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Influence of Spraying Two Borate Compounds on Controlling Cercospora Leaf Spot Disease and Productivity of Sugar Beet

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Fifteen isolates of *Cercospora beticola* Sacc. were isolated from naturally diseased sugar beet plants collected from different localities at El-Behera Governorate, Egypt. All isolates were able to infect Pleno sugar beet cultivar and they significantly differed in their virulence. *In vitro* study, inhibitory effect of borates was tested on mycelial growth of *C. beticola* at different concentrations, *i.e.* 10, 20, 40, 60, 80 and 100 ppm. Borates were able to inhibit the mycelial growth of the pathogen, when they were added to the medium at all the tested concentrations. The results showed that borax strongly inhibited *C. beticola* mycelial growth and had more fungistatic and fungicidal activities than those of boric acid and the fungicide Cabrio Top 60%. Under field conditions, spraying of diseased plants with borates at concentrations of 0.50 and 1.00 g/l water was effective in decreasing disease severity. The highest reduction in disease severity was observed in case of borax treatment at concentration of 1.00 g/l water. Treatments with borates improved agronomic characters of roots, *i.e.* root yield, total soluble solids (T.S.S), and sugar percent. Moreover, they decreased potassium, sodium and alpha amino acids and increased the quality of sugar beet yield.

Keywords: Alpha amino acids, borates, *Cercospora beticola*, potassium, sodium, root yield, Sugar beet, sugar percent and total soluble solids.

Sugar beet (*Beta vulgaris* L.) is the second important sugar crop in Egypt and in many parts of the world after sugar cane. The total cultivated area in Egypt reached about 460488 feddans, which produced about 10044266 tons with an average of 21.81 ton/feddan during 2013/2014 season (FAO, 2015).

Cercospora leaf spot disease is the most serious foliar disease of sugar beet and causes severe problems in Egypt and the world (Gado, 2007; Budakov *et al.,* 2014 and Rosenzweig *et al.,* 2015). Inadequate control measures against this destructive disease could consequently cause high yield losses up to 50% (Shane and Teng, 1992). Losses of sugar percent occurs as new leaves are grown to replace those heavily damaged by Cercospora leaf spot (Vereijssen *et al.*, 2003). Till now, there are no available resistant varieties for this disease (Gado, 2007).

Boron is an essential microelement and has important physiological functions for healthy growth of plants (O'Neill *et al.*, 2001), especially sugar beet because its deficiency causes losses in yield and sugar percent. Hansch and Mendel (2009)

noted that boron has a main role in many processes especially transport of sugar and carbohydrate metabolism.

In recent years, borates (as boron compounds) have been used as antifungal compounds to control plant diseases (Qin *et al.*, 2010; Shi *et al.*, 2011 and Cao *et al.,* 2012). Also, Shi *et al.* (2012) showed that adding borate to the Potato Dextrose Broth (PDB) medium at concentration of 15mM significantly inhibited spore germination of *Colletotrichum gloeosporioides*. Thomidis and Exadaktylou (2010) reported that borate treatment was effective in controlling brown rot caused by *Monilinia laxa* in peach. Qin *et al.,* (2010) found that borate salts inhibited spore germination and mycelial growth of *Botrytis cinerea*, indicating that the effect of borate against gray mold on table grapes may be directly related to its antifungal activity. Boron in the form of potassium tetraborate inhibited the growth of *Penicillium expansum* by targeting the mitochondria of the fungal pathogen (Cao *et al.*, 2012).

The aims of this study were to evaluate the efficacy of borates in controlling Cercospora leaf spot disease and their effect on root yield, sugar content and quality of sugar beet yield.

Materials and Methods

Isolation, purification and identification of Cercospora beticola isolated from sugar beet leaves:

Sugar beet plants showing typical symptoms of Cercospora leaf spot were collected from different fields in major sugar beet growing regions in El-Behera Governorate. Infected leaves were cut into small pieces and surface sterilized using 1% sodium hypochlorite for 1 minute, then rinsed in sterilized water. The surface sterilized samples were dried by sterilized filter paper and plated onto sugar beet leaves extract dextrose agar medium to promote the mycelial growth of the pathogen. Petri dishes were incubated at 27ºC and were examined every 24 hrs to observe the hyphal growth in the plates. The obtained fungal growth was transferred onto water agar medium and single hyphal tips were transferred onto PDA medium to obtain pure cultures. Fungal isolates were identified according to their morphological and microscopic characteristics of conidial spores (Chupp, 1954 and Deighton, 1967) and confirmed by Assiut Univ. Mycol. Centre (AUMC). Pure cultures of all identified isolates were maintained at 4°C on PDA in slants until use.

