Effect of Application of Calcium Fertilization and Plant Growth Promoting Rhizobacteria on The population of *Bemisia tabaci* (Homoptera: Aleyrodidae) and Its Parasitoid, *Eretmocerus mundus* (Hymenoptera: Aphelinidae) on Soybean

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Abstract: To study the effect of different rates of calcium fertilizers and plant growth promoting rhizobacteria (PGPR, *Serratia* sp.) on the population density of the whitefly *Bemisia tabaci* (Gennadius) and rate of parasitism by *Eretmocerus mundus* Mercet, field trials were conducted on soybean in the two successive seasons of 2004 and 2005. Data indicated that calcium fertilizer was very important for insect's protection. The population was lower in PGPR treatments combined with calcium fertilizer spray, with an average of 2.2 and 3.5 individuals/leaf comparing to control (6.1and 6.3 individuals/leaf) in 2004 and 2005 seasons, respectively. Percentage of parasitism at lowest host densities corresponding with (PGPR) and calcium fertilizer (2000 ppm spray) was significantly greater than the other densities. Maximum parasitism rates were 90 and 95% in the beginning and mid of September in 2004 and 2005, respectively with overall seasonal averages of 60 and 65%, respectively. Therefore, the application of calcium fertilizers associated with the PGPR decreased the population of *B. tabaci* on soybean plants and increased rates of parasitism by *E. mundus*.

Keywords: *Bemisia tabaci*, *Eretmocerus mundus*, soybean, calcium fertilizers, PGPR

INTRODUCTION

A balanced supply of the essential nutrients for plant needs is the best way to increase resistance to various insects and diseases. Undoubtedly, calcium fertilizer is one of the essential minerals and is very important for protection against insect infestations (Dana and Richard 2001). Plant Growth Promoting Rizobacteria (PGPR) belonging to *Serratia* sp. are being exploited commercially as biofertilizer or in plant protection of different pests. PGRP is known to induce systemic resistance against various pests and diseases (Ramamoorthy *et al.*, 2001; Wilhelmina *et al.*, 2002; Cary *et al.*, 2004).

Soybean, *Glycine max* (L.) is one of the most important food plants in the world. It is an annual crop that produces more protein and oil per unit of land than almost any other crop. It is a versatile food plant that used in its various forms, capable of supplying most nutrients(Franklin, 1988). In addition, it is a high value food source for farm animals (Franklin, 1988).

Soybean is attacked by certain insect pests. The sweet potato whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) is considered one of the most dominant pests in soybean fields (Tengkano *et al.*, 1991; Kohji Hirano *et al.*, 1993). It is a polyphagous insect, widely distributed, attacks more than 500 species of host plants (Greathead, 1986). *B. tabaci* can seriously injure plants by sucking juices from them then causing wilting, stunting, irregular ripening of fruits or death (Oliveira *et al.*, 2001). It caused three types of damage, direct damage by feeding, indirect damage from its heavy secretion of honeydew on the plants that serves as a growing medium for sooty mold fungus and finally virus transmission such as Mungbean yellow Mosaic Geminivirus (MYMV) transmitted to soybean (Byrne *et al.*, 1990; Kohji Hirano *et al.*, 1993; Mitsuro, 2001). *B. tabaci* is subjected to the attack by scores of parasitoids and predators (Gerling *et al.*, 2001). Out of these parasitoids, *Eretmocerus mundus* Mercet (Hymenoptera: Aphelinidae) is one of the most abundant parasitoid species attacking *B. tabaci* in Egypt. It is a solitary external–internal parasitoid of whitefly (Gerling, 1966) and plays a rather important role in the biological control of the whitefly in Egypt (Hafez *et al.*, 1978).

There were no enough data available on the effect of calcium fertilization or application of plant growth promoting rizobacteria on the population of *B. tabaci* on soybean. Therefore, the main objective of the present work is to study the effect of different rates of calcium fertilizers and plant growth promoting rhizobacteria on population of *B.tabaci* and its parasitoid, *Eretmocerus mundus* in soybean fields.

MATERIALS AND METHODS

This field trial was carried out in the experimental farm of Ismailia Agricultural Research Station (IARS) in 2004 and 2005 seasons on soybean .

