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Influence of Cercospora Leaf Spot on Sugar Beet Yield Components in Egypt

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Six experiments were conducted in commercial fields, selected at Kafr El-Sheikh and Sharkyia Governorates, under natural infection stress during 2010/11, 2011/12 and 2012/13 growing seasons. These experiments were carried out to determine the relationship between Cercospora leaf spot (CLS) severity and sugar beet yield, sugar content and juice quality in roots of cv. Oscar Poly (susceptible cultivar). Plants were rated for disease severity, with a spot-percentage scale, according to the number of lesions per leaf at intensities <3%, and with standard area diagrams at intensities ≥3%. Decreases in root weight, percentages, in sucrose, quality and white sugar yield (WSY) and increase in non-soluble solids with increasing severities were detected across the full range of severities (1-7%). Significant decreases in root weight, percentages of sucrose, quality and WSY at or above 20% severity were observed. The regression analyses showed significant linear relationship ($P \leq 0.05$) between disease severity and root yield in kg, percentages of sucrose, quality, WSY and white sugar yield loss. The relationships also showed a high negative significantly correlated between disease severity and root yield/ kg, percentage of sucrose, quality and WSY. While, positive correlation was found between disease severity and potassium, sodium, alpha amino acids (mM) and white sugar yield loss.

Keywords: Alpha-amino acids, *Beta vulgaris*, *Cercospora beticola*, potassium, sodium, sugar beet and yield losses.

Sugar beet (*Beta vulgaris* L.) is a second commercial crop following sugar cane as major source of global sugar production (Shane and Teng, 1992). It is cultivated in the temperate and cold zones of the world. Sugar beet is still considered a new sugar crop in Egypt compared to sugar cane. It has been cultivated as a commercial crop since 1982 at Kafr El-Sheikh Governorate in about 16.943 feddan, reached about 403550 feddan in 2012, that yielding 1003514 tons of sugar representing about 50.1% of the total Egyptian production of sugar. It is planned to increase sugar beet cultivated area to decrease the gap (896000 ton) between local consumption and domestic production (Anonymous, 2013).

Cercospora leaf spot (CLS), caused by *Cercospora beticola* Sacc., is the most prevalent and destructive foliar diseases of sugar beet worldwide (Shane and Teng, 1992). It causes significant losses to growers in Minnesota and North Dakota and elsewhere in the United States and all over the world (Ruppel and Gaskill, 1971; Kelber, 1977a and Mukhopadhyay and Rao, 1978). Crop loss attributable to CLS is manifested as a reduction in root weight, reduced sugar content, and increased loss of sugar to molasses due to impurities (Smith and Martin, 1978). Losses due to CLS have gone as high as a 42% reduction in gross sugar and a 32% reduction in root weight (Smith and Martin, 1978). Shane and Teng (1992) reported that increases in concentration of impurities and decreases in sugar concentration in beet roots and decreases in root weight were generally correlated with the disease severity. Moreover, 50% disease severity recorded 10 days before harvest caused yield losses reached 27-43%. Also, Rossi *et al.* (2000) reported that losses due to *C. beticola* affected theoretical sugar production up to and often over 25-30%. In Egypt, loss in root yield resulted from infection by CLS ranged from 14.45 to 50.00% when Disease Severity was 10% & 80%, respectively, 10 days before harvest (Yassin, 2008).

The present study was designed to estimate sugar beet yield loss, reduction in root weight and sugar content as a result of infection by Cercospora leaf spot under Egyptian conditions.

Materials and Methods

Effect of Cercospora leaf spot (CLS) on sugar beet yield as weight of fresh root and quality expressed as juice qualities in the susceptible cv. Oscar Poly was determined at the end of the tested growing seasons.

Experiments were conducted in commercial fields, where sugar beets heavily infected by *C. beticola* under natural infection, at Kafr El-Sheikh and Sharkyia Governorates during 2010/11, 2011/12 and 2012/13 seasons. The experiments were designed in a complete randomized block design with three replicates. Each replicate was divided into 10 plots to constitute 10 categories of disease severities. These severities were attained by varying frequencies of spraying with the fungicide Score 25% EC (Dipheconazole) at the recommended dose (0.5 ml/l) at 15 days intervals immediately starting from the disease. Plots comprised of 6 rows, 5-m-long rows spaced 50cm apart and 25cm between plants. Seeds of the susceptible cv. Oscar Poly were sown in the beginning of August in the prepared plots. Uniformity of plant populations for all treatments was observed. Likewise, agronomic practices were carried out as ideally recommended. In order to minimize as much as possible the risk of interpolate interference, the plots were separated from each other by a one meter space distance as a buffer zone, free of sugar beet plants.

