
Effect of Cercospora Leaf Spot Disease on Sugar Beet Yield

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Abstract: Cercospora leaf spot disease (CLS), caused by *Cercospora beticola* Sacc., considered one of the most damaging foliar diseases, attacks sugar beet causing significant loss in the final yield. The direct impact of CLS on sugar beet yield and yield components was investigated in the field trials conducted in Sakha, Kafr El-Sheikh governorate in 2017/2018 and 2018/2019 seasons. Pleno cultivar was cultivated under natural infection and disease severity was controlled by Eminent fungicide (Tetraconazole 12.5%, 1ml/L). Leaf weight (LW), root weight (RW), total soluble sugar (TSS) and sucrose % (S) were measured at the harvest time and the gross sugar (GS) was estimated then collected data were statistically analyzed. All parameters of the yield components were significantly affected due to CLS infection. Actual losses in the LW, RW, TSS and S reached 82.9%, 55.1%, 34.8% & 40.3% in the first season and 69.3%, 46%, 29.1% & 33.6% in the second season respectively. Additionally, monetary return (Egyptian Pound) per feddan (4200 m²) was decreased due to infection by CLS disease. The reduction ranged from 294-1668 Egyptian pounds during the two seasons depending on the disease severity occurred. Finally, the possibility to predict loss % in yield components according to disease severities was illustrated and equations were concluded using the single point model.

Keywords: Sugar Crops, *Beta vulgaris*, Pleno Cultivar, CLS

1. Introduction

Sugar beet (*Beta vulgaris* L.) is one of the main sugar crops in Egypt since the cultivated area of this crop reached more than 500000 Feddan produce about 1.5 million ton of sugar [1]. However, leaf spot incited by the widespread and destructive foliar fungus, *Cercospora beticola* Sacc., is one of the most common diseases affecting sugar beet production and yield quality in Egypt [2-6]. In addition to Beta genus, this fungus capable of infecting many plants belonging to Acanthaceae, Apiaceae, Brassicaceae, Chenopodiaceae, Malvaceae, Plumbaginaceae, and Polygonaceae families [7, 8]. Under favorable conditions, lesions of CLS disease firstly appear on the host older leaves within 5–11 days after inoculation. In case of susceptible varieties grown in high humidity and warm temperatures, an epidemic progression will take place and complete leaf senescence rapidly occurs [9].

Growing resistant varieties following an appropriate crop rotation associated with good cultural practicing is very important to minimize the impact of CLS on sugar beet yield [10, 11]. Otherwise, considerable root yield losses up to 40%, as well as more than 50% losses of sugar yield and sucrose concentration could be attributed to CLS infection when susceptible untreated cultivars grown in warm and humid areas [12-14]. Although the impact of Cercospora leaf spot disease on sugar beet yield was studied in Egypt, until now there is no report related to the influence of CLS on the monetary return obtained from sugar beet yield. So, the current work was aimed to investigate the effect of CLS disease on sugar beet yield components under different levels of disease severity, as well as its impact on the monetary return per feddan (4200 m²).

2. Materials and Methods

2.1. Field Experiments

Field trials were conducted in Sakha Agric. Res. Station, Kafr El-Sheikh governorate under natural infection, where beet plants heavily infected by *C. beticola* in the previous seasons. A randomized complete block design with four replicates was used over two seasons (2017/2018 and 2018/2019). Plots consisted of four (6m long) rows spaced 60 cm apart. Rows were planted on 20 and 25 August with the *Cercospora* leaf spot-susceptible cv. Pleno in the first and second seasons respectively. Plants were hand-thinned to one, 20cm distance between plants. Symptoms of CLS were detected in plots at 90 days after planting. To obtain various levels of disease severity, Eminent (Tetraconazole 12.5%, Lots Agric. Develop. Co.), the more efficient fungicide for controlling CLS disease [5], was applied (1ml/L) and the disease severity was determined using the standard area diagram [15]. Just after reaching the desired severity, fungicide was applied with 15d intervals using a backpack sprayer (20L capacity). Control treatment (zero severity) was sprayed by the fungicide, 10 days before anticipated symptom appearance. Meanwhile, the non-sprayed treatment was used to obtain the highest disease severity.

