameters:

3-a- Sugar Losses to molasses:

Average data in Table 4 cleared that foliar application with Fe, Mn and S individually significantly decreased SLM% in both seasons.

Table 4: Effect of iron, manganese and sulpher on juice quality of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Characters / Treatments	Sugar loss to molasses %		Sucrose %		Extractable sugar %		Purity %	
	2010/2011	2011/2012	2010/2011	2011/2012	2010/2011	2011/2012	2010/2011	2011/2012
A: Fe-.levels								
control	1.57	1.74	16.18	16.13	14.02	13.78	93.52	92.70
1.0 g/L	1.52	1.63	16.46	16.34	14.34	14.09	93.90	93.29
2.0 g/L	1.47	1.58	16.67	16.59	14.60	14.42	94.26	93.72
F.test	*	*	*	*	*	*	*	*
LSD at 5%	0.053	0.026	0.012	0.021	0.099	0.021	0.153	0.113
B: Mn- levels								
control	1.54	1.69	16.33	16.26	14.19	13.98	93.74	93.05
0.5 g/L	1.52	1.66	16.44	16.36	14.32	14.10	93.88	93.23
1.0 g/L	1.49	1.62	16.55	16.43	14.45	14.21	94.05	93.43
F.test	*	*	*	*	*	*	*	*
LSD at 5%	0.016	0.025	0.021	0.021	0.044	0.160	0.139	0.042
C: S- levels								
control	1.53	1.69	16.35	16.28	14.22	13.99	93.79	93.04
8 cm/L	1.50	1.62	16.53	16.42	14.42	14.20	94.00	93.43
F.test	*	*	*	*	*	*	*	*
Interactions								
Ax B	NS	NS	*	*	NS	NS	NS	NS
Ax C	NS	*	*	*	*	NS	NS	*
Bx C	NS	NS	NS	NS	NS	NS	NS	*
Ax Bx C	NS	NS	*	NS	NS	NS	NS	NS

As for the effect of Fe and Mn. Data showed that the highest level of Fe (2g/L) or Mn (1g/L) exhibited the lowest value of SLM% in both seasons. These results are in the same trend with those obtained by Moustafa, Shafika and El-Masry (2006) and Safaa and El -Geddawy (2007) .

With respect to the influence of S. It could be noticed that treating beet plants with 8 cm S/L as foliar application significantly decreased SLM% as compared with control.

Interactions effect :

The interaction between Fe x S levels significantly affected SLM% in the 2nd season only (Table 4 b).

3-b- Sucrose %, extractable sugar % and purity%:

Data obtained in Table 4 illustrated that foliar spray with Fe, Mn and S individually significantly increased sucrose %, extractable sugar (EXS%) and purity % in both seasons.

Regarding the influence of Fe and Mn. It could be noticed that the highest level of Fe (2g/L) and Mn (1g/L) exhibited the highest values of these traits. Neveryanskaya *et al.* (1978) stated that treating sugar beet plant with trace elements has a considerable influence on the metabolic activities in plants and hence in turn exerts an increase in plant sugar content. These results are in accordance with those of Moustafa and El-Masry (2006), Safaa and El-Geddawy (2007), Moustafa *et al* .(2011) and Safaa (2012).

With respect to the influence of S. it is worth to mention that treating beet plants by 8 cm S/L as foliar application significantly increased sucrose %, extractable sugar % and purity% as compared with control. These results are in line with those obtained by El-Adl (2002) and Moustafa *et al.* (2006).

Interactions effect :

Results cleared that the interaction between Fe levels x Mn levels significantly affected sucrose % in both seasons(Table 4 a). Also, the interaction between Fe levels x S levels affected significantly sucrose% in both seasons, extractable sugar % in the 1st season and purity% in the 2nd season (Table 4 b). Moreover, the interaction between Mn levels x S level significantly affected purity% in the 2nd season only (Table 4c). Further, the interaction among Fe x Mn x S significantly affected sucrose% in the 1st season only (Table 4d)

Table 4a :Significant interaction between iron and manganese on sucrose % of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Interactions		2010/2011	2011/2012
Fe (A)	Mn (B)	Sucrose %	Sucrose %
Control	Control	16.05	15.99
	0.5 g/L	16.21	16.18
	1 g/L	16.29	16.21
1 g/L	Control	16.33	16.29
	0.5g/L	16.47	16.33
	1 g/L	16.59	16.40
2 g/L	Control	16.61	16.52
	0.5 g/L	16.63	16.57
	1 g/L	16.76	16.69
LSD at 5%		0.035	0.036

Table 4b : Significant interaction between iron and sulpher on juice quality of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Interactions		2010/2011		2011/2012		
Fe(A)	S(C)	Sucrose %	Extractable Sugar %	Sugar losses to molasses %	Sucrose %	Purity %
Control	Control	16.09	13.92	1.76	16.03	92.59
	8 cm/L	16.27	14.11	1.73	16.22	92.82
1 g/L	Control	16.41	14.28	1.70	16.30	93.02
	8 cm/L	16.51	14.40	1.60	16.37	93.56
2g/L	Control	16.54	14.45	1.61	16.51	93.51
	8 cm/L	16.80	14.75	1.34	16.68	93.93
LSD at 5%		0.042	0.061	0.030	0.031	0.086

Table 4c : Significant interaction between manganese and sulpher on purity % of sugar beet at harvest during 2011/2012 season.