Disease severities were assessed 150 days after sowing on 50 plants selected at random in each plot, according to Shane and Teng (1992). Only the central rows of each plot were used for assessment (0.5 m at the end of each row was omitted). At harvest time, three replicated samples, each of 50 roots for each category of disease severity, were randomly collected, defoliated and weighted for root yield. Fifty roots from each plot, avoiding roots on ends of the plot, were chosen for sugar analyses.

Juice analyses were done at the Sugar Factory Laboratory (Belkas, Dakahliya), where sucrose percentage (using standard polarmetric method) was estimated. Alpha amino acids, potassium and sodium were estimated by flourimetric methods as sugar purity (Schneider *et al.*, 2002).

Disease assessment:

Disease severity (%) of CLS was assessed using scale adopted by Shane and Teng (1992) as shown in Table (1) and Fig. (1).

Table 1. Spot-percentage scale for assessment of CLS of sugar beet

Class on grade	Average number of spots/leaf	Disease severity (%)
1	0	0.00
2	< 1*	0.01
3	1-5	0.10
4	6-12	0.35
5	13-25	0.75
6	26-50	1.50
7	50-75**	2.50

* This category is used for plants where the disease was observed but the average number of spots per leaf is less than one.

** For each tested plant, a minimum of five leaves were examined for CLS. At low severities (<3%), each plant was categorized according to spots per leaf as given above; at high disease intensities, disease severity was estimated by comparison of leaves with standard area diagrams (Fig.1).

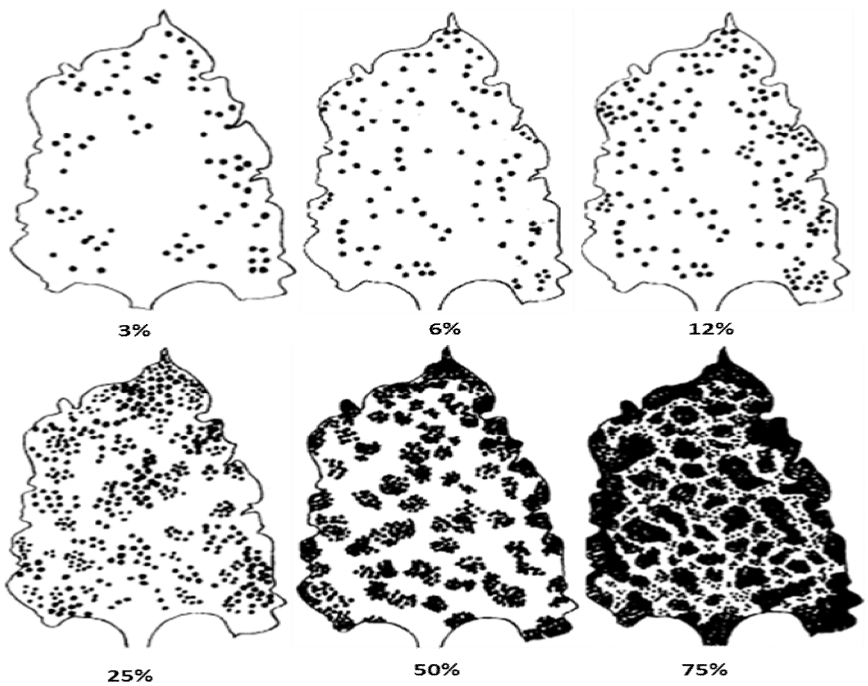


Fig. 1. Standard area diagrams for assessment of disease severity for CLS of sugar beet according to Shane and Teng (1992).

Sugar content:

Sucrose was estimated in roots at harvest time using the method of McGinnis (1982).

Sugar yield production:

The WSY (%) was calculated using the following equation:

WSY (%)= Juice quality (%) X Sucrose (%) in root juice

Sugar yield loss:

Sucrose loss (%) was estimated using the simple equation adopted by Calpouzos *et al.* (1976) as follows:

$$\text{Loss (\%)} = \frac{\text{Yield of healthy plant - Yield of diseased plant}}{\text{Yield of healthy plant}} \times 100$$

Statistical analysis:

Data were statistically analyzed, whenever needed, using the analysis of variance (ANOVA) test as described by Anonymous (1996). Means were compared by least significant difference (L.S.D.) test at $P \leq 0.05$ level. The relationships between root yield/kg, sucrose (%), quality (%), WSY (%) and white sugar yield loss (%) as well as disease severity (%), were estimated. Statistical analyses were determined using correlations and linear regressions.

Results

Six experiments were conducted in commercial fields selected at Kafr El-Sheikh and Sharkyia Governorates under natural infection stress during 2010/11, 2011/12 and 2012/13 growing seasons.

