STUDIED ON SUGAR BEET RUST DISEASE IN EGYPT
II: MANAGEMENT OF DISEASE UNDER FIELD CONDITIONS

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ABSTRACT

All sugar beet (*Beta vulgaris*) cultivars tested were susceptible to different extents against the infection with *Uromyces betae* **Tul Kick**. They were categorized as less susceptible "LS" cvs. (Farida, Gloria, Top and Toro), moderate susceptible "MS" cvs. (Negma, Gazail and Pleno) and the high susceptible "HS" cvs. (Raspoly, Lola and Kawmeia). The LS cvs. produced higher dry matter, root length, root diameter and fresh and dry weights of sugar beet roots followed by MS and HS cvs. The rust disease severity (DS) on sugar beet strictly correlated with sowing time. DS was higher on the early sowing (15th August) than the late sowings (15th September, 15th October and 15th November). Regardless sowing date, the disease was very low at 15th February then increased gradually until reached its maximum at 15th April. The DS recorded minimize levels on sowings performed at 15th October and/or 15th November.

The DS was minimized and yield was maximized by using the less susceptible "LS" cvs Farida combined with spraying plants with the recommended dose of the fungicide Caramba or garlic extract (0.3%) just at the first appearance of rust symptoms. Also, spraying plants with IAA (300ppm) after 70 days from sowing, using N and P fertilizers together at rate of 60 kg N and 30 kg P2O5 per feddan, respectively and sowing sugar beet seeds at the proper distance between both rows (60cm) and plants (30cm) each alone gave satisfactory results.

In fact, using the N fertilizer alone at rate of 100 kg (N)/feddan significantly increased DS and root fresh weight while decreased total soluble solids % (TSS) % and sucrose content in roots increased comparing with the other N levels including control receiving no N fertilization. However, the P fertilizer used alone at 15 and 30 kg (P_2O_5)/feddan gave the best disease control in both seasons comparing with the control receiving no P fertilization.

Intercropping sugar beet with broad bean (*Vicia fabae*) significantly increased both DS and fresh weight of sugar beet roots meanwhile decreased total soluble solids (TSS %) and sucrose content in roots in comparison with the control (sugar beet alone). Intercropping the two crops at rate 1:3 and 3:1 resulted in the highest decreases in both later criteria, respectively.

Key words: Sugar beet, Rust, *Uromyces betae*, Cultivars, Sowing date, Fungicides, Garlic, IAA, Intercropping,

INTRODUCTION

Uromyces betae **Tul Kick** caused beet rust disease occurred widely and considered one of the most problems affecting sugar beet plants in Europe and the United States **(Walker, 1952)** as well as in Egypt **(Mehiar *et al.*, 1977). Ata (2005)** stated that, the sugar beet rust spreads in the Egyptian North Delta governorates, (Kafr El-Sheikh, Beheira, Dakahleia and Domiat). Disease severity was higher in Domiat, obviously decreased in Garbeia and Sharkeia governorates and rarely occurs in Fayoum governorate. The disease was not recorded during the survey in Beni-Sueif and Menia.

The rust diseases could be controlled by several means i.e. foliar spraying with different fungicides (**O'Sullivan, 1996**; **Ata; 2005);** plant growth regulators (**Moustafa Zeineb *et al*., 200l; Fayza (El-Taweel) *et al*., 2004)** and plant extracts (**El-Kazzaz *et al*., 2003).** The rust diseases could be controlled also by means of agriculture practices such as sowing date (**Ahmed, 2000; Mohamed, 2000; Ata, 2005);** distance between plants (**Hassanin, 2001**; **Ahmed, 2003),** intercropping (**Fininsa, 1996; Khan** *et al*., **2002**). **Ata (2005)** studied the effects of beet rust on crop yield and industrial qualities. Significant differences were recorded between healthy and diseased plants concerning root weight, sucrose %, chemical component, and quality %. Root weight, sucrose % and quality were reduced parallel to disease severity reduction. Consequently, sugar recovery was reduced due to the increase in non-sugar component, which impede sugar crystallization and finally white sugar yield.

The present study was carried out mainly to study some factors affecting management of sugar beet production and rust disease in middle delta of Egypt through application of plant extracts, plant growth regulators and fungicides. In addition to some agricultural practices (intercropping and growing distance) and sowing dates in relation to disease progress and its epidemiological appearance were also investigated.

MATERIALS and METHODS

All following field experiments were carried out in randomized complete block design with three plots "replications" and performed twice during two successive growing seasons (2001-2002) at Sakha Research Station (Kafr-El-Sheik governorate, Egypt). Unless otherwise mentioned, each plot (15 m^2) consisted of 6 rows, 5 m long and 50 cm apart, distance between plants was 20 cm and irrigation and fertilization were practiced as recommended by Sugar Crops Research Institute (A.R.C). The P (super phosphate) fertilizer (15% P_2O_5) was added at rate of at 30 kg P_2O_5/feddan before sowing. The N fertilizer (Urea, 46% N) was applied in two equal doses (each 40 kg N/fed) added 30 and 45 days after sowing, respectively. while K (potassium sulfate) fertilizer at the rate of 48 kg K_2O (48% K_2O) was added with N fertilizer. In all experiments (except sowing date), the sugar beet seeds were planted at the first week of November in each season. Also, the sugar beet cv. Farida was used in all experiments (except the experiment dealing with responses of sugar beet cvs.).

