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MANAGMENT OF BRINJAL SHOOT AND FRUIT BORER (*LEUCINODES ORBONALIS* GUENEE) WITH INTEGRATED PEST MANAGEMENT PACKAGE(S)

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ABSTRACT

The study was conducted to evaluate the performance of different IPM packages for management of brinjal shoot and fruit borer (BSFB) (*Leucinodes orbonalis* Guenee) in brinjal field during September 2015- February 2016. The tested IPM packages were package 1: clipping off infested brinjal shoot and fruit (mechanical control) + NSKE; package 2: clipping off infested shoot and fruit + NSKE + Rambo 10 EC; package 3: clipping off infested shoot and fruit + NSKE + Rekhaphos 20 EC; package 4: clipping off infested shoot and fruit + NSKE + Kinalux 25 EC; package 5: clipping off infested shoot and fruit + NSKE + Abamectin 1.8 EC; and an untreated control. The rates of shoot infestation at pre-fruiting and fruiting stages among the treatments ranged from 04.34%-14.09% and 01.92%-08.79% and the results differed significantly. All the IPM packages showed significantly lower rates of infestation compared to control and the package 2 had the lowest rates of infestation. The lowest fruit infestation of 10.55% by number and 09.08% by weight was recorded from package 2. The rate of reduction of fruit infestation over control was 71.75, 53.39, 53.02, 47.51, and 41.69% by number and 70.09, 52.07, 55.58, 49.36 and 45.10% by weight in package 2, package 3, package 4, package 5 and package 1, respectively. The marketable yield in different packages ranged from 19.53 – 38.76 t ha^{-1}. The highest adjusted net return and BCR of Tk. 520488.10 and 9.23, respectively were obtained from package 2 treated plots. The second highest BCR of 5.0 was calculated from package 3, which was followed by package 5 (4.94) and package 1 (3.15) treated plot. The lowest BCR of 3.12 was found in package 4. The IPM packages 2, 3 and 5 were effective to suppress BSFB attacking brinjal shoot & fruit.

Keywords: *Leucinodes orbonalis,* insecticides, clipping, neem.

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INTRODUCTION

Brinjal (*Solanum melongena* L.) is one of the most common and popular vegetables grown both summer and winter seasons in Bangladesh. Brinjal shoot and fruit borer (BSFB) *Leucinodes orbonalis* Guenee is the most destructive insect pest of brinjal. The shoots and fruits of Brinjal are truly harmed by the larval phase of this pest. Pest larvae penetrate the young shoots during the vegetative stage and consume the internal tissues, resulting in drooping and withering shoots. In the reproductive phase, larvae feed on the pith tissues of the infested fruits and make zigzag tunnels. The fruits that are infested are not suitable for human consumption or sale (Shaukat et al. 2018). Farmers of Bangladesh like other Asian countries mostly depend on chemical insecticides for the management of BSFB (Alam *et al*. 2003). Such reliance on chemical insecticides has created many problems like very frequent application of insecticides that lead to environmental pollution, excessive residues on marketable vegetable, concern general consumer's health and hazards to non-target organisms, increased production cost etc. (Pedigo 2002, Debach and Rosen 1991). For ensuring safety food and minimization of environmental hazards, appropriate management practices against BSFB incorporating different methods needed, ought to be devised consistent with the modern pest management concept. Researcher have been trying to combine various components of IPM such as cultural, mechanical, pheromone trap and selected chemicals etc. for the control of brinjal shoot and fruit borer (FAO 2003, Alam *et al*. 2003).

Mechanical control such as collection and destruction of infested shoot and fruit in combination with insecticide treatments reduce BSFB infestation, increased yield of fruit and ensured the higher benefit of the farmer (FAO 2003, Alam *et al*. 2003, Rahman *et al*. 2002). Patnaik *et al*. (1998) reported that the use of balanced fertilizer and application of insecticides decreased the fruit damage both in quantity and quality. Field sanitation through removal of plant debris and refuges and cleaning reduce BSFB infestation significantly. For the management of this pest, mixture of various plant parts (leaf, bark, and seed) and vegetable oils are traditionally being practiced (Rejesus *et al.* 1989). Botanicals and indigenous plant materials are cheaper and nonhazardous in comparison to chemical insecticide (Misra 2014). However, none of the individual method alone provides satisfactory protection of the crop against BSFB. Their combination in a best compatible manner (package) is expected to render desirable protection of the crop.