1. Effect of infection by CLS on root weight:

Results presented in Table (2) show the effect of CLS on root yield under different disease severities. Decrease in root weight (kg/50 roots) was detected with increased severities across the full range of severity (1-70%) in the six experiments as compared with the controls (0.0% severity). Significant decrease in root weight (kg/50 roots) caused by disease severity reached 20% or above, at Kafr El-Sheikh. Whereas, it reached 30% or above at Sharkyia. Data also show that insignificant differences were recorded among the values of root weight and a particular severity and others (50-70%) at Kafr El-Sheikh and (40-70%) at Sharkyia.

2. Effect of infection by CLS on sugar content of roots:

Percentages of sucrose contents gradually decreased by increasing in disease severity (Table 3). Disease severity, at or above 20%, at the two inspected Governorates, significantly reduced sucrose percentages compared to that of healthy plants (0.0% severity). These results indicate that CLS disease has no significant effect on percentage of sucrose between 50% and above severity at Kafr El-Sheikh and 40% and above severity at Sharkyia.

Table 2. Influence of infection by CLS at different percentages of disease severities on root weights (kg/50 roots)

CLS disease severity (%)	Kafr El-Sheikh			Sharkyia		
	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13
0	53.0	58.9	55.3	47.8	50.0	48.6
1	52.7	58.8	55.2	47.7	49.8	48.5
5	52.3	58.6	55.0	47.4	49.4	48.3
10	51.9	58.2	54.7	47.0	49.0	48.1
20	51.4	58.0	54.3	46.6	48.6	47.8
30	50.5	57.0	53.5	45.8	47.9	46.7
40	49.5	56.2	52.6	45.0	47.2	45.7
50	48.6	55.6	51.9	44.3	46.9	45.3
60	48.0	55.3	51.5	44.5	46.7	45.0
70	47.8	55.1	51.4	44.0	46.6	44.9
L. S. D (0.05)	1.15	1.47	1.06	1.43	1.04	2.35

Table 3. Effect of infection by CLS at different percentage of disease severities on sucrose contents of roots

CLS disease severity (%)	Kafr El-Sheikh			Sharkyia		
	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13
0	21.9	21.2	21.4	21.4	20.1	21.4
1	21.5	20.9	21.2	21.2	19.8	21.2
5	21.1	20.3	20.9	20.8	19.5	21.0
10	20.4	19.8	20.5	20.3	19.0	20.6
20	19.5	19.4	19.8	19.4	18.2	20.0
30	18.1	18.2	17.9	17.8	16.9	18.9
40	16.9	16.7	15.8	16.2	16.4	17.5
50	15.9	15.2	14.4	15.7	15.3	16.2
60	15.4	14.4	13.6	15.2	14.5	15.2
70	15.3	14.1	13.3	14.9	14.3	14.9
L. S. D (0.05)	1.9	1.6	2.15	1.8	1.3	2.4

3. Effect of infection by CLS on the impurities of the roots:

Results presented in Tables (4 and 5) indicate that, in general, sugar beet plants infected by CLS produced roots contained high (amounts) of non-sucrose chemical components (potassium, sodium and alpha amino acids). Over all trials, the effect of infection on the non-sucrose chemical components was increased gradually by increasing the severity percent from 5% up to 70%. Significantly, controversial results for the mM/ 100g root of Na and alpha amino acids were obtained at 5% of disease severity. However, at 10% of disease severity, infection caused significant increases in all of the three components, *i.e.* K, Na & alpha amino acids, over the three seasons and the two inspected Governorates.

Table 4. Effect of infection by CLS at different percentages of disease severities on the non-sucrose chemical components, Kafr El-Sheik experiments

CLS disease	Potassium (mM)			Sodium (mM)			Alpha amino acids (mM)		
severity (%)	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13
0	4.2	2.54	2.8	1.2	1.2	1.2	2.9	1.9	2.6
1	4.4	2.97	3.5	1.4	1.4	1.3	3.0	2.2	2.7
5	4.9	3.12	4.1	1.5	1.7	1.4	3.1	2.3	2.8
10	5.5	3.81	4.7	1.8	1.8	1.7	3.6	2.9	3.1
20	6.0	4.09	5.2	2.1	2.0	1.7	3.9	3.1	3.4
30	6.4	4.77	6.1	2.2	2.2	2.1	3.9	3.2	3.9
40	7.5	5.13	6.7	2.3	2.3	2.3	4.2	3.5	4.1
50	7.9	6.04	7.4	2.5	2.5	2.4	4.7	3.9	4.4
60	8.8	6.71	8.1	2.8	2.8	2.9	5.2	4.1	5.0
70	9.3	7.34	8.9	3.0	2.9	3.1	5.8	4.5	5.7
L.S.D.(0.05)	0.5	0.51	0.54	0.32	0.31	0.29	0.25	0.22	0.31

