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POTENCY OF PREDATOR (*Menochilus sexmaculatus*) AUGMENTATION FOR WHITE FLY (*Bemisia tabaci*) MANAGEMENT AND ITS EFFECT ON GEMINI VIRUS INFESTATION ON TOMATO

W. Setiawati, N. Gunaeni, T.S. Uhan, and A. Hasyim

Indonesian Vegetables Research Institute
Jalan Tangkuban Perahu 517 Lembang, PO Box 8413 Bandung 40391
Phone +62 22 2786245, Fax. +62 22 2786416
Email: balitsa@litbang.deptan.go.id
Corresponding author: wsetiawati@yahoo.com

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ABSTRACT

Bemisia tabaci (Genn.) (Homoptera: Aleyrodidae) is one of the most serious pests on tomato. It is mainly controlled by chemical means, requiring some 25 sprays during the average growing season. The extensive and repeated use of insecticides has disrupted the natural balance between this pest and its natural enemies. In this study, *Menochilus sexmaculatus* F. was evaluated as a possible biological control agent of *B. tabaci* and its effect on gemini virus infestation. The study was conducted at the experimental station of the Indonesian Vegetables Research Institute (IVeGRI) in Lembang, West Java (1,250 m above sea level) from August to December 2008. The experimental plots consisted of 0.35 ha of tomato (± 100 m^2 per plot) and spatially separated with four rows of maize (a minimum of 1 m) inter-plot distance to prevent cross-contamination among plots. The experiment was arranged in completely randomized block design with eight treatments and four replications. *M. sexmaculatus* were released at 24 days after planting. The treatments were designed according dosages and schedules at three released populations (i.e. 10 predators per plot, 20 predators per plot, and 10 predators per plot at vegetative stage followed by 20 predators per plot at generative stage); two places of release (center and edge of the plot); and two schedules of release (weekly and biweekly). Efficacy of the predator was measured in terms of the density of *B. tabaci*, both before and after release of the predator and its effect on gemini virus infestation. The result indicated the potential use of *M. sexmaculatus* to control *B. tabaci* and its effect on gemini virus infestation on tomato. Reductions in *B. tabaci* populations and subsequent tomato yields were significant. *B. tabaci* population in plots receiving 10 predators showed 73.62% and 75.75% reductions by the end of experiment. The incidence and intensity of gemini virus were consistently and significantly lowest and tomato yield gain was observed when 10 predators were released at weekly intervals. It is suggested that release of *M. sexmaculatus* against *B. tabaci* on tomato may be offered as an alternative solution to increase implementation of biologically-based *B. tabaci* management.

[***Keywords*****:** *Lycopersicon esculentum, Menochilus sexmaculatus, Bemisia tabaci*, gemini virus]

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important solanaceous vegetable crops in Indonesia. Its total estimated harvested area in 2010 was 61,154 ha producing 891,616 tonnes fruits (BPS 2011). Various insect pests and diseases are found on tomato plants and cause significant yield loss. One of them is whitefly, *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae). *B. tabaci* is one of the most serious pests on tomato because it has an extremely wide host range and can be a vector for plant viruses, including gemini virus on tomato. The number of hosts of *B. tabaci* appears to be increasing (Bleeker *et al*. 2009; Setiawati *et al.* 2009; Idris *et al.* 2001).

B. tabaci causes direct and indirect damage on plant. Direct damage is caused by its feeding activities including: (1) stomatal closure by honey mildew layer, such as *Cladosporium* spp. and *Alternaria* spp.; (2) forming chlorotic spots on leaves as affected by damage of tissues caused by stylet puncture; (3) forming anthocyanin pigment; and (4) leaf fall and inhibiting plant growth (de Barro 1995; Inbar and Gerling 2008; Hoddle 2011). Indirect damage by *B. tabaci* is transmission of plant-pathogenic viruses (Byrne and Bellows 1990; Jones 2003), particularly on tomato (Brown *et al*. 1995; Perring 2001). Damage caused by virus infection ranges from mild symptoms, such as leaf discoloration, to overall yield reduction, severe fruit necrosis, flower and fruit abortions, and plant death (Maruthi *et al*. 2003).

On tomato plants, the viral diseases such as gemini virus can lead to failure of fruit formation and subsequent yield loss. Tomato farmers reported their yield losses caused by *B. tabaci* and gemini virus infestation ranged from 25% to 100% (Setiawati *et al*. 2011). In India, tomato yield loss caused by gemini virus infestation reached 93.3% (Sastry and Singh 1979).

