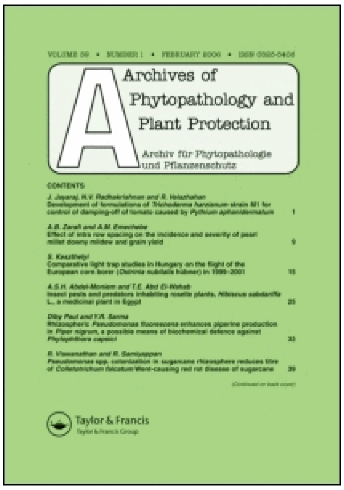

Archives Of Phytopathology And Plant Protection
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713454295

Effect of some materials on Sesamia cretica infesting some maize and sorghum varieties

H. A. Ezzeldin [a]; A. A. A. Sallam [b]; T. Y. Helal [a]; H. A. Fouad [b]
[a] Plant Protection Department, Faculty of Agriculture, Assiut University, Assiut, Egypt [b] Plant Protection Department, Faculty of Agriculture, South Valley University, Sohag, Egypt

First Published:March2009

To cite this Article Ezzeldin, H. A., Sallam, A. A. A., Helal, T. Y. and Fouad, H. A.(2009)'Effect of some materials on Sesamia cretica infesting some maize and sorghum varieties',Archives Of Phytopathology And Plant Protection,42:3,277 — 290

To link to this Article: DOI: 10.1080/03235400601037180

URL: http://dx.doi.org/10.1080/03235400601037180

Archives of Phytopathology and Plant Protection
March 2009; 42(3): 277–290

Effect of some materials on *Sesamia cretica* infesting some maize and sorghum varieties

H. A. EZZELDIN[1], A. A. A. SALLAM[2], T. Y. HELAL[1], & H. A. FOUAD[2]

[1]*Plant Protection Department, Faculty of Agriculture, Assiut University, Assiut, Egypt, and* [2]*Plant Protection Department, Faculty of Agriculture, South Valley University, Sohag, Egypt*

(Received 16 September 2006)

Abstract
Field experiments were carried out at the experimental farm of the Faculty of Agriculture, Sohag, South Valley University during two successive seasons, 2002 and 2003, to study the relative susceptibility of some maize and sorghum varieties to infestation by greater sugar cane borers, *Sesamia cretica L.*, and the effect of chemical insecticide (methomyl), microbial insecticide (*B.t.*) i.e. Agrein, petroleum oil (Sisi 6), and in organic salt (barium nitrate) against these pests, under field conditions. The roles of controlling *S. cretica* by these materials in increasing the yield of maize and sorghum varieties were also studied. Results revealed that all tested maize and sorghum varieties infested by *S. cretica* had significant differences observed between them. Infestation percentage of *S. cretica* in maize and sorghum varieties generally increased gradually with plant age. Data indicated that methomyl was the most effective material in reducing the infestation of maize plants by *S. cretica*, followed by Agrein, Sisi 6, and barium nitrate. The same potency order of tested materials on maize was also found on sorghum varieties during the two seasons. Results also revealed that the reduction of *S. cretica* population play an important role in increasing the yield of maize and sorghum. The yield of all treated plants was higher than that of untreated plants. However, methomyl was the most active material followed by Agrein in controlling the pest and resulted in increasing yield of all maize and sorghum varieties.

Keywords: *Susceptibility,* Sesamia cretica*, maize, sorghum, yield, infesting, insecticide, control*

Introduction

Maize (*Zea mays* L.) is one of the staple foods for the majority of Egyptian farmers. Maize foliage is also a major constituent in cattle feeds. It is cultivated in an area of about 1.7 million feddans annually (Anonymous 2001a). Also, sorghum (*Sorghum vulgar* L.) is considered the most important cereal crop grown principally during summer in Upper Egypt. Sorghum was cultivated a long time ago for bread making and recently for many other purposes such as green foliage, grain for feeding animals and as a raw material for other industries. It is cultivated in about half million feddans in Upper Egypt (Anonymous 2001a).

Sesamia cretica is one of the most important corn borers in Egypt. This pest attacks maize and sorghum plants less than 4 – 6 week old. Damage to young plants ranges from feeding on

Correspondence: A. A. A. Sallam, Plant Protection Department, Faculty of Agriculture, South Valley University, Sohag, Egypt. Tel: 002-0102576247. E-mail: sallam_unv@yahoo.com

ISSN 0323-5408 print/ISSN 1477-2906 online
DOI: 10.1080/03235400601037180

the whorl leaves causing dead-heart to feeding on older plants causing longitudinal tunnels. Maize and sorghum plants are broken below or above ear level (Soliman & Mihim 1997). In sorghum, larvae tunnel into young plants, stalks, tops of panicles, peduncles, tillers and the main axis of the ear head (Woodhead & Taneja 1987). In nature, corn borers are active in maize and sorghum fields between late spring and late autumn. They hibernate then as full-grown larvae, in the stalks and crops and remain from late October or early November until April or early May. Adult moths emerge from the hibernating larvae and represent the source of new infestation on the next year's crop (Isa et al. 1969).

Various methods of protecting maize and sorghum plants from infestation by *S. cretica* have been tried. Chemical insecticides are commonly used to control *S. cretica*, but given the negative environmental side effects associated with chemical control, development of maize cultivars with resistance to *S. cretica* offers a better alternative. A great deal of work had been carried out on the effect of some materials against the pink stalk borer (Zaki 1991; Ridgway et al. 1996; Ibrahim & Farrag 1997; Fediere et al. 1997; Nasr & Ibrahim 1997; Bader et al. 1999; Abou-Taleb et al. 2001). Also, several researchers have investigated the yield loss associated with pink stalk borer injury. Bailey and Pedigo (1986) infested 2–4 leaf corn plants with larvae of the stalk borer and found that significant yield loss occurred when the whorl of the plant was killed (dead heart). Leaf feeding, however, did not cause significant yield losses. Levine et al. (1984) observed that natural infestations of stalk borer caused greater yield losses in corn at earlier stages of development. However, they were not able to quantify the losses because of inherent differences in plant population, hybrid, and infestation level. Fediere et al. (1997) revealed that microbial and chemical insecticide treatments noticeably reduced the numbers of *S. cretica* larvae. Regarding yield, the mean weight of seeds was higher for the plots which were treated with either virus or insecticide than untreated ones. However, they found that chemical insecticide treatments were more effective than the formulated virus treatments. Yield in ardab/fed. were 20.11, 16.04, and 12.79 for chemical insecticide, viral insecticide and control treatments, respectively. In another study, El-Serwy (1993) discovered the relationship between infestation with *S. cretica* and yield loss of sorghum crop. Results showed that Hybrid 119 had higher percentages of panicles (21.6 and 24.2%) and yield loss (9.6 and 14.0%) than other tested varieties in two regions, i.e. Al-Akab and Abu-Soubera at the Aswan governorate during the 1992 season. Local 29 had the smallest percentage of infested panicles and yield loss despite highly infested joints and holes bearing large numbers of larvae, pupae and empty pupal cuticles, thus reflecting a high tolerance level.