Table 5. Effect of infection by CLS at different percentages of disease severities on the non-sucrose chemical components, Sharkyia experiments

CLS disease	Potassium (mM)			Sodium (mM)			Alpha amino acids (mM)		
severity (%)	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13
0	3.5	3.9	3.5	1.1	1.1	1.1	2.8	2.1	2.6
1	3.9	4.1	3.7	1.3	1.7	1.2	2.9	2.2	2.8
5	4.3	4.4	4.1	1.5	1.3	1.4	3.0	2.4	3.0
10	5.0	4.8	4.2	1.5	1.7	1.7	3.4	2.9	3.1
20	5.6	5.2	4.4	1.7	2.0	1.8	3.8	3.1	3.4
30	6.1	5.4	4.7	1.8	2.2	1.9	4.1	3.4	3.8
40	6.7	5.9	5.0	2.1	2.5	2.1	4.2	3.9	4.1
50	7.3	6.2	5.4	2.3	2.6	2.5	4.9	4.2	4.4
60	7.9	6.9	5.9	2.5	2.9	2.8	5.2	4.7	4.9
70	8.9	7.3	6.2	2.9	3.1	3.0	5.6	4.9	5.1
L.S.D.(0.05)	0.50	0.35	0.54	0.20	0.27	0.38	0.34	0.26	0.31

4. Effect of infection by CLS on the sugar quality in roots:

Results in Table (6) indicate that quality (%) was gradually decreased with increasing disease severities from 1 to 70%. Significant decrease in juice quality (%) was found at or above 20% at Kafr El-Sheikh (2010/11) and Sharkyia in 2012/13 and at or above 30% in the other seasons as compared with healthy plants (0.0% severity). No significant differences were recorded between values of 50% severity to 70% in the six experiments, except between those of 50% (81.46) and of 70% (79.19) in Kafr El-Sheikh (2010/11).

5. Effect of infection by CLS on WSY of roots:

Results of Table (7) indicate that the impact of CLS was a reduction of WSY (%). WSY increased by increasing in percentages of sucrose and quality, while it was decreased by increasing in disease severity. Significant reduction of WSY (%) was recorded at or above 20% severity at Kafr El-Sheikh and Sharkyia as compared with control plants (0.0% severity). Results also show insignificant difference between the values of WSY (%) and a particular severity and others, *i.e*. (40-70%) and (50-70%), in all experiments.

Table 6. Effect of infection by CLS at different disease severities on juice quality

CLS disease severity (%)	Kafr El-Sheikh			Sharkyia		
	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13
0	90.3	89.8	87.2	89.4	88.0	90.3
1	90.1	89.5	87.1	89.2	87.8	90.2
5	89.4	89.1	86.5	88.8	87.5	89.4
10	88.7	88.7	85.8	87.9	87.2	88.5
20	87.8	88.1	85.2	87.0	86.8	87.5
30	85.4	86.2	83.3	85.2	84.8	85.4
40	83.2	84.2	81.3	83.2	83.5	83.9
50	81.5	82.9	79.8	82.1	81.5	83.0
60	79.6	82.1	79.3	81.4	80.6	82.4
70	79.3	81.6	79.0	81.3	80.3	82.2
L. S. D (0.05)	2.19	2.03	2.35	2.47	2.12	2.03

Table 7. Effect of infection by CLS at different disease severities on WSY (%) of roots

CLS disease severity (%)	Kafr El-Sheikh			Sharkyia		
	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13
0	19.7	19.1	18.7	19.2	17.7	19.4
1	19.4	18.7	18.4	18.9	17.4	19.2
5	18.9	18.1	18.1	18.4	17.0	18.8
10	18.1	17.5	17.5	17.8	16.6	18.3
20	17.1	17.1	16.8	16.9	15.8	17.6
30	15.5	15.7	14.9	15.2	14.4	16.2
40	14.1	14.1	12.9	13.5	13.7	14.7
50	12.9	12.6	11.5	12.9	12.3	13.4
60	12.3	11.8	10.8	12.4	11.7	12.6
70	12.1	11.5	10.6	12.1	11.5	12.2
L. S. D.(0.05)	2.00	1.63	2.19	1.90	1.95	2.44

6. Effect of infection by CLS on percentages of white sugar yield loss (%):

Results in Table (8) show that positive effect of CLS severities reached up to 70% on percentages of WSY loss. Increases in WSY loss was detected across the full range of severities (1-70%) in the six experiments. In case of disease severity lesser than 70%, the WSY (%) decreased by 38.7, 39.6, and 43.53% in 2011, 2012, and 2013, respectively, in Kafr El-Sheikh. Meanwhile, reductions by 36.6, 34.9 and 36.8% were detected in Sharkyia during 2011, 2012 and 2013, respectively.