Chemical insecticides are widely applied to control *B. tabaci* and farmers may spray up to 25 times in a season with a mixture of insecticides (Setiawati *et al.* 2011). Extensive and repeated use of insecticides has disrupted the natural balance of pests-natural enemies (Amer and Marei 2001). Therefore, the use of safe alternative control methods such as predators is important (Ahmed *et al.* 2001). Predators are one of the major groups of natural enemies which effectively used against different insect pests.

Predators belonging to the family Coccinellidae have been intensively studied as biological control agents due to their ability to feed on a large number of preys, including *B. tabaci* (Heinz *et al.* 1999; van der Werf *et al*. 2000; Ellis *et al*. 2001; Isikber and Copland 2002; Kutuk *et al.* 2008a). Few greenhouse and field studies showed predators were effective in various degrees to control *B. tabaci* (Breene *et al.* 1992; Gerling *et al.*1997; Sarmento *et al.* 2007; Kutuk *et al.* 2008b).

Menochilus sexmaculatus (Coleoptera: Coccinellidae) is widely distributed in the world and is known to be an important predator of many insects such as aphids, thrips, and whitefly (Bari and Sardar 1998; Ulrichs *et al.* 2001; Setiawati *et al.* 2005; Prabaningrum *et al*. 2006; Rana 2006; Solangi *et al*. 2007; Jagadish *et al*. 2010). The study aimed to evaluate the effects of *M. sexmaculatus* as biocontrol agent of *B. tabaci* on tomato and its effect on gemini virus infestation.

MATERIALS AND METHODS

The study was conducted at the experimental station of the Indonesian Vegetables Research Institute (IVeGRI) in Lembang, West Java (1,250 m above sea level) from August to December 2008. The soil type was Andisols with a pH range of 5.0-5.5. The experimental plots consisted of 0.35 ha of tomato (± 100 m^2 per plot) and spatially separated with four rows of maize (a minimum of 1 m) inter-plot distance to prevent cross-contamination among plots. The experiment was arranged in completely randomized block design with eight treatments and four replications. *M. sexmaculatus* were released 24 days after planting (DAP). The treatments were designed according dosages and schedules, which was decided based on the results of the study conducted earlier under laboratory or screen house conditions. Eight treatments were established, namely:

A. Ten predators released at the center of plot at one week intervals (eight times per season)
B. Ten predators released at the edge of plot at one week intervals (eight times per season)
C. Twenty predators released at the center of plot at two-week intervals (four times per season)
D. Twenty predators released at the edge of plot at two-week intervals (four times per season)
E. Ten predators released at the center of plot at a week interval at the vegetative stage followed by 20 predators at two-week intervals at the generative stage (six times per season)
F. Ten predators released at the edge of plot at a week interval in the vegetative stage followed by 20 predators at two-week intervals at the generative stage (six times per season)
G Imidacloprid (200 g a.i. l^{-1}) as the standard recommended check (eight times per season)
H. No predatory release (control).

These plots were maintained following standard commercial growing practices with the exception that no insecticide applications were made except in plot G. Mancozeb (2 g a.i. l^{-1}) and metalaxyl (40 g a.i. kg^{-1}) + mancozeb (640 g a.i. kg^{-1}) were applied at recommended dosage to control late blight (*Phytophthora infestans*) and other soil borne fungal disease infestations.

Insect Culture

Menochilus sexmaculatus were obtained from the culture at the IVeGRI. Adult *M. sexmaculatus* were collected from the vegetable fields and reared in screen house at 27 ± 2°C. The field collected material was sorted out in the screen house and pairs were selected for oviposition. The selected pairs were kept in separate cages (oviposition cages) to get the batches of eggs. Larvae and adults were fed with live aphids on maize. The adults of less than 48-hour-old were used in this experiment. Ten to twenty adults were placed at the center and the edge of plots depending on the treatments.

Experimental Technique

The predators were placed on the plastic containers measuring of 10 cm deep. Twenty-four-day-old tomato (cv. Martha) plants were inoculated with 10-20 predators per plot (depending on the treatments) by shaking the contents of the container gently onto the top growth of the crop and allowed to spread and settle the populations of predators of the plants, so that the moving ability of the predators could be noted. The predators (80 adults) were released in the bio-control area for 6-8 consecutive periods. The release times were before flowering (vegetative stages), at flowering, and at the end of flowering (generative stages). Before and after one week of predators released, observations on reduction or increase in *B. tabaci* populations, infestations and incidence of gemini virus, and number of predators recovered were recorded separately.