There exist a number of methods particularly with insecticides for controlling the pest in Bangladesh. But attempt to control BSFB utilizing non-chemical approaches with little reliance on insecticides and economizing the application at various growth stages is still unexploited. Therefore, the effective control of BSFB in brinjal cultivation demands some new approaches which do not rely solely on the use of chemicals, rather reduce the use of chemicals, safeguard the environment and ensure economic and social acceptance. Considering the above facts the present research was undertaken to assess the effectiveness of different IPM packages against the BSFB.

MATERIALS AND METHODS

The study was laid out in a randomized complete block design (RCBD) with three replications in the experimental field of the Entomology Department, at the Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur, Bangladesh in winter season (September 2015 to February 2016). The site was situated in the subtropical climatic zone and geographically the location lies between 24.09^0 N latitude and 90.26^0 E longitudes with an elevation of 8.50 meter from the sea level. BARI Begun 8 was cultivated and following the recommended practices according to Rashid (1999). The evaluated IPM packages (P) were: P_1 = Clipping off infested shoot and fruit (Mechanical control) + Neem (*Azadirachta indica*) Seed Kernel Extract (NSKE) @ 50g l^{-1} of water sprayed at seven days interval. P_2 = Clipping off infested shoot and fruit (Mechanical control) + NSKE @ 50g l^{-1} of water + Rambo 10 EC (Cypermethrin) @ 1ml l^{-1} of water sprayed alternately at seven days interval. P_3 = Clipping off infested shoot and fruit (Mechanical control) + NSKE @ 50g l^{-1} of water + Rekhaphos 20 EC (Chlorpyriphos) @ 2ml l^{-1} of water sprayed alternately at seven days interval. P_4 = Clipping off infested shoot and fruit (Mechanical control) +NSKE @ 50g l^{-1} of water + Kinalux 25 EC (Quinalphos) @ 3ml l^{-1} of water sprayed alternately at seven days interval. $P_{5=}$ Clipping off infested shoot and fruit (Mechanical control) + NSKE @ 50g l^{-1} of water + Suntec 1.8 EC (Abamectin) @ 0.5ml l^{-1} of water sprayed alternately at seven days interval and an untreated control.

Mechanical control practiced cutting infested shoots and fruits weekly with sharp knife and destroyed soon after collection and this was started at the first appearance of shoot infestation. For package 1 (P_1) Neem Seed Kernel Extract (NSKE) were applied 6 times at seven days interval regularly and in case of remaining packages

($P_{2,}$ $P_{3,}$ P_4 and P_5), all insecticides with Neem Seed Kernel Extract (NSKE) were applied alternately at seven days interval starting from the first appearance of shoot infestation. The total number of shoots as well as the number of infested shoots was recorded from 5 selected plants of each plot at weekly intervals. Shoot infestation was calculated in percent. Fruits were harvested at 7 days intervals and the numbers of healthy and infested fruits were sorted for calculating the percent fruit bored and the number of fruits plant^{-1}. The weight of healthy and infested fruits was recorded separately plot^{-1} treatment^{-1}. Twelve harvests were done throughout the fruiting period and percent fruit infestation by number and weight were calculated. The cumulative plot yields of healthy, infested and total fruits of 12 harvests were transformed into healthy and infested yield (t ha^{-1}).

Benefit cost ratio (BCR) was analyzed considering the total expenditure of growing the crop and the total return from that particular treatment. BCR was calculated for a hectare of land. The cost was calculated by adding all costs incurred for labours and inputs for each treatment including control plot during the entire vegetative and fruiting period. The yield of each treatment was converted into tons per hectare. The yield in terms of taka was calculated by multiplying the total yield by the unit price of brinjal at that time (Tk. 30 kg^{-1}). Net return was calculated by subtracting treatment wise management cost from gross return. The adjusted net return was determined by subtracting the net return of control plot from the net return of a particular treatment. Adjusted net return = Net return of a particular treatment – net return of control plot. Finally the Benefit Cost Ratio (BCR) was calculated by dividing the adjusted net return by the respective total management cost for each treatment following the formula:

Benefit cost ratio = Adjusted net return/Total pest management cost.

