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EVALUATION OF DIFFERENT IPM PACKAGES USED AGAINST LEAF BEETLE, *CEROTOMA TRIFURCATA* (COLEOPTERA: CHRYSOMELIDAE) OF FRENCH BEAN

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ABSTRACT

Experiment was carried out to evaluate the effectiveness of four IPM packages and an untreated control against leaf beetle of French bean. Results revealed that the lowest number of plant infestation by leaf beetle and the highest per cent (82.88%) of plant infestation reduction over control was found in package 1 (Yellow sticky trap + Bioneem plus) treated plots at 38, 48 and 58 days after sowing (DAS). The lowest mean number of leaf beetle (1.05/Plant) and the highest percentage of leaf beetle population reduction (79.00%) over control were recorded from package 1. The lowest percent leaf area damaged (2.19%) and the highest percentage (90.45%) of leaf area damage reduction over control was found in package 1 treated plots. There was a strong negative correlation of total yield with number of leaf beetle, percent plant infestation and percent leaf area damage package 1 comprising yellow sticky trap + Bioneem plus 1% EC @ 1ml/1litre of water was found to be the best integrated management package for the management of leaf beetle and produced maximum fresh pod yield (15180.50 kg/ha) and highest percent yield increase over control of French bean while the second highest (21.02) MBCR was obtained by adopting the package 1. Though the highest (33.91) MBCR was obtained by adopting the IPM package 3 but IPM package 1 could be the best package for the management of leaf beetle as eco-friendly package.

Keywords: French bean, insecticides, IPM package, leaf beetle, yellow sticky trap

INTRODUCTION

The French bean, *Phaseolus vulgaris* (Linnaeus) is a photo insensitive and self-pollinated vegetable crops belong to the Fabaceae (formerly Leguminosae) family

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derived from a wild species. The French bean is synonymies as bush bean, kidney bean, snap bean, pinto bean, green bean, raj bean, common bean, basic bean, haricot bean, navy bean, pole bean, wax bean, string bean and bonchi in different parts of the world (Salukhe *et al*. 1987). In Bangladesh, the crop is known in different names in different locations such as in Sylhet it is known as Farashi Ori and Farashi Choi in Chittagong and Jharshim in most part of the country. French bean is the second largest legume producing vegetable in the world (Rashid 1999). It is an important food in most tropical and subtropical countries of the world and is second to cereals as a food source for humans and animals (Graham and Vance 2003). It is a dual purpose crop grown as pulse and also consumed as immature tender fruits. The French bean is highly nutritious and provides one of the most important sources of protein (Arulbalachandran and Mullainathan 2009) and is rich in vitamins, minerals and dietary fibre (Ndegwa *et al*. 2006). French bean is an important source of several essential micronutrients for both men and domestic animals. Yield potential of French bean is generally very low due to lack of high yielding varieties, poor production technology, including optimum date of sowing and spacing, poor fertility and irrigation management (Saini and Negi 1998). Worldwide, yield losses due to insect pests alone have been estimated to be from 35% to 100% annually (Singh and Schwartz 2011). The major constraints of French bean production include marketing, transport diseases and insect pests (Monda *et al*. 2003). The crop is attacked by a number of insect pests during its life span. Thirty nine species of insect pests were found to infest soybean crop at their different growth stages in Noakhali region of Bangladesh during January to May, 2010 and 2011 (Biswas 2013). Fifteen to 20% of the total bean production is lost directly or indirectly by the attack of insect pests every year (Biswas 2008). An estimated 35 to 100% of crop losses worldwide are attributed to insect pests alone each year (Singh and Schwartz 2011). Sahoo and Giraddi (2023) reported five species of insects and one mite species infesting pole bean at various phases of crop growth. These include- the serpentine leaf miner (*Liriomyza trifolii*), pod fly (*Melanagromyza obtusa*), seed fly (*Anthomyia* sp.), leafhopper (*Ianagallia bifurcate*), tobacco caterpillar (*Spodoptera litura*), and red spider mite (*Tetranychus urticae*). The natural enemies include- *Brachymeria* sp. (Chalcididae), *Ichneumon* sp. (Ichneumonidae) and *Microplitis* sp. (Braconidae). In Bangladesh, bean leaf beetle and whitefly have become a serious threat to French bean cultivation in Sylhet and Chittagong regions. Adult bean leaf beetles prefer to eat tender young plant tissue. They feed primarily on the undersides of leaves, creating round, 0.31 cm diameter holes. High populations of adults can defoliate the first true leaves and kill young seedlings. Extensive feeding can reduce the vigor and yields of bean plants. The grubs of bean leaf beetle feed on soybean root nodules, whereas the adults feed on the above ground parts of soybean such as cotyledon, leaves, and pods. Bean leaf beetle is also a very efficient vector of Bean pod mottle virus, a widespread virus of soybean in the south and south-eastern United States with recent expansion into the north central region of the country (Hadi *et al.* 2012). Most of the farmers reported that use of pesticides effectively controlled the pests and diseases (Ndungu *at al.* 2004, Monda *et al.* 2003, Ndegwa *et al.* 2006). Chemical control is generally being advocated for the management of insect pests of French bean. Many workers have tried to control pest with varying degrees of success by frequent application of insecticides as foliar treatments (Chowdhury and Roy 1975). But indiscriminate use of chemicals led to impose certain well known undesirable side effects including environmental pollution, secondary pest outbreaks, pest resurgence, upset, resistance to pesticide, and health hazards killing beneficial organisms,' residues in food and feeds. Due to high yield loss caused by insect pests, the deleterious effects of insecticides and the inability of small scale farmers to afford expensive chemical pesticides, there is a need of developing a sustainable strategy for controlling insect pests. Considering above fact the experiment was undertaken to evaluate the effectiveness of integrated pest management packages for the management of leaf beetle attacking French bean.

