EFFECT OF RUST INFECTION ON SUGAR BEET YIELD COMPONENTS

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Abstract

The effect of sugar beet rust (*Uromyces betae* Tul. ex. Kick) on crop yield and industrial qualities was quantitatively investigated . Significant differences were found between healthy and diseased plants, in root weight, sucrose % in root, non-sucrose chemical components (potassium, sodium and alpha amino acids), and quality %. Root weight, sucrose % and quality % were inversely affected by disease severity . Consequently, white sugar yield (WSY) was reduced due to the increase of non-sugar constituents which impede sugar crystallization .

Key words : Rust, *Uromyces betae*, sugar beet (*Beta vulgaris* L.), white sugar yield (WSY) and Eminent .

INTRODUCTION

Diseases infecting sugar beet (Beta vulgaris L.) plant have strong effect on sugar accumulation in plant root . In this respect, Smith and Martin (1978) indicated that *Cercospora beticola* infection increased the non-sucrose chemical compounds such as sodium nitrate, amino nitrogen and total nitrogen and decreased total sucrose yield and purity of sugar beet juice . Regarding rust disease, Muchembled (1996) and Sorensen and Marcussen (1996) have proved that rust infection decreased sugar content in roots of infected plants .

On the other hand, rust control by fungicides has direct effect on root sugar content. All trials indicated that sugar content was negatively proportional to disease severity (O'Sullivan, 1996 and 1997, Hermann and Meeus, 1999, Hermann *et al.,* 2000) .

The objective of this study was to investigate the effect of sugar beet rust on crop yield and its industrial qualities under Egyptian conditions since no work was done before due to the recent introduction of the crop into the country.

MATERIALS AND METHODS

Effect of rust disease on crop yield as weight of fresh root and quality expressed as juice qualities in the susceptible cultivar Pleno was determined and compared with those of healthy plants.

Trials were carried out at farmer fields selected at Damietta and Kafr-El-Sheikh Governorates under natural infection during 2002/2003 growing season . To obtain different disease severities, the fungicide Eminent was applied in different numbers of sprays, when the first detectable infection started . One, two and three sprays were adopted at 15 day intervals in a complete block randomized design with three replications of five rows (5 m length) and twenty plants / row . At harvest, three replicate samples, each of twenty roots for each category of disease severity were randomly collected for crop yield analysis .

Simultaneously, to show any fungicide effects on yield components, fungicide sprays were carried out on rust free plants at the same locations and under the same agro-conditions . Juice analysis was done at the Sugar Factory Laboratory (Belkas, Dakahleia), where sucrose % (using standard polarimetric method), quality % and potassium, Sodium and alpha amino acids (mM / 100 g. root) were estimated . Alpha amino acids were estimated by the Flourimetric method .

The scale adopted by Peterson *et al.* (1948) and modified (Table 1), by Ata (unpublished), was followed for disease severities assessment .

Table 1. Adopted scale for rust disease assessment. Number of pustules per leaf, % leaf infected area per total leaf area, disease categories and calculated % disease severity.

Disease category	No. of pustules / leaf	% leaf infected area /leaf area	% disease severity
1	1 - 10	0.04 - 0.4	1
2	11 - 40	0.44 - 1.6	5
3	41 - 90	1.64 – 3.6	10
4	91 - 160	3.64 – 6.4	20
5	161 - 250	6.44 – 10.0	30
6	251 - 360	10.04 – 14.4	40

Loss percentage of sucrose was estimated using the simple equation adopted by Calpouzos et al., 1976 as follows:

Loss % = [1 – Yd/ Yh] 100

Where Yd = Yield of diseased plant .

Yh = Yield of healthy plant .

The results from each location were analysed separately using analysis of variance procedures and differences among disease severities were compared using the least significant difference (LSD) , according to Snedecor and Cochrane (1967).

RESULTS

Tables (2) and (3) and Figs. (1) and (2) demonstrate the effect of different rust severities on root weight/plant, sucrose and quality percentage and other components at Damietta and Kafr El-Sheikh Governorates . Root weight/plant was reduced and reduction was increased due to disease severity increase. Root weight/plant was decreased from 1.058 (0 rust severity) to 0.867 kg (40 % rust severity) at Damietta and from 1.125 to 0.925 at Kafr El-Sheikh. Significant difference were recorded among most of the used rust severities.

Sucrose percentage decreased significantly from 22.33 (0 rust severity) to 17.17 % (40 % rust severity) as a result of disease severity increase at Damietta and from 21.833 to 17.467 % at Kafr El-Sheikh. Significant differences were recorded between 0 and other rust severities (1 – 40 %) . There was no significant differences between 1 and 5 % , 10 and 20 % and 30 and 40 % rust severities at Damietta and between 10 and 20 % , 30 and 40 % at Kafr El- Sheikh .

Significant differences in the percentage of juice qualities % (purity %) were found among all rust severities from 0 to 40 % and were reduced by disease severity increase from 88.47 (0 rust severity) to 78.53 % (40 % severity) at Damietta and from 89.867 to 79.693 % at Kafr El-Sheikh.