The rust disease severity (DS) was estimated at harvest time in all experiments according to the modified Cobb's scale **(Peterson *et al.*, 1948).** Also, fresh weight of roots (ton/fed), sucrose % and total soluble solids (TSS %) were determined at harvest. The (TSS %) was determined in fresh roots using hand Refractometer **(Me Ginnis (1982)**. While, sucrose percentage was estimated by adding 26 g from the minced root to 177 ml of lead acetate (50 g/liter of distilled water), shacked for 5 minutes and filtered. The filtered solution was measured by Saccharometer as mentioned by **Le-Docte (1927)**.

1- RELATION BETWEEN SOWING TIMES AND EPIDEMIOLOGY OF THE SUGAR BEET RUST DISEASE:

Seeds of sugar beet cv. Farida were sown at 15th August, 15th September, 15th October and 15th November (during 2001 & 2002 seasons). The DS was recorded at 15th February, 1st March, 15th March, 1st April and 15th April in each season. The Meteorological data (air and soil temperatures) prevailed during the growing seasons at the experimental area were recorded (un published). The area under disease progress curve (AUDPC, **Pandy** *et al.,* **1989**) and rate of disease increase (r-value) were determined according to the following formulae**:**

AUDPC = D $(1/2(Y_1+Y_k)+Y_2+Y_3+Y_4+Yk_{-1})$ Where: D = time interval (=15 days), (Y_1+Y_k) = summation of the first and last disease scores, $(Y_2+Y_3+Y_4+Yk_{-1})$ = summation of all disease scores between the first and last ones.

r-value = 1/(t2-t1)((log(X2)-(1-X1)-(log(X1)-(1-X2) Where: t1 and t2 = the intervals (in days) between date1 and date2 at which disease severity was recorded (here = 15 days), X1 = the proportion of the infected tissue at date1, X2 = the proportion of the infected tissue at date2.

2- EVALUATION OF SOME SUGAR BEET CULTIVARS FOR RESISTANCE AGAINST NATURAL INFECTION WITH SUGAR BEET RUST DISEASE:

The following sugar beet cultivars (Gloria, Toro, Top, Raspoly, Kawmeia, Gazailla, Negma, Lola, Farida and Pleno) were evaluated, during 2000 and 2001 seasons, for their responses against natural infection with the sugar beet rust disease. At harvest, the natural rust disease severity %, root dry matter (%), root length and widest diameter (cm), root yield and fresh weight of top (leaves) in (ton/fed) were determined for all cultivars tested.

3- CHEMICAL CONTROL:

In this study, the fungicides namely Eminent (Tetraconazole), Caramba (Tetraconazole), Plantvax (Oxycarboxin), Impact (Flutriafol), Saprol (Triforine), Anvil (Hexaconazole) and Sumi-8 (Diniconazole) were used during 2000 and 2001 growing seasons at their recommended doses i.e. 1.0 ml/l for the first five fungicides and 0.25 ml/l and 0.35 ml/l for the last two, respectively. The fungicidal application was done one time just at the first appearance of rust disease on sugar beet leaves (cv. Farida). At harvest, rust disease severity (%), fresh root weight (kg), total soluble solids % and sucrose % were determined as mentioned before.

4- EFFECT OF PLANT EXTRACTS:

Two experiments were carried out during 2000 and 2001 seasons to study the effect of spraying sugar beet plants (cv. Farida) with 0.3% conc. of some plant extracts (**Table, 5**) on controlling the sugar beet rust disease. The plant extracts were sprayed once on sugar beet plants just at the first appearance of disease symptoms on sugar beet leaves. At harvest, disease severity (%), fresh root weight (kg), total soluble solids % and sucrose % were determined as mentioned before.

5- EFFECT OF PLANT GROWTH REGULATORS:

Seeds of sugar beet plants (cv. Farida) were planted on the first week of November during 2002 and 2003 growing seasons then plants were sprayed with the growth regulator solutions after 70 days from sowing using hand-atomizer until complete coverage. Plants sprayed with water served as control. The growth regulators Indole-3-acitic acid (IAA), Gibberellic acid (GA_3) and Naphthalene acetic acid (NAA) were applied singly at concentration of 0.03 % (prepared in tap water). At harvest, disease severity (%), fresh root weight (kg), total soluble solids % and sucrose % were determined as mentioned before.

6- SELECTION OF THE PROPER DISTANCES BETWEEN ROWS AND/OR PLANTS:

Two experiments were carried out during 2000 and 2001 growing seasons to evaluate the combined effects of spaces between rows (50 and 60 cm) and between plants (10, 20 and 30 cm) on the natural infection with rust disease on the sugar beet cv. Farida. At harvest, disease severity (%), fresh root weight (kg), total soluble solids % and sucrose % were determined as mentioned before.

7- EFFECT OF FERTILIZERS:

This experiment was performed in a complete randomized block design during the two successive growing seasons 2002 and 2003. Seeds of sugar beet cv. Farida were sown on the first week of November of each season. Four levels of urea (46.5% N) as N fertilizer (0, 60, 80, and 100 kg N/fed) and three levels of super phosphate (15% P2O5) as P fertilizer (0, 15 and 30 kg P2O5/fed). Any dose of N fertilizer was divided into two equal amounts added after 1 and 2 months after sowing, respectively. However, the P levels were added at seedbed preparation after ridging. Physical properties of the upper 20 cm of soil of the experimental site were 53.29 % clay, 33.41 % silt, and 13.30 % sand. All other agricultural practices were practiced as commonly recommended by Sugar Crops Research Institute, A.R.C. At harvest time, disease severity (%), root fresh weight (ton/fed), total soluble solids % and sucrose % were determined as mentioned before.