2.2. Parameters Assays

Five sugar beet plants were randomly selected from the center two rows of each plot. The roots and hand defoliated leaves of the selected plants were weighed separately and obtained data were recorded [4]. Selected roots and leaves of 4 replicates were used in yield assessment. Sucrose % was estimated according to the method described by Association of official analytical chemists [16]. Root slices (2mm in thickness) were shredded with a kitchen grade and thoroughly mixed. After that, 26g of sample was taken for cold extraction procedure for sucrose determination. Sample was blended with 173ml of dilute basic lead acetate solution (3%) in an electric blender for 2 minutes. The mixture was then filtered through filter paper (Whatman No.1). The clear filtrate was used to measure sucrose % by the aid of saccarometer. TSS was also measured in a drop of sugar beet juice using hand refract-meter as reported by Mc Ginnis [17]. Gross sugar was calculated as recorded by Abdel-Motagally and Attia [18] according to the following formula:

$$\text{Gross sugar \%} = \text{root yield} \times \text{sucrose \%}$$

2.3. Assessment of Loss in Yield Components

Data of leaves weight (LW), roots weight (RW), total soluble sugar (TSS%), sucrose % (S), and gross sugar (GS) of the two seasons under different levels of disease severity were used for determining the impact of CLS disease on sugar beet yield components [5].

2.4. Monetary Return (Egyptian Pound)

The monetary return was calculated regarding the total number of beet plants/Feddan (40,000) and 600 Egyptian

pounds/Ton (average price in the study seasons) [1]. The reduction in the pounds return was estimated by subtracting the income of CLS infected plants from that of the healthy "protected ones" [15].

2.5. Estimation of the Predicted Yield Loss

The obtained data of RW loss, S loss and GS loss along with the associated disease severity were employed to estimate the predicted yield loss using single point model of James [19].

2.6. Data Analysis

All collected data were subjected to statistical analysis using SPSS software package version 16.0. The least significant difference LSD ($P \leq 0.05$) was used to identify differences and compare means.

3. Results

Sugar beet yield components i.e. LW, RW (Table 1), TSS and S (Table 2) were generally decrease as disease severity increase. Significant differences were found between means of all parameters ($p < 0.05$) over seasons. Disease severity of 10%, resulted in about 17%, 12%, 5% and 4% losses of LW, RW, TSS and S, respectively, over seasons compared with the protected plants (Figure 1). When disease severity reached 30%, losses of 45%, 35%, 12% and 15% in LW, RW, TSS and S respectively were recorded. Whereas seasonal losses of more than 50%, 45%, 18% and 23% in LW, RW, TSS and S, respectively were recorded, when disease severity reached 50% (Figure 1). On the other hand, actual loss of gross sugar (GS) was ranged from 16% to 69%.

Table 1. Effect of *Cercospora* leaf spot (CLS) disease on leaves weight (LW) and roots weight (RW) of sugar beet plants.

D.S%*	First season		Second season	
	LW(Kg)**	RW(Kg)**	LW(Kg)**	RW(Kg)**
00.00	6.125	6.313	5.575	5.975
10.00	5.638	5.700	4.225	5.125
20.00	4.675	5.338	3.575	4.525
30.00	4.450	4.950	3.075	3.900
40.00	3.550	3.563	2.650	3.675
50.00	3.363	3.350	2.550	3.900
60.00	2.494	3.100	2.000	3.400
70.00	1.713	3.038	1.725	3.450
80.00	1.050	2.838	1.713	3.225
LSD (0.05)	0.165	0.289	0.304	0.549

* mean of DS% taken from two rows 6m-long with four replicates.

** Mean of roots and leaves weight of 5 sugar beet plants selected randomly from the center two rows with four replicates.

In respect to monetary return, loss of root yield due to CLS disease was associated with significant reduction in annual money return. Such reduction ranged from 294 to 1668 and from 408 to 1320 Egyptian pounds per feddan in the first and second seasons respectively (Figure 2). On the other hand, employment of the actual yield loss % in the single point model to predict yield loss revealed that three equations were

achieved. These equations are; Loss = 0.745 (DS), Loss = 0.469 (DS) and Loss =1.003 (DS) and could be used to predict loss of roots weight (RW), sucrose % (S) and gross sugar (GS) respectively depending on the disease severity (Figure 3).

