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Role of the Cultural Practices and Natural Enemies for Suppressing Infestation of the Pink sugarcane Mealybug, *Saccharicoccus sacchari* (Cockerell) (Hemiptera: Pseudococcidae) in Sugarcane Fields at Minia Governorate, Middle Egypt

Tohamy, T. H. ; A. A. Abd El-Raheem and A. M. El-Rawy
Plant Protection Research institute, Agricultural Research Center, Dokki, Giza, Egypt

ABSTRACT

Field experiments were conducted, to evaluate the role of cultural practices and natural enemies (parasitoids and predators) for suppressing population of the pink sugarcane mealybug (PSMB), *Saccharicoccus sacchari* in sugarcane fields at Mallawi district, Minia Governorate, Middle Egypt, during the two successive seasons of 2006 and 2007. Results proved that the varieties Giza 21/95 and Giza 37/85 were highly susceptible to (PSMB) infestation followed by the varieties G.T. 54/9 and Giza 47/88, while the other varieties (Giza 96/74 and Ph 8013 were less susceptible based on percent infested internodes and number of mealybug individuals per stalk. Also, the number of mealybugs (nymphs and adults) per plant associated with infested internodes significantly decreased as the space between rows increased. Furthermore, the percentage of infested internodes and numbers of mealybugs differed within seasons and among stages of the sugarcane crop cycle, where the PSMB infestation started earlier and much greater in ratoon crops than plant crops. As well, burning of dry leaves left in the field integrated with flood irrigation application after harvesting sugarcane stubble during March and April, significantly reduced the percentage of infested internodes by 73.5 and 70.2% and reduced numbers of mealybugs per plant by 67.5 and 64.3 % in both seasons, respectively in comparison with the control .The species of *Anagyrus sacharicola* Timberlake (Hymenoptera: Encyrtidae) was identified as a primary endoparasitoid of the mealybug pest. Highest parasitism was recorded during September in plant cane and during August in first ratoon cane. Survey of the predators associated with sugarcane mealybug revealed the presence of *Scymuns syricacus* Mars (26.0, 20.64 %).; true spiders (15.0,16.28 %); *Rodolia cardinalis* (13.37, 14.29%);*Orius albidipenis* Reut.(11.47, 11.26 %); *Complomma nicolasi* Puton (10.28, 10.60 %); *Peaderus alferii* Koch; (9.41, 8.55 %) *Coccinella undecimpunctata* L.(7.83, 9.05%); *Geocoris* sp. (3.48, 4.91 %) ; and *Cydonia vicina* isis Gr.(3.16, 4.42%) of the total predators population in both plant and 1st ratoon crops, respectively. Thus, these studies may help in recommending a successful control program to check the ravages of sugarcane mealybug.

Key Words: *Saccharicoccus sacchari,* cultural practices, varieties, natural enemies, *Anagyrus* sp. and predators.

INTRODUCTION

Sugarcane is undoubtedly, the most important crop for sugarcane production, besides to produce black honey (molasses), fresh juice and several chemical byproducts in Egypt. Throughout the whole period of plant growth, sugarcane plants are attacked by many insect pests such as *Sesamia critica* L. and *Chilo agammenon* Bles. Furthermore, the pink sugarcane mealybug, *Saccharicoccus sacchari* (Cockerell) (Homoptera: Pseudococcidae) has recently been a nuisance to sugarcane growers especially in Middle Egypt (Tohamy, 1999). This pest was the most common and occurred almost all the year round. .It forms colonies on the stalk under overlapping leaf-sheaths, below the node, and spread, down the internode and buds which grows into large cotton – like masses of white waxes deposit on internodes and buds. In addition, their direct damage for plant by sucking sap, mealybugs damage include wax and honeydew production and virus transmission which may be due to the relatively long period that spend as sessile insects. Mealybugs usually have 3 to 5 annual generations, most of them occur during the summer, since they are mainly warm climatic insects. Many authors, in different parts of the world reported that the population density and loss of the sap and sugar due to heavy infestation by mealybug insect can be reduced by using certain agricultural practices *i.e.* varieties, row spacing, aging, fertilizer, flood irrigation and trashes burning (Rezende *et al.*, 1980; in Brazil; Borah and Datta, 1995; Parsana *et al.*, (1995), in India; Abou Dooh *et al.*, 1999 in Egypt and Graham and Michael, 2005 in Australia). Natural enemies include arthropod predators and parasitoids can suppress the mealybug infestation and limit the attack by other pests in different countries, *i.e.* (Srivastava, 1973 in India; Carver *et al.*, 1978 in Australla). Parasitic Hymenoptera, *Anagyrus sacchariсola* plays a major role in regulating the numbers of mealybugs (Barro, 1990 in Queensland; Hernandez *et al.* 1996 in Cuba Karam and Abou–El-Khair, 1996 in Egypt and Giron *et al.*, 2005 in Colombia and have been responsible for more success of biological control than all other groups of natural enemies. (Alam, 1972; Kapadia *et al.* 1995 in India; Rajendra, 1974 in Srilanka and Abd-Rabou, 2002 in Egypt).

The present work aimed to shed light on the promising cultural practices and natural enemies that could suppress the populations of the sugarcane mealybug, *S. sacchari* below economic injury level.

MATERIALS AND METHODS

The present study was conducted at the experimental farm of the Agricultural Research Station at Mallawi, Minia Governorate Middle Egypt, during the two successive seasons 2005/06 and 2006/07. The randomized complete block design was followed in the whole experimental area. Four replicates were used for each treatment. Each treatment was planted in 6x7 meter plots (1/100 of a feddan). The experimental area received the usual recommended agricultural practice and no insecticides were applied for pest control throughout the whole seasons. The plants were exposed to normal field conditions and natural infestation. Biweekly observations were carried out from beginning of May to the end of February (harvest- time) in all experimental areas in both seasons.

1-Effect of certain cultural practices on the incidence of pink mealybug:

1.1. Varietals susceptibility:

An area of one feddan was selected at Agricultural Research Station at Mallawi and divided to 6x 2= 24 plots. Six sugarcane varieties (G.T.54/9, Giza.21 /95, Giza.96/74, Giza37/85, Giza 47/88 and PH80/13) were obtained from sugarcane crop department. Varieties were planted in plots 6x7 m (1/100 of a feddan) in randomized complete- block design. Four replicates were used for each variety, the experiment was cultivated in December 2005, representing 1st year (plant cane) and continued until March 2007 as a 1st ratoon cane.