8- EFFECT OF INTERCROPPING:

Different intercropping systems (broad been/sugar beet) were evaluated for their effects on the rust disease severity percentage and some crop properties during 2001 and 2002 growing seasons. Rows in plots were planted alternatively with sugar beet and broad bean to perform the following nine intercropping treatments: 1:1, 1:2, 1:3, 2:1, 2:2, 2:3, 3:1, 3:2, 3:3, respectively. Sugar beet (cv. Farida) planted alone served as control. At harvest time, rust disease severity (%), fresh root weight (ton/fed), total soluble solids % and sucrose % were determined as mentioned before.

All data obtained were statistically analyzed according to **Snedecor and Cochran (1981)**.

RESULTS AND DISCUSSION

1- RELATION BETWEEN SOWING TIMES AND EPIDEMIOLOGY OF THE SUGAR BEET RUST DISEASE:

Data in **Table (1)** show that the severity of rust disease on sugar beet plants seemed strictly correlated with sowing time. The early sowing (15th August) exhibited the highest rust infection followed by sowing on 15th September, 15th October and 15th November, respectively. During both seasons 2001 and 2002, the rust infection was very low at 15th February then gradually increased until reached its maximum at 15th April. The r-value (percentage increase of sugar beet rust disease/day) was obviously higher on sugar beet plants sown at 15th November comparing with any sowing dates particularly those sown at 15th August during both seasons. While, the values of area under disease progress curve (AUDPC) seemed behaved unlike r-values. The AUDPC in both seasons was obviously higher on plants sown at 15th August comparing with those sown 15th November. The average value of AUDPC was higher in 2001 than 2002 season whereas average of r-value showed the opposite trend. In fact, the sugar beet plants might be more predisposed to rust infection on middle of April because favored temperatures either in air (17.4-18.8ºC) or in soil (18.5-22.7ºC). This explanation is in agreement with **Ellis and Ellis (1985)** who recorded that the sugar beet rust (*Uromyces betae*) is favored by temperatures around 18°C. These results suggested that the selected planting dates might play a significant role in the epidemiological progress of sugar beet rust. To minimize natural infection with sugar beet rust disease, the sugar beet seeds must sown during the period extended from 15th October to 15th November.

Table (1): Effect of sowing date on disease severity (%) rate of rust disease increase (r-value) and area under disease progress curve (AUDPC) on sugar beet cv. Farida during 2001 and 2002 growing seasons.

Sowing dates		Time of disease reading						r-value	AUDPC
		15th Feb.	1st March	15th March	1st April	15th April	Mean		
2001	15th August	0.35	0.93	4.32	17.53	20.67	8.76	0.0449	499.35
	15th September	0.14	0.65	3.82	15.83	18.95	7.88	0.0450	447.68
	15th October	0.00	0.36	1.94	14.00	16.92	6.64	0.0610	371.40
	15th November	0.00	0.22	1.52	12.79	14.87	5.88	0.0652	329.48
	Mean	0.12	0.54	2.90	15.04	17.85	7.29	0.0515	411.98
2002	15th August	0.00	0.13	1.28	12.79	14.87	5.81	0.0702	324.53
	15th September	0.00	0.11	1.04	10.96	12.88	5.00	0.0712	278.25
	15th October	0.00	0.05	0.73	10.63	11.69	4.62	0.0806	258.83
	15th November	0.00	0.03	0.19	9.55	10.59	4.07	0.1163	225.98
	Mean	0.00	0.08	0.81	10.98	12.51	4.88	0.0786	271.89

MANAGEMENT OF RUST DISEASE ON SUGAR BEET PLANTS UNDER FIELD CONDITIONS:

2- EVALUATION OF SOME SUGAR BEET CULTIVARS FOR RESISTANCE AGAINST NATURAL INFECTION WITH SUGAR BEET RUST DISEASE:

The data in **Tables (2a & 2b)** reveal that the sugar beet cultivars being significantly varied in their responses against the natural infection with *U. betae*. All sugar beet cultivars tested were susceptible but to different extents against the infection with *U. betae*. The tested cultivars could be categorized as less susceptible "LS" cvs. (Farida, Gloria, Top and Toro), moderate susceptible "MS" cvs. (Negma, Gazail and Pleno) and the high susceptible "HS" cvs. (Raspoly, Lola and Kawemia). Such variations in the DS might be affected by the prevalent races or pathotypes of the rust pathogen and the used sugar beet cultivars **(Lewellen and Skoyen, 1988)**.

Table (2a): Disease responses and some growth characters of ten sugar beet cultivars as affected by natural infection with sugar beet rust disease under field conditions during season 2000.

Cultivar	Disease severity %	Dry matter % in root		Root diameter (cm)		Root length (cm)		Root-fresh weight (Ton/feddan)		Shoot fresh weight (Ton/feddan)	
		H	I	H	I	H	I	H	I	H	I
Farida	10.25	44.5	37.0	16.94	13.73	25.4	19.3	36.00	20.60	6.95	4.97
Gloria	15.85	41.5	36.9	16.34	13.06	23.6	17.7	27.09	17.85	5.88	4.73
Top	18.44	41.4	36.1	15.35	11.33	22.5	17.3	26.85	17.27	5.56	4.68
Toro	19.02	40.9	35.5	14.94	11.76	22.2	16.6	22.66	13.15	5.56	4.24
Negma	20.28	40.8	34.6	14.53	11.34	21.5	16.5	22.63	12.06	5.52	3.73
Gazail	20.91	40.6	34.5	14.02	11.03	20.4	16.5	21.75	11.72	5.04	2.88
Pleno	23.34	39.7	33.4	13.32	11.00	19.5	15.7	21.25	9.35	4.36	2.76
Kawmeia	24.34	38.7	33.1	12.56	10.78	18.4	15.6	18.17	9.33	4.33	2.46
Lola	26.64	38.6	31.8	12.52	10.46	17.6	15.5	16.59	8.95	3.65	2.39
Raspoly	27.43	36.7	31.1	12.14	9.47	17.4	11.6	16.08	7.33	3.40	2.25
Mean	20.65	40.3	34.4	14.27	11.40	20.9	16.2	22.91	12.76	5.03	3.51

L.S.D. at 5%	DS %	Dry matter	Root diameter	Root length	Root-fresh weight	Shoot fresh weight
Cultivars	1.54	NS	0.77	0.766	2.441	0.693
Healthful	--	0.44	0.15	0.153	0.488	0.139
Interaction	--	NS.	NS	NS	NS	NS

Table (2b): Disease responses and some growth characters of ten sugar beet cultivars as affected by natural infection with sugar beet rust disease under field conditions during season 2001.