Data analysis: The data were analyzed by using MSTAT-C software and the analysis of variance (ANOVA) of different parameters was done and the means were separated by using the Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Effects of various IPM packages on percent shoot infestation by BSFB at pre-fruiting and fruiting stages are presented in Table 1. Shoot infestation by BSFB was ranged 04.34-14.09% at pre-fruiting and 01.92-08.79% at fruiting stages in different treated packages.

At pre fruiting stage, the lowest rate of shoot damage (04.34%), was recorded from package 2 (consisting of clipping off infested shoot and fruit + NSKE + Rambo 10 EC) which was statistically similar (04.48 %) to package 4 (comprising of clipping off infested shoot and fruit + NSKE + Kinalux 25 EC). The second highest rate of shoot damage (10.37%), was recorded in package 1 (having clipping off infested shoot and fruit + NSKE) which was followed by package 5 (comprising of clipping off infested shoot and fruit + NSKE + Suntec1.8 EC) (8.00%) and package 3 (using clipping off infested shoot and fruit + NSKE + Rekhaphos 20 EC) (07.63%) and both packages 5 & 3 was statistically identical (Table 1).

Table 1. Effect of different IPM packages on the rate of shoot infestation by BSFB at pre-fruiting and fruiting stages of brinjal grown during winter

IPM packages	Pre-fruiting stage		Fruiting stage	
	Shoot infestation (%)	Infestation reduction over control (%)	Shoot infestation (%)	Infestation reduction over untreated control (%)
P_1	10.37 b	26.40	05.18 b	41.07
P_2	04.34 d	69.20	01.92 e	78.04
P_3	07.63 c	45.85	02.70 d	69.28
P_4	04.48 d	68.20	02.04 de	76.79
P_5	08.00 c	43.22	04.42 c	49.72
Untreated control	14.09 a	-	08.79 a	-
CV (%)	07.88	-	08.86	-

Means within the same letter (s) within a column do not differ significantly (P=0.05) according to DMRT. P_1: Clipping off + NSKE, P_2: Clipping off + NSKE + Rambo 10 EC, P_3: Clipping + NSKE + Rekhaphos 20 EC, P_4: Clipping off + NSKE + Kinalux 25 EC, P_5: Clipping off + NSKE + Suntec 1.8 EC

At pre-fruiting stage, the highest reduction in shoot infestation over control was achieved with package 2 (69.20%) treated plot which was followed by package 4 (68.20%), package 3 (45.85%), package 5 (43.22%), and package 1 (26.40%) treated plot (Table 1).

At fruiting stage, the lowest shoot infestation was found in package 2 (01.92%) followed by package 4 (02.04%) and package 3 (02.70%). They were statistically comparable. The second highest shoot infestation was recorded from package 1

(05.18%), which was followed by package 5 (04.42%) and they were significantly different (Table 1). At fruiting stage, reduction in shoot infestation over control was ranged 41.07 to 78.04% in different IPM packages. The lowest reduction over untreated control was achieved by package 1 (41.07%) and highest in package 2 (78.04%) treated plot.

The present study revealed that efficacy of the each IPM package was promising but the supporting reports are scanty. However, Mishra *et al.* (2002) reported that Neemax (Neem seed kernel extract) combined with insecticide lowered BSFB incidence by 11.7-13.3% compared to the untreated control (16.90%). The rate of infestation reduction would be lower than that of the present finding.

As revealed from Fig. 1 the lowest level of fruit infestation 10.55% by number and 9.08% by weight in IPM package 2 treated plots followed by package 4, package 3, package 5 and package 1. Significantly the highest percent fruit infestation was 35.27 % by number and 32.14 % by weight observed in untreated control plot.