1.2. Effect of row space:

An area of 1/4 feddan was selected also at Mallawi Agricultural Research Station Farm and divided to 16 plots and individual plots 6x7 m (1/100 feddan). The commercial sugarcane variety (G.T.54/9) was planted 15 December in 2005 season (autumn plantation) with four different rowing system, *i. e.,* and the distance between rows was 70, 90, 110 and 120 cm. Each type of rowing was replicated 4 times (randomized complete block design).

1.3. Evaluation of sugarcane aging on infestation:

An area of two feddans was selected at Mallawi region. This area was cultivated with the variety G.T. 54/9 in five cycles or with different cane aging in the field during 2006 and 2007 seasons These aging include: spring plantations; autumn plantations, the first, second and the third ratoons. Every age or group was replicated 4 times (randomized complete block design).

1.4. Effect of flooding irrigation and burning of trash on infestation:

An area of one and half feddans was selected at Mallawi region after harvest- time in February during 2006 and 2007seasons. This area was divided into three equal parts, each part included 4 plots. Flooding irrigation only was applied separately in the first part, while the trashes and dry leaves was burned alone in the second part after harvesting. The third part was specialized to the two previous treatments together.

Sampling technique:

A sample of 20 stalks of each treatment was randomly selected from each plot at 15 days intervals starting from the beginning of May to the end of February (harvest–time), while it was increased to100 stalks /plot at harvest-time .Each stalk per treatment was carefully examined to determine:

1- Total number of internodes. 2- Total number of infested internodes

3- The percentage of infested internodes was calculated from the following formula:

$$\% \text{ infested internodes} = \frac{\text{No of infested internodes}}{\text{Total No of internodes}} \times 100$$

4- Number of mealybug insects (nymphs and female adults) per stalk.

2-Effect of cultivating six sugarcane varieties on natural enemies' populations:

In order survey the natural enemies associated with mealybug inhabiting each variety, direct field counts were carried out during the period from May till February

2.1. Survey of Parasitoids:

Samples of 20 – 25 stalks infested with *S. sacchari* per variety were collected biweekly starting from the beginning of May to the end of February (harvest–time) from each variety and picked up to laboratory in polyethylene bags. Samples were examined using a stereomicroscope to count the number of parasitized mealybug (mummies). Percentage of parasitism in each variety was calculated as follows:

$$\% \text{ parasitism} = \frac{\text{No of emerged parasitoids (mummified mealybugs)}}{\text{Total No of mealybugs (adults + nymphs)}} \times 100$$

Parasitized mealybugs (mummies) were individually kept in gelatin capsules and sent to Plant Protection Research Institute for identification of the emerged parasitoids species.

2.2. Survey of Predators:

Weekly direct count of predatory species associated with sugarcane mealybug on sugarcane varieties were estimated on 20 stalks per variety (5 stalks/plot) throughout the growing seasons.

Statistical analysis:

Data obtained from the previous studied were statistically analyzed by using F test and Duncan's multiple – range at 0.05 probability level through SAS computer program(Statistical Analysis System) and the final results were discussed.

RESULTS AND DISCUSSION

1-Effect of certain cultural practices on PSMB, *S. sacchari* infesting sugarcane plants

1.1. Relative susceptibility of sugarcane varieties:

i- Percent infested internodes:

Response of sugarcane varieties to PSMB, *S. sacchari* attack, expressed as percent of infested internodes and number of mealybugs (nymphs and female adults) on plant and 1st ratoon cane is shown in Tables (1 and 2). The percentage of internodes infestation started in May in all varieties and recorded sudden increase and fluctuated from month to the other reaching its maximum value during September in plant cane and in August in 1st ratoon cane. The results indicated that the sugarcane varieties, Giza 21/95 and Giza 37/85 were the most susceptible varieties from beginning of the season till harvest–time, showing an average of 12.5 and 10.5 % in plant cane and 15.7 and 13.6% in the 1st ratoon, respectively. However, Giza 96/74 and Ph8013 were the least susceptible variety, whereas the general average of 2.6 and 4.5% in the plant cane and 4.0 and 6.5% in 1st ratoon cane, respectively. Meanwhile, G.T54/9 and Giza 47/88 varieties received a moderate infestation showing an average of 7.3 and 7.2% in plant cane and 10.3 and 9.4 % in 1st ratoon, respectively. Statistical analysis of the data showed significant differences among means of the percentage of infested internodes for the tested varieties in both plant and 1st ratoon cane, except between Giza 37/85 and Giza 21/95 in both seasons.

ii– Number of mealybugs (nymphs + adults) per stalk:

Data in Table (2) clear that the mean number of PSMB, *S. sacchari* (nymphs + adults) per 20 stalks recovered from tested varieties gave the same trend previously desecrated in number of infested internodes. Whereas, the highest mean number of mealybug was noticed in the most susceptible varieties (Giza 21/95 and Giza 37/85). Meanwhile, the moderate mean number of mealy bugs recorded in the moderately resistant (G.T54/9 and Giza 47/88). On the other hand, the lowest mean number of mealybugs was found in the resistant varieties (Ph8013 and Giza 96/74) in plant and 1st ratoon canes. The mean number of mealybug/20 stalks on these varieties was 86.2; 76.5; 61.9; 45.7; 28.2 and 22.4 individuals in 2006 season and 103.1; 92.5; 78.8; 55.5; 33.1 and 27.9 individuals in 2007 season, respectively. In conclusion, the tested varieties

Table (1): Monthly means of infested internodes percentage caused by mealybug in different sugarcane varieties, the plant and 1st ratoon cane at Mallawi, Minia, Egypt, 2006 and 2007 seasons.

Sampling	G.T54/9		Ph80/13		G.47/88		G.37/85		G.21/95		G.96/74	
Dates	P	R	P	R	P	R	P	R	P	R	P	R
May/2006	1.2	1.0	0.0	0.0	0.0	1.2	0.0	2.5	0.0	3.0	0.0	1.0
June	2.0	4.2	1.0	1.5	3.0	4.7	1.5	5.2	2.3	8.3	1.0	1.6
July	4.9	8.7	1.7	2.2	5.2	9.0	5.5	8.2	5.2	14.6	1.2	2.0
August	8.8	20.0	4.2	12.5	9.5	25.5	13.8	28.5	14.7	32.4	3.0	7.9
September	16.6	13.6	9.2	8.4	19.8	13.5	25.8	19.8	30.4	19.9	6.1	5.0
October	8.9	10.0	6.8	9.7	6.5	9.5	17.0	14.2	18.7	15.5	2.9	3.5
November	7.7	15.0	4.1	10.0	7.8	14.3	9.9	19.6	12.8	24.4	2.3	6.0
December	10.9	12.8	7.8	7.5	12.4	7.6	13.7	15.4	21.8	16.3	4.3	5.1
Jan./2007	6.6	8.9	5.3	6.7	5.1	5.5	9.7	13.7	11.5	12.9	2.8	4.3
Feb	6.4	8.3	5.2	6.1	2.9	3.2	7.8	9.0	7.5	10.8	2.4	3.6
Mean	7.3b	10.3^{B}	4.5^{c}	6.5^{C}	7.2^{b}	9.4^{B}	10.5^{a}	13.6^{A}	12.5^{a}	15.7^{A}	2.6^{c}	4.0^{C}