Observations were made on 10 plants per plot which was systematically determined with a U-shape. The observations made consisted of:

1. Population of *B. tabaci* (nymphs and adults), observed every week from 23 DAP until 79 DAP on plant strata, namely the upper, middle and lower, representing various stages and distribution of leaves on the plants (Horowitz 1986; Kohji *et al*. 1993). Leaf samples were kept in plastic bags labelled with bed number and leaf stratum. The leaves were then brought to the laboratory where the nymphs and adults of whitefly were counted under a dissecting microscope.
   Percentage of *B. tabaci* population reduction was calculated with formula = 100 * (1- ((Ta x Cb) / (Tb x Ca))
   where:
   Ta = number of larvae after release
   Tb = number of larvae before release
   Ca = number of larvae in the control after release
   Cb = number of larvae in the control before release.
2. Populations of the predator, observed every week from 23 DAP with interval of 7 days on tomato plant.
3. Incidence and intensity of virus symptom (Green *et al*. 2005). Observation on intensity of virus symptom on tomato plant was carried out visually and estimated using the following equation:

$$I = \frac{\sum (n \times v)}{N \times V} \times 100\%$$

   where:
   I = intensity of infestation symptom
   n = number of plants categorized in particular symptom scale
   v = value of observed plants
   N = number of observed plants
   V = value of observed severity scale

   Symptom severity scale was classified as follows:
   0 = healthy plant, no infestation symptom
   1 = plant showed light yellow and mosaic symptoms
   2 = plant with moderate yellow and mosaic symptoms
   3 = plant with severe yellow and mosaic symptom
   4 = plant with yellow, malformation, dwarf symptoms
4. Tomato fruit yield, evaluated at the end of the experiment for each treatment. Data are presented as expected weight (t ha^{-1}).

Statistical Analysis

The data were subjected to one way ANOVA (SAS Program). Significantly different means ($P < 0.05$) were separated using Duncan Multiple Range Test (DMRT) at 5% probability. Count data were x + 0.5 transformed and percentage data arcsine-square root transformed. In graphs and figure, the original data and their standard errors are presented.

RESULTS AND DISCUSSION

The *B. tabaci* density (per three leaves) of all plant strata before release of the predators (Table 1 and 2) was almost uniform in all of the treatments and no significant difference was found between the treatments. However, following the release of predators, *B. tabaci* numbers were significantly lower in treated plots than that in the control plot. In general, all the treatments invariably reduced the pest populations. At 65 DAP, highly significant differences were observed among the treatments. The *B. tabaci* density on the treatments ranged from 8.10 to 14.40 and 24.75 in control plot for nymphs, and from 9.60 to 20.60 on the treatment and 45.50 in control plot for adults. The lowest *B. tabaci* density was found in the case of 10 predators released at weekly intervals, followed by 10 predators released at the vegetative stage with weekly intervals and 20 predators released at the generative stage with biweekly intervals. The mean numbers of *B. tabaci* in weekly, weekly at vegetative stage release plots and the imidacloprid plot were significantly different from that of the control, but were never significantly different from each other. Rajabpour *et al*. (2011) reported that only periodical release of a predator could significantly suppress population of pests before they reach uncontrollable levels.

Table 1. The average of nymphal population of *Bemisia tabaci* on tomato plants treated with predator *Menochilus sexmaculatus*, Lembang, West Java, 2008.