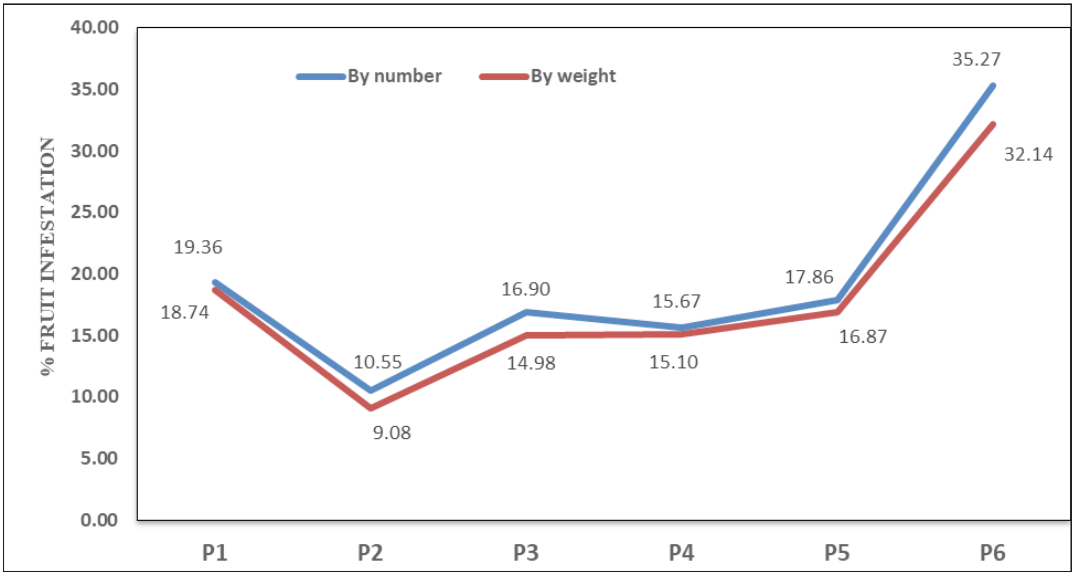

Fig. 1. Effect of different IPM packages on fruit infestation of brinjal at Gazipur in Bangladesh during winter (September 2015 to February 2016. *P_1: Clipping off + NSKE, P_2: Clipping off + NSKE + Rambo 10 EC,* ***P_3*:** *Clipping + NSKE + Rekhaphos 20 EC, P_4: Clipping off + NSKE + Kinalux 25 EC, P_5: Clipping off + NSKE + Suntec 1.8 EC, P_6: Untreated control*

The percent fruit infestation reduction over control of all the IPM packages was shown in the Fig. 2. The highest percent reduction of fruit infestation over control (70.09% by number and 71.75% by weight) was recorded in IPM package 2 (comprising of clipping off infested shoot and fruit + NSKE + Rambo 10 EC) treated plot followed by IPM package 3, package 4, package 5 and package 1 were 53.39, 53.02, 47.51, and 41.69% by number and 52.07, 55.58, 49.36 and 45.10% by weight, respectively. Findings of the present experiment revealed that Rambo 10 EC played a vital role in controlling BSFB compared to other packages. The highest rate of infestation reduction over control was recorded from the IPM packages 2 (Fig. 2).