P = Plant cane(2005/06 R= 1st Ratoon cane (2006/07)

Two means in plant crop and 1st ratoon cane took the same letter are not significantly differed at 5% level of probability

Table (2): Monthly mean numbers of mealybug (nymphs and adults)/ 20 stalks, in different sugarcane varieties at Mallawi, Minia, Egypt, 2006 and 2007 seasons.

Samp. Dates	G.T54/9		Ph8013		G.47/88		G.37/85		G.21/95		G.96/74	
	P	R	P	R	P	R	P	R	P	R	P	R
May/	7	11	0	3	0	12	0	6	0	15	0	2
June	12	17	7	9	10	24	6	22	16	25	3	7
July	19	31	13	27	20	47	30	80	25	69	9	12
Aug.	79	139	34	73	49	139	108	189	90	184	20	60
Sep.	133	122	64	41	109	67	164	176	190	158	62	42
Oct.	96	97	38	30	71	71	125	79	125	94	35	30
Nov.	75	101	36	63	65	75	97	115	95	165	19	40
Dec.	89	119	58	39	79	42	98	106	119	125	39	35
Jan./	62	93	19	29	36	43	85	85	110	112	20	30
Feb.	49	58	13	17	18	25	52	67	92	84	17	21
Total	619	788	282	331	457	555	765	925	862	1031	224	279
Mean	61.9^{c}	78.8^{C}	28.2^{e}	33.1^{E}	45.7^{d}	55.5^{D}	76.5^{b}	92.5^{B}	86.2^{a}	103.1^{A}	22.4^{e}	27.9^{E}

Two means in plant crop and 1st ratoon cane took the same letter are not significantly differed at 5% level of probability

Table (3): Monthly means of infested nodes percentage caused by sugarcane mealybug in different row–width in the plant and 1st ratoon cane at Mallawi, Minia, Egypt, 2006 -2007.

Sampling Dates	70 cm		90 cm		110 cm		120 cm	
	P	R	P	R	P	R	P	R
May	2.3	3.5	2.4	2.7	1.4	1.5	1.6	1.8
June	4.4	7.7	3.5	3.8	2.8	3.4	2.6	2.8
July	7.0	15.3	4.0	5.8	4.6	5.4	4.0	4.4
August	13.2	28.7	7.6	14.4	5.7	13.5	5.5	12.8
September	22.3	19.8	12.5	11.5	10.5	10.2	9.8	9.6
October	17.2	13.5	10.0	9.7	8.6	5.0	6.7	7.3
November	12.5	19.7	5.6	11.8	4.4	9.7	3.2	9.1
December	16.7	15.9	7.2	9.8	6.6	6.9	6.0	4.9
January	13.1	14.5	5.5	7.0	4.5	5.0	4.2	4.3
February	11.8	13.7	4.7	5.6	3.2	3.8	3.8	3.5
Mean	12.06^{a}	15.23^{A}	6.40^{b}	8.21^{B}	5.23^{bc}	6.44^{C}	4.74^{c}	6.05^{C}

Two means in plant crop and 1st ratoon cane took the same letter are not significantly differed at 5% level of probability

Table (4): Monthly mean numbers of mealybug ((nymphs + adults)/20 stalks in different row–width in the plant and 1st ratoon cane at Mallawi, Minia, Egypt, 2006 and 2007 seasons.

Sampling Dates	70 cm		90 cm		110 cm		120 cm	
	P	R	P	R	P	R	P	R
May	10	19	11	15	6	11	7	8
June	31	56	29	44	18	22	12	16
July	69	87	40	62	27	35	23	28
August	96	217	62	119	39	77	33	65
September	173	155	95	82	67	41	55	33
October	110	94	51	59	34	44	41	39
November	93	133	38	78	40	67	30	58
December	105	117	75	65	66	45	43	37
January	68	93	40	58	31	34	34	32
February	55	66	27	36	19	25	22	24
Total	810	1037	468	618	347	407	300	340
Mean	81.0^{a}	103.7^{A}	46.8^{b}	61.8^{B}	34.7^{c}	40.7^{C}	30.0^{c}	34.0^{D}

Two means in plant crop and 1st ratoon cane took the same letter are not significantly differed at 5% level of probability
P = Plant cane(2006) R = 1st Ratoon (2007)

can be arranged based on infested internodes and number of mealybugs/20 plants in a descending orders as follows: most susceptible varieties were Giza 21/95 and Giza 37/85 and moderately resistant varieties were G.T54/9 and Giza 47/88, while the least susceptibile varieties were 96/74 and Ph8013. Statistical analysis revealed significant differences among the tested varieties based on number of mealybugs per 20 stalks in both seasons. However, these results are supported by Hafez and Salama (1970); Mesbah, *et al.* (1980); Abdel- EL- Rassoul and Abou El- Fattah (1993); Abou Dooh *et al.*, 1999 and Solouma (2002) in Egypt. They clearly demonstrated that the different sugarcane varieties varied greatly in their susceptibility to *S. sacchari* infestation. They could be classified according to their susceptibility into many significantly separated groups namely susceptible; moderately susceptible and resistant groups. Characters such as the height and weight of plants, the number of internodes and leaves and stalk thickness could not be related to susceptibility for this pest. However, percentage sugar content influenced the susceptibility to both types of pest, and the number of tillers to mealybugs. Also, Jayanthi *et al.*, (1994) in India, found that the stem surface waxes stem hardness and softness of bud portion as physical factors was not related to the infestation and severity of *S. sacchari.*

1.2. Effect of sugarcane row space on PSMB, *S. sacchari* infestation:

1.2.1. Number of infested internodes:

Percents of infested internodes caused by PSMB, *S. sacchari* in sugarcane plants using different row spaces are shown in Table (3). The results indicated that the infestation percentage expressed as number of infested internodes was increased from beginning of the season in May reaching its peak in September in the plant cane and in August in 1st ratoon cane, regardless the rowing spaces. It is obvious that the percent of infested internodes was increased by decreasing space between rows. The mean percent of infested internodes averaged 12.06; 6.40; 5.23 and 4.74% in plant cane and15.23; 8.21; 6.44 and 6.05 in 1st ratoon cane on sugarcane cultivated at 70, 90, 110 and 120 cm, respectively. Statistical analysis showed significant differences for infested internodes percent between plant and 1st ratoon cane cultivated at 70cm space and both ones cultivated at 90; 110 and 120 cm spaces. No significant differences were found between the plants cultivated at 110 and 120cm spaces for infested internodes percent.