The present work aimed to study the efficacy of tested materials, i.e. methomyl, Agrein, Sisi 6, and barium nitrate against *S. cretica* infesting maize and sorghum plants, and the role of controlling this pest to give increased yield.

Materials and methods

Tested materials

A – Chemical insecticides: Methomyl 90% S.P. *S*-methyl-*N*-[(methyl-carbamoyl)oxy]thioacetimidate.

B – Microbial insecticides (Agrien), *Bacillus thuringiensis* var. aegyptica 6.5% W.P. (32000) international unit/mg of productive.

C – Petroleum oils: Sisi-6 10% E.C. Prepared by neutralization of aryl alkyl sulphonate with potassium alkaline, used at concentration of 1.5 % (V/V).

D – Inorganic salt: barium nitrate, Ba $(NO3)_2$.

Crops

Two crops were used in the present study:

1 – *Zea mays L.* (maize) varieties, i.e. hybrid single 10 (H.S.10.), Hybrid single 3080 (H.S. 3080), Hybrid third 313 (H.T. 313), and balady.
2 – *Sorghum vulgare L.* (Sorghum) varieties, i.e. Giza 15 and Giza 113 are long stem plants, whereas Schendwill 6 and Dorado are short stem plants.

The field experiment

The field work was carried out in the Experimental Farm of the Faculty of Agriculture, Sohag, South Valley University, during two successive seasons, 2002 and 2003. The experimental design was a complete randomized blocks design with the replicates. The plot area was 42 m^2 ($^1/_{100}$ Fadden). Each plot consisted of 10 rows of 6 m length and 70 cm width. Maize and sorghum seeds were cultivated in early June 2002 and 2003 seasons, respectively. Three plots were left untreated to serve as controls. All agricultural practices were manipulated and are recommended in the commercial production of crops. The tested materials, i.e. methomyl, Agrien, Sisi-6, and barium nitrate were applied after 35 days from the sowing date. The plants were sprayed once in each season on 5/6/2002 and 8/6/2003, respectively. The used rates were 300 g/fed; 500 g/fed, 3000 ml/ fed and 100 g/fed, respectively (Anonyomus 2001b). A knapsack hand spray fitted with one nozzle was used for spraying the treatments. Each plot was thoroughly sprayed using 10.0 litres of diluted pesticide solution, which is equivalent to ca. 200 litres of spray solution per feddan. The control plots were sprayed with water. Also care was taken to avoid any drift among the treated plots.

Samples of 10 plants were randomly collected from each replication to examine in the field. Infestation was assessed before spraying and after 1, 2, 3, 4, 5, 6, 7, 8, and 9 weeks. The percentage reduction of infestation in each case was calculated using the Henderson and Tilton equation (1955).

Yield evaluation

At harvest, 10 maize plants from each plot were taken randomly to determine ear height (cm), number of ears/plant, ear length (cm), ear diameter (cm), number of rows per ear, number of kernels/row, seed index (g/100 grains), grain yield per plant (g), and grain yield per feddan. Data represented yield in ardabs (1 ardab = 145 kg).

In sorghum at harvest, random samples of 10 heads from each plot were taken to determine seed index (g/100 grains), grain yield per plant (g), and grain yield per feddan. These data represent yield in ardabs for both treated and untreated plots (1 ardab = 145 kg).

From each plot, the yield weight of 10 heads with infested panicles was compared with that of a similar number of heads treated with the tested materials for controlling the pest to evaluate the yield increase.

Results and discussion

Relative susceptibility of some maize and sorghum tested varieties to infestation with the greater sugar cane borer, S. cretica

Susceptibility of maize varieties. Four maize varieties, Hybrid single 10, Hybrid single 3080, Hybrid third 313, and Balady were tested to reveal their susceptibility to *S. cretica*.

The experiment was carried out from June to September during 2002 and 2003 seasons. Data in Table I revealed that the infestation percentages of *S. cretica* against maize varieties generally increased gradually with the plant age. The percentage of infestation reached its peak by late August and early September in both tested seasons in all tested varieties. According to the overall average in the 2002 season (Table I), Hybrid single 3080 was the most tolerant to be infested by *S. cretica* (2.54%) followed by the Balady variety (3.42%) with no significant difference between them, whereas significant differences were observed among the above varieties and the other two tested varieties. Percentages were 4.50% and 5.54% for Hybrid third 313 and Hybrid single 10, respectively. In the 2003 season, no significant differences were observed among Hybrid single 3080, Hybrid third 313 and Balady varieties. Hybrid single 10 was the only variety that showed a significant difference (infestation = 5.37%) compared with the other tested varieties. In both tested seasons, tested varieties could be arranged in descending order according to the infestation percentage of *S. cretica* as: Hybrid single 10, Hybrid third 313, Balady and Hybrid single 3080. It showed the following percentages: 5.54, 4.50, 3.42 and 2.54, respectively, for the 2002 season while they were 5.37, 3.50, 3.32 and 3.17, respectively, for the same corresponding varieties in the 2003 season. From these data, it can be concluded that Hybrid single 10 was the most able variety to be infested with *S. cretica*, while Hybrid third 313 was the least able one. These results were in agreement with Allam (2003) who found that maize plants in July 1998 had the highest larval population of *S. cretica* for Single cross (S.C. 10) variety (0.8 larvae/20 plants) followed by S.C. 129 and third way (T.W. 310) varieties, which received the same average larval population (0.3 larvae/plants).