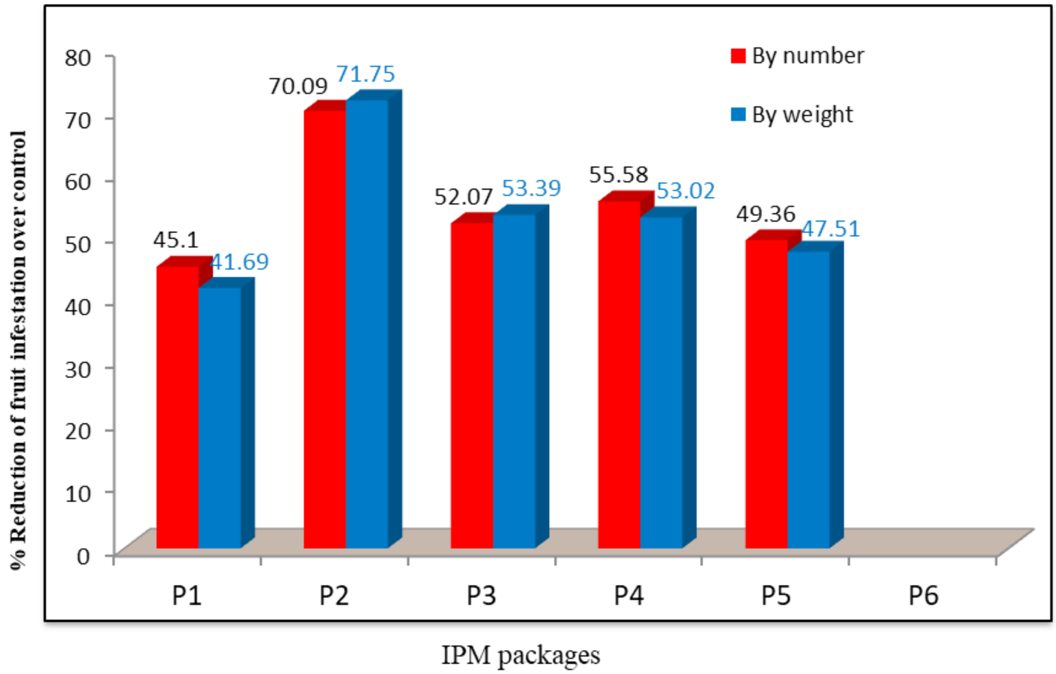

Fig. 2. Effect of different IPM packages on reduction of fruit infestation over control. *P_1: Clipping off + NSKE, P_2: Clipping off + NSKE + Rambo 10 EC, P_3: Clipping + NSKE + Rekhaphos 20 EC,* ***P_4:*** *Clipping off + NSKE + Kinalux 25 EC, P_5: Clipping off + NSKE + Suntec 1.8 EC, P_6: Untreated control*

Rahman *et al.* (2002) obtained reduce rate of shoot/fruit infestation and increased yield by using the IPM packages consisting of cypermethrin 10EC sprayed on grafted eggplant and mechanical control of infested shoots and fruits. Effect of different IPM packages on yield (t ha^{-1}) has been evaluated in terms of healthy or marketing, and infested brinjal fruit yield (t ha^{-1}) obtained in each package treated plot during the entire period of the crop (Table 2). Significantly the highest marketable yield (38.76 t ha^{-1}) was recorded from package 2 (comprising of clipping off infested shoot and fruit + NSKE + Rambo 10 EC) treated plot which was significantly higher than any other treated IPM packages. The second highest yield of healthy fruits (30.90 t ha^{-1}) was found in package 3 (consisting of clipping off infested shoot and fruit + NSKE + Rekhaphos 20 EC) (30.90 t ha^{-1}) which was statistically similar to package 5 (comprising of clipping off infested shoot and fruit + NSKE + Suntec 1.8 EC) (30.06 t ha^{-1}) and package 4 (consisting of Clipping off infested shoot and fruit + NSKE + Kinalux 25 EC) (29.48 t ha^{-1}) and package 1(using of clipping off infested shoot and fruit + NSKE) (27.44 t ha^{-1}) treated plots. The lowest yield of healthy fruits (19.53 t ha^{-1}) was recorded from untreated control plot (Table 2).

Significantly the lowest infested yield (03.87 t ha^{-1}) was recorded from package 2 treated plot against the highest (09.26 t ha^{-1}) being in untreated control plot. The weight of infested yield of (06.33 t ha^{-1}) was found in package 1 which was comparable to infested yield (06.10 t ha^{-1}) package 5. On the other hand the weight of infested yield (05.44 ha^{-1}) was found in package 3 which was similar to infested yield (06.10 ha^{-1}) of package 4 (Table 2).

The analysis of the yield data to assess the impact of each IPM package on yield increase/decrease over control was shown in Table 2. Table revealed that IPM package 2 ensured the highest increase (98.46%) of healthy fruit yield over control followed by gradually decrease in package 3 (58.22%), Package 5 (53.92%), package 4 (50.95%) and package 1(40.50%) (Table 2).

On the other hand, the highest reduction (58.21%) of infested fruit yield over control was calculated in IPM package 2 while it was lowest in package 1 (31.64%) followed by package 5 (34.13%) and Package 3 (41.25%).