1.2.2. Number of mealybug (nymphs + adults):

Table (4) represents the effect of row space on number of PSMB, *S. sacchari.*It is obvious that the same trend in number of infested internodes was achieved, whereas, the mean number of mealybugs (nymphs and adults) per 20 plants were decreased when spacing between rows increased. Monthly mean numbers of mealybugs varied from 30.0 to 81.0 individuals in plant cane and from 34.0 to 103.7 in 1st ratoon cane with decreasing the distance between rows from 120 to 70 cm, respectively. In conclusion, according to infestation by PSMB, *S. sacchari*, the rowing spaces could be arranged in a descending order as follows:

1-Group A (least infested plants): 110 and 120 cm distance between rows.

2-Group B (moderately infested plants): 90 cm distance between rows.

3-Group C (highly infested plants): 70 cm distance between rows.

The statistical analysis recorded significant differences among the number of mealybugs/20 stalks in the tested different distances between rows in plant and 1st ratoon canes.

It is evident that planting sugarcane on wide row distances seemed to afford better ventilation since air circulation demonstrated better conditions to reduce infestation. Humidity was negatively correlated with wide row spacing and consequently infestation was less. The previous finding are in agreement with the results obtained by Isa and Awadallah (1974), in Egypt, who suggested that relative humidity in sugarcane fields with crowded plants growing in narrow row was higher than in fields planted with wider rows as better aeration occurred in the latter field distance between sugarcane rows.

1.3. Evaluation of the PSMB, *S. sacchari* infestation as monitored by sugarcane aging:

The number of infested internodes caused by S. *sacchari*, and its number of mealybugs were made at weekly intervals in different sugarcane ages during the period extend from May to February in both seasons. Data in Tables (5) and (6) showed that the general trend of infestation based on percentage of infested internodes and number of mealybugs (nymphs and adults) associated with it indicated:

1- The highest infestation by *S. sacchari* was observed in August followed by November in the ratoon canes, and in September in the spring and autumn plantations. The number of mealybug associated with infested internodes was very few in February in both seasons. However, the infestation was lower in the spring plantations compared to other treatments (ratoons).

2- The third ratoon cane showed the highest infestation by PSMB, *S. sacchari* followed by the second and

Table (5): Monthly means of infested internodes percentage caused by mealybug in different sugarcane plantations (ages) at Mallawi , Minia, Egypt, 2006 and 2007 seasons.

Sampling Dates	Autumn		Spring							
	Plantation		Plantation		First ratoon		Second ratoon		Third ratoon	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
May	2.3	2.6	0.0	0.0	3.7	4.4	4.7	5.0	4.4	6.2
June	4.3	3.7	1.5	2.0	7.4	7.6	8.9	9.5	10.5	11.7
July	8.0	7.1	2.0	3.3	11.4	13.7	17.8	19.0	23.7	26.7
August	14.1	12.6	3.2	5.0	18.8	21.5	26.5	30.6	33.6	36.8
September	11.6	9.3	7.5	10.7	14.4	17.4	19.4	25.7	27.3	30.7
October	7.7	6.1	4.5	6.6	9.3	12.1	14.8	20.7	19.0	21.8
November	9.5	7.9	5.7	7.2	12.5	15.8	17.8	15.2	23.4	28.0
December	7.7	9.8	6.7	8.0	13.9	14.5	14.8	18.5	19.8	24.3
January7	5.7	6.5	5.5	7.0	8.4	8.5	11.0	10.8	12.8	17.8
February	2.8	3.5	3.8	4.5	4.6	6.5	7.8	7.0	9.5	12.0
Mean	7.4^{d}	6.9^{D}	4.0^{e}	5.3^{D}	10.4^{c}	12.6^{C}	14.5^{b}	16.2^{B}	18.4^{a}	21.6^{A}

Two means in plant crop and 1st ratoon cane took the same letter are not significantly differed at 5% level of probability

Table (6): Monthly mean number of mealybug (nymphs + adults)/20 stalks in different sugarcane plantations (ages) at Mallawi, Minia, Egypt, 2006 and 2007 seasons.

Sampling Dates	Autumn		Spring							
	Plantation		Plantation		First ratoon		Second ratoon		Third ratoon	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
May/	21	25	0	0	25	29	22	30	41	48
June	46	56	14	22	44	60	45	55	69	74
July	60	72	34	53	77	85	80	95	88	100
August	99	119	55	75	166	142	187	144	209	241
September	155	173	85	109	122	190	132	200	153	172
October	102	87	23	39	126	107	153	177	159	175
November	113	110	44	60	143	142	164	160	172	187
December	86	123	63	80	101	155	121	129	143	158
January/	27	34	12	26	55	62	77	86	98	111
February	16	19	5	19	32	35	45	54	67	75
Total	724	818	335	483	891	1007	1046	1130	1199	1341
Mean	72.4^{d}	81.8^{D}	33.5^{e}	48.3^{E}	89.1^{c}	100.7^{C}	104.6^{b}	113.0^{B}	119.9^{a}	134.1^{A}

Two means in plant crop and 1st ratoon cane took the same letter are not significantly differed at 5% level of probability

first ratoons, while, the spring and the autumn plantations were the least. This may be due to the earlier emergence of ratoon canes to reach the more susceptible stages early. The mean percentage of infested internodes was 4.0; 7.4 ; 10.4 14.5 and 18.4 % in the first season and 5.3 ; 6.9 ; 12.6 ; 16.2 and 21.6 % in the second season in spring ; autumn plantations; 1st ; 2nd and 3rd ratoon cane , respectively (Table 5). The mean number of mealybugs per 20 plants was 33.5; 72.4 ; 89.1; 104.6 and 119.9 individuals in the first tested seasons and 48.3 ; 81.8 ;100.7 ; 113.0 and 134.1 individuals\plant in spring ; autumn plantations; 1st; 2nd and 3rd ratoons , respectively in the second season (Table ,6).