Soybean was planted during May (2004-2005); the agricultural practices and fertilizers were followed as commonly practicized. Insecticides and herbicides were not used during the experiment. The experiment included two main plots; one treated with PGPR (1×10^8 colony forming unit (CFU)/ml) at a rate of 20 L/ feddan as soil drench and the other free of PGPR. Each plot was divided into five sub plots; representing five treatments: control and four plots provided with different rates of calcium fertilizer at rates of 1 ton gypsum/feddan, 2 tons gypsum/feddan, 1000 ppm calcium spray and 2000 ppm calcium spray.

Soybean plants were observed and checked weekly until the detection of the first whitefly infestation. Then, weekly samples of 10 random leaves per plot were collected, taken to the laboratory and examined under the stereomicroscope to estimate the population of *B. tabaci* immature stages during the two successive

seasons of 2004 and 2005. Data were recorded in forms of numbers of *B. tabaci* eggs, nymphs and pupae.

B. tabaci was examined for parasitism by *E. mundus*. Weekly samples of infested leaves with *B. tabaci* were collected with a total of 2600 and 2800 random *B. tabaci* nymphs or pupae in 2004 and 2005, respectively. Nymphs/pupae were dissected for the presence of larvae, pupae or emergence holes of *E. mundus*.

Data Analysis:

Data from different treatments were compared using analysis of variance (ANOVA) Split-Split Plot design and means were separated using (DMRT) (SAS Institute, 1999).

RESULTS AND DISCUSSION

Effect of PGPR and calcium fertilizers on population of *B. tabaci*

As presented in Tables 1 and 2, it is clear that the application of calcium fertilizers and PGPR affected the population of *B. tabaci* on soybean. The trend of the population of *B. tabaci* was similar in 2004 and 2005.

In season 2004, the average numbers of *B. tabaci* immature stages in PGPR treatments 1 ton gypsum, 2 tons gypsum, 1000 ppm Ca, 2000 ppm Ca and control were 6.1, 4.6, 4.1, 3.5 and 2.2 individuals/ leaf, respectively. It was opposed to, 10.7, 7.4, 6.3, 4.8 and 3.3 individuals /leaf in PGPR free treatments (Table 1).

In 2005, the average numbers of *B. tabaci* immature stages in PGPR treatments 1 ton gypsum, 2 tons gypsum, 1000 ppm Ca, 2000 ppm Ca and control were 6.3, 4.8, 4.2, 3.6 and 3.5 individuals/leaf, respectively. The respective average numbers in PGPR free treatments were 10.6, 7.9, 6.6, 5.5and 4.6 individuals/leaf (Table 2).

Statistical analysis during the two seasons further indicated that there were significant differences between the treatments with PGPR and without PGPR application in forms of number of immature stages of *B. tabaci* per leaf. Moreover, calcium fertilizers affected significantly the population of whitefly in the two studied seasons and there was no significant difference between 1 ton and 2 tons gypsum treatments and the population density during the first and second season. Also, there was no significant difference between 1000 and 2000 ppm calcium spray and the population density in the two investigated seasons.

Data in this study showed that the population of *B. tabaci* was lower in PGPR treatments than in PGPR free treatments and in calcium fertilizer spray than in gypsum treatments. This finding is in harmony with that reported by Dana and Richard (2001) who mentioned that calcium was very important for protection against insect infestation. Also, in this study the application of PGPR and calcium provides strength to cell walls and membranes. The infestation was inversely proportional to the amount of calcium in the leaf tissue (El-Basha, unpublished). These findings also are in accordance to those reported for different spider mite pests on cucumber by Tomezyk (1999) who found that bacterized plants with PGPR suppressed the development of mite population and the fecundity of spider mite females was also decreased after feeding on plants with bacteria.

Effect of PGPR and calcium fertilizers on percent parasitism of *B. tabaci*

Rate of parasitism in *B. tabaci* nymphs and pupae was determined by the presence of living parasitoid larvae, pupae or emerging holes of parasitoid adults. Data are presented in Figs 1and 2.

In 2004 season, the average percentage of parasitism was higher in PGPR treatments, 1ton gypsum, 2tons gypsum, 1000 ppm, 2000 ppm and control, respectively than in PGPR free treatments being 39.6, 45.3, 50.3, 55.3 and 60.0%, (Fig. 1). In case of PGPR free treatments, these rates were 32.6, 38.8, 43.0, 47.6 and 52.6 % in the same levels of fertilizers. The general trend of parasitism in 2004 season was similar to that in 2005 season but parasitism rates were higher in the latter season.