Non-sucrose chemical components (potassium, sodium and alpha amino acids) were positively correlated with ascending disease severities . Potassium increased from 4.73 (0 rust severity) to 9.12 mM /100g root (40% severity) at Damietta and from 4.30 to 7.067 at Kafr El-Sheikh . Sodium increased from 1.23 (0 rust severity) to 2.16 mM /100g.root (40 % severity) at Damietta and from 0.713 to 1.893 at Kafr El-Sheikh. Alpha amino acids increased from 2.96 (0 rust severity) to 4.96 mM /100g root (40 % severity) at Damietta and from 0.837 to 1.66 at Kafr El-Sheikh.

Percentage of white sugar yield (WSY) is calculated as juice quality % x sucrose % in roots . WSY increased by the increase in sucrose % and quality % and was reduced by disease severity increase . It decreased from 19.75 (0 rust severity)

Table 2. Effect of different disease severities % on root weight, sugar contents, quality and other components under field conditions at Damietta Governorate during the growing season 2002-2003. Readings recorded at the end of the season (on ripen roots) .

Rust severity %	Root weight* (kg)	Sucrose %	Potassium mM	Sodium mM	alpha amino acid mM	Quality %	WSY**	WSY loss %
0	1.058	22.333	4.733	1.233	2.967	88.467	19.75	0.0
1	1.025	21.167	5.167	1.167	3.167	86.667	18.34	7.14
5	1.000	20.333	5.417	1.383	3.470	85.333	17.35	12.15
10	0.958	19.167	6.527	1.587	3.247	83.667	16.04	18.78
20	0.925	18.500	7.320	1.600	2.913	82.333	15.23	22.87
30	0.892	17.833	8.490	1.423	5.180	80.667	14.39	27.14
40	0.867	17.167	9.120	2.157	4.963	78.527	13.48	31.75
L. S. D (0.05)	0.0416	0.8756	1.1626	0.3302	0.8624	0.9688	0.4117	

* Mean weight of 20 roots .
** WSY % : white sugar yield % .

Table 3. Effect of different disease severities % on root weight, sugar contents, quality and other components under field conditions at Kafr El-Sheikh Governorate during the growing season 2002-2003 . Readings recorded at the end of the season (on ripen roots) .

Rust severity %	Root weight* (kg)	Sucrose %	Potassium mM	Sodium mM	Alpha amino acids mM	Quality %	WSY %**	WSY loss %
0	1.125	21.833	4.300	0.713	0.837	89.867	19.62	0.0
1	1.068	20.800	4.903	0.753	0.903	88.333	18.37	6.37
5	0.983	19.800	4.800	0.850	0.950	87.650	17.35	11.57
10	0.975	18.900	5.117	0.997	0.883	86.423	16.33	16.77
20	0.975	18.433	5.500	1.177	1.007	84.737	15.62	20.39
30	0.950	17.667	6.033	1.267	1.383	83.033	14.67	25.23
40	0.925	17.467	7.067	1.893	1.660	79.693	13.92	29.05
L. S. D (0.05)	0.0357	0.6857	0.5589	0.6131	0.2963	2.9071	0.2113	

* Mean weight of 20 roots .
** WSY % : white sugar yield % .

to 13.48 % (40 % severity) at Damietta and from 19.62 to 13.92 at Kafr El-Sheikh. Significant differences between all of the used rust severities were recorded .

Results also show the effect of rust severities from 0 to 40 % on white sugar yield (WSY) losses . It increased by disease severity increase . In infected sugar beet plants showing 40 % rust severity, white sugar yield decreased by 31.75 and 29.05 % compared with healthy plants (0 rust severity)) at Damietta and Kafr El-Sheikh, respectively .

Data in Table (4) show that the fungicide Eminent has no significant effect on yield components . Hence, changes in yield components are ascribed to the rust disease (Tables 2 and 3).

Table 4. Effect of Eminent fungicide on root weight, sugar content, quality and other yield components in healthy plants .

Treatments	Root weight* (kg)	Sucrose %	Potassium mM	Sodium mM	Alpha amino acids mM	Quality %	WSY %**
Control (without fungicide)	0.734	18.90	6.16	2.28	3.73	81.89	15.48
Eminent	0.750	19.01	6.00	2.07	4.56	82.64	15.67

* Mean weight of 20 roots .
** WSY % : white sugar yield %.