Statistical analysis of data obtained in both percent infested internodes and number of mealybug per stalk showed significant differences among different sugarcane plantations in both seasons.

Generally, it could be concluded from the obtained data that third ratoon cane is the most susceptible to *S. sacchari* regarding number of infested internodes and number of mealybugs.However, the first and second ratoon canes were moderately infested. Meanwhile, the autumn and spring received the least attack.. These results were supported by Hafez and Salama (1970), in Egypt, they indicated that_sugarcane infestation by *S. sacchari* was lightest on the first-year crops and was_significantly highest on the fourth-year crops than on any of the others. Abou-Dooh *et al.* (1999) ,in Egypt showed that the virginal cane proved to be less infested by *S. sacchari*, whereas the first ratoon cane was severely infested and exhibited a higher significant difference from the virginal cane. Graham and Michael (2005), in Australia, stated that the *S. sacchari* infestation started earlier and was much greater in ratoon crops than plant crops throughout the sampling period.

Table (7):Monthly mean of infested internodes and number of mealybug (nymphs + adults)/ 20 stalks in relation to flooding irrigation and burning of trash as monitored in the 1st and 2nd ratoon canes, Mallawi, Minia, Egypt, 2006 -2007.

Treat. Samp. Dates	Flooding irrigation				Burning of trash				Flooding +burning				Control			
	Infested internodes		No nymphs + adults		Infested nternodes		No nymphs + adults		Infested internodes		No nymphs + adults		Infested internodes		No nymphs + adults	
	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2	R1	R2
May	2.6	2.8	9	12	2.4	2.7	8	11	1.5	2.8	5	9	4.2.	5.3	13	21
June	3.5	3.8	14	18	3.8	4.5	16	21	2.4	4.2	11	12	9.3	8.5	27	25
July	5.6	8.8	21	39	5.5	9.6	24	28	3.8	6.5	18	22	16.8	19.7	67	87
Aug.	13.3	17.8	67	82	15.4	19.7	71	88	9.0	11.4	48	67	28.9	33.7	121	152
Sept.	11.6	13.3	48	65	12.9	15.8	59	74	7.3	8.2	39	41	21.2	23.9	91	111
Oct.	6.4	9.5	26	35	6.5	9.8	32	38	3.5	4.1	16	25	13.2	17.8	70	94
Nov.	12.3	13.8	56	66	12.3	14.5	52	65	6.8	7.5	30	40	20.5	22.4	87	103
Dec.	7.2	7.6	37	44	7.2	8.4	43	48	4.6	6.3	27	36	19.6	20.7	81	90
Jan.	5.5	6.0	12	17	3.1	6.6	21	27	3.7	3.9	18	23	17.8	16.8	76	68
Feb	3.6	4.8	8	13	2.8	5.5	11	19	2.4	2.0	8	12	10.8	13.4	44	52
Total	71.6	98.2	288	391	770	970	337	419	450	570	220	287	7.7	9.0	677	803
Mean	7.2^{b}	8.8^{B}	28.8^{b}	39.1^{B}	7.7^{b}	9.7^{B}	33.7^{b}	$41.9B^{}$	4.5^{c}	5.7^{C}	22.0^{c}	28.7^{C}	$17.0.5^{a}$	19.1^{A}	67.7^{a}	80.3^{A}
Red. %	57.6^{b}	53.9^{B}	57.5^{b}	51.3^{B}	54.7^{c}	49.2^{C}	50.2^{c}	47.8^{C}	73.5^{a}	70.2^{A}	67.5^{a}	64.3^{A}	--	--	--	--

R1= first ratoon cane (2006) R2 = second ratoon cane (2007)

Two means in plant crop and 1st ratoon cane took the same letter are not significantly differed at 5% level of probability

Table (8): Monthly mean number of mealybug (nymphs and adults)/ 20 stalk. and percentage of parasitism by *Anagyrus* sp and number of predator in different sugarcane varieties in the plant cane, Mallawi, Minia, Egypt, 2006 season.

Samp. Dates	G.T54/9			Ph80/13			G.47/88			G.37/85			G.21/95			G.96/74		
	P1	%P2	P3	P1	%P2	P3	P1	%P2	P3	P1	%P2	P3	P1	%P2	P3	P1	%P2	P3
May	7	0.0	1	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0	0	0.0	0
June	12	8.3	3	7	0.0	3	10	0.0	2	6	0.0	1	16	6.3	2	3	0.0	1
July	19	5.3	5	13	9.2	5	20	10.0	3	30	7.1	2	25	4.0	3	9	11.1	5
Aug.	79	10.1	8	34	14.7	9	49	17.9	10	108	6.1	7	90	7.8	7	20	24.0	9
Sep.	133	14.3	13	64	29.7	30	109	23.6	22	164	15.1	15	190	11.2	11	62	39.0	32
Oct.	96	11.5	9	38	23.7	15	71	21.5	10	125	12.2	10	125	8.8	8	35	27.7	17
Nov.	75	12.0	8	36	25.0	12	65	15.6	7	97	11.5	6	95	8.4	6	19	26.3	12
Dec.	89	9.0	9	58	11.2	17	79	11.6	12	98	10.2	7	119	7.6	7	39	21.1	19
Jan.	62	4.9	5	19	10.5	7	36	9.7	6	85	5.3	5	110	6.4	5	20	10.0	9
Feb.	49	2.0	3	13	7.7	4	18	5.6	3	52	5.1	2	92	5.4	2	17	5.9	6
Total	619	-	64	282	-	90	457	-	75	765	-	55	862	-	50	224	-	102
Mean	61.9^{c}	7.7^{B}	6.4^{b}	28.2^{c}	13.2^{A}	10.2^{a}	45.7^{d}	11.6^{AB}	7.5^{b}	76.5^{b}	7.2^{B}	5.5^{b}	86.2^{a}	6.6^{B}	5.0^{b}	22.4^{c}	15.6^{A}	11.0^{a}

Table (9): Monthly mean number of mealybug (nymphs and adults) / 20 stalk. percentage of parasitism by *Anagyrus* sp. and number of predator in different sugarcane varieties in the first ratoon cane at Mallawi,Minia, Egypt, 2006/ 2007.