Interactions		2011/2012
Mn (B)	S (C)	Purity %
Control	Control	92.91
	8 cm/L	93.20
0.5 g/L	Control	93.03
	8 cm/L	93.44
1 g/L	Control	93.18
	8 cm/L	93.67
LSD at 5 %		0.086

Table 4d : Significant interaction among iron, manganese and sulpher on sucrose % of sugar beet at harvest during 2011/2011 season.

2010 / 2011			
Interactions		Sucrose %	
Fe (A)	Mn (B)	S (C)	
		Control	8 cm / L
Control	Control	15.95	16.15
	0.5 g/L	16.10	16.32
	1 g/L	16.23	16.35
1 g/L	Control	16.30	16.35
	0.5 g/L	16.43	16.50
	1 g/L	16.50	16.68
2 g/L	Control	16.49	16.74
	0.5 g/L	16.50	16.76
	1 g/L	16.63	16.89
LSD at 5 %		0.073	

4- Yield and its components:

Results given in Table 5 cleared that the examined levels of Fe, Mn and S individually have significant effect on yields of top, root and sugar in both seasons.

Table 5: Effect of iron, manganese and sulpher on yields (ton/fed) of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Characters / Treatments	Top yield		Root yield		Sugar yield	
	2010/2011	2011/2012	2010/2011	2011/2012	2010/2011	2011/2012
A: Fe-.levels						
control	8.53	9.99	24.97	29.60	3.50	4.08
1.0 g/L	8.69	10.12	26.12	30.22	3.75	4.26
2.0 g/L	8.91	10.35	27.54	31.49	4.03	4.54
F.test	*	*	*	*	*	*
LSD at 5%	0.106	0.059	0.059	0.219	0.077	0.086
B: Mn- levels						
control	8.38	10.00	25.12	29.77	3.57	4.17
0.5 g/L	8.74	10.16	26.48	30.33	3.79	4.28
1.0 g/L	9.00	10.30	27.04	31.22	3.91	4.44
F.test	*	*	*	*	*	*
LSD at 5%	0.042	0.045	0.050	0.203	0.046	0.061
C: S- levels						
control	8.54	10.02	25.21	29.79	3.59	4.17
8 cm/L	8.88	10.28	27.22	31.09	3.93	4.42
F.test	*	*	*	*	*	*
Interactions						
Ax B	*	*	*	NS	*	NS
Ax C	*	*	*	*	*	*
Bx C	*	NS	*	*	*	*
Ax Bx C	*	NS	*	*	Ns	NS

Regarding to Fe and Mn influence on yields. Data in Table 5 exhibited that the highest level of Fe (2g/L) or Mn (1g/L) gave the highest value of top, root and sugar yields. These effects may be attributed to that iron is involved in protein synthesis and root merstiem growth (Mangel and kirkby ,1979). Manganese acts as activator in enzymes involved in carboxylic acid cycle and carbohydrate metabolism (Sayed *et al.* 2011). These results are in agreement with those obtained by Moustafa,Shafika and El-Masry (2006), Selim *et al.* (2009) and Safaa (2012).

As for S influence on yields. Data showed that treating beet plants with 8 cm S /L as foliar application significantly improved yields of top, root and sugar as compared with control. These results are in agreement with those obtained by El-Adl (2002), Moutafa, Zeinab *et al.* (2006), Osman and Shehata, Mona (2010) and Ferweez *et al.* (2011).

Interactions effect :

Results showed that the interaction between Fe levels x Mn levels significantly affected top yield in both seasons as well as root yield and sugar yield in the 1st season only (Table 5 a). Also, the interaction between Fe levels x S level significantly affected yields of top, root and sugar in both seasons (Table 5 b). Moreover, the interaction between Mn levels x S levels significantly affected top yield in the 1st season as well as root and sugar yield in both seasons (Table 5c). Further, the interaction among Fe x Mn x S levels significantly affected top yield in the1st season and root yield in both seasons (Table 5 d).

Table 5a :Significant interaction between iron and manganese on yields (ton/fed) of sugar beet at harvest during 2010/2011 season and top yield during 2011/2012 season.

Interactions		2010 / 2011			2011/2012
Fe (A)	Mn (B)	Top	Root	Sugar	Top
Control	Control	8.19	23.54	3.26	9.94
	0.5 g/L	8.59	25.40	3.57	9.98
	1 g/L	8.81	25.98	3.68	10.04
1 g/L	Control	8.40	24.80	3.52	9.97
	0.5 g/L	8.65	26.44	3.79	10.14
	1 g/L	9.03	27.12	3.93	10.26
2 g/L	Control	8.56	27.03	3.93	10.08
	0.5 g/L	8.99	27.59	4.02	10.37
	1 g/L	9.18	28.01	4.13	10.60
LSD at 5%		0.074	0.087	0.079	0.079

Table 5b :Significant interaction between iron and sulpher on yields (ton/fed) of sugar beet at harvest during 2010/2011 and 2011/2012 seasons.