In 2005 season, the average percentages of parasitism in PGPR 4 respective calcium fertilizer and control treatments were 45.3, 50.7, 55.3, 60.0 and 65.3%, respectively. While in treatments free of PGPR the average rates of parasitism were 37.5, 42.1, 47.5, 53.2 and 57.8% in control and four respective treatments (Fig. 2).

Therefore, data showed that higher parasitism level coincided with lower host densities, and the percentage of parasitism at lowest host densities corresponded with PGPR. Parasitism rates in calcium fertilizer treatments (2000 ppm spray) were significantly greater than the other treatments. The maximum rates of parasitism at 90 and 95% were recorded in first half of September in 2004 and 2005 seasons, with an overall seasonal average of 60 and 65% in the two respective seasons.

Results of parasitism in this study are similar to those reported from different host plants in Egypt. Parasitism of *B. tabaci* on *Lantana camara* fluctuated seasonally and reached 90 % (Hafez *et al.,* 1978). Also, Gerling (1984) found that parasitism of *B. tabaci* by *E. mundus* ranging from zero to 71% in soybeans in Indonesia.

It could be concluded that the application of calcium fertilizer as foliar spray associated with plant growth promoting rhizobacteria (PGPR) plays a crucial role in reducing the population density of *B. tabaci* on soybean. A positive correlation was found between rates of parasitism in *B. tabaci* by *E. mundus* and the application of calcium fertilization and PGPR .

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Table (1): Effect of plant growth promoting rhizobacteria (PGPR) and calcium fertilization on the population of *B. tabaci* on soybean in 2004.

Date	Meteorological factors		Mean number of *B. tabaci* immatures per leaf									
			PGPR treatments					PGPR free treatments				
	Temp.	R.H.	N1	N2	N3	N4	N5	C1	C2	C3	C4	C5
14- Jul.	30.9	54.2	7.6	7.2	6.6	5.7	2.0	14.4	10	9.5	7.0	2.6
21- Jul.	27.5	58.5	8.0	7.8	7.7	6.6	3.2	18.8	11	10.8	8.0	4.1
28- Jul.	28.9	56.4	11.5	8.9	8.0	6.8	4.8	20.2	17.1	12.2	10.0	7.5
04-Aug.	28.2	58.5	16	9.0	8.4	7.6	6.0	26.3	17.5	16.6	13.2	10.4
11-Aug.	29.2	59.3	8.4	6.2	5.2	3.9	3.0	9.7	7.5	6.8	5.1	4
18-Aug.	28.8	59.2	5.7	3.6	3.1	2.8	1.4	10.0	6.5	4.8	3.1	2.7
25-Aug.	28.5	57.6	6.1	4.2	3.5	3.0	2.0	12.0	7.9	5.5	3.5	3.0
01-Sep.	27.8	62.9	3.8	3.0	2.5	1.7	1.0	8.0	4.7	3.3	2.7	1.4
08 -Sep.	28.2	59.5	2.8	1.5	1.5	1.4	0.9	4.8	2.5	2.2	1.2	0.9
15-Sep.	25	59.8	2.4	2.4	2.0	1.7	1.4	4.1	3.6	3.3	2.5	2.0
22-Sep.	26.2	56.5	2.4	2.2	1.7	1.5	0.6	3.0	2.6	2.4	2.0	1.5
29-Sep.	25.6	56.5	2.5	2.2	2.0	1.8	1.0	4.2	2.8	2.4	2.1	1.8
06- Oct.	25.6	57.7	2.7	2.4	2.0	2.0	1.3	4.5	3.0	2.6	2.2	2.0
Total	360.4	756.6	79.9	60.6	54.2	46.5	28.6	140.0	96.4	82.4	62.6	43.9
Ave.	27.7	58.2	6.1 a	4.6 b	4.1 b	3.5 c	2.2 d	10.7 a	7.4 b	6.3 b	4.8 c	3.3 d

Means followed with the same letters in the same row are not significantly different (P>0.05)

Table (2): Effect of plant growth promoting rhizobacteria (PGPR) and calcium fertilization on the population of *B. tabaci on* soybean in 2005.