Samp. Dates	G.T54/9			Ph8013			G.47/88			G.37/85			G.21/95			G.96/74		
	P1	%P2	P3	P1	%P2	P3	P1	%P2	P3	P1	%P2	P3	P1	%P2	P3	P1	%P2	P3
May	11	9.1	1	3	0.0	1	12	8.3	1	6	0.0	0	15	6.7	0	2	0.0	0
June	17	11.8	3	9	11.1	3	24	9.1	4	22	5.9	1	25	5.0	2	7	14.3	2
July	31	12.9	4	27	19.8	5	47	14.8	7	80	11.4	4	69	8.7	7	12	19.0	4
Aug.	139	16.8	12	73	29.5	21	139	27.1	16	189	27.9	15	184	18.3	11	60	44.7	21
Sep.	122	15.5	10	41	23.3	12	67	25.8	13	176	22.2	11	158	12.0	8	42	26.0	14
Oct.	97	10.5	7	30	20.4	9	71	21.7	11	79	17.4	5	94	12.8	5	30	21.7	10
Nov.	101	12.8	5	63	25.3	18	75	24.0	13	115	18.2	13	165	10.9	7	40	25.0	15
Dec.	119	8.9	6	39	20.5	11	42	15.0	10	06	12.5	10	125	11.6	4	35	22.8	12
Jan.	93	5.4	5	29	6.9	7	43	6.1	5	85	6.7	5	112	6.8	2	30	6.4	11
Feb.	58	4.1	4	17	5.9	5	25	3.8	3	67	5.0	1	84	5.0	1	21	5.8	7
Total	788	-	56	331	-	92	555	-	84	925	-	65	1031	-	46	79	-	96
Mean	78.8^{c}	10.8^{B}	5.7^{b}	33.1^{c}	16.3^{A}	9.2^{a}	55.5^{d}	15.6^{A}	8.4^{a}	92.5^{b}	12.6^{B}	6.5^{b}	103.1^{a}	9.1^{C}	4.6^{b}	27.9^{c}	18.6^{A}	9.6^{a}

P1= Mealybug pest number /20 stalks % P2 = Percentage of parasitism P3 = Predator number/ 20 stalks

Two means in plant crop and 1st ratoon cane took the same letter are not significantly differed at 5% level

1.4. Effect of flooding irrigation and burning of trash on *S. sacchari* infestation:

Data in Table (7) showed the number of infested internodes caused by *S. sacchari* and number of mealybugs (nymphs and adults) associated with it in sugarcane plots treated with both flooding irrigation burning trash separately(alone) and ones treated with flooding irrigation integrated with burning trash after harvesting the crop in 1st and 2nd ratoon canes. It is obvious that using the flooding irrigation and burning trash together after harvesting, gave significant least infested internodes (4.5 and 5.7%) with reduction of 73.5 and 70.2%. Also, two treatments together recorded the least in population of mealybugs (22.0 and 28.7 individuals/20 plants) with a reduction of 67.5 and 64.3% when compared with the control area in the first and second ratoons canes, respectively. However, using the flooding irrigation alone gave the moderately percentage of infested internodes(7.2 and 8.8%) with a reduction of 57.6 and 53.9% followed by the plots treated with only burning trash in sugarcane fields (7.7 and 9.7%) with reduction of 54.7 and 49.2% in the 1st and 2nd ratoon crops, respectively. The reduction in mean number of mealybugs per 20 stalks was significantly higher in case of using the flooding irrigation integrated with burning trash after harvesting (67.5 and 64.3%) than in plots treated with burning trash (50.2and 47.8%) separately with these treated with flooding irrigation (57.5 and 51.3%) in both 1st and 2nd ratoon canes, respectively.

In conclusion, using flood irrigation integrated with burning the trash after harvesting the crop can help reducing the infestation by *S. sacchari* more than using any treatment separately or alone.

Burning the trash and the dry leaves left in the field after harvesting sugarcane stubble during March-April when pest is usually found in large numbers in fresh ratoon sprouts, proves helpful in destroying the pest in the early stages of its activity. However, treatment with mixtures of flood irrigation and burning when used together, gave effective and economic control, without being phytotoxic.

Using cultural practices to reduce any populations can also reduce densities of mealybugs by allowing natural enemies greater access. Flood irrigation and burning of the trash and the dry leaves can be used to disrupt ant populations. The ants (black ant), which usually carry the female bugs from one plant to another and disseminate the pest may be controlled by flood irrigation and burning of the trash and the dry leaves.

2. Relative susceptibility of sugarcane varieties to *S. sacchari* infestation in relation to natural enemies' population:

2.1. The role of parasitoids in suppressing the population of mealybug, *S. sacchari*

- Identification of parasitoids:

In this experiment, the identification of emerged parasitoids revealed that, *Anagyrus saccharicola* Timberlake was the solitary endoparasitoid secured from the PSMB. Data presented in Tables (8) and (9) and Fig.(1) revealed that the encyrtid parasitoid, *A. saccharicola* occurred during all months in 1st ratoon and only during nine months from June to February on plant cane. Regardless to variety, data in Table (8) showed that the lowest percentage of parasitism was recorded in June when it ranged from 6.3 to 8.3%) and in February (ranged from 2.0 to 7.7%), while the highest percentage of parasitism ranged from11.2 – 39.0% in September in the plant cane. In the 1st ratoon cane, data obtained in Table (9) cleary demonstrated that the parasitism rate started during May, in a low level, varied from 0.0 to 9.1% and increased gradually to record the maximum level of parasitism in August (16.8–44.7%). However the percentage of parasitism was decreased during January and February and varied from 3.8 to 6.9 %., regardless of the variety.

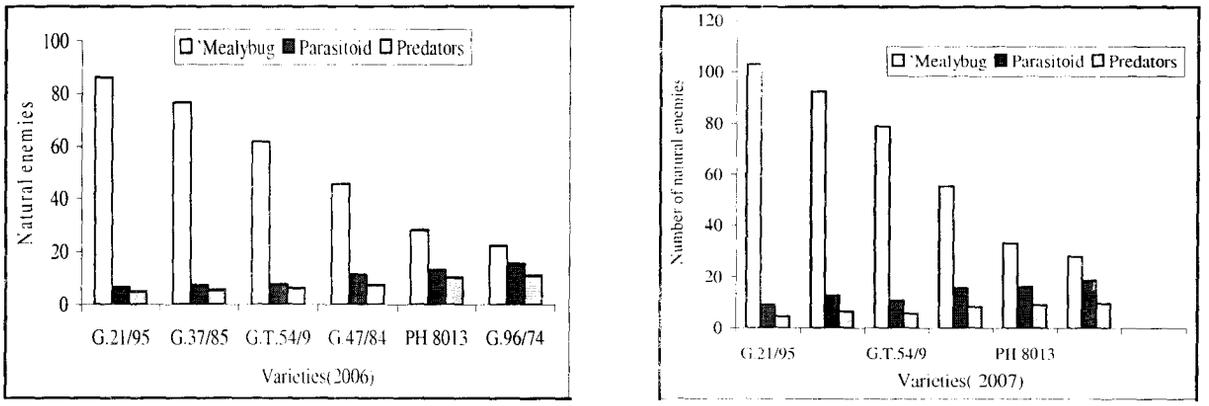

Fig.(1) Monthly mean number of mealybugs, percentage of parasitism by *Anagyrus* sp and number of predator in different Sugarcane varieties at Mallawi, Minia, Egypt, 2006 and 2007 seasons.