Cultivar	Disease severity %	Dry matter % in root		Diameter root (cm)		Root length (cm)		Root-fresh weight (Ton/feddan)		Shoot fresh weight (Ton/feddan)	
		H	I	H	I	H	I	H	I	H	I
Farida	22.67	32.2	29.3	13.45	12.91	23.5	20.3	17.34	15.77	5.83	5.14
Gloria	27.09	30.1	27.0	12.97	12.75	21.7	20.1	17.04	15.39	5.76	5.17
Top	28.91	27.8	25.7	13.00	12.62	21.7	19.2	16.87	14.74	5.51	4.91
Toro	33.45	27.0	24.0	12.81	12.27	21.2	19.2	16.11	13.84	5.34	4.88
Negma	33.80	27.3	23.3	12.11	11.22	21.2	18.3	16.05	13.62	5.15	4.52
Gazail	34.83	26.0	23.8	11.82	10.84	20.9	18.4	15.61	13.10	4.87	4.26
Pleno	34.55	25.8	24.6	11.60	10.17	20.2	18.2	14.97	12.62	4.66	3.81
Kawmeia	35.87	25.5	22.7	10.81	9.44	19.8	17.7	14.71	11.99	4.53	3.46
Lola	37.03	24.3	22.1	10.25	9.12	19.4	17.0	13.96	11.70	4.38	3.39
Raspoly	40.96	24.2	21.4	9.82	7.28	19.2	16.3	13.76	10.43	4.28	3.26
Mean	32.92	27.0	24.4	11.86	10.86	20.9	18.5	15.64	13.32	5.03	4.28

LSD						
Cultivars	1.493	1.351	0.766	0.439	0.160	0.065
Healthful	--	0.270	0.153	0.088	0.032	0.013
Interaction	--	NS	NS	NS	0.160	0.065

No doubt that, the genetic background for a known plant species plays an important role in its reaction against infection with any known plant pathogen. The sugar beet cultivars evaluated as LS, MS and HS might have different adherent morphological, chemical and biological characters. **Wolf and Verreet (2002)** reported that the occurrence of sugar beet leaf diseases varied from year to year depending on differences in weather and cultivar selection. The

LS cvs. Farida and Golria produced the highest values of dry matter (%) and root length (cm) followed by cvs. Top, Toro, Negma, Gazail, Pleno, Kawmeia, Lola and Raspoly, respectively. The latter two cvs. considered high susceptible (HS). Similar trend was noticed in root diameter and fresh and dry weights of sugar beet roots particularly in the 2nd season. The values of all determined growth characters, in all tested cvs. were significantly higher in healthy sugar beet plants than the rust-infected ones.

3- CHEMICAL CONTROL:

As for chemical control, the obtained results **(Table, 3)** reveal that the fungicide Caramba was the best of all for reducing infection with sugar beet rust (*U. betae*) followed by Eminent, Sumi eight, Plantvax, Impect, Saprol and Anvil, respectively. The Caramba and Eminent fungicides were the most effective for suppressing rust infection and induced the highest values of root fresh weight, total soluble solids and sucrose content in roots while fungicides Anvil and Saprol were the least effective in this respect. However, **Sorensen and Marcussen (1996)** found that the best control of beet rust *(Uromyces betae)* was obtained with Lyric (flusilazole), Score (difenconazole) and Corbel (fenpropimorph). Moreover, **O'Sullivan (1997)** found that the most consistent effect of controlling rust was increasing sugar concentration in the roots. Increases in root weight and in sugar extractability were also recorded. **Ata (2005)** found that Caramba, Sumi-8, Score, Opus and Eminent fungicides controlled rust disease under field natural infection. He reported that disease severity was markedly decreased as compared to the untreated control. Regarding fungicide efficacy, he mentioned that Eminent ranked first followed by Opus, both Score, Sumi-8 and Caramba, in a descending order.

Table (3): Effect of some fungicide treatments on % severity of natural infection and some characters on sugar beet cultivar Farida during 2000 and 2001 growing seasons.

Fungicide	disease severity (%)		Root yield (ton/fed)		TSS %		Sucrose content %	
	2001	2002	2001	2002	2001	2002	2001	2002
Sumi-eight	7.29	5.49	30.01	32.17	23.25	24.29	19.07	20.15
Caramba	2.24	1.80	31.38	33.54	23.94	24.09	19.85	21.75
Plantvax	9.31	6.48	28.76	30.24	22.92	23.37	18.64	20.85
Impect	10.55	7.43	28.53	29.10	22.83	23.18	18.26	19.33
Saprol	12.29	10.36	26.83	28.08	21.19	24.21	17.54	18.82
Anvil	13.41	10.17	26.26	26.94	21.88	22.92	17.28	18.45
Eminent	5.56	5.95	30.35	32.51	23.54	24.73	19.25	21.54
Control	22.19	17.59	21.94	23.19	17.84	20.35	13.64	16.83
Mean	10.35	8.16	28.08	29.44	22.17	23.39	17.94	19.72
L.S.D. 5%	0.486	1.235	5.057	3.190	0.045	1.027	0.039	0.023