Pathogenicity test:

Pathogenicity of *C. beticola* was carried out on Pleno sugar beet cultivar (multigerm seeds). Three seeds were sown directly in each perforated plastic bag (30 cm in diam) on 1st Oct., and irrigation was done twice a week. Spore suspension of each isolate was prepared by growing it on sugar beet leaves extract dextrose agar medium. The growth of each isolate was collected and blended using a warring blender. The number of spores in the suspension was estimated by counting with a haemocytometer and adjusted to approximately 1×10^5 spore/ml. Sixty days old plants were sprayed with spore suspensions until runoff and covered with clear plastic bags to maintain high humidity and kept in the dark for 12 hrs. Covering bags

were loosened after 24 hours and removed after 48 hours, and then inoculated plants were kept under natural humidity as mentioned by Farrag (2011). Control plants were sprayed with distilled water. Three replicates were used for each isolate. Regular observations were made for the appearance and development of symptoms. Disease severity was calculated 10 days after inoculation using the diseased scales by Jones and Windels (1991) as follows: 0= no leaf lesions, 1= 25% or less infected leaf area, 2= 26 to 50 %, 3= 51 to 75 % and 4= 76 to 100% infected leaf area.

Effect of borates on mycelial growth of C. beticola:

Borates [borax (sodium tetraborate) and boric acid] were tested to study their effect on the mycelial growth of *C. beticola in vitro*. Borates were added to PDA medium at different concentrations, *i.e.* 10, 20, 40, 60, 80 and 100 ppm and then mixed thoroughly just before solidification as mentioned by Droby *et al*., (2003). Also, the fungicide Cabrio Top WG 60 % was used with the same concentrations as comparison treatment. The stock medium (PDA) for each concentration was poured into Petri dishes. Four plates for each treatment were used as replicates, as well as other four Petri dishes without borates or the fungicide were served as control. All plates were inoculated in the centre with equal discs (6 mm) taken from 15 days old culture of *C. beticola* and incubated at 27 ºC. Data were recorded as diameter of linear growth when any plate was completely covered by the fungal mycelium. The percentage of linear growth reduction of the pathogen was calculated by using the following formula:

$$\text{Linear growth reduction (\%)} = \frac{\text{Growth in the control - Growth in the treatment}}{\text{Growth in the control}} \times 100$$

Effect of spraying with borates on Cercospora leaf spot disease under field conditions:

Field experiments were carried out at Nubaria Research Station, El-Behera, Governorate, during growing seasons 2014 and 2015 to study the effect of borate compounds on Cercospora leaf spot disease of sugar beet plants. All tested treatments were applied under field conditions by two concentrations 0.50 and 1.00 g/l water. Seeds were sown directly in plots of 3×3.5 m^2 arranged in completely randomized design, with three plots for each treatment as replicates. Sugar beet plants were sprayed with a spore suspension of *C. beticola* as mentioned before under pathogenicity test. Infected plants were sprayed with each compound separately at concentrations 0.5 and 1 g/l water, when the first sign of disease has appeared (Gado, 2007). The spreading agent Bladbuff 5 (BB5) was added to the spray solution to ensure full distribution on the surfaces of plants. Each treatment was applied either as one, two and three sprays (10 days between each spray) for different plots and disease severity was calculated for each plot as mentioned before. At the end of the experiment, root yield for each treatment was collected from plants, which were sprayed three times and recorded for determination of root yield and sugar analysis. Total soluble solids (T.S.S %) in roots was measured in juice of fresh roots by using Hand Refractometer. Quality and percent of sugar were measured at the sugar factory laboratory (Nobaryia Sugar Refining Company) (using standard polarimetric method) and were estimated by (Schneider *et al.,* 2002). Alpha amino

acids, potassium and sodium were estimated according to the flourimetric methods (Hoffman, 2005).

Statistical analysis:

The obtained data were subjected to statistical analysis using MSTAT-C program version 2.10 (1991). Least significant difference (L.S.D., $p = 0.05$) for comparison between means of treatments was used as mentioned by Gomez and Gomez (1984).