The results in both seasons , showed that the highest mean percentage of parasitism by *A. saccharicola* was found associated with the resistant varieties (Giza 96/74 and Ph 8013),showing means of 15.6 and 13.2 % in plant cane and18.6 and 16.3% in 1st ratoon cane , respectively, when the number of mealybugs per 20 plants was low. While the least percentage of parasitism was noticed associated with susceptible varieties to mealy bug; Giza 21/95 (6.6 and 9.1 %) and Giza 37/85(7.2 and 12.6%) in both seasons, respectively, when the population of mealybug reached a maximum.

In general, it is clearly from data, that the overall parasitism rates in the sugarcane field ranged from 6.6 to 15.6% in plant cane and from to 9.1 to 18.6% in 1st ratoon cane depending on the season and sugarcane management practices. Studies also show that if parasitoids are present and active early in the season, substantial reductions in mealybug densities can occur.

According to Abd-Rabou (2000); in Egypt and Giron *et al.,* (2005) in Colombia, *A. saccharicola* is considered one of the most abundant parasitoids attacking *S. sacchari* on sugarcane.

2.2. The role of predators in suppressing the population of mealybug, *S. sacchari*

As presented in Tables (10 and 11) nine arthropod predators were recorded attacking mealybugs in sugarcane. The most common arthropod predators in the sugarcane fields are *Scymuns syricacus* Mars; true spiders; *Rodolia cardinalis*; *Orius albidipenis* Reut.; *Complomma nicolasi* Puton; *Peaderus alferii* Koch; *Coccinella undecimpunctata* L.; *Geocoris* spp. and *Cydonia vicina* isis Gr. in both plant and 1st ratoon crops. Data in Tables (8), (9) and Fig. (1), demonstrate the change in population density of the predators in six sugarcane varieties. The population abundances of prevailed predators occurred in scarcely numbers of the beginning of the season during May and June and increased reaching a peak during August and September. However, gradual decrease in numbers of predators was achieved by the end of the season during January and February in both seasons. Regardless to the variety, data in the same tables, showed that the highest number of predators varied from 11–32 during September in the plant cane and from 11 to 21 individuals/20 stalks during August in the 1st ratoon cane coincided the highest number of mealybugs which it varied 62 – 190 and 60 - 184 individuals/20 stalks at the same time in both the plant and ratoon canes , respectively. The overall mean numbers of insect predators/20 stalks collected from resistant varieties; Giza 96/74 (11.0, 9.6 individuals) and Ph8013 (10.2, 9.2 individuals) were more than those collected from the susceptible varieties Giza 21/95 (5.0, 4.6 individuals) and Giza 37/85 (5.5, 6.5 individuals), this led to the number of mealybugs in the resistant varieties were lower than in those susceptible ones in both plant and 1st ratoon crops, respectively. Statistical analysis of the data showed no significant differences among varieties mean number of predators per 20 plants, except between Giza 96/74 and Ph8013 in both seasons. This means that some genotypes play an important role in attracting predators and parasitoids.

This case was previously recorded by Bottrell (1992) in Philippines, who found that the different genotype of rice differ in their attraction of different parasitoids and predators.Liu *et al.* (1985) indicated that *S. sacchari* was suppressed by natural enemies preserved through lower and judicious use of insecticides, and cultural control measures to provide a good habitat for natural enemies.

Generally, the results indicated that the highest total numbers of natural enemies were found in plots

Table (10): Monthly mean number of predators /20 stalks associated sugarcane mealybug as monitored the plantcane, Mallawi Minia, Egypt, 2006 season..

Samp Dates	No of mealybug	*Scymnus syricacus*	*Coccinella undecimpunctata*	*Rodolia cardinalis*	*Cydonia vicina*	*Peaderus alferii*	*Orius albidipenis*	*Geocoris* sp.	*Complomma nicolasi*	True spider	Total
May	23.00	1.00	0.00	0.00	0.00	1.75	1.50	0.00	0.00	2.00	6.25
June	69.00	2.00	1.25	1.50	0.00	2.25	1.75	0.00	2.25	2.50	13.50
July	85.25	5.50	2.25	2.75	1.25	4.75	2.75	1.00	4.25	5.75	30.25
Aug	172.5	12.75	4.00	7.50	2.75	5.50	4.50	2.25	6.75	8.50	54.50
Sept	187.0	19.50	7.75	11.50	2.50	6.75	8.75	3.50	9.50	13.00	82.75
Oct.	125.0	17.50	3.50	6.25	1.50	2.25	4.50	1.75	2.75	3.75	43.75
Nov	109.0	11.50	2.00	4.00	1.00	2.00	2.75	1.50	2.00	2.75	29.50
Dec	53.50	7.25	2.75	5.25	1.00	3.25	5.50	1.00	3.50	4.50	34.00
Jan.	20.75	3.25	1.25	2.00	0.00	1.25	2.75	0.00	1.50	2.75	14.75
Feb.	8.00	1.75	0.00	1.50	0.00	0.00	1.50	0.00	0.00	2.00	6.75
Total	744	82.00	24.75	42.25	10.00	29.75	36.25	11.00	32.50	47.50	316.0
% D	-	26.00	7.83	13.37	3.16	9.41	11.47	3.48	10.28	15.00	100

D: Dominant degree

Table (11): Monthly mean number of predators / 20 stalks associated sugarcane mealybug as monitored the first ratoon cane, Mallawi , Minia, Egypt, 2007 season .