The highest percentages of WSY loss were recorded in 2012/13 season as 70% severity at Kafr El-Sheikh Governorate (43.5) and Sharkyia (36.8). Meanwhile, in case of 70% severity, the low WSY losses were recorded in seasons of 2010/11 at Kafr El-Sheikh (being 38.7) and 2011/12 at Sharkyia (being 34.9).

Table 8. Effect of infection by CLS at different percentages of disease severities on white sugar yield loss (%) of roots

CLS disease severity (%)	Kafr El-Sheikh			Sharkyia		
	2010/11	2011/12	2012/13	2010/11	2011/12	2012/13
0	0	0	0	0	0	0
1	1.8	1.6	1.4	1.2	1.5	1.1
5	4.3	5.2	3.3	3.8	3.7	3.1
10	8.3	8.0	6.5	7.0	6.1	5.7
20	13.5	10.3	10.0	12.0	10.9	9.4
30	21.6	17.8	20.1	20.8	18.8	16.4
40	28.7	26.0	31.2	29.5	22.7	24.2
50	34.5	33.9	38.4	32.9	30.6	30.6
60	37.9	38.0	42.3	35.3	33.8	35.2
70	38.7	39.6	43.5	36.6	34.9	36.8

7. The relationships among infection by CLS and the losses in roots and final sugar yield under stresses of different disease severities:

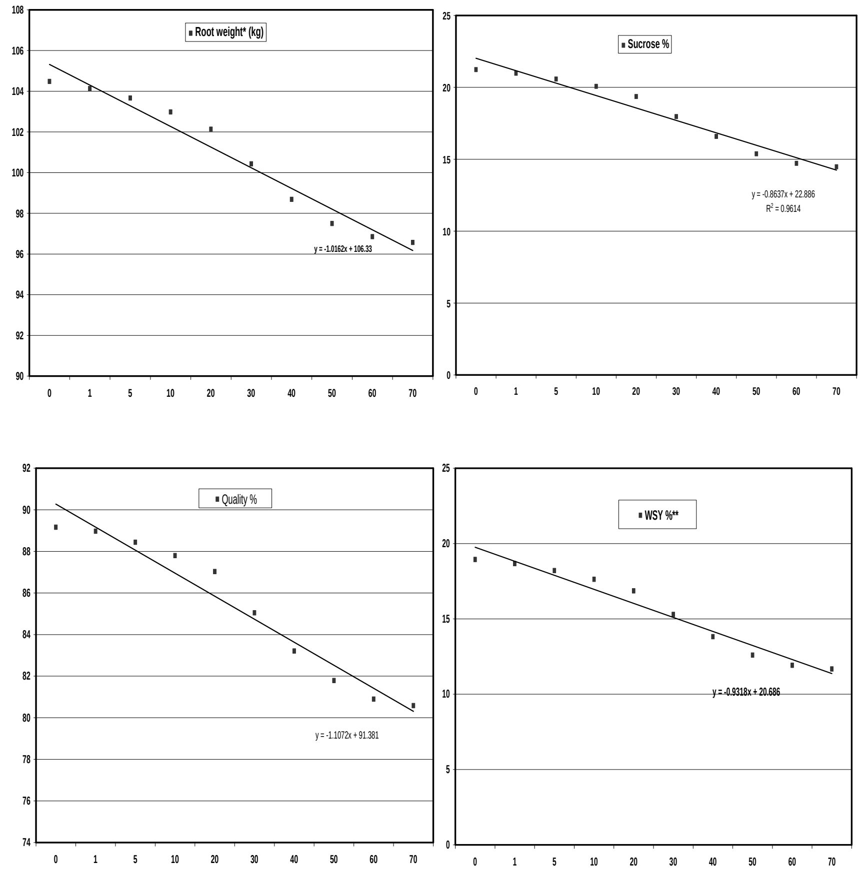
The relationships between disease severity and root yield/ kg, percentages of sucrose, quality, WSY and white sugar yield loss related to linear regression revealed general decreases in root yield/ kg, sucrose, quality and WSY, while white sugar yield loss was increased (Fig. 2).

The relationships showed a highly negative significant correlation ($P \leq 0.05$) between disease severity and root yield/ kg, percentages of sucrose, juice quality and WSY, while it was positive between disease severity and potassium, sodium, alpha amino acids (mM) and percentages of white sugar yield loss (Table 9). On the other hand, the contribution percentage (R^2) of disease severity in root yield/kg as well as percentages of sucrose, juice quality and WSY, reached 79.7, 85.6, 88.0 and 86.9, respectively. Other records, reached 95.5, 91.2, 95.5 and 87.4 for potassium, sodium, alpha amino acids (mM) and percentages of white sugar yield loss, respectively.