Treatments	*B. tabaci* population at ... DAP								
	23[1)]	30	37	44	51	58	65	72	79
10 predators released at the center of plot at one-week intervals	0.73a	1.40b	1.30c	1.00b	1.80c	3.20bc	8.10c	6.30b	6.50b
10 predators released at the edge of plot at one-week intervals	0.77a	1.60b	1.70c	2.10c	1.40c	2.70c	8.50c	7.50b	6.30b
20 predators released at the center of plot at two-week intervals	0.70a	4.40b	4.70b	1.90b	2.30c	3.80bc	14.90a	8.70b	7.70b
20 predators released at the edge of plot at two-week intervals	1.53a	3.40b	3.40b	1.30b	3.10c	3.40bc	17.40a	18.70a	10.10b
10 predators released per week at vegetative stage and 20 predators per two weeks at generative stage at the center of plot	1.13a	5.60ab	5.90b	1.90b	5.10b	6.60b	11.40b	11.40a	12.70a
10 predator released per week at vegetative stage and 20 predators per two weeks at generative stage at the edge of plot	1.30a	5.80ab	6.30ab	2.60b	4.40b	6.40b	14.40b	17.20b	7.70b
Imidacloprid (200 g a.i. l^{-1}) per week	0.70a	1.75b	1.00c	3.75b	1.25c	1.50c	10.25b	9.00a	6.75b
Control	0.87a	7.25a	13.75a	14.75a	20.00a	12.75a	24.75a	19.75a	22.00a

[1)]One day before treatments; DAP = days after planting.
Mean values in columns followed by differing letters differ significantly by the DMRT (P = 0.05).

Table 2. The average of adult population of *Bemisia tabaci* on tomato plants treated with predator *Menochilus sexmaculatus*, Lembang, West Java, 2008.

Treatments	*B. tabaci* population at ... DAP								
	23[1)]	30	37	44	51	58	65	72	79
10 predators released at the center of plot at one-week intervals	0.8a	3.38b	3.88b	7.15a	6.13b	4.40b	9.20b	7.00b	7.40b
10 predators released at the edge of plot at one-week intervals	1.4a	3.65b	3.70bc	7.15a	6.60b	4.30b	9.20b	8.20b	6.50b
20 predators released at the center of plot at two-week intervals	0.7a	5.75ab	5.90e	7.15d	11.40b	8.00b	20.60b	10.90b	13.60b
20 predators released at the edge of plot at two-week intervals	1.3a	5.43b	6.10de	7.28cd	10.90b	5.70b	20.60b	18.30b	10.00b
10 predators released per week at vegetative stage and 20 predators per two weeks at generative stage at the center of plot	1.2a	5.95ab	7.45a	6.20b	9.95b	9.90b	16.50b	18.30b	8.60b
10 predators released per week at vegetative stage and 20 predators per two weeks at generative stage at the edge of plot	1.1a	6.08a	7.47a	5.95bc	9.98b	7.00b	15.00b	7.80b	8.70b
Imidacloprid (200 g a.i. l^{-1}) per week	0.7a	2.30b	2.43cd	7.38cd	14.40a	6.50b	15.60b	8.75b	9.50b
Control	1.9a	7.50a	10.20a	10.80a	25.50a	18.10a	45.50a	41.90a	33.25a

[1)]One day before treatments; DAP = days after planting.
Mean values in columns followed by differing letters differ significantly by the DMRT (P = 0.05).

Differences in *B. tabaci* populations beetwen treatments were significant only for dosages of predator release and number of releases per growing season. Moreover, there was no significant difference between the two different places of release. Results from the present study suggest that *M. sexmaculatus* should be released as soon as or shortly after *B. tabaci* first appears on tomato plant.

Although *M. sexmaculatus* inundative release has successfully controlled *B. tabaci* in this experiment, sole reliance on biological control as a management tactic has usually failed to provide effective control of the pest, especially at high population densities. Cloutier *et al.* (2002) suggested that biorational, selective insecticides could be a key in increasing the role of biological control in *B. tabaci* management.

The results presented in Table 2 indicate that the population of *B. tabaci* adults was significantly reduced in treated plots as compared to the control plot during the growing season. Among the treatments, 10 predators released at weekly intervals were found to be most effective in controlling the incidence of *B. tabaci* followed by imidacloprid. Kutuk (2008a) reported that the predator *Serangium parcesetosum* failed to control *B. tabaci* even when the predator was released six times during the growing season.

Population dynamics of *B. tabaci* at various treatments are shown in Figure 1. Population trends were similar in all of the treatments. Generally, *B. tabaci* populations started to increase and reached the highest peak during flowering and fruiting stages. The populations decreased when the plants reached the end of economic life of three months for tomato plants. These trends were due to the presence of host plants at initial stage of population growth, and then they reached the highest peak mainly due to availability of food and good shelter. Subsequently, the population started to decrease due to sudden reduction of food and the older leaves became unsuitable for immature whiteflies. The densities of whiteflies in plots receiving predators showed fluctuations to a level lower than that in the control plot that received no predators. Control of *B. tabaci* populations was achieved within two weeks after release for all treatments.