Samp Date	No of mealybug	*Scymnus syricacus*	*Coccinella undecimpunctata*	*Rodolia cardinalis*	*Cydonia vicina*	*Peaderus alferii*	*Orius albidipenis*	*Geocoris* sp.	*Complomma nicolasi*	True spider	Total
May	40.00	1.50	1.00	1.75	0.00	1.75	2.00	0.00	1.25	2.75	12.00
June	87.75	3.75	2.25	3.75	1.25	2.75	3.25	1.00	2.75	3.75	24.50
July	134.75	6.50	4.00	9.00	2.75	4.00	4.50	2.75	5.50	8.50	47.50
Aug.	251.50	23.50	9.50	13.50	4.50	9.75	12.00	6.00	12.25	17.50	108.5
Sept.	237.25	18.50	7.25	11.00	4.00	7.00	9.25	4.50	8.00	14.25	83.75
Oct.	168.50	11.75	4.25	5.75	2.25	3.50	4.00	2.50	4.25	6.00	44.25
Nov.	181.25	13.75	5.50	8.25	3.00	4.25	7.50	3.25	6.75	9.50	61.75
Dec	97.00	6.75	3.50	5.50	1.25	3.00	5.00	1.25	3.75	5.25	35.25
Jan.	53.25	4.75	2.25	4.25	1.00	1.50	2.00	1.00	2.25	4.00	23.00
Feb.	15.75	2.75	1.50	2.00	0.00	1.25	1.50	0.00	1.25	2.25	12.50
Total	1267	93.50	41.00	64.75	20.00	38.75	51.00	22.25	48.00	73.75	453.0
%D	-	20.64	9.05	14.29	4.42	8.55	11.26	4.91	10.60	16.28	100

D: Dominant degree

cultivated with the resistant varieties (Giza 96/74 and Ph8013). Finally, it can be concluded that the populations of mealybug in sugarcane fields are greatly regulated by their natural enemies, especially the parasitoids, and the predators.

The peaks of predators were recorded during September in the plant cane and during August in 1st ratoon cane.

S. syricacus and true spiders were the most dominant species as their mean numbers reached 82 (26%) and 47 (15.0%) of the total catch in the plant cane and 93.5 (20.64%) and 73.75 (16.28%) of the total predators population in 1st ratoon cane, respectively. It is obvious that *R. cardinalis*; *O. albidipenis*, *C. nicolasi*, *P. alferii* and *C. undecimpunctata* were found in a moderate numbers *i.e.* 13.37; 11.47; 10.28; 9.41 and 7.83% in plant cane and 14.29; 11.26; 8.55; 10.60 and 9.05 % of the total predators population in 1st ratoon cane , respectively. However, *Geocoris* sp. and *Cydonia vicina* isis Gr. were relatively found in low numbers showing 11(3.48%) and 10 (3.16%) in plant cane and 22.25 (4.91%) and 20 (4.42%) in 1st ratoon, respectively. Highest number of predators was recorded during August and September. Numbers of predators gradually decreased towards the end of the seasons during January and February. Many authors notably Srivastava, 1973; Liu *et al.*, 1985 and Giron *et al.*, 2005, reported similar results on the mealybug associated with sugarcane fields.

In Egypt, the PSMB, *S. sacchari* has not become an economically important pest, probably because of the role of its several natural enemies.

Finally, it can be concluded that *S. sacchari* was suppressed in sugarcane fields by natural enemies preserved through use of cultural control measures such as varieties, spacing, ages, burning of trash and flood irrigation to provide a good habitat for natural enemies. Thus, the present results may help in planning a successful control program to check the ravages of sugarcane mealybug.

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الملخص العربي

دور العمليات الزراعية والأعداء الحيوية في خفض الإصابة ببق القصب الدقيقى (*Saccharicoccus sacchari*) في حقول قصب السكر بمحافظة المنيا (مصر الوسطى)

تهامى حامد تهامى ،عبد الرحيم احمد عبد الرحيم وعادل محمد الراوي

معهد بحوث وقاية النباتات، مركز البحوث الزراعية، الجيزة، مصر

تم عمل تجارب حقلية لتقويم دور العمليات الزراعية والأعداء الحيوية في خفض إصابة قصب السكر ببق القصب الدقيقى (*Saccharicoccus sacchari*) فى منطقة ملوي بمحافظة المنيا خلال موسمين متتاليين ٢٠٠٦، ٢٠٠٧. أثبتت التجارب في الموسمين أن صنفي قصب السكر جيزة ٩٥/٢١ ، جيزة ٨٥/٣٧ كانا الأعلى قابلية للإصابة بالآفة ، بينما صنفي س٥٤/٩ وجيزة٨٨/٤٧ كانا متوسطي الإصابة أما باقي الأصناف (جيزة ٧٤/٩٦، Ph ٨٠١٣) سجلت أقل إصابة طبقا للنسبة المئوية للعقل المصابة وأعداد البق الدقيقى/ النبات . أيضا وجد أن أعداد البق الدقيقى (حوريات والحشرات الكاملة) تقل معنويا بزيادة مسافات الزراعة بين خطوط قصب السكر وأكثر من ذلك وجد أن النسبة المئوية للعقل المصابة وأعداد البق الدقيقى/ العود تختلف من موسم لأخر وحسب مراحل أعمار القصب حيث تكون الإصابة بالبق الدقيقى مبكرة وعالية جدا في القصب الخلفة عن القصب الغرس. ومن ناحية أخرى أدى حرق السفير(متخلفات المحصول) متكاملا مع الري بالغمر بعد كسر المحصول في مارس وأبريل أدى إلى خفض معنوي في النسبة المئوية للعقل المصابة بمقدار ٥و٧٣، ٣و٧٠ % وكذلك في أعداد البق الدقيقى في النبات بمقدار ٥و٦٧ ، ٣و٦٤ % في كلا الموسمين على التوالي بالمقارنة بالكنترول. تم تعريف طفيل *Angyrus sacharicola* Timberlake على موميات بق القصب الدقيقى. وبلغت أعلى نسبة للتطفل خلال شهري أغسطس وسبتمبر فى القصب الخلفة والغرس على التوالى. تم حصر أعداد المفترسات المصاحبة لهذه الآفة حسب نسب تواجدها من جملة المفترسات الكلية كالآتي أبوالعيد أسكيمنس (٢٦,٠٤، ٢٠,٦٤) ; العناكب الحقيقة(١٥,٠، ١٦,٢٨) ،أبو العيد روداليا(١٣,٣٧، ١٤,٢٩)، بق الأوريس (١١,٤٧، ١١,٢٦)، بق الكاميبلوما (١٠,٢٨، ١٠,٦٠) ، الرواغة (٩,٤١ ، ٨,٥٥)، أبو العيد ذو أحدى عشر نقطة (٧,٨٣، ٩,٠٥)، بق الجيوكورس (٣,٤٨، ٤,٩١) ،ابو العيد البنى(٣,١٦ ، ٤,٤٢) في كلا من القصب الغرس والخلفة الأولى على التوالي. وهكذا تساعد هذه الدراسات فى عمل توصيات لبرنامج مكافحة ناجح يحد من الإصابة ببق القصب الدقيقى .