Table 9. Relationships between infection by CLS and the root yield, sucrose, quality, WSY and white sugar yield loss in the roots and final sugar yield under stresses of different disease severities

Treatment	Correlation	Contribution (%)
Root yield weight (kg)	- 0.89**	79.74
Sucrose (%)	- 0.93**	85.56
Potassium (mM)	0.98**	95.45
Sodium (mM)	0.96**	91.20
Alpha amino acids (mM)	0.98**	95.45
Quality (%)	- 0.94**	87.98
WSY (%)	- 0.93**	86.86
WSY loss (%)	0.94**	87.42

** Highly significant.



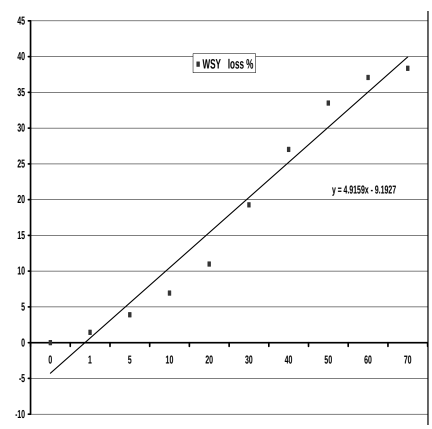


Fig. 2. Regression equations that describe the relationships between disease severity and root yield/ kg, sucrose (%), quality, WSY and white sugar yield loss under field conditions at Kafr El-Sheikh and Sharkyia Governorates during 2010 /11, 2011/12 and 2012/13 growing seasons.

Discussion

Leaf spot disease caused by *Cercospora beticola* Sacc. is considered as one of the most worldwide destructive foliar disease of sugar beet (Smith and Ruppel, 1974). It causes great reduction to the yield and quality of sugar (Shane and Teng, 1992). Many investigators recorded decreases in root weight and sugar content and increases in impurities, especially sodium and alpha amino acids (mM), in association with CLS epidemics (Finkner and Farus, 1968; Kelber, 1977 b; Ruppel and Gaskill, 1971; Smith and Martin, 1978; Shane and Teng, 1992 and Mittler *et al.*, 2004).

Results of the present research recorded a high negative correlation among disease severities and root weight, percentages of sucrose, quality and WSY. Also, high positive correlations among disease severities and potassium, sodium, and alpha amino acids (mM) and white sugar yield loss (%) were found throughout the six experiments. These results are similar to those reported by Gaurilcikiene *et al.* (2006) who found that the WSY were highly significant for the resistant sugar beet cultivar compared with the susceptible cultivar. They suggested that white sugar content in both cultivars was mostly dependent on CLS disease severity.

Decreases in yield of sugar beet may be due to the effect of CLS infection on the physiological state and biological activities of the host plant. Infection by *C. beticola* can cause destruction in the mesophyll tissue, reduction in chlorophyll and carotene content (Bala and Dhillon, 1987; El-Kholi, 1995 and Hasan, 2001). De Jesus Junior *et al.* (2001) mentioned that the effect of angular leaf spot of beans was mainly due to defoliation that leads to a reduction of the total leaf area, which yielded a decrease in leaf photosynthesis. Sugar beet plants display remarkable defensive capacities, once the plants have passed the delicate seedling stage (Shane and Teng, 1992). Jones *et al.* (1955) found no appreciable effect on sugar beet root weight and sugar content when 25% of green foliage was removed by mechanical defoliation at the eight-leaf stage. Additionally, defoliated plants were allowed to regenerate leaves and, thus, restore the photosynthetic capacity. Unlike defoliated leaves, affected leaves on diseased plants block sunlight to remaining healthy leaves (Shane and Teng, 1992). This may be supported with the findings of Smith and Campbell (1996) who attributed the decreases in root weight to disease severity.

Loss, however, was found to be as a result of various factors including cultivar aspect, CLS disease and fertilization, which play a major role in affecting the leaf growth dynamics, thus the accumulation of saccharine in the roots was influenced significantly (Meriggi *et al.*, 2003).