Figures 1-B and 1-E show that population densities of *B. tabaci* increased rapidly from 10 to 40 (Fig 1-B) and from 15 to 80 (Fig1-E) at 30 and 65 DAP, respectively. This result showed that *M. sexmaculatus* could not suppress *B. tabaci* by four times releases of 20 predators at two-week intervals. In the A treatment, *M. sexmaculatus* could suppress *B. tabaci* compared to other treatments. *M. sexmaculatus* kept the pest under good control without insecticide application. These results indicate that *M. sexmaculatus* were successfully established using both application methods and *B. tabaci* declined to low numbers during the monitoring period. The early release of predators to coincide with the appearance of *B. tabaci* on tomato is an important factor for successful control of the pest.

The overall average of reductions of *B. tabaci* populations is illustrated in Figure 2. Population reductions showed significant differences between the seven tested treatments for *B. tabaci*. Ten predators released at weekly intervals resulted in 75.75% and 73.62% reductions in whitefly populations and gave better results than the commercially available imida-

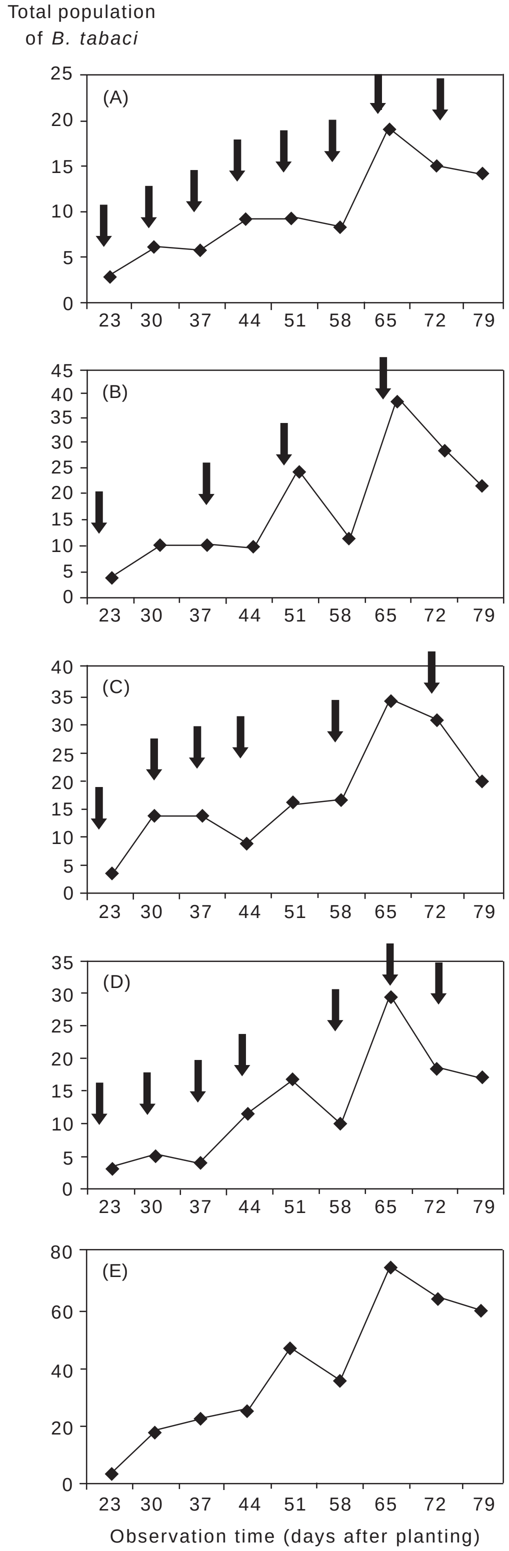


Fig. 1. Population dynamics of *Bemisia tabaci* on tomato plants treated with predator *Menochilus sexmaculatus*: (A) eight-time releases of 10 predators per plot with weekly interval, (B) four-time releases of 20 predators per plot with two-week intervals, (C) six-time releases of 30 predators per plot with weekly and two-week intervals, (D) eight-time applications of imidacloprid (200 g a.i l^{-1}) per week, (E) no release (control). Arrows indicate predator introductions or insecticide applications.

cloprid (68.14%), while 20 predators released at two-week intervals and 10 predators released weekly at the vegetative stage and 20 predators released at two-week intervals at the generative stage reduced *B. tabaci* population by an average of 55.54% and 55.73%, respectively. Imidacloprid had a median control effect as represented by the percentage of reduction in insect populations. This may be due to a level of resistance in the insect because the insecticide has been used for almost two decades. Imidacloprid may also cause a decline in the populations of natural enemies (Al-Kherb 2011).