4- EFFECT OF PLANT EXTRACTS ON INFECTED SUGAR BEET PLANTS:

Data in **Table (4)** indicated that spraying sugar beet plants with garlic extract was the best treatment to reduce disease severity followed by thyme extract compared with the control treatment during the two seasons 2000 & 2001, respectively. Extract of toothpick weed (*Ammi visnaga*) was the least effective in this respect in both seasons, respectively. However, garlic (*Allium sativa*) extract produces the highest averages of root yield followed by thyme (*Thymus vulgaris*), Tasmanian blue gum (*Eucalyptus globulus*), black nightshade (*Solanum nigrum*), Christmas berry (*Schinus terebenthifolius*) and toothpick weed comparing with the control treatments in both seasons, respectively. As well as, spraying sugar beet plants with garlic extract was the best in this respect as it increased averaged TSS followed by thyme extract that recorded compared with the control treatments during the two seasons, respectively. The lowest significant increase in TSS, however, was produced by extract of toothpick weed in both seasons, respectively. Spraying plants of sugar beets with any plant extract tested led to significant increase in sucrose content % in roots. Spraying with the garlic extract produces the highest increase in sucrose followed by thyme extract. The lowest significant increase percentage of sucrose, however, was produced by plants of sugar beet sprayed with extract of toothpick weed. These results are in harmony with the effects of these plant extracts for controlling disease incidence under greenhouse conditions **(El-Fiki *et al.,* 2007)**.

5- EFFECT SPRAYING WITH SOME GROWTH REGULATOR SUBSTANCES ON INFECTED SUGAR BEET PLANTS:

Data in **(Table, 5)** indicate that spraying plants of sugar beets with any of the promoting growth substances tested was significantly effective for suppressing natural rust infection in sugar beet during seasons 2000 and 2001. In this regard, spraying with Indole acetic acid (IAA) was the most effective during both seasons followed by naphthalene acetic acid (NAA) and Gibberellic acid GA_3, respectively comparing with the control. All promoting growth substances tested significantly increased fresh weight of sugar beet roots (ton/fed). In this regard, spraying with IAA was the most effective during both seasons followed by NAA and GA_3, respectively comparing with the control. Concerning the percentages of total soluble solids (TSS) and sucrose content % in roots of sugar beets data showed significantly higher contents in beet plants sprayed with any tested promoting growth substance than the control plants. Roots of plants sprayed with IAA contained the highest TSS % followed by those sprayed with NAA and GA_3 comparing with the control treatments in both seasons, respectively. In fact, some important metabolic activities might be changed due to applying the tested growth regulators. **Saswati *et al*. (1988)** found that, the pretreated rice plants with GA_3 exhibited induced resistance to rice sheath rot disease. **EI-Nagar (1998)** indicated that the phenolic compounds, especially the total phenols were more increased in the stem rust infected wheat plants pretreated with different concentrations of GA_3, as compared with the infected, untreated plants. **Fayza, El-Taweel *et al*. (2004)** found that foliar application of GA_3 at 300 ppm significantly produced the higher root diameter, root length, root weight, total soluble solids % and sucrose % in sugar beet cvs .

Table (4): Effect of spraying natural infected sugar beet plants (Farida cv) with some plant extracts on severity (%)and some characters during 2000 and 2001 seasons.

Extracts	disease severity (%)		Root yield (ton/fed)		Total soluble solids (TSS)		Sucrose content %	
	2001	2002	2001	2002	2001	2002	2001	2002
Allium sativa	7.98	6.27	31.15	32.51	23.17	23.34	19.15	19.83
Tymus vulgaris	10.73	8.63	30.13	31.26	22.75	22.55	18.75	18.34
Eucalyptus globbulus	12.93	9.95	26.71	30.58	21.54	22.16	17.65	18.32
Solanum nigrum	14.85	11.70	25.15	30.01	20.33	21.63	16.85	17.66
Schinus terebenthifolius	15.63	13.71	25.35	27.40	20.07	21.44	16.65	17.36
Ammi visnaga	17.93	14.63	24.44	27.17	19.78	21.36	15.20	17.47
Control	22.19	16.92	21.94	23.19	16.84	21.35	12.64	16.83
L.S.D. 5%	1.69	1.42	3.29	2.79	0.043	0.034	0.043	0.040

Table (5): Effect of spraying natural infected sugar beet plants (Farida cv) with some promoting growth substances on severity (%)and some characters during 2000 and 2001 seasons.

Growth substance	disease severity (%)		Root yield (Ton/Feddan)		TSS %		Sucrose content %	
	2001	2002	2001	2002	2001	2002	2001	2002
IAA	12.47	9.94	30.89	29.03	22.32	23.42	18.63	19.59
NAA	15.74	10.83	29.30	28.01	21.43	23.31	17.68	19.53
GA3	16.74	11.83	28.12	26.68	21.14	23.24	16.93	18.89
Control	22.20	17.59	21.98	23.23	17.78	20.35	13.64	16.83
L.S.D. 5%	0.222	0.053	0.348	0.372	0.126	0.025	0.072	0.023

6- SELECTION OF THE PROPER DISTANCE BETWEEN ROWS AND SOWN PLANTS:

The data in **Table (6)** reveal that, rust disease severity has significantly increased while yield parameters (root fresh weight, total soluble solids % and sucrose %) decreased by applying the narrower spacing between rows (50 cm) or between plants (10 cm) compared with wider spacing between rows (60 cm) and between plants (20 & 30 cm). Combination using wider spaces between rows and plants resulted in the lowest disease severity and highest yield in comparison with the narrower distances between row and plants. In fact, the low distance whether between rows and/or hills led to an increase in plant density, this might create soil, and atmospheric conditions particularly temperature and relative humidity that favored development of rust infection. **Khafaga et al. (1957)** planted sugar beet on ridges spaced at 40, 50, 60 and 70 cm apart and 15, 20 and 25 cm between hills. They found that the wide spaces decreased the percentage of sugar content in roots and that spacing 50 cm gave the highest sucrose percent. **Hanna *et al.* (1988)** concluded that planting sugar beet at 15 cm hill spacing gave the highest root: top ratio, root yield, top yield and sugar yield/fed. On the other hand, the higher percentages of sucrose and juice purity were related to the 10 cm hill spacing. However, **Mahmoud *et al.* (1990)** obtained the highest sucrose and purity percentage from plants grown at 20 cm between plants. **Adipala, *et al*. (2001)** found that high plant density resulted in high Cercospora leaf spot disease severity comparing with the low plant density. **Hassanin (2001)** stated that the distance 20 cm between sugar beet plants out yielded 15 or 25 cm was the best in root and sugar yields/fed, while 25 cm hill spacing produced superior root length, diameter and weight, as well as top yield. On the other hand, the distance 15 cm gave the best sucrose%, whereas TSS% and purity% were not affected by hill spacing. **Ahmed (2003)** found that narrowing planting distance from 30 to 20 cm between hills increased significantly root, top and sugar yield /fed. These results suggested that planting sugar beet cv. Farida at the wider spacing between rows (60 cm) and between plants (20 or 30 cm) were the best agricultural practices for suppressing rust infection and increasing the resultant yields.

Table (6): Percentage of natural infection of sugar beet rust disease and some yield and yield components as affected by distance between rows and/or plants during two growing seasons, 2001&2002).

Planting distance "P"		Infection %		Root yield (ton/fed)		TSS %		Sucrose content %	
		2001	2002	2001	2002	2001	2002	2001	2002
50cm	10cm	29.38	21.75	24.72	25.41	19.02	22.06	15.25	18.15
	20cm	26.31	21.17	31.04	31.26	19.61	22.66	15.73	19.60
	30cm	22.41	17.41	17.15	17.38	21.06	23.07	17.49	19.59
60cm	10cm	29.03	21.41	26.94	28.48	20.49	23.37	16.71	19.53
	20cm	24.04	18.83	32.06	33.31	20.80	24.52	16.49	20.00
	30cm	21.17	17.66	19.25	18.34	21.48	24.96	18.10	21.25
L.S.D. at 5%		0.874	0.900	2.919	4.22	0.375	0.577	0.521	0.615

7- SELECTION OF THE PROPER DOSE OF FERTILIZERS:

It is well known that, a well-balanced supply of soil nutrients will result in healthy, vigorous plants, which should have a greater chance of withstanding attack by pathogens that unhealthy plants would. However, many pathogens also grow under ideal growth conditions, particularly biotrophic pathogens, such as rusts and viruses. The major nutrients that influence plant and pathogen success are nitrogen, phosphorous, potassium and calcium. The present results proved that, rust severity was decreased while TSS % and sucrose content in roots were increased significantly by using the N fertilizer at low and middle levels (60 and 80 kg/feddan) while the higher level (100 Kg/feddan) showed the opposite results comparing with unfertilized treatment **(Table, 7)**. This trend was noticed in both seasons and in all treatments, the DS was conspicuously higher in 2002 than 2003 season. The combination between N and P fertilizers was suppressing of DS. Applying the P fertilizer at 15 and 30 kg (P_2O_5)/feddan gave the best disease control in both seasons comparing with the control receiving no P fertilization. Whoever, the lowest DS, , was produced by using the combined fertilization treatment consisted of N fertilizer (60 kg/feddan) and P fertilizers (30kg/feddan). In fact, **Graham (1983)** reported that, the high N plants are highly susceptible to rust disease. He added that the nutrient additions could increase plant disease incidence if the addition creates a nutrient imbalance in the host. **Hegab and Beshir (1994)** stated that increased nitrogen fertilizer increased plant height, straw yield, seed yield, as well as plant infection by *Botrytis fabae* and *Uromyces viciae-fabae*. Susceptibility to *U. viciae-fabae* increased by increasing nitrogen levels. **Marschner (1995)** stated that increase N is thought to increase infection by obligate fungal parasites because it may alter the biochemistry of the leaf. For example, increased nitrogen may lead to a decrease in the phenol level in leaves, lowering the fungistatic effect of this chemical. Increasing nitrogen leads to greater shoot growth and a higher proportion of young tissue, which may promote disease.

Table (7): Effect of different levels of nitrogen and phosphorus fertilization on severity of sugar beet rust disease (%) and some yield component of sugar beet cv. Farida under field conditions, during 2002 and 2003 growing seasons.