In the 2003 season, the tested varieties could be arranged in descending order according to the infestation percentage of *S. cretica* as 5.37, 3.50, 3.32 and 3.17% for Hybrid single 10, Hybrid third 313, Balady and hybird single 3080, respectively. These results coincide with the same trend deduced from data depicted in the 2002 season. Balady has been categorized as number three among varieties for susceptibility to *S. cretica* and may be tolerant to infestation. These results do not correspond with the findings of Metwally (1988), Ali et al. (1989) and Abdel-Rassoul (1992). Metwally (1988) found that D.C. 202 and Balady were susceptible, while Giza proved to be a relatively resistant cultivar. Ali et al. (1989) revealed that D.C. 202 was highly susceptible, Balady was susceptible, Giza 2 was considered to be relatively resistant and D.C. 514 was highly resistant. Abdel-Rassoul (1992) found from studying seven maize varieties that Giza 215 and Balady were very susceptible.

By careful review of the literature and the present investigation, it was revealed that the susceptibility of maize cultivars to certain insect pest is governed by many factors such as environmental conditions, planting region and pest status. On the other hand, Hybrid single 3080, which had the lowest infestation percentage of *S. cretica*, were found to have the lowest yield loss. It may be due to leaf nature (vertical). Some relation between leaf angle and percentage infestation was found. Soliman (1998) found a positive correlation between leaf angle and percentage of infested plants, indicating that selection for a narrower leaf angle might help in preventing moths of *S. cretica* to lay their eggs beneath the leaf sheath and therefore resulting in selecting for a lower percentage of infestation. Variation in evaluation of Balady in the present study may be attributed to variation in pest status and/or cultivating regional environment. Metwally (1988) stated that Giza 2 is relatively resistant, while Semeada (1985) stated that the same variety proved to be susceptible under low infestation rate at Gemiza or Sids regions or under a high level of pest infestation at Bahtim.

Susceptibility of sorghum varieties. Studies on the relative susceptibility of some sorghum varieties: Giza 15, Giza 113, Shandwil 6 and Dorado to infestation with *S. cretica* were carried out during the 2002 and 2003 seasons. Data in Table II show the degree of infestation of the

Table I. Susceptibility of maize tested varieties to infestation with *Sesamia cretica* during 2002 and 2003 seasons.

Infestation date	Plant age (days)	Infestation percentage			
		Hybrid single 10	Hybrid single 3080	Hybrid third 313	Balady
June 2002					
23	21	0.67 A	0.00 A	0.00 A	0.00 A
30	28	2.67 A	0.67 A	2.00 A	1.33 A
Average		1.67 A	0.33 A	1.00 A	0.67 A
July 2002					
5	34	4.67 A	2.00 B	4.00 A	2.00 B
13	42	5.33 A	2.67 B	4.00 AB	2.67 B
20	49	6.00 A	3.33 B	4.67 AB	4.67 AB
27	56	6.00 A	3.33 B	4.67 AB	4.67 AB
Average		5.50 A	2.83 D	4.33 B	3.50 C
August 2002					
4	63	6.00 A	3.33 B	4.67 AB	4.67 AB
11	70	6.67 A	4.00 B	5.33 AB	5.33 AB
18	77	7.33 A	3.33 C	6.67 A	5.33 B
25	84	8.00 A	4.00 C	6.67 AB	5.33 BC
Average		7.00 A	3.67 B	5.83 A	5.17 AB
September 2002					
1	91	8.00 A	3.33 C	6.67 AB	5.33 B
8	98	8.00 A	3.33 B	7.33 A	5.33 B
Average		8.00 A	3.33 B	7.00 A	4.33 B
Overall average		5.54 A	2.54 B	4.50 A	3.42 B
June 2003					
25	21	1.33 A	0.67 A	0.00 A	1.33 A
Average		1.33 A	0.67 A	0.00 A	1.33 A
July 2003					
2	28	4.00 A	0.67 B	1.33 B	2.67 AB
8	34	6.00 A	3.33 B	2.67 B	2.67 B
16	42	6.67 A	2.67 B	2.67 B	2.67 B
23	49	6.67 A	3.33 B	3.33 B	2.67 B
30	56	7.33 A	3.33 B	3.33 B	3.33 B
Average		6.13 A	2.67 B	2.67 B	2.93 B
August 2003					
6	63	7.33 A	4.67 B	3.33 B	3.33 B
13	70	8.00 A	4.67 B	3.33 B	3.33 B
20	77	8.00 A	4.67 B	3.33 B	4.00 B
27	84	8.67 A	4.67 B	4.67 B	5.33 B
Average		8.00 A	4.67 B	3.67 B	4.00 B
September 2003					
3	91	8.67 A	4.67 B	7.33 AB	5.33 AB
10	98	8.67 A	4.67 B	8.00 A	4.67 B
Average		8.67 A	4.67 B	7.67 A	5.00 B
Overall average		5.37 A	3.17 B	3.50 B	3.32 B

Means followed by the same letter (s), within the same row in each season, are not insignificantly different at a 5% level of probability according to Duncan's Multiple Test.

Table II. Susceptibility of sorghum tested varieties to infestation with *S. cretica* during 2002 and 2003 seasons.

Infestation date	Plant age (days)	Infestation percentage			
		Giza 15	Giza 113	Shandwil 6	Dorado
June 2002					
23	21	2.00 A	2.00 A	0.00 B	0.00 B
30	28	2.67 A	2.00 A	0.67 A	0.67 A
Average		2.33 A	2.00 A	0.33 B	0.33 B
July 2002					
5	34	6.00 A	4.00 B	2.67 B	2.67 B
13	42	6.00 A	4.00 B	3.33 B	3.33 B
20	49	6.00 A	4.67 AB	4.00 B	3.33 B
27	56	6.00 A	4.67 A	4.67 A	6.00 A
Average		6.00 A	4.33 B	3.67 B	3.83 B
August 2002					
4	63	6.67 A	4.67 B	4.67 B	6.00 A
11	70	7.33 A	6.00 B	6.00 B	8.00 A
18	77	7.33 AB	6.00 B	7.33 AB	9.33 A
25	84	8.00 B	6.00 C	8.00 B	11.33 A
Average		7.33 B	5.67 D	6.50 C	8.67 A
September 2002					
1	91	9.33 B	7.33 B	9.33 B	13.33 A
8	98	10.00 B	10.00 B	11.33 B	14.67 A
15	105	10.00 B	10.00 B	11.33 B	16.00 A
22	112	11.33 B	10.67 B	12.00 B	16.67 A
Average		10.16 B	9.50 B	11.00 B	15.17 A
Overall average		6.45 A	5.37 B	5.37 B	7.00 A
June 2003					
25	21	2.67 A	2.33 A	2.00 A	2.00 A
Average		2.67 A	2.33 A	2.00 A	2.00 A
July 2003					
2	28	3.33 B	7.33 A	3.33 B	2.67 B
8	34	8.00 AB	9.33 A	5.33 B	6.00 B
16	42	8.00 AB	9.33 A	5.33 B	6.00 B
23	49	10.67 A	10.00 A	6.00 B	6.00 B
30	56	10.67 A	10.00 A	6.00 B	6.67 B
Average		8.133 A	9.20 A	5.20 B	5.47 B
August 2003					
6	63	11.33 A	10.00 A	6.67 B	7.33 B
13	70	11.33 A	10.00 A	6.67 B	10.67 A
20	77	11.33 A	10.00 A	9.33 A	11.33 A
27	84	12.00 B	10.00 B	9.33 B	13.33 A
Average		11.50 B	10.00 A	8.00 B	10.67 A
September 2003					
3	91	12.00 B	10.00 C	10.00 C	14.67 A
10	98	12.00 B	10.67 B	13.33 B	18.00 A
17	105	12.67 B	11.33 B	14.00 B	20.67 A
24	112	14.00 B	11.33 B	14.67 B	22.00 A
Average		12.67 B	10.83 B	13.00 B	18.83 A
Overall average		8.74 A	8.09 AB	7.05 B	9.24 A