Date	Meteorological factors		Mean number of *B. tabaci* immature per leaf									
			PGPR treatments					PGPR free treatments				
	T	RH	N1	N2	N3	N4	N5	C1	C2	C3	C4	C5
06-Jul.	29.5	55.1	8.3	7.5	7.0	6.1	4.2	16.6	11.5	10.2	8.0	5.5
13-Jul.	28.6	57.0	9.7	8.5	7.8	6.8	5.5	19.5	15.0	12.2	9.4	7.8
20-Jul.	30.1	55.1	13.7	9.0	7.1	6.3	5.7	26.0	17.0	13.5	12	9.8
27-Jul.	30.3	56.0	16.4	10.0	8.2	7.1	6.2	18.0	13.0	10.5	9.0	8.0
03-Aug.	29.6	58.0	6.2	5.0	4.1	3.8	3.2	9.0	7.5	6.2	5.5	5.0
10-Aug.	30.9	57.0	6.0	4.5	3.8	3.2	2.7	9.8	8.0	7.0	4.5	4.2
17-Aug.	30.1	58.9	7.2	6.5	5.7	4.8	4.0	15.0	10.0	9.1	7.9	7.0
24-Aug.	29.1	59.1	4.7	4.0	3.5	3.0	2.7	10.0	7.7	6.1	5.7	5.0
31-Aug.	28.1	56.1	3.3	3.0	2.8	2.6	2.1	6.4	5.0	4.2	3.8	3.2
07-Sep.	27.4	58.2	2.6	2.0	1.8	1.7	1.5	4.4	4.0	3.5	3.0	2.8
14-Sep.	29.1	55.3	2.4	1.7	1.6	1.2	1.0	3.5	3.0	2.7	2.0	1.8
21-Sep.	27.9	55.0	2.0	1.5	1.2	1.0	8.0	3.0	2.5	2.1	1.8	1.3
28-Sep.	25.4	55.8	3.0	2.5	2.0	2.0	1.5	4.0	3.1	2.8	2.6	2.0
05-Oct.	25	54.8	3.2	2.8	2.4	2.0	1.8	4.5	3.5	3.1	2.8	2.0
Total	401.1	791.4	88.7	68.5	59.0	51.6	50.1	149.7	110.8	93.2	78.0	65.4
Ave.	28.65	56.53	6.3 a	4.8 b	4.2 b	3.6 c	3.5 c	10.6 a	7.9 b	6.6 b	5.5 c	4.6 c

Means followed with the same letters in the same row are not significantly different (P>0.05)

N1= Control of (PGPR)
N2= 1 ton gypsum+ (PGPR)
N3= 2 tons gypsum+ (PGPR)
N4= 1000 ppm Ca+ (PGPR)
N5= 2000 ppm Ca+ (PGPR)

C1= Control of untreated (PGPR)
C2= 1 ton gypsum+ untreated (PGPR)
C3= 2 tons gypsum+ untreated (PGPR)
C4= 1000 ppm Ca+ untreated (PGPR)
C5= 2000 ppm Ca+ untreated (PGPR)