MATERIALS AND METHODS

The experiment was carried out in the research field of Regional Horticultural research Station, Shibpur, Narsingdi to know the effectiveness of different IPM packages for the management of leaf beetle attacking French bean during November 2018 to February 2019. The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. The whole field was divided into 4 unit blocks represented replications and each unit block was divided into 5 sub unit plots. The total number of plots was 20 and the size of the individual plot was 3.0m × 3.0m. The distance between two unit plots was 0.75m and between block to block was 1m. The treatments were randomly distributed to the plots within a block. HYV

BARI Jharshim-2 was used as study material. The seeds were sown on 15 November 2018 at the rate of 120-125 kg/ha depending on the variety. The seeds were placed in the line continuously at a depth of 4-5 cm and covered by loose soil with the help of hand. The spacing was 30 cm between rows and 15 cm between plants. At first trifoliate stage, seedlings were carefully thinned to retain one seedling hill $^{-1}$. Seed germination occurred from 7th day after sowing. On the 12th day the percentage of germination was more than 80% while on the 15th day nearly all the seedlings came out from the soil. Intercultural operations were done as and when necessary to ensure normal growth and development of crops.

The packages of the experiment assigned were package 1: Yellow sticky trap + Bioneem plus 1% EC @ 1ml/L of water, package 2: Yellow sticky trap + Nitro 505 EC @ 1 ml/L of water, package 3: Bioneem Plus 1% EC @ 1ml/L of water +Nitro 505 EC @ 1 ml/L of water, package 4: Yellow sticky trap+ Bioneem Plus 1% EC @ 1ml/L of water +Nitro 505 EC @ 1 ml/L of water and an untreated control. Data on number of insects were recorded at an interval of 10 days commencing from first incidence. Population of leaf beetle were recorded at 38, 48, and 58 days after sowing (DAS) depending on the commencing from first incidence. The number of infested and healthy leaves were recorded from the selected 1 m^2 area of the centre of each unit plot to determine the level of infestation by leaf beetle at 38, 48, and 58 days after sowing.

Statistical analysis: The collected data were statistically analysed following the analysis of variance (ANOVA) using MSTAT C program and the mean differences were adjudged by LSD (Least significant difference).

RESULTS AND DISCUSSION

Effect of different IPM packages on leaf beetle at 38 DAS: The effect of different IPM packages at 38 DAS on leaf beetle population and its infestations are presented in Table 1. The number of leaf beetle varied significantly and it ranged from 0.77 to 4.50/plant. The lowest number of leaf beetle (0.77/plant) was observed in package 1 (0.77) treated plots followed by package 4 (0.78), package 2 (0.93) and package-3 (0.93) treated plots. Although the package 2 and package 3 were statistically similar but the highest number of leaf beetle was recorded in untreated control plots (4.50/

plant) which was statistically different from all other treatments. Accordingly, the highest percentage of leaf beetle reduction (82.88%) over control was found in package 1 treated plots followed by package 4 (82.66%), package 2 (79.33%) and package 3 (79.33%).