Means followed by the same letter (s), within the same row in each season, are not significantly different at a 5% level of probability according to Duncan's Multiple Test.

tested varieties with *S. cretica*. These data revealed that the infestation percentages against tested sorghum varieties increased gradually with plant age. The percentage of infestation reached its peak by September in the 2002 season while it started to reach its peak by late August in the 2003 season. According to the overall average, slight differences were observed among the tested varieties. Infestation percentages of *S. cretica* against sorghum varieties were 6.45, 5.37, 5.37 and 7.00% for Giza 15, Giza 113, Shandwil 6 and Dorado, respectively, in the 2002 season, while it was 8.74, 8.09, 7.05 and 9.24% for the same corresponding varieties in the 2003 season.

The obtained results in Table II revealed the highly positive correlation between percentage of infestation and plant age in all tested varieties in both seasons, indicating that the percentage of infestation increased with an increase in plant age. The varieties differed significantly in the average weekly rate of percentage increase in infestation. Several investigators studied the relative susceptibility of different sorghum varieties to infestation with *S. cretica* (Attia & Farag 1989; El-Serwy 1993; Mohamed 2001). In conclusion, differential response of the tested varieties to the pink borer's damage (% infestation and % joints bored) varied among years. Average percent infestation of each variety increased during the growing season with slight fluctuations of intensity of infestation recorded among months, varieties and year. The gradual increase of infestation during the growing season is documented by Salman (1995) for sorghum in Sohag Governorate.

Effect of tested materials against S. cretica *infesting maize and sorghum plants in the field*

Field application of maize plants. The effect of chemical insecticides (methomyl), microbial insecticide (Agrein), petroleum oil (Sisi 6), and inorganic salt (barium nitrate) against *S. cretica* in the field were tested. Reduction percentages of infestation by *S. cretica* due to the application of tested materials are shown in Table III. The results indicated that methomyl was the most effective material in reducing the infestation, representing 89.73, 92.92, 83.29,and 92.30% reduction during the 2002 season on hybrid single 10, hybrid single 3080, hybrid third 313, and balady varieties, respectively. The rest of the tested materials can be arranged in descending order according to their potency as: Agrein, Sisi 6, and barium nitrate toward all tested varieties during the same season. In the 2003 season, the same order was found in (H.S.10), and (H.S. 3080), and the activity of methomyl and Agrein was almost the same on (H.T. 313) and balady varieties. Barium nitrate was also the least effective material in

Table III. Efficiency of the tested materials (mean of % reduction) against *S. cretica* infesting Maize tested varieties in the field during 2002 and 2003 seasons.

Pesticides \ Varieties	Hybrid single 10	Hybrid single 3080	Hybrid third 313	Balady	Mean
			2002		
Methomyl	89.73 AB	92.92 A	83.29 B	92.30 A	89.56 A
Agrein	76.31 BC	81.16 AB	69.10 C	85.06 A	77.91 B
Sisi 6	70.18 AB	76.24 A	63.37 B	70.79 AB	70.15 C
Barium nitrate	60.87 A	63.87 A	46.01 B	68.91 A	59.93 D
			2003		
Methomyl	78.20 A	81.37 A	77.04 A	65.57 B	75.54 A
Agrein	52.21 B	67.55 A	72.06 A	68.49 A	65.08 B
Sisi 6	29.31 C	46.08 B	58.50 A	48.06 B	45.49 D
Barium nitrate	24.33 B	18.86 B	50.62 A	31.40 B	31.24 C

all tested varieties during the 2003 season. These results agree with many investigators, e.g. Fediere et al. (1997) revealed that microbial and chemical insecticide treatments noticeably reduced the numbers of *S. cretica* larvae. However, they found that chemical insecticide (methomyl and monocrotophos) treatments were more effective than the formulated virus (GV) treatment. Ibrahim and Farrag (1997) studied the toxic effects of bacterial insecticides (Dipel 2x and bactospine) as well as some chemical insecticides, against the larvae of the greater sugar cane borer. Abou-Taleb et al. (2001) found that *Bacillus thuringiensis* Var. *kurstuki* alone or in combination with insect growth regulator (pyriproxyfen) and/or synthetic pyrethroid insecticide (fenvalerate) significantly reduced infestation of corn plants by *S. cretica* and *O. nubilalis*. According to the recommendation of the Egyptian Ministry of Agriculture for using natural products and safe materials in controlling pests, effective materials should give an initial effect of not less than 70% reduction and a residual effect of not less than 40% reduction. According to this recommendation, the results in Table III show that petroleum oil (Sisi 6) succeeded in controlling *S. cretica*, since it reduced infestation to 70.18, 76.24, 63.37, and 70.79% for Hybrid single 10, Hybrid single 3080, Hybrid third 313, and Balady varieties in the 2002 season, respectively. Sisi 6 was less effective in reducing infestation in the 2003 season, where the corresponding values were 29.31, 46.08, 58.50, and 48.06%, respectively. Ridgway et al. (1996) stated that some mineral oils may also play an important role as effective alternatives. Inorganic salts (barium nitrate) succeeded in controlling this pest, where the percentage reduction of infestation was 60.87, 63.87, 46.01, and 68.91% for Hybrid single 10, Hybrid single 3080, Hybrid third 313, and Balady varieties in the 2002 season. The corresponding values in the 2003 season were 24.33, 18.86, 50.62, and 31.40%, respectively. Mousa and El-Sisi (2001) evaluated the efficiency of some inorganic salts, i.e. ammonium floride, barium nitrate, sodium phosphate and potassium bromate against sucking pests infesting *Phaseolous vulgaris*. Results obtained indicated that a concentration 0.2% of each salt was suitable for controlling spider mite, *Tetranychus urtica*; aphid, *Aphis gossypii* and jasside, *Empoasca lybica*, without any phytotoxic effect against *Phaseolous vulgaris* seedlings.