Results

Isolation and identification of the causal organism of Cercospora leaf spot disease of sugar beet plants:

Fifteen fungal isolates were isolated from diseased sugar beet plants collected from different localities of El-Behera Governorate. The cultural and microscopic examination showed that the obtained isolates were *Cercospora beticola*. The isolates were identified according to their morphological and microscopic characteristics of conidial spores.

Determination of pathogenic capability of C. beticola isolates on sugar beet plants:

Data presented in Fig. (1) indicate that all *C. beticola* isolates were able to infect Pleno sugar beet cultivar and produced typical symptoms of Cercospora leaf spot disease. The tested isolates significantly differed in their ability to cause leaf spot disease on sugar beet plants and their severity was greatly differed. The highest percentage of disease severity was caused by *C. beticola* isolate No. 3 (44.15%), followed by isolates No. 12 (39.86%), then isolate No. 7 (34.69%) and isolate No. 10 (33.13%). Meanwhile, isolates No. 5 and No. 15 caused the lowest percentages of infection (4.53 and 5.23%, respectively) followed by isolate No. 8 (7.58%), while other isolates gave a moderate percentages of infection.

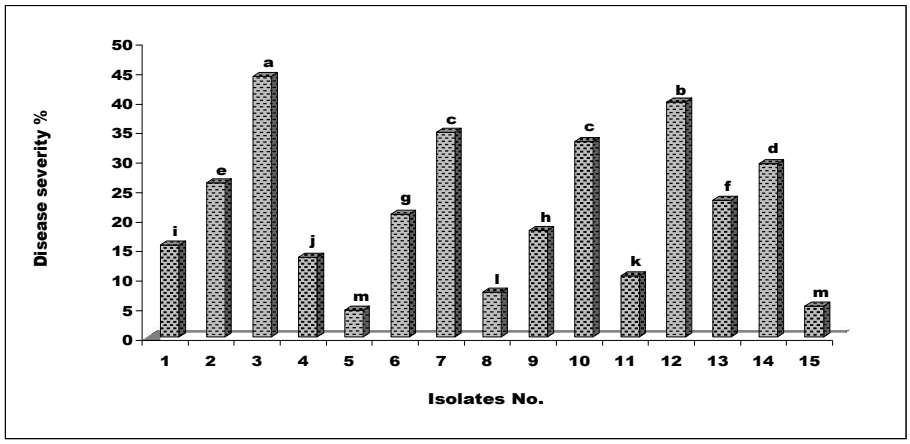

Fig. 1. Pathogenicity tests of *C. beticola* isolates on sugar beet Pleno cultivar. Different letters indicate significant differences among isolates according to Duncan's multiple range test (P< 0.05).

Effect of different concentrations of two borate compounds on the mycelial growth of C. beticola in vitro:

Data shown in Table (1) and Fig. (2) indicate that the two borates, *i.e.* borax (sodium tetraborate) and boric acid significantly inhibited the mycelial growth of *C. beticola* compared to the control. In general, addition of borate compounds to the medium significantly inhibited the growth of the pathogen at all the tested concentrations compared to untreated medium. The reduction of mycelial growth was increased by increasing the concentration of borates and reached its maximum using the concentration of 100 ppm. As shown in Fig. (2), borax was the most effective in reducing the mycelial growth of *C. beticola* on PDA medium more than boric acid and the fungicide Cabrio Top 25%. Data also indicate that borax was effective against the pathogen when added at 80 and 100 ppm. The highest reduction of the mycelial growth of the pathogen was occurred by borax at the concentration of 100 ppm (88.06%) followed by boric acid (82.28%), while the fungicide Cabrio Top (71.24%) caused the lowest inhibition of the fungal growth. Cultural colour of *C. beticola* was changed in treated medium with borates at all the tested concentrations compared to untreated plates as shown in Fig. (2).