Fertilizers (Kg/feddan)		Infection %		Yield (Ton/feddan)		TSS %		Sucrose %	
N	P_2O_5	2002	2003	2002	2003	2002	2003	2002	2003
0kg	0Kg	36.73	10.04	10.08	10.35	14.04	15.34	11.62	12.64
	15Kg	33.25	9.78	10.39	11.05	15.31	16.21	12.89	13.46
	30Kg	32.76	8.36	10.47	11.31	16.53	17.36	13.42	14.31
60kg	0Kg	32.37	9.21	13.43	14.28	17.64	18.45	14.19	15.84
	15Kg	31.42	8.65	13.67	14.65	18.08	19.81	15.97	16.65
	30Kg	29.35	7.03	14.04	15.30	19.22	20.11	16.78	17.29
80kg	0Kg	40.92	8.02	13.57	25.43	18.42	21.17	15.38	16.41
	15Kg	26.53	7.96	27.41	29.48	21.25	22.06	18.47	19.47
	30Kg	24.66	7.15	27.92	29.76	22.13	23.01	19.35	20.35
100kg	0Kg	37.82	12.74	29.47	28.83	11.91	12.38	8.96	9.93
	15Kg	35.61	11.81	29.83	31.61	12.75	13.76	9.81	10.82
	30Kg	33.84	10.38	30.50	31.98	13.53	13.65	10.73	11.91
L.S.D. at 5%		1.832	1.063	0.635	1.179	0.228	0.141	0.017	0.012

However, the responses of yield and yield components of sugar beet against different N and/or P fertilization treatments were reported by several investigators. **Badawi (1989)** reported that increasing nitrogen levels up to 60 kg/ fed for growing sugar beet plants, recorded higher values for root length, root diameter and foliage fresh weight as well as root, top and sugar yields characters. Moreover, increasing N rates reduced sucrose and purity percentage. **Khan *et al.* (1990)** stated that, increasing rates of P increased root and sugar yields. Moreover, they mentioned that P fertilizer increased root sucrose content. They concluded that 60-90 kg N was optimum for high yields and good quality sugar beet. **Badawi (1996)** reported that increasing nitrogen rate from 0 to 60 Kg N/ fed induced a favorable effect on sugar beet yields and their attributes. However, raising nitrogen rate from 60 to 80 Kg N/ fed did not induce marked effects for morphological studied characters. On the other hand, raising N rates caused decrease in TSS%, sucrose % and purity%. **Salama and Badawi (1996)** found that increasing N-levels from 50 to 70 kg N/ fed significantly increased root diameter and sugar yield/ fed of sugar beet crop. However, raising N- rates from 70 to 90 kg N/ fed did not induce marked effects for most studied trails and markedly reduced TSS and sucrose%. **Basha (1999)** observed that increasing nitrogen fertilizer level to sugar beet plants up to 90 kg N/fed. significantly increased root length, root diameter and root / top ratio. Increasing nitrogen fertilizer level to sugar beet plants up to 120 kg N/fed significantly increased top and root weights/plant. He concluded that sucrose and apparent purity percentages were adversely and significantly affected by increasing nitrogen level and the highest values were obtained by adding 60 kg N/fed. **Wilting (1999)** found that sugar beet root weight (ton/ha) was gradually increased by the gradual increase in N fertilization from 0 to 50, 100, 150 and 200 Kg N per hectare while root sugar content was gradually decreased from 16.0% to 15.4, 15.5, 15.1 and 14.8%, respectively. **El-Fahhar Samia (2003)** found that fertilizer play an important role in reducing disease severity of Cercospora leaf spot resulting in increasing root sucrose yield. Application of nitrogen (90 kg N/fed) reduced in general disease severity percentage of all tested cultivars. In addition application of the recommended dose of nitrogen increased both

TSS% and sucrose yield. In fact, the recommended rates of N and P_2O_5 for sugar beet crop were 60 and 80 kg/ha, respectively **(**Ministry of Agriculture and Land Reclamation "**MALR", 2003)**.

8- EFFECT OF INTERCROPPING:

Intercropping of different crop species can be used as strategy to increase the amount of diversity within an individual field. The mechanisms that are thought depending function to limit disease development in an intercropping system have been reviewed by **Burdon (1978)** and **Boudreau and Mundt (1997)**. In the present work, the obtained results **(Table, 8)** revealed that all intercropping treatments (sugar beet/broad bean) significantly increased disease severity as well as fresh weight of sugar beet roots in comparison with the sole sugar beet. Sugar beet intercropped with broad bean at rate 3:1 and 1:3 (row/row) resulted in the highest increase in the disease severity and root fresh weight, respectively. On the contrary, total soluble solids (TSS %) and sucrose content in roots were significantly decreased by all tested intercropping treatments in comparison with the control (sugar beet alone). Intercropping the two crops at rate 1:3 and 3:1 resulted in the highest decreases in both criteria, respectively. The observed increase in sugar beet rust disease severity in the two intercropped crops might be due to root exudates of the broad bean plants which altered microbial activities in soil and this may make sugar beet plants more susceptible to rust infection.

Table (8): Rust disease severity (%) and some characters on sugar beet cv. Farida as affected by intercropping with broad bean under field conditions during 2001 and 2002 growing seasons.

Intercropping system (row/row)		disease severity (%)		Root yield (ton/fed)		Total soluble solids (TSS)		Sucrose content %	
Sugar beet	Broad bean	2001	2002	2001	2002	2001	2002	2001	2002
1	1	21.55	18.68	30.69	32.31	16.70	21.25	16.42	17.36
1	2	22.50	19.51	29.67	31.26	16.61	21.14	15.35	17.24
1	3	28.06	25.40	31.98	33.39	16.05	18.55	12.73	14.65
2	1	23.56	20.58	38.45	30.27	16.51	20.97	15.23	16.14
2	2	24.68	21.50	27.14	29.07	16.45	20.83	14.13	16.06
2	3	25.44	22.54	25.24	28.08	16.33	19.85	14.03	15.93
3	1	29.41	26.63	21.00	24.59	15.87	17.45	12.62	13.55
3	2	26.33	23.74	23.38	27.06	16.23	19.72	13.93	15.84
3	3	27.38	24.64	22.09	25.16	16.15	18.66	13.85	14.73
Control	-	19.49	16.55	20.04	23.84	18.64	22.85	17.36	18.72
Mean		24.840	21.978	25.96	28.49	16.555	20.129	14.563	16.022
L.S.D. at 0.05		1.38	1.14	5.35	2.97	0.471	0.454	0.074	0.071