Inorganic salts achieved this aim as they are considered as a new group; moreover, they are characterized by their cheap cost and easy preparation from primary parent materials. Also, each salt molecule contained two different moieties, one which is poisonous to living organisms such as: fluoride, bromate, barium, and phosphate, whilst the other is a fertilizing element such as nitrogen (ammonium and nitrate), phosphour (phosphate), and potassium. The toxic effect of the inorganic salts is due to their effect as a stomach poison which is retained in the mid-gut epithelium protoplasm (Spencer 1968; Gleason et al. 1969; Tomlin 1994).

Field application of sorghum plants. Data presented in Table IV show the effect of different treatments, i.e. methomyl, Agrein, Sisi 6, and barium nitrate against *S. cretica* infestation sorghum varieties, i.e. Giza 15, Giza 113, Schandwil 6, and Dorado planted at the experimental farm during 2002 and 2003 seasons. Results showed that chemical treatment (methomyl) caused the highest reduction in infestation with *S. cretica* in all sorghum varieties. The tested materials showed the same potency order in the two tested seasons, as on maize varieties (see Table III). Methomyl was the most effective material, followed by Agrein, Sisi 6, and barium nitrate with all sorghum varieties. According to the mean reduction percentage, methomyl caused reduction of *S. cretica* infestation by 73.20, 75.97, 75.36 and 65.34% for Giza 15, Giza 113, Schandwil 6 and Dorado varieties in the 2002 season, respectively. While in the 2003 season, the percentages were 67.77, 61.00, 69.81, and 69.26% for the same corresponding varieties. Reduction percentages ranged from 51.85 to 73.34; 43.11 to 64.23; and 34.49 to 54.60 for Agrein, Sisi 6, and barium nitrate, respectively, in the 2002 season.

Reduction percentage of Agrein in the 2003 season ranged from 49.12 to 59.98%. The mean reduction values in the 2003 season in Table IV for Sisi 6 and barium nitrate were less than 46% with all tested varieties. Shojai et al. (1995) concluded that the mass production of parasitoids, i.e. *Platyelenomus buueolae* Gahan., and *Habrobracon hebetor* L. and their release with application of microbial insecticides (*B.t.* sub sp. *Kurstaki*) and cultural methods can give very good results in integrated pest management (IPM) of maize stem borer *S. cretica* in Iran.

Yield evaluation of maize and sorghum varieties

Yield of maize varieties. Data for yield and its characteristics of the tested maize varieties for both seasons are presented in Table V. Hybrid single 10 showed a higher yield than the other varieties in number of kernels/row, grain yield/plant (g.) and grain yield/fed. (Ardab) in the 2002 season, while in the 2003 season, it significantly surpassed the other varieties only in grain yield/plant. Balady variety gave the poorest yield in both seasons. Hybrid single 3080 and Hybrid third 313 occupied intermediate position. These results were in agreement with those of Nawar et al. (1992). They found that the genotypes were significantly different in all plant characteristics, including yield and its components.

Table IV. Efficiency of the tested materials (mean of % reduction) against *S. cretica* infesting Sorghum tested varieties in the field during 2002 and 2003 seasons.

Varieties / Pesticides	Giza 15	Giza 13	Shandwil 6	Dorado	Mean
			2002		
Methomyl	73.20 A	75.97 A	75.36 A	65.34 B	72.46 A
Agrein	63.46 B	67.20 AB	73.34 A	51.85 C	63.96 B
Sisi 6	54.00 B	60.39 AB	64.23 A	43.11 C	55.43 C
Barium nitrate	35.92 B	54.60 A	43.90 AB	34.49 B	42.23 D
			2003		
Methomyl	67.77 A	61.00 B	69.81 A	69.26 A	66.96 A
Agrein	59.98 A	49.12 B	56.31 A	55.71 A	55.28 B
Sisi 6	44.22 A	31.77 B	41.77 A	45.64 A	40.85 C
Barium nitrate	29.18 A	27.02 B	26.68 B	39.55 A	30.61 D

Means followed by the same letter (s), within the same row in each season, are not significantly different at a 5% level of probability according to Duncan's Multiple Test.

Table V. Yield and its component of four maize varieties during 2002 and 2003 seasons.

Characters / Varieties	Ear length	No. of rows/ear	No. of kernels/row	Seed index g/100 grains	Grain yield per plant (g)	Grain yield ardab*/fed.
				2002		
Hybrid single 10	19.4 A	11.4 A	36.8 A	26.32 A	132.89 A	18.33 A
Hybrid single 3080	16.6 B	13.6 A	30.0 B	26.43 A	110.05 B	15.3 B
Hybrid third 313	18.0 A	11.6 A	30.4 B	28.25 A	116.07 B	15.88 B
Balady	11.2 C	9.8 B	20.8 C	22.49 B	64.04 C	8.88 C
				2003		
Hybrid single 10	21.4 A	12.4 A	40.4 A	31.46 A	150.07 A	20.6 A
Hybrid single 3080	18.0 A	14.4 A	42.4 A	30.96 B	127.38 B	17.87 B
Hybrid third 313	19.4 A	11.8 AB	34.4 B	33.16 A	140.3 AB	19.4 A
Balady	11.6 B	10.4 B	24.2 C	26.32 C	82.07 C	11.57 C

With regard to seed index, no significant differences were found among Hybrid single 10, Hybrid single 3080 and Hybrid single 313 in both seasons. Balady gave a significantly lower seed index compared with the others. These differences in seed index may be due to variation in the genetic make-up between Balady and the other varieties. From Table V it can be observed that Hybrid single 10 produced significantly the highest grain yield/plant representing 132.89 and 150.07 g in 2002 and 2003 seasons, respectively, while the lowest grain yield/plant was obtained from Balady (64.04 and 82.07). Hybrid single 3080 and Hybrid third 313 occupied an intermediate position in both seasons. The superiority of Hybrid single 10 was in grain yield/plant and grains yield/fed. Mason and Zuber (1976) found that the differences in yield among maize varieties depended on differences in leaf area, which increased with increasing leaf area.