Table 1. *In vitro* effect of different concentrations of borates on mycelial growth of *C. beticola*

Treatment	Inhibition of the mycelial growth (%) at (ppm)							
	0.0	10	20	40	60	80	100	Mean
Borax	0.00	38.64	49.50	59.72	70.28	75.00	88.06	54.46
Boric acid	0.00	34.03	45.50	54.55	65.45	71.37	82.28	50.45
Cabrio Top	0.00	36.39	47.90	56.43	61.19	68.38	71.24	48.79
Mean	0.00	36.35	47.63	56.90	65.64	71.58	80.52	-
L.S.D. at 5% for: Treatments (T) = 0.87 Concentrations (C) = 1.33 Interaction (T×C) = 2.30								

Effect of spraying sugar beet plants with borates in controlling Cercospora leaf spot under field conditions:

Data presented in Table (2) indicate that spraying of sugar beet plants with borates at concentrations 0.5 and 1.00 g/l water significantly decreased Cercospora leaf spot disease compared to untreated plants. The tested concentration 1.00 g/l water was more effective in reducing the disease severity more than 0.50 g/l concentration in both seasons. Generally, borax caused the highest reduction to the severity of the disease followed by boric acid. While, the fungicide Cabrio Top gave the lowest effect in controlling the disease. Borax (1.00 g/l) decreased the severity of the disease to 5.00 and 6.07 % during 2014 and 2015 growing seasons, respectively. There were significant differences between each of the first spray, the second and the third sprays with borates. Also, data revealed that three sprays with any treatment gave the best results in controlling the disease.

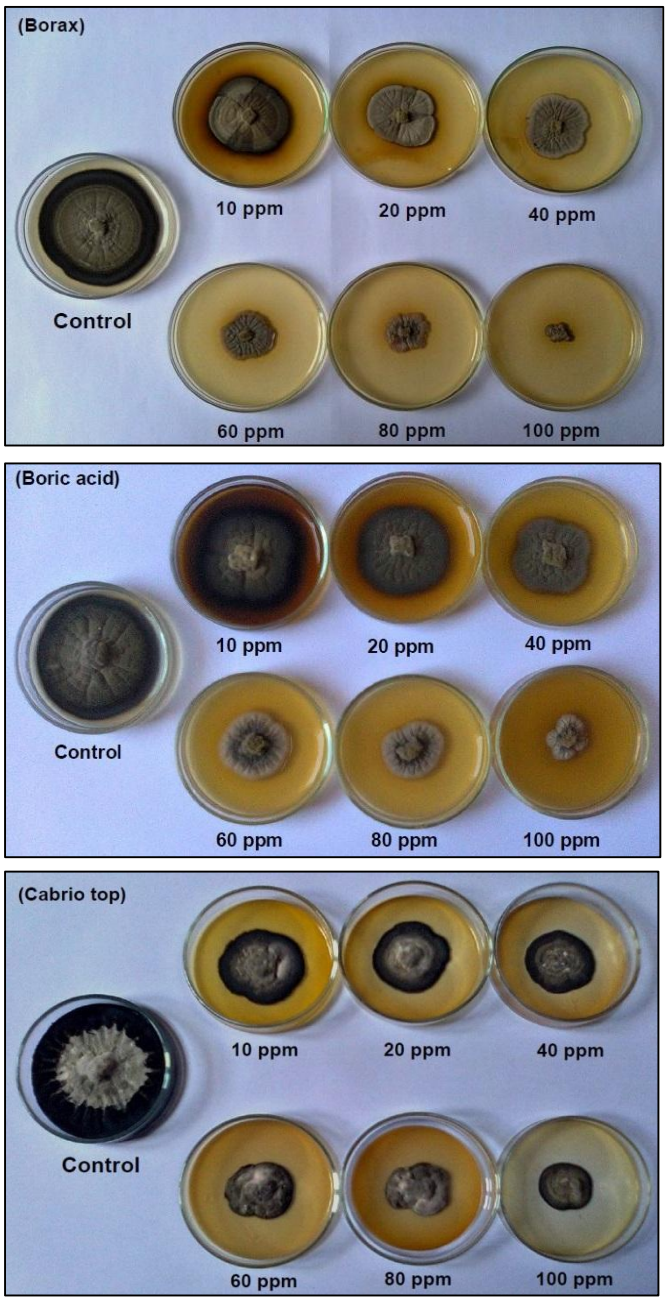

Fig. 2. Effect of borax, boric acid and Cabrio Top at different concentrations on the mycelial growth of *C. beticola in vitro*.