Smith and Martin (1978) reported that increased non sucrose chemical components (potassium, sodium, and alpha amino acids mM) impede crystallization of sucrose, consequently decreased sugar recovery. Increased impurity concentration in sugar beet yield was found to be affect by CLS may be a result of decreases in root size associated with CLS, rather than enhanced production of impurities (Shane and Teng, 1992). CLS disease is an abnormal factor which interferes in the function of plant physiology and affects metabolism and resulting metabolites. The metabolites include the non sucrose soluble solids (Na, K and alpha amino acids) and their increases in diseased plants may be due to the disturbance in the plant physiology. In addition, the absorption of these chemicals from soil differed between sites due to its availability. This partially agrees with Zaiter *et al.* (1991). Sugar beet amino nitrogen concentrations were greater in the Rosemount experiment compared to the Murdock data. It is possible that soil nitrogen availability influences the impact of CLS disease on sugar loss to molasses (Shane and Teng, 1983).

Results also demonstrated that the percentages of white sugar yield loss owing to CLS vary from year to year. These results agree with that of Kelber (1977 a) who found that the severity-loss relationship may differ from year to year. The present study recorded higher white sugar yield loss (%) at Kafr El-Sheikh than Sharkyia during 2012/13 season. This might be attributed to the increase in concentrations of sodium, potassium and alpha amino acids (mM), which led to decrease in percentages of sucrose and quality at Kafr El-Sheikh. On the other hand, differences in yield components may be due as well, to the variation in weather climatic factors at the two inspected Governorates, especially temperature and air relative humidity, these results are in agree with Cioni *et al.* (2004). In addition, the differences observed in sodium, potassium and alpha amino acids (mM) at the two inspected Governorates may be attributed to the soil contents of Na, K and N. The obtained data also revealed that, a disease severity of 20% approximately at harvest corresponding to white sugar yield loss of 15%.

References

Anonymous, 1996. SAS/ STAT Users Guide, Version 6, 12th Ed. SAS Institute, Inc. Cary, North Carolina, 846 pp.

Anonymous, 2013. Annual report of the Central Council for Sugar Crops. Ministry of Agric. and land Reclamation, Egypt (In Arabic).

Bala, M. and Dhillon, M.C. 1987. Chlorophyll content of *Cercospora* infected groundnut leaves in susceptible and resistant varieties. *Ann. Appl. Boil*., **3**(3): 61-63.

Calpouzos, L.; Roelfs, A.P.; Madson, M.E.; Martin, R.B.; Welsh, J.R. and Wilcoxson, R.D. 1976. A new model to measure yield losses caused by stem rust in spring wheat. *Tech. Bull. Agric. Exp. St.* No. **397**(7): 1-23. Univ. MN. St. Paul.

Cioni, F.; Tugnoli, V. and Zavanella, M. 2004. CLS: The effects on sugar content reduction. Proc. 67th IIRB Cong., Bruxelles (B).

De Jesus Junior, W.C.; Do Vale, F.X.R.; Coelho, R.R.; Hau, B.; Zambolini, L.; Costa, L.C. and Bergamin Filho, A., 2001. Effects of angular leaf spot and rust on yield loss of *Phaseolus vulgaris*. *Phytopathology,* **91**: 1045-1053.

El-Kholi, M.M. 1995. *Cercospora beticola* Sacc. and its effect on sugar beet plants. Egypt. *J. Agric. Res*., **73**(4): 1035-1045.

Finkner, R.E. and Farus, D.E. 1968. Effects of CLS and dates of harvest on sugar beet varieties with or without maneb treatment. *J. Am. Soc. Sugar Beet Technol*., **14**: 643-663.

Gaurilcikiene, Irena; Deveikyte, M. and Petraitiene, E. 2006. Epidemic progress of *Cercospora beticola* Sacc. in *Beta vulgaris* L. under different conditions and cultivar resistance. *Lietuvos mokslu akademijos, Biologi*, **4**: 54-59.

Hasan, Manal Y.H. 2001. Phytopathological studies on sugar beet leaf spot caused by *Cercospora beticola* Sacc. Ph.D. Thesis, Fac., Agric., Cairo, Univ., Egypt, 134pp.

Jones, P.G.W.; Dunning R.A. and Humphries, K.P., 1955. The effects of defoliation and loss of stand upon yield of sugar beet. *Ann. Appl. Biol*., **43**:63-70.

Kelber, E. 1977a. Multivariate models for the estimation of yield losses in sugar beet due to *Cercospora beticola*. *Z. Pflanzenkrankh. Pflanzenschutz*., **84**: 174-186.

Kelber, E. 1977b. Handing of experimental data in a secondary evaluation for disease intensity-crop loss relationships. *Z. Pflanzenkrankh. Pflanzenschutz*, **84**: 100-113.

McGinnis, R.A. 1982. Analysis of sucrose content. Pages: 67-76. In: *Beet Sugar Technology*. 3rd Ed. McGinnis, R.A. (ed.). Beet Sugar Development Foundation, Denver, Colorado, USA.