The study showed that *M. sexmaculatus* could survive, develop, reproduce and establish in tomato plants from first inundation to end of the trial, and they were able to prey on nymphs and adults of *B. tabaci* (Fig. 3). The increase in *M. sexmaculatus* densities matched a decrease in the *B. tabaci* populations in the same treatments. The number of *M. sexmaculatus* in B and C treatments was much lower than that in another treatments, ranging between 32 and 30, respectively. The occurrence of these predators might have been due to number of releases, either increase in prey availability or due to abundance of floral resources. The ability to feed on alternative foods increases the predator's chance to survive under natural food scarcity conditions and population density of the host insect (Kehatthe 2001). Lundgren and Wiedenmann (2004) reported that maize pollen directed the dispersal and spatial patterns of predators. Van der Werf *et al*. (2000) reported that the occurrence of the predator is not only orientated toward its prey, but also influenced by physical factors such as light.

Incidence and intensity of gemini virus infestation showed that the symptoms were developed within 3-4 weeks after planting (Figs. 4 and 5). Virus disease incidences varied between the different treatments. The ranges in the percentages of virus incidence and intensity were 6.25-14.90% and 4.78-12.66%, respec-

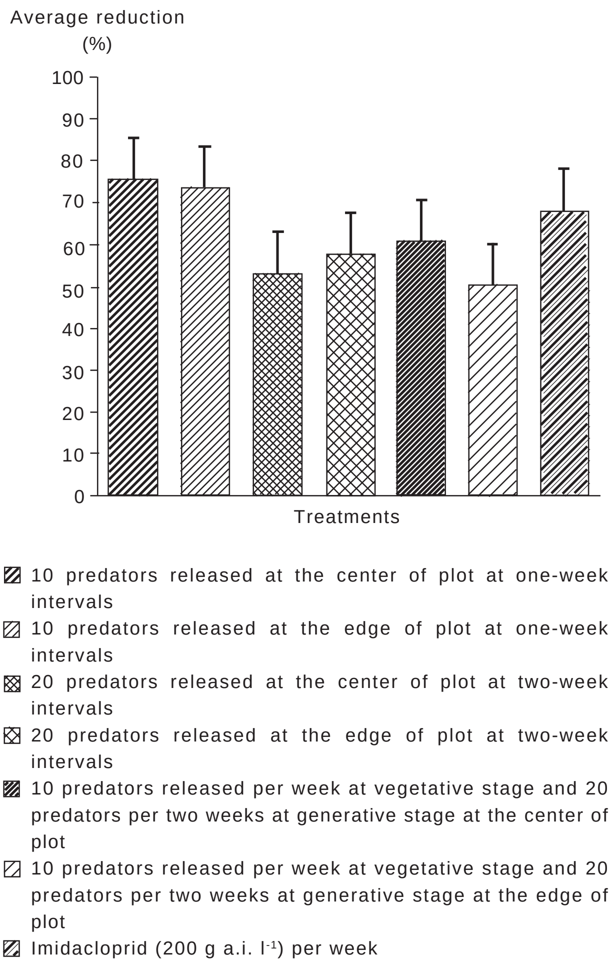


Fig. 2. Average reduction of *Bemisia tabaci* population on tomato plants (mean ± SE) treated with predator *Menochilus sexmaculatus*, Lembang, West Java, 2008.