Table 2. Effect of borates as foliar spray on the severity of infection by Cercospora leaf spot of sugar beet under field conditions during 2014 and 2015 growing seasons

Treatment	Conc. g/l water	Disease severity (%)								
		Season 2014				Season 2015				General mean
		One spray	Two sprays	Three sprays	Mean	One spray	Two sprays	Three sprays	Mean	
Borax	0.5	7.92	7.92	4.89	6.63	8.96	7.19	4.68	6.94	6.79
	1.0	5.83	5.00	4.17	5.00	8.02	6.35	3.85	6.07	5.54
Boric acid	0.5	15.21	14.06	13.85	14.37	13.96	12.08	11.15	12.40	13.39
	1.0	13.75	12.50	11.46	12.57	13.33	11.56	10.42	11.77	12.17
Cabrio top 60%	0.5	17.50	15.84	15.63	16.32	17.08	15.11	13.96	15.38	15.85
	1.0	12.92	11.25	10.21	11.46	13.44	11.15	11.46	12.02	11.74
Control (untreated)	-	33.75	34.58	39.06	35.80	36.37	40.63	43.23	40.18	37.99
Mean	-	15.27	14.33	14.18	-	15.92	14.87	14.11	-	-
L.S.D. at 5%										
Treatments (T)		1.20				0.47				
Concentrations (C)		0.85				0.33				
Sprays (S)		0.41				0.72				
Interaction: (T×C)		1.70				0.67				
(T×S)		0.82				1.44				
(C×S)		0.58				1.02				
(T×C×S)		1.16				2.03				

Effect of borates as foliar spray on agronomic characters of sugar beet under field conditions:

It was shown from data presented in Tables (3 and 4) that treatment with borates significantly increased the root yield and improved agronomic characters of sugar beet, *.i.e.* root yield, T. S. S, sugar and quality percent at both concentrations (0.50 and 1.00 g/l water). Data also indicated that borates showed a significant positive effect on the root yield of sugar beet crop. The highest yield was recorded in treatment with boric acid at concentration 1.00 g/l water at both seasons (2014 and 2015) being 40.85 and 37.90 ton/feddan, respectively as compared to the control. However, concentration 0.50 g/l of borates gave the lowest values of root yield, sugar, T. S. S and quality percent. Results showed that borates led to increase in T.S.S and sugar percentages of the treated plants at both seasons (27.20 and 22.74%, respectively) compared to untreated control. Root yield, T.S.S and sugar values were reduced by increasing disease severity.

Table 3. Effect of borates as foliar spray on root yield and T.S.S of sugar beet under field conditions during 2014 and 2015 growing seasons

Treatment	Conc. g/l water	Root yield tons/feddan			T.S.S %		
		Season 2014	Season 2015	Mean	Season 2014	Season 2015	Mean
Borax	0.50	29.20	26.40	27.80	25.50	24.70	25.10
	1.00	32.72	29.81	31.27	27.60	26.80	27.20
Boric acid	0.50	35.41	33.60	34.51	21.25	21.00	21.13
	1.00	40.85	37.90	39.38	23.00	23.00	23.00
Cabrio top 60%	0.50	26.30	25.03	25.67	21.30	22.30	21.80
	1.00	30.64	28.11	29.38	22.70	21.20	21.95
Control (untreated)	-	28.12	25.71	26.92	20.00	19.00	19.50
Mean	-	31.89	29.51	-	23.05	22.57	-
L.S.D. at 5%							
Treatments (T)			0.84			0.39	
Concentrations (C)			0.60			0.28	
Seasons (S)			1.00			0.24	
Interaction: (T×C)			1.19			0.55	
(T×S)			2.01			0.49	
(C×S)			1.42			0.34	
(T×C×S)			2.84			0.69	

Table 4. Effect of borates as foliar spray on sugar and quality percent of sugar beet under field conditions during 2014 and 2015 growing seasons

Treatment	Conc. g/l water	Sugar			Quality		
		Season 2014	Season 2015	Mean	Season 2014	Season 2015	Mean
Borax	0.50	22.11	21.82	21.97	89.53	86.44	87.99
	1.00	23.02	22.46	22.74	90.56	89.18	89.87
Boric acid	0.50	19.06	20.02	19.54	89.02	85.50	87.26
	1.00	21.74	21.51	21.63	89.59	88.14	88.87
Cabrio top 60%	0.50	17.41	18.74	18.08	85.89	82.65	84.27
	1.00	18.56	18.11	18.34	86.55	83.91	85.23
Control (untreated)	-	16.56	15.93	16.25	75.15	77.30	76.23
Mean	-	19.78	19.80	-	86.61	84.73	-
L.S.D. at 5%							
Treatments (T)			0.20			1.30	
Concentrations (C)			0.14			0.92	
Seasons (S)			0.17			0.90	
Interaction: (T×C)			0.29			1.84	
(T×S)			0.34			1.80	
(C×S)			0.24			1.27	
(T×C×S)			0.49			2.55	