Table 2. Effect of Cercospora leaf spot (CLS) disease on Sucrose (S), Total soluble sugar (TSS) and Gross sugar (GS) in sugar beet plants.

D.S%*	First season			Second season		
	S (%)**	TSS (%)**	GS (kg) **	S (%)**	TSS (%)**	GS (kg) **
00.00	25.550	27.600	1.61	21.850	25.050	1.31
10.00	23.900	26.350	1.36	21.200	24.300	1.09
20.00	23.900	25.625	1.28	20.050	23.850	0.91
30.00	23.050	24.950	1.14	18.600	22.250	0.73
40.00	21.900	23.550	0.78	17.250	20.850	0.63
50.00	20.000	22.450	0.67	16.800	20.350	0.66
60.00	16.750	20.350	0.52	15.750	18.700	0.54
70.00	16.050	19.200	0.49	15.300	18.150	0.53
80.00	15.250	18.000	0.43	14.500	17.750	0.47
LSD (0.05)	0.404	0.508	0.046	0.421	0.289	0.112

* mean of DS% taken from two rows 6m-long with four replicates.

** Mean resulted from five sugar beet roots selected randomly from the center two rows with four replicates.

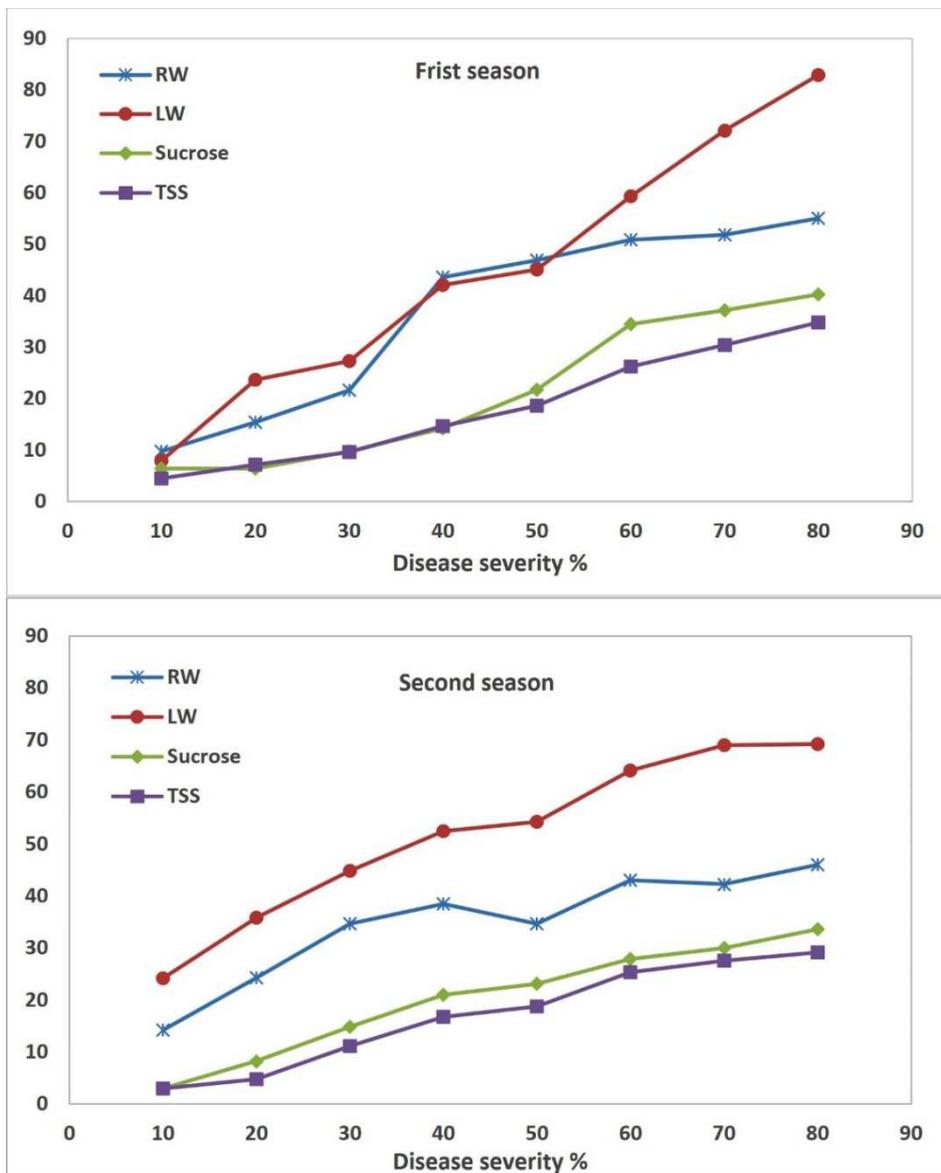


Figure 1. Percentages of loss in sugar beet yield components due to Cercospora leaf spot disease.

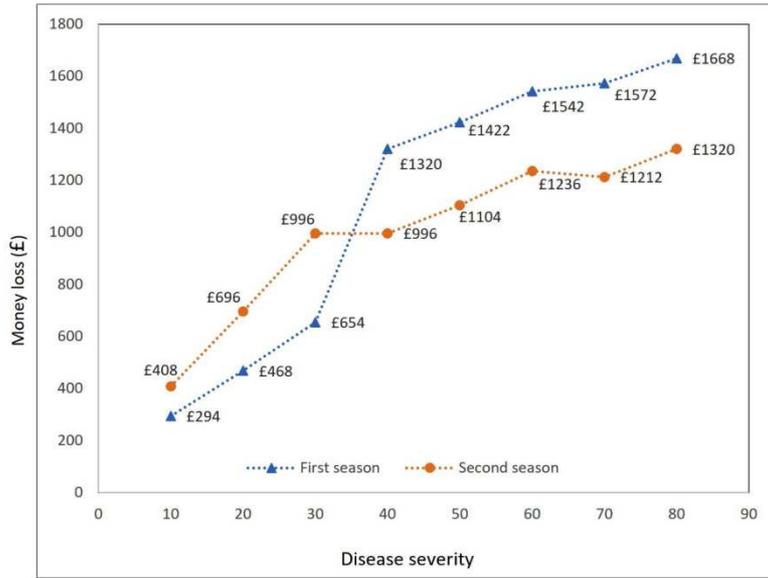


Figure 2. Reduction in annual monetary return by Egyptian pounds/Feddan due to disease severity of CLS in sugar beet.