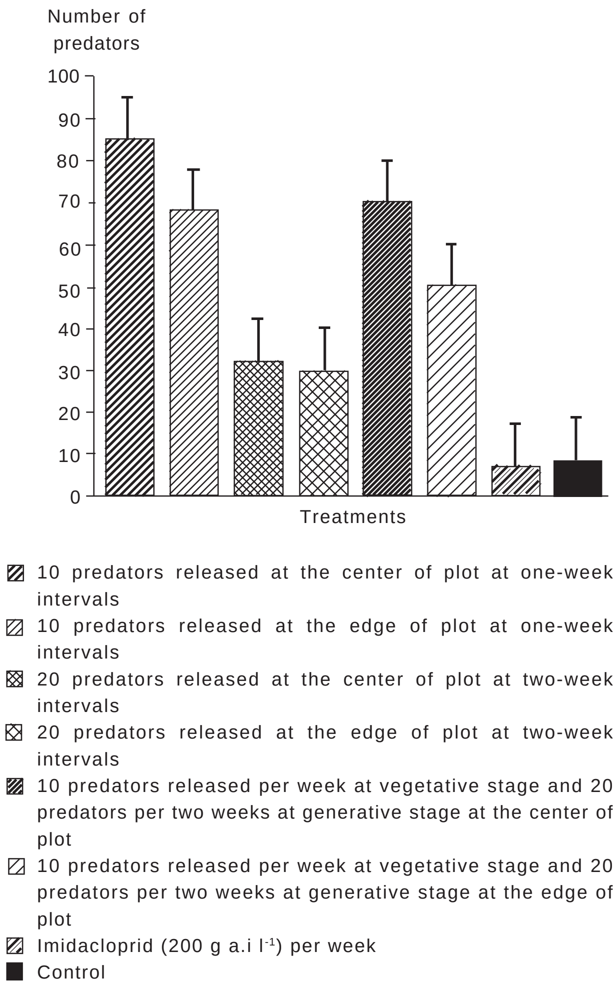


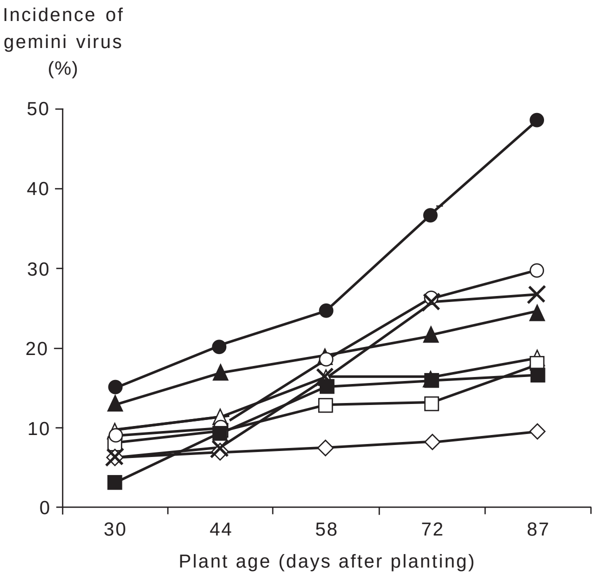
Fig. 3. Total population of predator *Menochilus sexmaculatus* on tomato plants (mean ± SE) at various treatments of releases, Lembang, West Java, 2008.

tively. Virus diseases spread very fast due to activity of the vector, *B. tabaci* and with the population size of this insect.

Incidence and intensity of gemini virus symptom were continuously enhanced in line with the increase in plant age. Prior to harvest (72-85 DAP), treatments with predator release resulted in 8.19-29.69%, compared to 16.59% (imidacloprid) and 48.56% in the non-treated plot. The incidence and intensity of gemini virus were consistently and significantly low in A and B treatments (10 predators released at weekly intervals) than those in the non-treated plot and other treatments.

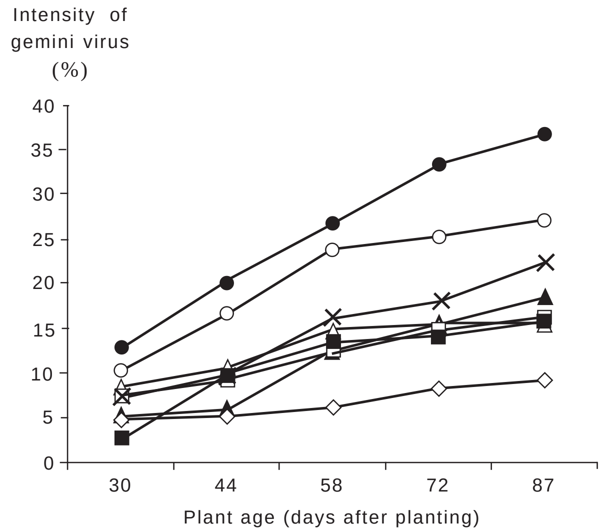
Tomato yields obtained are illustrated in Table 3. Results revealed that yields were affected by the treatments. Ten predators released at weekly intervals at the center of plots gave the highest yields followed by both 10 predators released at the vegetative stage at the center and the edge of plots, while 20 predators released at two-week intervals was the least rank during the growing season. There were no significant differences in fruit yields between imidacloprid treatment and release of predators. Increase in yields was proportional to *B. tabaci* population and gemini virus reduction.