Effect of borates as foliar spray on the percentage of potassium and sodium elements as well as alpha amino acids in sugar beet roots

Data shown in Table (5) indicate that foliar spray with borates at the two tested concentrations 0.50 and 1.00 g/l water significantly decreased the potassium, sodium and alpha amino acids percentages during both seasons. Generally, application of borax at 0.50 g/l had more effect on potassium (4.78 and 5.12%), sodium (0.42 and 0.56%) and alpha amino acids (1.91 and 2.02%) during seasons 2014 and 2015 respectively, than the other treatments when compared to the sugar percent. Also, data revealed that there were significant differences among all treatments and their concentrations (0.50 and 1.00 g/l water) on sodium, potassium and α-amino acids percentages at both seasons (2014 and 2015).

Table 5. Effect of borates as foliar spray on percentage of potassium, sodium and alpha amino acids in sugar beet roots under field conditions during 2014 and 2015 growing seasons

Treatment	Conc. g/l water	Potassium			Sodium			α-amino acids		
		Season 2014	Season 2015	Mean	Season 2014	Season 2015	Mean	Season 2014	Season 2015	Mean
Borax	0.5	4.78	5.12	4.95	0.42	0.56	0.49	1.91	2.02	1.97
	1.0	5.70	5.21	5.46	0.41	0.60	0.51	1.88	2.11	2.00
Boric acid	0.5	4.51	4.63	4.57	0.43	0.43	0.43	1.77	1.85	1.81
	1.0	4.78	4.01	4.40	0.42	0.45	0.44	1.99	2.06	2.03
Cabrio top 60%	0.5	3.59	4.71	4.15	0.16	0.36	0.26	1.06	1.96	1.51
	1.0	3.74	3.90	3.82	0.18	0.36	0.27	1.08	1.92	1.50
Control (untreated)	-	4.96	5.46	5.21	0.37	0.49	0.43	1.93	2.21	2.07
Mean	-	4.58	4.72	-	0.34	0.46	-	1.66	2.03	-
L.S.D. at 5%										
Treatments (T)		0.07			0.03			0.15		
Concentrations (C)		0.05			0.02			0.10		
Seasons (S)		0.04			0.02			0.10		
Interaction: (T×C)		0.10			0.04			0.21		
(T×S)		0.08			0.04			0.21		
(C×S)		0.06			0.03			0.15		
(T×C×S)		0.12			0.05			0.29		

Discussion

Fifteen isolates of *C. beticola* were isolated from diseased sugar beet plants collected from different localities of El-Behera Governorate. Pathogenicity of these isolates was evaluated on sugar beet Pleno cultivar under greenhouse conditions. All the tested isolates were able to cause Cercospora leaf spot symptoms and their pathogenic properties were varied from low to severe infection.

In this study, adding of borates at different concentrations into the medium significantly reduced the mycelial growth of *C. beticola* at all the tested concentrations. The obtained results are in agreement with those obtained by many other researchers (Shi *et al.,* 2011; Cao *et al*., 2012 and Ali *et al*., 2014). Borate disrupted the cell membrane of *B. cinerea*, eventually leading to leakage of cytoplasmic materials and the death of the fungal pathogen (Qin *et al*., 2007). Ali *et*

al., (2014) showed that boric acid was able to decrease Saprolegnia spores activity and mycelial growth in all the tested concentrations above 0.2 g/l, while complete inhibition to germinated spores and the growth was observed at the concentration of 0.8 g/L. Shi *et al.,* (2012) concluded that borate treatment can stimulate reactive oxygen species (ROS) accumulation in fungal spores, resulting in mitochondrial damage, which may act as an antifungal mechanism of borate inhibiting spore germination of *C. gloeosporioides* and controlling anthracnose in mango fruit.