Maize varieties depended on differences in leaf area as this increased with increasing leaf area. Khalifa et al. (1983) found that the highest yielding maize varieties possessed greater leaf areaand heavier ears as well as greater weight of kernels/ear. There were some significant differences in grain yield/fed among the varieties in both seasons as shown in Table V. The grain yield/fed. ranged from 8.88 to 18.33 and from 11.57 to 20.60 ardab/fed. for the varieties tested during the 2002 and 2003 seasons, respectively. Moreover, it is clear from the same table that Hybrid single 10 produced the highest grain yield/fed., while Balady gave the lowest yield in both seasons. The rest of tested varieties occupied an intermediate position. Except for Hybrid third 313 in the 2003 season which exhibited an insignificant difference compared with Hybrid single 10. The differences in yield and its components are in conformity with the results obtained by Khalifa et al. (1983), El-Kholy (1987), Ahmed (1989), El-Deeb (1990) and Nawar et al. (1992).

Yield of sorghum varieties. Yield of the four sorghum varieties, i.e. Giza 15, Giza 113, Shandwil 6 and Dorado were evaluated during the two tested seasons.

Regarding the letter(s), Table VI shows the significant and insignificant differences among all varieties. Results indicated that slight differences were found in grain yield of sorghum crop among tested varieties. Grains yield/fed. (Ardab) ranged from 14.73 to 16.05 and from 14.99 to 17.12 in 2002 and 2003 seasons, respectively. According to the seed index, Giza 15 and Giza 113 varieties showed significantly higher weights than Shandwil6 and Dorado in both

Table VI. Yield and its component of four sorghum varieties during 2002 and 2003 seasons.

Variety \ Character	Seed index g/100 grains	Grain yield per plant (g)	Grain yield ardab*/fed.
		2002	
Giza 15	4.27 A	54.99 AB	15.05 AB
Giza 13	4.19 A	49.03 B	14.73 B
Shandwil 6	3.25 B	61.45 A	16.05 A
Dorado	3.65 B	57.36 AB	15.33 AB
		2003	
Giza 15	5.11 A	56.75 B	15.71 AB
Giza 13	4.93 A	51.69 B	14.99 B
Shandwil 6	3.67 B	66.14 A	17.12 A
Dorado	3.79 B	64.11 B	16.13 A

*Ardab = 145 kg.

Means followed by the same letter (s), within the same row in each season, are not significantly different at a 5% level of probability according to Duncan's Multiple Test.

seasons. However, Shandwil 6 had the highest grain yield but there was an insignificant difference between it and Giza 15 and Dorado in both tested seasons. Mohamed (2001) found significant differences in crop yield among Giza 15, Giza 113, Dorado and Mena planted at Assiut Governorate during 1998, 1999 and 2000 seasons.

Role of controlling S. cretica *by some materials in increasing yield of maize and sorghum varieties*

Table VII shows that the infestation percentage, yield of maize varieties and percentage of yield increase resulted from controlling *S. cretica* with the tested materials. Results generally indicated that methomyl was the most active material followed by Agrein in controlling the pest and concomitantly increasing the yield of all tested maize varieties. Mothomyl was the highest active material in increasing the yield of Hybrid single 10 and Hybrid third 313 in the 2002 season. Agrein was the most effective material in increasing the yield of Hybrid single 3080 and Balady varieties in the same season. Treatment with Sisi 6 caused an increase of the yield ranging from 6.17 to 15.17% in the 2002 season while barium nitrate was 1.43 – 11.46%. Our results are in line with those reported by Lynch (1980) who stated that loss in maize yield results primarily from physiological damage due to European corn borer, *Ostrinia nubilalis* infestation rather than loss of harvestable ears. Umeozor et al. (1985) reported that reduction in maize yield by *O. nubilalis* ranged from 102.72 to 465.79 kg/ha per cavity. Yield reduction was affected by infestation date, infestation

Table VII. Effect of controlling *S. cretica* in increasing yield of maize varieties during 2002 and 2003 seasons.

Variety \ Treatment	Average infestation (%)	Yield (ardab/feddan)				
		Methomyl	Agrien	Sisi 6	Barium nitrite	Control*
				2002		
Hybrid single 10	5.54 A	19.82 A (23.34)**	19.49 A (21.28)	18.35 AB (14.19)	17.94 ABC (11.64)	16.07 CDE
Hybrid single 3080	2.54 B	16.71 BCD (19.87)	16.89 BCD (21.16)	14.80 EFG (6.17)	14.14 FG (1.43)	13.94 FG
Hybrid third 313	4.50 A	16.88 BCD (19.63)	16.58 BCDE (17.54)	16.25 CDE (15.17)	15.56 DEF (10.28)	14.11 EFG
Balady	3.42 B	9.78 H (22.56)	9.79 H (22.68)	8.65 H (8.40)	8.23 H (3.13)	7.98 H
				2003		
Hybrid single 10	5.37 A	24.19 A (35.29)	21.20 B (18.57)	20.61 BC (14.19)	19.14 CD (11.64)	17.88 DE
Hybrid single 3080	3.17 B	20.55 BC (28.92)	18.53 DE (16.25)	17.82 DE (6.17)	16.50 E (1.43)	15.94 EF
Hybrid third 313	3.50 B	21.22 B (24.44)	21.23 B (24.38)	19.77 BCD (15.17)	17.72 DE (10.28)	17.06 E
Balady	3.32 B	12.65 FG (25.00)	12.05 (19.07)	11.17 G (10.38)	11.17 G (3.13)	10.12 G

Means followed by the same letter (s), within the same row in each season, are not significantly different at a 5% level of probability according to Duncan's Multiple Test.

*Yield of untreated plants (control); **Numbers in parentheses are % of yield increase resulting from the treatment.

level, and year (rainfall). Davis and Pedigo (1991) studied the effect of feeding by stalk borers, *Papaipema nebris* (Guenee), on the visible injury and grain yield of individual corn (*Zea mays* L.) plants, infested at various development stages. Results obtained indicate that injury profiles differed by growth stage, with younger plants having a higher incidence of severe injury (dead heart, tillering, and plant death). Plants attacked at the six-leaf stage or older were not as vulnerable to severe injury because tunnelling occurred below the growing point. Grain yield, number of kernels per plant, and average kernel weight declined as the severity of injury increased. Fediere et al. (1997) revealed that microbial and chemical insecticide treatments noticeably reduced the numbers of *S. cretica* larvae. Regarding yield, the mean weight of seeds was higher for the plots which were treated with either virus or insecticide than untreated ones. However, they found that chemical insecticide treatments were more effective than the formulated virus treatments. Yields in ardab/fed. were 20.11, 16.04, and 12.79 for chemical insecticide, viral insecticide, and untreated treatments, respectively.