Interactions		2010 / 2011			2011 /2012		
Fe (A)	S(C)	Top	Root	Sugar	Top	Root	Sugar
Control	Control	8.35	24.18	3.36	9.85	29.32	4.01
	8 cm/L	8.70	25.77	3.64	10.12	29.88	4.15
1 g/L	Control	8.49	25.19	3.60	9.95	29.55	4.14
	8 cm/L	8.89	27.05	3.90	10.30	30.89	4.38
2 g/L	Control	8.78	26.25	3.80	10.26	30.48	4.36
	8 cm/L	9.04	28.83	4.26	10.44	32.49	4.73
LSD at 5 %		0.066	0.082	0.070	0.058	0.238	0.056

Table 5c : Significant interaction between manganese and sulpher on yields (ton/fed) of sugar beet at harvest during 2010/2011 season and yield of root and sugar 2011/2012 season.

Interactions		2010 / 2011			2011/2012	
Mn (B)	S (C)	Top	Root	Sugar	Root	sugar
Control	Control	8.18	24.37	3.44	29.35	4.08
	8 cm/L	8.58	25.87	3.70	30.20	4.25
0.5 g/L	Control	8.64	25.46	3.62	29.74	4.16
	8 cm/L	8.85	27.49	3.97	30.91	4.61
1 g/L	Control	8.80	25.79	3.70	30.27	4.26
	8 cm/L	9.20	28.28	4.12	32.16	4.61
LSD at 5 %		0.066	0.082	0.070	0.238	0.056

Table 5d: Significant interaction among iron, manganese and sulpher on top and root yield (ton/fed) of sugar beet at harvest during 2010/2011 season and root yield during 2011/2012 season.

Interactions		2010 / 2011				2011/2012	
Fe(A)	Mn (B)	Top		Root		Root	
		S (C)		S (C)		S (C)	
		Control	8 cm/L	Control	8 cm/L	Control	8 cm/L
Control	Control	7.95	8.42	23.28	23.79	28.85	28.97
	0.5 g/L	8.45	8.73	24.52	26.28	29.19	29.97
	1 g/L	8.66	8.95	27.33	27.23	29.93	30.71
1 g /L	Control	8.18	8.62	24.07	25.52	29.07	30.15
	0.5 g/L	8.54	8.75	25.55	27.33	29.51	30.58
	1 g/L	8.75	9.30	25.94	28.30	30.08	31.94
2 g /L	Control	8.42	8.70	25.75	28.31	30.12	31.47
	0.5 g/L	8.92	9.06	26.32	28.86	30.52	32.18
	1 g/L	8.99	9.36	26.69	29.32	30.81	33.82
LSD at 5 %		0.155		0.141		0.411	

Generally, treating beet plant with 2g Fe/L+1g Mn/L+8 cm S/L as foliar application exhibited the highest roots yield (29.32 and 33.82 ton/fed) in the 1st and 2nd seasons, respectively.

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تأثير الرش بالحديد والمنجنيز المخلبي مع الكبريت على إنتاجية وجودة بنجر السكر

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أجريت تجربتان حقليتان بمحطة بحوث سخا- بكفر الشيخ خلال موسمي ٢٠١٠/٢٠١١ و ٢٠١١/٢٠١٢ لدراسة تأثير الرش والتفاعل بين ثلاث مستويات من الحديد المخلبي (كنترول و ١جم و ٢ جم/لتر) وثلاث مستويات من المنجنيز المخلبي (كنترول و ٠.٥جم و ١جم/لتر) ومعاملتان من الكبريت السائل (كنترول و ٨سم/لتر) على محصول وجودة بنجر السكر.

يمكن تلخيص النتائج المتحصل عليها كما يلي:

- أدى زيادة مستوى الرش من الحديد المخلبي حتى ٢جم/لتر والمنجنيز المخلبي حتى ١جم/لتر وأيضاً الرش بالكبريت السائل بمعدل ٨سم/لتر إلى زيادة معنوية في طول وقطر الجذر / نبات وكذلك النسبة المئوية للسكروز والسكر المستخلص والنقاوة وأيضاً محصول العرش والجذور والسكر بالطن/فدان بينما انخفضت محتوى الشوائب (البوتاسيوم والصوديوم والفا أمينو نيتروجين) والسكر المفقود بالمولاس في كلا الموسمين.
- أوضحت النتائج أن رش بنجر السكر بمعدل ٢جم/لتر حديد مخلبي + ١جم/لتر منجنيز مخلبي + ٨سم/لتر من الكبريت السائل أعطى أعلى محصول من الجذور (٢٩.٣٢و ٣٣.٨٢) بالطن/ فدان في الموسم الأول والثاني على الترتيب.

ويوصى البحث برش بنجر السكر بمعدل ٢ جم/لتر من الحديد المخلبي + ١جم/ لتر من المنجنيز المخلبي + ٨سم من الكبريت/لتر للحصول على أعلى محصول من الجذور تحت ظروف محافظة كفر الشيخ

قام بتحكيم البحث

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