The results obtained under field conditions indicated that both borate compounds significantly reduced the severity of Cercospora leaf spot infection at all the tested concentrations. These findings are in harmony with those obtained by Qin *et al.* (2007), where, they found that borate could significantly limit the pathogenicity of *Penicillium expansum* and effectively control postharvest diseases in fruit, such as grey rot caused by *B. cinerea* in table grapes (Qin *et al.,* 2010) and anthracnose caused by *C. gloeosporioides* in mango fruit (Shi *et al.,* 2011). In addition, they showed that the antifungal action of borate is associated with antioxidant enzymes and oxidative damage of the fungal pathogen. Shi *et al.* (2011) observed that mango inflorescences sprayed with borate significantly increased the number of fruit that set per branch compared to the control, and lower disease incidence of anthracnose during postharvest periods. Also, they found that borate at concentration of 1% could be inhibit blue rot caused by *P. expansum* in harvested apple fruit, and were able to demonstrate that the mechanisms involved in changing expression of antioxidant proteins and hydrolytic enzymes, based on comparative analysis of cellular and extracellular proteome (Qin *et al*., 2007).

Application of borates as foliar spray not only resulted in reducing the disease severity of Cercospora leaf spot but also improved agronomic characters of roots, as well as increased root yield, quality of yield and sugar percent compared to untreated plants. These results are in harmony with those obtained by Dordas *et al.,* (2007); Hellal *et al*., (2009); Abido, (2012) and Armin and Asgharipour, (2012). Gobarah and Mekki (2005) found that root yield, sucrose and juice purity percentage increased by boron addition which may be attributed to decrease Na and K uptake in root juice of sugar beet. Data also indicated that all borate treatments gave significant reduction in potassium, sodium and alpha amino nitrogen. Sugar beet quality was increased by increasing the percentage of sugar percent and reduced by increasing the percentages of potassium, sodium and alpha amino nitrogen. These findings are in agreement with those obtained by Armin and Asgharipour (2012) who found that boron application increased root yield and sucrose concentration by 12.12 and 26.35%, respectively, decreasing K, Na, amino-N and molasses sugar compared with those of the control. Similar results have been reported by Javaheripour *et al*. (2005) who found that application of 10 and 20 kg boric acid/ha prior to sowing did not increase the sodium content over the control. Tariq *et al*., (1993) showed that application of boron decreased sodium content in sugar beet root. From the obtained results, it could be concluded that the quality of sugar beet yield was increased by decreasing in non-sugary soluble solids. In conclusion, use of borates in disease control is a good and effective method and must be gave more attention due to its drastical effect on the pathogens.

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تـأثير الـرش بنـوعين مـن مركبـات البـورات علـى مقاومـــة مـــرض تبقـــع الأوراق السركـــسبورى وإنتاجية بنجر السكر

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تم الحصول على خمسة عشر عزلة من الفطرسركسبورا بيتيكولا من نباتات بنجر السكر المصابة من مناطق مختلفة فى محافظة البحيرة. وتم اختبار قدرة العزلات على اصابة نباتات بنجر السكر الصنف بلينو، وتبين أن جميع العزلات قادرة على إصابة نباتات بنجر السكر، وأن هذه العزلات اختلفت في قدرتها على إحداث المرض.

وتهدف هذه الدراسة إلى تقييم فاعلية البورات [البوراكس (الصوديوم تترابورات) وحامض البوريك] في مقاومة هذا المرض. وتحت ظروف المعمل تم اختبار البورات على نمو الفطر المسبب بتركيزات مختلفة وهى 10، 20، 40، 60، 80 و100 جزء فى المليون. حيث اتضح أن هذه المركبات كانت قادرة على تقليل نمو الفطر الممرض وذلك عند إضافة هذه المواد الى البيئة بكل التركيزات المختبرة. وأظهرت النتائج أن البوراكس كان الأكثر فاعلية فى تقليل نمو الفطر المسبب مقارنة بحامض البوريك والمبيد (كابريو توب 60 %).

تحت ظروف الحقل، أدى رش النباتات المصابة بالبورات بتركيزات 0,50 و 1,00جم/لتر ماء إلى تقليل شدة المرض، ولوحظ انخفاض واضح في شدة المرض في حالة الرش بالبوراكس عند تركيز 1جم/لتر ماء وأظهرت النتائج أيضا أن المعاملة بالبورات أدت إلى تحسين الصفات المحصولية للجذور، وكذلك زيادة محصول الجذور ونسبة السكر بها مقارنة بالنباتات غيرالمعاملة. وعلاوةعلى ذلك، فالمعاملة بالبورات أدت إلى انخفاض نسبة المواد الغير سكرية فى الجذور وهى البوتاسيوم والصوديوم والأحماض الأمينية الأليفاتية وبالتالى زيادة جودة المحصول.