The performance of the different IPM packages against BSFB in different aspects, such as percent shoot and fruit infestation, reduction of infestation over control, healthy and infested yield as found in the present study were more or less in conformity with the findings of several other authors. Gapud *et al.* (1999) reported that removal of damaged shoots and fruits at every week produced higher yield than plants sprayed at every three weeks. In an AVRDC study in Jashore, Bangladesh an IPM strategy consisting of weekly removal of BSFB infested shoots, installation of pheromone traps to catch BSFB males and withholding of chemical pesticides to allow natural enemies to regulate BSFB population led to lower production costs and higher net incomes for farmers (Alam *et al.* 2003). Combination of 4 cultural practices, such as flooding the field (during dry season) by irrigation, pruning of older leaves and use of wide spacing (1m × 1.5m), field sanitation and proper disposal of BSFB-infested plant material and fertilizer use as per recommended rate (on the basis of soil testing) controlled 70% of BSFB population in brinjal (FAO 2003). Mishra *et al.* (2002) reported that Neemax (neem seed kernel extract) combined with insecticide application lowered the fruit borer infestation by 11.7-13.3% compared to the untreated control, which had the highest infestation of 16.90%.

Table 2. Effect of different IPM packages against brinjal shoot and fruit borer (BSFB) on fruit yield (t ha^{-1}) of brinjal plant

IPM packages	Marketable yield (t ha^{-1})	Increase over control (%)	Infested yield (t ha^{-1})	Decrease over control (%)
P_1	27.44 b	40.50	06.33 b	31.64
P_2	38.76 a	98.46	03.87 d	58.21
P_3	30.90 b	58.22	05.44 c	41.25
P_4	29.48 b	50.95	05.24 c	43.41
P_5	30.06 b	53.92	06.10 b	34.13
Untreated control	19.53 c	-	09.26 a	-
CV (%)	07.08	-	09.22	-

Means within the same letter (s) within a column do not differ significantly (P=0.05) according to DMRT. P_1: Clipping off + NSKE, P_2: Clipping off + NSKE + Rambo 10 EC, P_3: Clipping + NSKE + Rekhaphos 20 EC, P_4: Clipping off + NSKE + Kinalux 25 EC, P_5: Clipping off + NSKE + Suntec 1.8 EC

Table 3 shows that the BCR was the highest 9.23 in IPM package 2 followed by BCR 5.00, 4.94, 3.15 and 3.12 in the IPM packages 3, 5, 1 and 4, respectively.

Table 3. Benefit cost ratio analysis of different IPM packages for the management of brinjal shoot and fruit borer

IPM packages	Management cost (Tk)	Yield (t/ha)	Gross return (Tk)	Net return (Tk)	Adjusted net return (Tk)	BCR
P_1	57144.00	27.44	823200.00	766056.00	180156.00	3.15
P_2	56411.98	38.76	1162800.00	1106388.10	520488.10	9.23
P_3	56811.98	30.90	927000.00	870189.00	284289.00	5.00
P_4	72311.97	29.48	884400.00	812088.61	226188.61	3.12
P_5	53211.99	30.06	901800.00	848588.59	262688.59	4.94
Untreated control	0.00	19.53	585900.00	585900.00	0.00	-

P_1: Clipping off + NSKE, P_2: Clipping off + NSKE + Rambo 10 EC, P_3: Clipping + NSKE + Rekhaphos 20 EC, P_4: Clipping off + NSKE + Kinalux 25 EC, P_5: Clipping off + NSKE + Suntec 1.8 EC, Farm gate value of brinjal = Tk.30 kg^{-1}

The findings of the present study indicate that the alternate use of various insecticides, NSKE and mechanical control (Clipping off infested shoot and fruit) in different packages combinations were effective to manage the infestation of BSFB in brinjal field. Similar findings have been reported by other workers for other borers. Haque (1998) reported that alternate use of botanicals and insecticide for the management of Okra shoot & fruit borer (OSFB) increased the healthy & marketable fruit yield of okra. Maleque *et al*. (1998) found BCR of 3.4:1 and 3.3:1 by using mechanical control + application of Cypermethrin at 5% ET and scheduled spray of Cypermethrin at 7 days intervals. Alam *et al.* (2006) reported that the BCR was 3.4 and 1.7 in IPM and non-IPM brinjal farmers (to control BSFB), respectively in winter trials.

The alternate use of chemical and botanical components gave better result in this study which may reduce the excess use of chemicals to ensure suppression of BSFB infestation and in turn decrease environmental pollution and health hazards. The IPM package 2, comprising alternate spraying of NSKE & Rambo 10 EC along with mechanical control (clipping off infested shoot and fruit) against BSFB in the present study was highly effective.

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