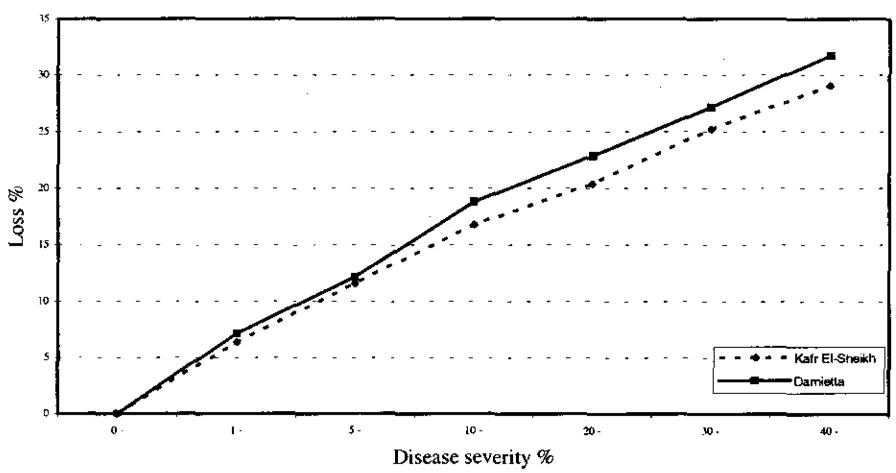

Fig. 1. Effect of beet rust disease severity on WSY loss % at Kafr El-Sheikh and Damietta during 2002-2003 growing season.

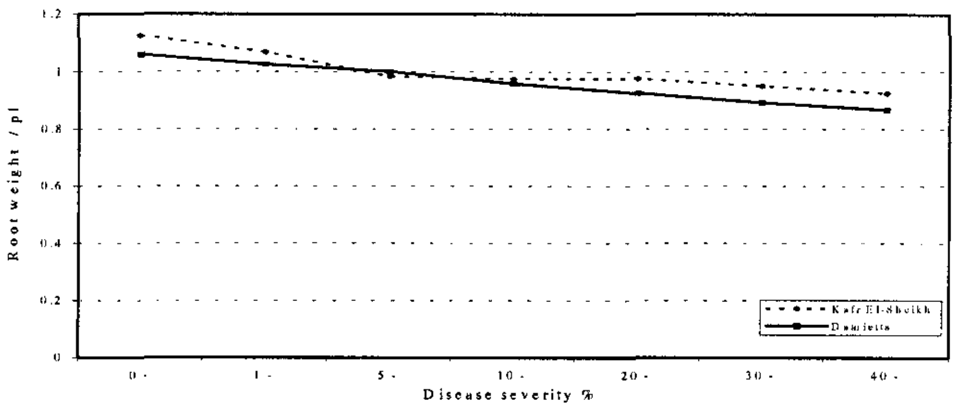

Fig. 2. Effect of beet rust disease severity on root weight (kg) at Kafr El-Sheikh and Damietta during 2002-2003 growing season .

DISCUSSION

Beet rust disease reduced root weight, sucrose % and quality % of sugar beet infected plants . Reduction was increased by disease severity increase . These results are in agreement with Muchembled (1996), O'Sullvian (1996,1997), Hermann and Meeus (1999) and Hermann *et al.* (2000) .

Mittler *et al.* (2004) showed that *Uromyces betae* is among fungi causing foliar diseases of sugar beet in Germany,. Sixty % of the cultivated area was treated with fungicides against Cercospora leaf spot (CLS). White sugar yield (WSY) from treated sites was higher compared to the untreated ones. Relating yields and losses in WSY was strongly influenced by disease severity. A one % increase in disease (CLS) severity resulted in a 0.2 % reduction in WSY . de Jesus Junior *et al.* (2001) mentioned that severe effect of bean rust *Uromyces appendiculatus* on yield may be connected with the biotrophic nature of this pathogen . The rust pustules act as sinks for carbohydrates (Zaki and Durbin, 1965, Liven and Daly, 1966), which then could not be allocated for production of yield. In other words, some carbohydrates are trapped and cannot translocate to other parts of the plant .

Results also revealed that, non-sucrose chemical components (potassium, sodium, and alpha amino acids) increase by increasing disease severity . Smith and Martin (1978) reported that increased non sucrose chemical components impedes crystallization of sucrose, conequently decreased sugar recovery.

Rust disease or any other leaf spot of sugar beet is an abnormal factor which interferes in the functions 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 increase 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).

The differences in yield components may be due to the variation in weather factors at the two location. In addition the differences observed in sodium, potassuim and alpha amino acids at the two locations may be attributed to the soil contents of Na, K and N.

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تأثير الإصابة بالصدأ على الصفات المحصولية لبنجر السكر

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تم التقدير الكمي لتأثير صدأ البنجر على المحصول وصفاته التصنيعية وظهر من الدراسة وجود فروق معنوية بين النباتات السليمة والمصابة في وزن المحصول والنسبة المئوية للسكروز في الجذر ومكونات العصير الكيميائية الأخرى (وهي البوتاسيوم والصوديوم والأحماض الأمينية) والنسبة المئوية للجودة حيث انخفض كل من وزن الجذور و نسبة السكروز في الجذر وكذالك الجودة وكانت هذه الانخفاضات متناسبة طرديا مع شدة المرض ومن ثم انخفضت نسبة استخلاص السكر بسبب تأثير المكونات الكيميائية غير السكرية سابقة الذكر والتي تعوق بلورة السكروز ، مما يؤدى في النهاية إلي خفض كمية السكر الأبيض الناتج .