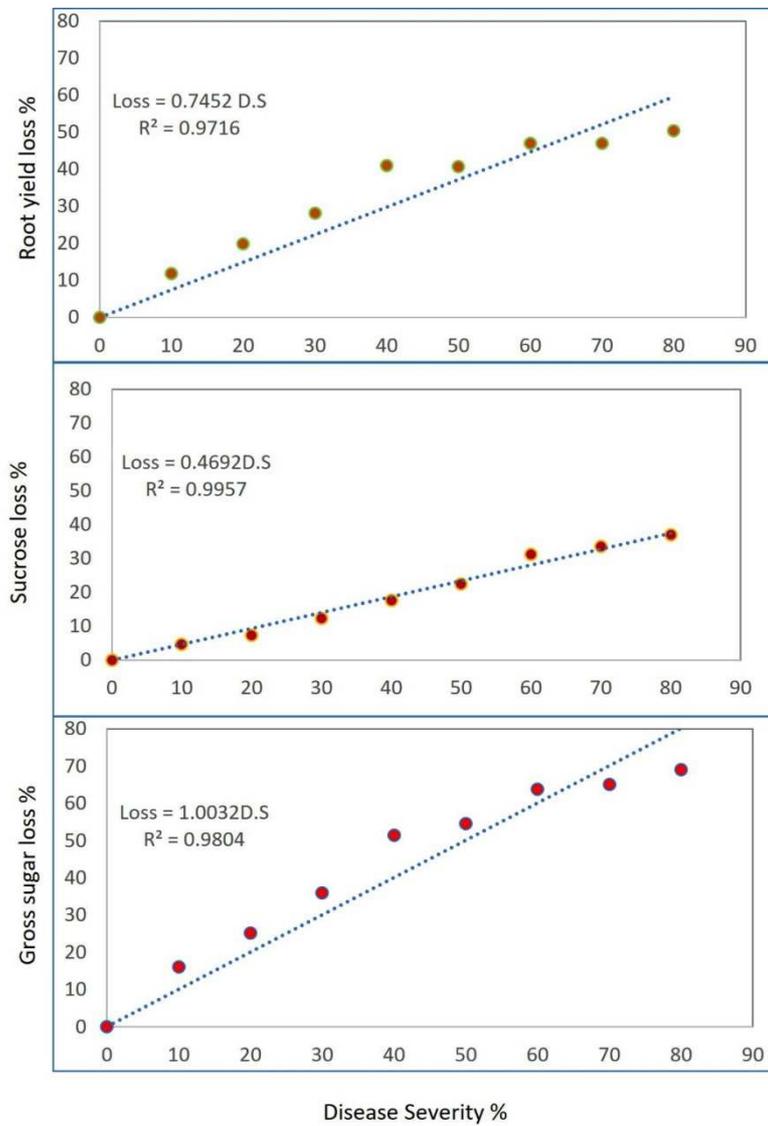


Figure 3. Equations for prediction of losses in RW, S and GS depending on DS of CLS disease of sugar beet.

4. Discussion

The effect of CLS disease on the sugar beet yield was investigated in this study. It was found that disease severity of the fungicide-untreated sugar beet plots reached 80% reflecting the suitability of this region for *Cercospora* Leaf Spot (CLS) disease due to the existence of favorable conditions required for initial infection and disease spreading [5, 20]. Previous studies concluded that cultivating the susceptible sugar beet varieties like Pleno, in the North regions of the Egyptian Delta, in August, resulted in severely CLS during December and January where warm, humid and wet conditions are existed [4, 21]. An epidemic onset occurred when infection frequency of beet plants reached 50% (disease severity = 0.01%) in the natural field [22], where such favorable conditions was suitable for rapid disease cycles "12 days each" [23-26].

In this study, significant loss in sugar beet leaves, root weight, TSS and sucrose % as well as in gross sugar were associated with an increasing disease severity. Yassin [3] reported that root yield loss following severe CLS infection has been documented to reach 50%. However, the main documented cause of yield reduction following CLS disease, is plant leaves injury which provide a small assimilation area required for photosynthesis [27]. Additionally, rapid leaf senescence and drying from outside to inside due to CLS resulting in reduction in leaves and root growth [28, 29]. On the other hand, leaf senescence make plants produce new leaves to replace those which fell instead of root growth and sucrose production [30]. Sucrose %, TSS, and gross sugar losses following CLS in this study were also consistent with the previously documented data [4, 31, 32]. Moreover, infection by CLS often resulted in increased concentrations of impurities specially potassium, sodium, and alpha-amino nitrogen rates [15, 33]. The significant reduction in the monetary return due to CLS was illustrated in this study and found to be consistent with the reported data of Shane and Teng [15]. Finally, current study provided a possibility to predict yield losses % in beet root, sucrose % as well as gross sugar according to disease severities [3] and in turn the final amount of money loss [15].

5. Conclusion

CLS is one of the most important and common diseases affecting sugar beet production in Egyptian Delta. Significant reduction in leaves, roots and sugar yield due to the early infection of susceptible cultivars was found in Kafr El-sheikh District. More than 50%, 23% and 70% loss in RW, S and GS respectively was found in this study under high levels of disease severity. As a result, maximum loss of the monetary return reached about 1320-1668 Egyptian pounds. Since the full protection provided by Eminent (Tetraconazole 12.5%) against CLS, fungicide application is recommended if DS is less than 10% to avoid subsequent losses. Moreover, further studies are needed for managing the disease with suitable

combination of fungicides to avoid appearance of resistant strains as reported elsewhere.

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