Meriggi, P.; Candolo, G. and Paganini, U. 2003. Indicazioni per contenere il fenomeno della retrogradazione nella barbabietola da zucchero. *Agronomica*, **1**: 11-17.

Mittler, S.; Petersen, J.; Jorg, E. and Racca, P. 2004. Integrated control of leaf diseases in sugar beet. Proc. 67th RB Cong., Bruxelles(B).

Mukhopadhyay, A.N. and Rao, S.V.R.K. 1978. Losses caused by CLS in sugar beets. *Indian Phytopathol*., **31**: 229-231.

Rossi, V.; Meriggi, P.; Biancardi, E. and Rosso, F. 2000. Effect of CLS on sugar beet growth, yield and quality. *Advances in Sugar Beet Res.*, **2**: 49-76.

Ruppel, E.G. and Gaskill, J.O. 1971. Techniques for evaluating sugar beet for resistance to *Cercospora beticola* in the field. *J. Am. Soc. Sugar Beet Technol*., **16**: 384-389.

Schneider, K.; Schäfer-Pregl, R.; Borchardt, D. and Salamini, F. 2002. Mapping QTLs for sucrose content, yield and quality in a sugar beet population fingerprinted by EST-related markers. *TAG Theoretical and Applied Genetics*, **104**: 1107-1113.

Shane, W.W. and Teng, P.S. 1983. Epidemiology of CLS. Sugar beet Res. Ext. Rep., **13**: 201-213.

Shane, W.W. and Teng, P.S. 1992. Impact of CLS on root weight, sugar yield and purity of *Beta vulgaris*. *Plant Dis*., **76**: 812-820.

Smith, G.A. and Campbell, L.G. 1996. Association between resistance to *Cercospora* and yield in commercial sugar beet hybrids. *Plant Breed*., **115**: 28-32.

Smith, G.A. and Martin, S.S. 1978. Differential response of sugar beet cultivars to CLS disease. *Crop Sci*., **18**: 39-42.

Smith, G.A. and Ruppel, E.G. 1974. Heritability of resistance to CLS in sugar beet. *Crop Sci.*, **14**: 113-115.

Yassin, M.A.A. 2008. Studies on CLS disease of sugar beet. Ph.D. Thesis, Plant Pathol. Dept., Fac. Agric., Cairo Univ., 126 pp.

Zaiter, H.Z.; Coyne, D.P.; Clark, R.B. and Steadman, J.R. 1991. Medium pH and leaf nutrient concentration influence rust pustule diameter on leaves of dry beans. *Hort. Sci*., **26**(4): 412-414.

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تأثير مرض تبقع الأوراق السركسبوري على المكونات المحصولية لبنجر السكر في مصر

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أجريت ٦ تجارب تحت ظروف العدوى الطبيعية في محافظتي كفر الشيخ والشرقية مواسم ٢٠١٠/٢٠١١ ، ٢٠١١/٢٠١٢ و٢٠١٢/٢٠١٣ بهدف دراسة العلاقة بين إصابة نباتات بنجر السكر بمرض تبقع الأوراق السركسبوري وكلا من وزن الجذور والنسبة المئوية للسكروز ، الجودة ، محصول السكر الناتج والفقد في محصول السكر النهائي في جذور بنجر السكر ، صنف اوسكار بولي (حساس للمرض) ومكونات العصير الكيميائية الأخرى وهي البوتاسيوم والصوديوم والأحماض الأمينية (حيث تعوق بلورة السكروز الناتج).

أثبتت النتائج أن زيادة شدة الإصابة تؤدي إلى انخفاض معنوي في كل من وزن الجذور ونسبة السكروز في الجذور وكذلك الجودة وكانت هذه الانخفاضات متناسبة طرديا مع شدة المرض ، ومن ثم انخفضت نسبة استخلاص السكر بسبب تأثير المكونات الكيميائية غير السكرية سابقة الذكر والتي ارتفعت نسبتها بزيادة شدة الإصابة ، وهذا يؤدى في النهاية إلي خفض معنوي في كمية السكر الأبيض الناتج. كما وجد أن شدة الإصابة عندما تصل إلى ٢٠% ينتج عنها خسارة اقتصادية في محصول السكر النهائي. وبالتحليل الإحصائي لمعامل الارتباط والانحدار وجد ارتباط سالب عالي المعنوية بين شدة الإصابة ووزن الجذور ، نسبة السكروز ، النسبة المئوية للجودة ومحصول السكر النهائي في الجذور ، كما وجد ارتباط موجب عالي المعنوية بين شدة الإصابة والفقد في محصول السكر النهائي ومكونات العصير الكيميائية الأخرى.