Data in Table VIII quantify the relationship between the control of greater sugar cane borer, *S. cretica*, on sorghum plants and yield. Results demonstrated that the yield of all treated sorghum plants was higher than that of untreated plants. Treatment with methomyl was the most effective in increasing the yield, followed by Agrein, Sisi 6 then barium nitrate toward all tested varieties in 2002 and 2003 seasons. The highest yield increase was in the treatment of Giza 15 with methomyl (23.10%), while the lowest yield increase was in the treatment of Giza 113 with barium nitrate (6.18% in the 2002 season. In the 2003 season, the highest increase percentage was in the treatment of Giza 15 with methomyl (25.45%),

Table VIII. Effect of controlling *S. cretica* in increasing yield of sorghum varieties during 2002 and 2003 seasons.

Treatment / Variety	Average infestation (%)	Yield (ardab/feddan)				
		Methomyl	Agrien	Sisi 6	Barium nitrite	Control*
				2002		
Giza 15	6.45 A	16.63 AB (23.10)**	15.56 AB (15.25)	14.96 AB (10.73)	14.57 AB (7.85)	13.51 AB
Giza 113	5.37 B	16.25 AB (22.46)	15.17 AB (14.32)	14.85 AB (14.91)	14.09 AB (6.18)	13.27 AB
Shandwil 6	5.37 B	16.91 A (15.82)	16.76 A (14.79)	16.28 AB (11.51)	15.68 AB (7.40)	14.60 AB
Dorado	7.00 A	16.57 AB (20.68)	15.98 AB (16.39)	15.41 AB (12.24)	14.87 AB (8.30)	13.73 B
				2003		
Giza 15	8.74 A	17.35 ABC (25.45)	16.93 ABC (22.42)	15.81 ABCD (14.32)	14.62 BCD (5.71)	13.83 CD
Giza 113	8.09 AB	16.84 ABCD (25.11)	15.32 BCD (13.82)	14.88 BCD (10.55)	14.43 BCD (7.21)	13.46 CD
Shandwil 6	7.05 B	19.48 A (25.35)	18.57 A (14.50)	16.29 ABCD (4.83)	15.72 ABCD (1.16)	15.54 BCD
Dorado	9.24 A	17.35 ABC (24.73)	17.15 ABC (23.29)	16.31 ABCD (17.25)	15.94 ABCD (14.74)	13.91 BCD

Means followed by the same letter (s), within the same row in each season, are not significantly different at a 5% level of probability according to Duncan's Multiple Test.

*Yield of untreated plants (control); **Numbers in parentheses are % of yield increase resulting from the treatment.

while the lowest was in the treatment of Schandweel 6 with barium nitrate (1.16%). These results agree with El-Serwy (1993) who found the relationship between infestation with *S. cretica* and yield loss of sorghum crop. Results showed that Hybrid 119 had higher percentages of panicles (21.6 and 24.2%) and yield loss (9.6 and 14.0%) than other tested varieties in two regions, i.e. Al-Akab and Abu-Soubera at the Aswan governorate during the 1992 season. Mohamed (1997) revealed that *B.t.* formulation SAN 4151, Nemazal, and Admeral were the most toxic materials against the large sugar cane borer, *S. cretica*, infested sorghum plants, since they exhibited infestation reduction of 67.60, 62.30, and 61.68%, respectively. On the other hand, the least effective materials were Thuricide HP with infestation reduction of 37.07%.

According to the present results, maize variety Hybrid single 10 and sorghum varieties Dorado or shandwil 6 may be recommended for plantation in Upper Egypt. For the protection of maize or sorghum plants from pink stalk borer, *S. cretica* L. (Lepidoptera: Noctuidae) infestation, conventional insecticides may be used alternatively with microbial insecticides (*B.T.*), and petroleum oil to keep the pest population under economic threshold levels, and by using integrated pest management (IPM).

References

Abdel-Rassoul MA. 1992. Susceptibility of some maize varieties to infestation with corn borers in Alexandria region. Alex Sci Exch 13:97 – 106.

Abou-Taleb HK, Sherby SM, Farag MM, Mansour NA. 2001. On-Farm efficacy of *Bacillus thuringiensis*, fenvalerate, and pyriproxyfen for stem corn borers. 1st conf. Safe alternatives of pesticides for pest management, Assiut, Egypt, (October 28 – 29) pp 35 – 44.

Ahmed MA. 1989. Effect of nitrogen fertilizer levels on yield and its components of some white and yellow maize cultivars grown in Egypt. Egypt J Agron 14:187 – 199.

Ali MA, Metwally MM, Abdel Gaffar MM, Metwally AS. 1989. Susceptibility of four local maize varieties to corn borer infestation under natural condition in Egypt. Acta Phytopathol Entomol Hung 24:13 – 16.

Allam REA. 2003. Evaluation of certain maize varieties against the pink borer, *Sesamia cretica* Led. and the European corn borer, *Osterinia nubilalis* Hub. M.Sc. Thesis, Fac. Agric. Kafr El- Sheikh, Tanta University.

Anonymous 2001a. Summer & Nile crops. Department of statistics, Ministry of Agriculture & Land Reclamation, Arab Republic of Egypt, Vol. 2, pp 16 – 55.

Anonymous 2001b. Professional recommendation in agriculture pests control. Ministry of Agriculture & Land Reclamation, A.R.E.

Attia MB, Farag AI. 1989. Population dynamics and seasonal abundance of corn borers at Shebin El-kom, Menoufia Governorate, Egypt. Al-Azhar J Agric Res 10:168 – 179.

Bader NA, Hindy MA, Negm MF, Abd El-Halem SM, El-Sisi AG. 1999. Performance of ground low-volume spraying machines for controlling cotton leaf worm larvae on clover plants. Egypt J Agric Res 77:1035 – 1043.

Bailey WC, Pedigo LP. 1986. Damage and yield loss induced by stalk borer (Lepidoptera: Noctuidae) in field corn. J Econ Entomol 79:233 – 237.