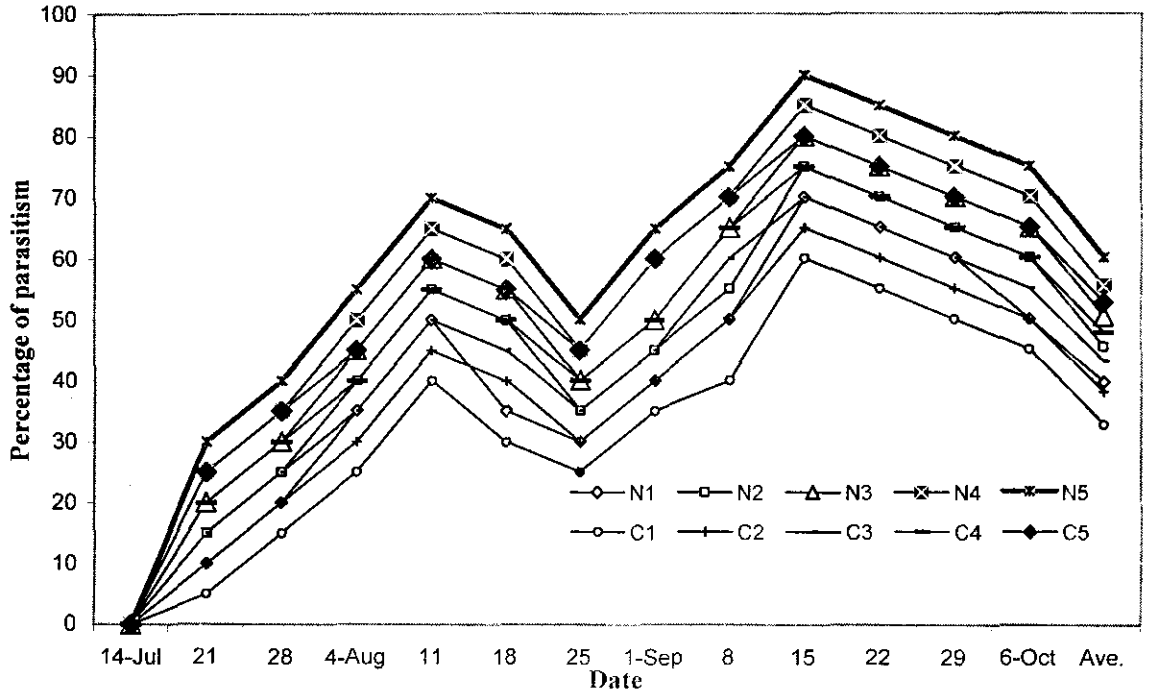

Fig. (1): Effect of calcium fertilization and PGPR on rates of parasitism of *B. tabaci* by *E. mundus* on soybean in 2004.

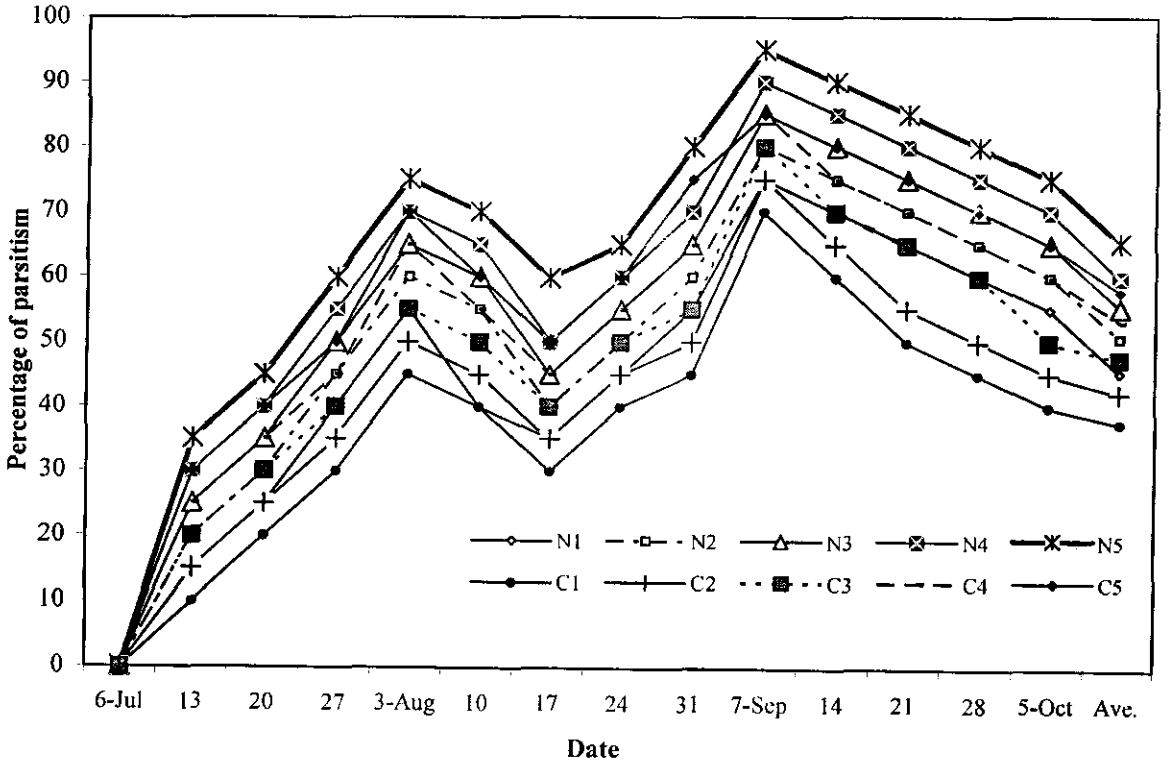

Fig. (2): Effect of calcium fertilization and PGPR on rates of parasitism of *B. tabaci* by *E. mundus* on soybean in 2005.

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