Field observation showed that two insect pest species were found on tomato plants throughout the growing season, i.e. *B. tabaci* and fruit worm (*Helicoverpa armigera*). There were no significant differences in *H. armigera* infestation between the treated plots and the control plots. The highest and statistically similar reduction in fruit damage infested by gemini virus was observed in plots treated with 10 predators released at weekly intervals at the center of plots (7.40%), 10 predators released at the vegetative stage at the center and the edge of plots (7.63-9.60%), and in plots treated with imidacloprid (8.46%). The reductions of fruit damage over untreated control ranged from 41.96% to 55.26%.



◇ 10 predators released at the center of plot at one-week intervals
□ 10 predators released at the edge of plot at one-week intervals
△ 20 predators released at the center of plot at two-week intervals
▲ 20 predators released at the edge of plot at two-week intervals
✕ 10 predators released per week at vegetative stage and 20 predators released per two weeks at generative stage at the center of plot
○ 10 predators release per week at vegetative stage and 20 predators per two weeks at generative stage at the edge of plot
■ Imidacloprid (200 g a.i. l^{-1}) per week
● Control

Fig. 4. The effect of different treatments of *Menochillus sexmaculatus* augmentation on incidence of gemini virus on tomato plant, Lembang, West Java, 2008.



◇ 10 predators released at the center of plot at one-week intervals
□ 10 predators released at the edge of plot at one-week intervals
△ 20 predators released at the center of the plot at two-week intervals
▲ 20 predators released at the edge of the plot at two-week intervals
✕ 10 predators released per week at vegetative stage and 20 predators per two weeks at generative stage at the center of plot
○ 10 predators released per week at vegetative stage and 20 predator per two weeks at generative stage at the edge of plot
■ Imidacloprid (200 g a.i. l^{-1}) per week
● Control

Fig. 5. The effect of different treatments of *Menochillus sexmaculatus* augmentation on intensity of gemini virus on tomato plant, Lembang, West Java, 2008.

Table 3. Tomato yield and fruit damage by gemini virus under different treatments of *Menochillus sexmaculatus* release, Lembang, West Java, 2008.

Treatments	Yield ($t\ ha^{-1}$)	Fruit damage (%)
10 predators released at the center of plot at one-week intervals	24.57a	7.40b
10 predators released at the edge of plot at one-week intervals	17.39ab	12.20a
20 predators released at the center of plot at two-week intervals	17.34ab	15.00a
20 predators released at the edge of plot at two-week intervals	15.77ab	14.40a
10 predators released per week at vegetative stage and 20 predators per two weeks at generative stage at the center of plot	22.09a	7.63b
10 predators released per week at vegetative stage and 20 predators per two weeks at generative stage at the edge of plot	23.38a	9.60b
Imidacloprid (200 g a.i. l^{-1}) per week	23.15a	8.26b
Control	11.58b	16.54a

Mean values in columns followed by differing letters differ significantly by the DMRT (P = 0.05).

Effectiveness of predators against *B. tabaci* did not significantly differ from imidacloprid at recommended concentration (200 g a.i. l^{-1}). Imidacloprid is a broad spectrum chloronicotinyl insecticide that is especially effective against sucking insect pests and also affects several Coleopteran, Dipteran, and Lepidopteran pests (Elbert *et al.* 1991). However, the use of imidacloprid could be harmful to the predators (Delbeke *et al.* 1997). Results here suggest that predator conservation may be enhanced by delaying the first application of insecticide or initially use more selective materials such as insect growth regulators.

CONCLUSION

Menochillus sexmaculatus is a potential predator that is effective against all stages of *B. tabaci* on tomato under field conditions. Releasing 10 predators at weekly intervals has the highest reduction percentage of *B. tabaci* population and incidence of gemini virus, and gave the highest tomato yield compared with the control. It is suggested that release of *M. sexmaculatus* against *B. tabaci* on tomato may be offered as an alternative solution to increase implementation of biologically-based *B. tabaci* management. Further studies are required to evaluate the effect of predator augmentation with other tactic controls such as cultural control and selective insecticide for more effective result.

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