Davis PM, Pedigo LP. 1991. Yield response of corn stands to stalk borer (Lepidoptera: Noctuidae) injury imposed during early development. J Econ Entomol 83:582 – 1586.

El-Deeb AA. 1990. Effect of plant density and nitrogen level on the yield models of certain maize cultivars. Proc. 4th Conf. Agron. 19:419.

El-Kholy ME. 1987. Response of some white and yellow maize varieties to nitrogen fertilization. M.Sc. Thesis, Agron. Dept., Fac. Agric. Ain Shams University.

El-Serwy SA. 1993. Evaluation of certain sorghum varieties for susceptibility to infestation with the pink stalk borer, *S. cretica* L. (Lepidoptera: Noctuidae) at Aswan Governorate. Bull Ent Soc Egypt Econ Ser 71:55 – 59.

Fediere G, El-Sheikh MAK, Semeada AM, El-Hefny A, Masri M, El-Sherif S. 1997. Production and field evaluation of a Granulosis virus for control of *Sesamia cretica* Led. (Lepidoptera: Noctuidae) in maize fields in Egypt. Appl Entomol 121:293 – 296.

Gleason MN, Gosselin RE, Hodge HC, Smith RP. 1969. Clinical toxicology of commercial products. Acute poisoning. 3rd ed. Baltimore, MD: Williams and Wilkins Co.

Henderson GF, Tilton EW. 1955. Test with acaricides against the brown wheat mites. J Econ Entomol 48:157 – 161.

Ibrahim SM, Farrag RM. 1997. The toxic effects of bacterial and chemical insecticides against the greater sugar cane borer, *Sesamia cretica* Led. Alex Sci Exch 18:163 – 169.

Isa AL, Awadallah WH, Tantawy AM. 1969. The susceptibility of some corn varieties to infestation with corn borers and other corn pests. Agric Res Rev Cairo 47:23 – 28.

Khalifa MS, Mahmoud EA, Nagouly OO. 1983. Response of local and exotic maize (*zea mays* L.) genotypes to nitrogen application. Proc. the 1st conf. of Agron. Ain Shams Univ., Egypt. 1-A. Cereal Crops, pp 165 – 186.

Levine E, Clement SL, McCartny DA. 1984. Effect of seedling injury by the stalk borer (Lepidoptera: Noctuidae) on regrowth and yield of corn. J Econ Entomol 77:167 – 170.

Lynch RE. 1980. European corn borer: yield losses in relation to hybrid and stage of corn development. J Econ Entomol 73:159 – 164.

Mason L, Zuber MS. 1976. Dialil analysis of maize for leaf angle, leaf area, yield and yield components. Crop Sci 16:693 – 696.

Metwally AS. 1988. Relative susceptibility of certain maize varieties to infestation with lepidopterous insects. M.Sc. Thesis, Fac. Agric., Al- Azhar University, Egypt.

Mohamed MSM. 2001. Studies on key insect pests infestating some sorghum varieties with reference to their natural enemies in Assiut Governorate. M.Sc. Thesis, Fac. Agric. Assiut University.

Mohamed SH. 1997. Effect of some chemical and microbial insecticides, and planting dates of maize on large Sugar-cane worm infestation and the associated predators. 1st National Conference of applied usage of natural enemies for controlling insect and mite pests, Mansoura, Egypt (March 4 – 5), pp 11 – 20.

Mousa GM, El-Sisi AG. 2001. Testing of some local alternative mineral oils, plant materials and surfactant against piercing and sucking pests infesting squash crop. 1st conf. safe alternatives of pesticides for pest management, Assiut, Egypt (October 28 – 29), pp 83 – 90.

Nasr FN, Ibrahim SG. 1997. Laboratory evaluation of *Bacillus* strains against the greater sugar cane borer, *Sesamia cretica* Led. (Lepidoptera: Noctuidae) Alex. Sci Exch 18:155 – 162.

Nawar AA, Ibrahim ME, Attia MB. 1992. Grain yield, yield components and infestation rates of corn borers and aphid of maize genotypes as influenced by nitrogen fertilization. Egypt J Agric 17:41 – 58.

Ridgway RL, Illum VL, Farrar RR, Calvin DD, Fleischer SJ, Insco MN. 1996. Granular matrix formulation of *Bacillus thuringiensis* for control of the European corn borer (Lepidoptera: Pyralidae). J Econ Entomol 89:1088 – 1094.

Salman AMA. 1995. Studies on the key insect pest problems of sorghum in Upper Egypt. Ph.D. Thesis, Fac. Agric. Ein Shams University, 214 p.

Semeada AM. 1985. Relative susceptibility of certain maize germplasm to infestation with the greater sugar-cane borer *Sesamia cretica* led. Ph.D. Thesis, Fac. Agric. Cairo University.

Shojai M, Abbas-Pour H, Nasrollahi A, Labbafi Y. 1995. Technology and biogenatic aspects of integrated biocontrol of corn stem borer, *Sesamia cretica* Led. (Lepidoptera: Noctuidae (Abstract)). J Agric Sci Islamic-Azar Univ 1:5 – 32.

Soliman MSM. 1998. Breeding studies on resistance to corn borer, *Sesamia cretica* Led. in maize, *Zea mays* L. Ph.D. Thesis, Fac. Agric. Alex. University.

Soliman M, Mihim JA. 1997. Corn borers affecting maize in Egypt. Insect resistant maize: recent advances and utilization, proceeding of International symposium held at the International Maize and Wheat Improvement Center (Abstract).

Spencer EY. 1968. Guide to the chemicals used in crop protection. 5th ed. Canada: Dept. of Agric., p. 483.

Tomlin C. 1994. The pesticide manual. Incorporating the agrochemical handbook, 10th ed. London: The Royal Society of Chemistry, Crop Protection, p 1341.

Umeozor OC, Vanduyn JW, Kennedy GG, Bradley JR. 1985. European corn borer (Lepidoptera: Pyralidae) damage to maize in Eastern North Carolina. J Econ Entomol 78:1488–1494.

Woodhead S, Taneja SL. 1987. The importance of the behaviour of young larvae in sorghum resistance to *Chilo partellus*. Entomol Expl Appl 45:47 – 54.

Zaki FN. 1991. Utilization of *Bacillus thuringiensis* for protection in Egypt. Emphasizing constraints, Intern. Workshop on *B.t.* and its applications in developing countries NRC. Cairo, Egypt, 4 – 6 Nov. 1991.