In fact, variability within the intercrop as a result of the presence of morphologically different crop components or an influence via an individual component of the intercrop canopy may produce less favorable microenvironmental conditions, leading to increase disease development. The intercropped sugar beet/broad bean system seems to be suitable whether for suppressing incidence of sugar beet rust disease or improving parameters of sugar beet yield. Similar results were reported by **Oliveira *et al*. (1990)** who intercropped potatoes with *Phaseolus vulgaris* and found that intercropping reduced potato tuber yields compared with pure stands. **Preston (2003)** recorded that some disease incidence, such as soybean or mung bean rusts, may increase when aggravated with high corn populations and over fertilization. Any disease or pest that prospers in shady conditions could increase under a taller crop such as corn or sunflowers. **Beuerlein, (2005)** stated that, multiple cropping drastically reduces the elapsed time between successive crops and therefore can greatly increase the disease pressure for both crops. Where intense multiple cropping is practiced, the beneficial effects of crop rotation (weed, insect, and disease control) are totally negated. However, other intercropping systems were suitable in this respect. **Toaima *et al* (2001)** found that intercropped sugar beet with onion and garlic resulted in greater yield, yield components and quality of sugar beet. **Khan, *et al* (2002)** found that two rows of sugar beet planted in 120 cm spaced sugarcane recorded the highest beet root and sugar yields while sugar content was not significantly differed by intercropping.

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دراسات على مرضِ صدأ بنجر السكر في مصر
ثانيا : إدارة المرض تحت ظروف الحقلِ

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الملخص العربى

تفاوتت أصناف بنجر السكر المختبرة في شدة إصابتها بمرض الصدأ الذى يسببه الفطر يوروميسس بيتا وكانت الأصناف (فريدة، جلوريا، توب و تورو) أقلها إصابة يليها الأصناف متوسطة الإصابة (النجمة، غزال و بلينو) ثم الأصناف شديدة الحساسية (راسبولي، لولا و كاويميا) على التوالى. وقد كانت القيم المعبرة عن نسبة المادة الجافة وطول وقطر الجذر والوزن الغض والجاف للجذور أعلا فى الأصناف الأقل إصابة مقارنة بالأصناف متوسطة أو شدية الإصابة بالمرض. هذا وقد أظهرت النتائج ارتباطا واضحا بين شدة الإصابة بمرض الصدأ وميعاد زراعة بنجر السكر حيث كانت شدة المرض أعلى على النباتات المنزرعة مبكرا في منتصف أغسطس مقارنة بالنباتات المنزرعة فى منتصف سبتمبر ، منتصف أكتوبر أو منتصف نوفمبر. أظهر تتبع قراءة المرض أن ظهور المرض كان منخفض جدا فى منتصف شهر فبراير ثم زاد بشكل تدريجي حتى وصل ذروته فى منتصف أبريل. وعموما كانت شدة الإصابة بالمرض فى أدنى مستوياتها على النباتات المنزرعة فى منتصف أكتوبر أو منتصف نوفمبر. كما أظهرت النتائج أيضا انخفاضا واضحا فى شدة المرض مع زيادة واضحة فى الوزن الغض للجذور وكذلك محتواها من السكروز عند استعمال الصنف الأقل إصابة (فريدة) مصحوبا برش النباتات فور ظهور أعراض المرض على الأوراق بالجرعة الموصى بها من المبيد كارامبا أو بمستخلص الثومِ (تركيز 0.3 %) فور ظهور أعراض المرض. أيضا أدت المعاملات التالية: رش النباتات عند عمر 70 يوما بتركيز 100 جزء فى المليون من منظم النمو (IAA) - استخدام السمادين الأزوتى (يوريا) والفوسفاتى (سوبر فوسفات) بمعدل 60 كيلوجرام آزوت و30 كيلوجرام (خامس أكسيد فوسفور) للفدان على التوالي - . الزراعة عند المسافات المناسبة بين كل من الخطوط (60 سم) والنباتات (30 سم) إلى تحسن ملحوظ فى كبح المرض مع زيادة معنوية فى المحصول.

أظهرت النتائج أن استعمال السماد الآزوتى منفردا بمعدل 100 كيلوجرام آزوت/فدان قد أدى إلى زيادة ملحوظة فى كل من شدة الإصابة والوزن الغض للجذور بينما سبب من ناحية أخرى انخفاضا معنويا فى محتوى تلك الجذور من المواد الصلبة القابلة للذوبان والسكروز مقارنة بالمعدلات الأخرى بما فيها معاملة المقارنة (غير مسمدة بالآزوت) بينما أدى استخدام السماد الفوسفاتى منفردا بمعدل 15 أو 30 كيلوجرام من خامس أكسيد الفوسفور إلى سيطرة واضحة على المرض مع زيادة جوهرية فى الوزن الغض للجذور ومحتواها من المواد الصلبة الكلية القابلة للذوبان والسكروز.

أدت جميع المعاملات المختبرة لزراعة الفول محملا على بنجر السكر إلى زيادة جوهرية فى شدة الإصابة بمرض الصدأ على بنجر السكر وكذلك الوزن الغض لجذور البنجر بينما أدت من ناحية أخرى إلى انخفاض جوهرى فى محتوى تلك الجذور من المواد الصلبة الكلية القابلة للذوبان والسكروز. وقد أدي تحميل بنجر السكر والفول بعدلات خط واحد : ثلاثة خطوط أو ثلاثة خطوط : خط واحد إلى أقصى انخفاض فى كل من المواد الصلبة الكلية القابلة للذوبان والسكروز على التوالى.