In case of infested plant by leaf beetle sqm^{-1} varied significantly and ranged from 2.75 to 23.50/sqm. The lowest number of plant infestation by leaf beetle (2.75/square meter) was observed in package 1 (Yellow sticky trap + Bioneem plus) treated plots followed by package 4 (3.50), package 2 (4.25) and package 3 (4.75). But the highest number of plant infestation per square meter was observed in untreated control plots (23.50/square meter) which was statistically different from all other treatments. Accordingly, the highest percentage of plant infestation reduction (88.29%) over control was found in package 1 treated plot followed by package 4 (85.10), package 2 (81.91%) and package 3 (79.78%) treated plot (Table 1).

Table 1. Efficacy of different IPM packages on the incidence of leaf beetle on French bean at 38 DAS

IPM packages	Number of leaf beetle /plant	Reduction of leaf beetle over control (%)	Number of infested plant by leaf beetle /sqm	Reduction of infested plant over control (%)
Package 1	0.77	82.88	2.75	88.29
Package 2	0.93	79.33	4.25	81.91
Package 3	0.93	79.33	4.75	79.78
Package 4	0.78	82.66	3.50	85.10
Untreated control	4.50	-	23.50	-
LSD (0.5)	0.17	-	1.23	-
CV (%)	6.96		10.34	-

Package 1- Yellow sticky trap + Bio-neem Plus @ 1 ml/L of water

Package 2 - Yellow sticky trap + Nitro 505 EC @ 1 ml/ L of water

Package 3 - Bioneem Plus @ 1ml/ L of water + Nitro 505EC @ 1 ml/ L of water

Package 4 -Yellow sticky trap + Bioneem Plus @ 1ml/ L of water+ Nitro 505 EC @ 1 ml/ L of water

Untreated control

Effect of different IPM packages on leaf beetle at 48 DAS: The effect of different IPM packages on leaf beetle population and its infestations are presented in Table 2. At 48 DAS, the number leaf beetle varied significantly and ranged from 0.71 to 5.25. The lowest number of leaf beetle (0.71/plant) was found in package 1 (Yellow sticky trap + Bioneem plus) treated plots followed by package 2 (0.78), package 3 (0.86) and package 4 (0.86). Here the package 1, package 2, package 3 and package 4 were statistically similar. The highest number of leaf beetle was observed in untreated control plots (5.25 /plant) which was statistically different from all other treatments. Accordingly, the highest percent of leaf beetle reduction (86.47%) over control was found in package 1 treated plots followed by package 2 (85.14%), package 3 (83.61%) and package 4 (83.617%) where package 3 and package 4 were statistically similar.

In case of infested plant by leaf beetle sqm^{-1} varied significantly and ranged from 0.71 to 23.50. The lowest number of leaf infestation by leaf beetle (0.71/square meter) was found in package 1 (Yellow sticky trap + Bioneem plus) treated plots followed by package 4 (0.78), package 3 (0.86) and package 2 (0.93). The highest number of infested plant per square meter was observed in untreated control plots (23.50 /square meter) which was statistically different from all other treatments. Accordingly, the highest percent of plant infestation reduction (96.97%) over control was found in package 1 treated plot followed by package 4 (96.68), package 3 (96.34%) and package 2 (96.04%) treated plot (Table 2).

Effect of different treatments on leaf beetle at 58 DAS: After 58 days of sowing, the effect of different IPM packages on leaf beetle population and its infestations are presented in Table 3. At 58 DAS, the number leaf beetle varied significantly and ranged from 0.71 to 7.00. The lowest number of leaf beetle (0.71 /plant) was observed in package 1 (Yellow stick trap + Bioneem Plus), package 2 (0.71) and package 4 (0.71) treated plots followed by package 3 (0.86). Here package 1, 2, 3 and package 4 were statistically similar. The highest number of leaf beetle was observed in untreated control plots (7.00 /plant) which was statistically different from all other treatments. Accordingly, the highest percentage of leaf beetle reduction (89.85%) over control was found inpackage1 treated plots which was statistically similar with package 2 (89.85%), package 4 (89.85%) followed by package 3 (87.71%).

Table 2. Effectiveness of different IPM packages on the incidence of leaf beetle on French bean at 48 DAS

IPM packages	Number of leaf beetle/plant	Reduction of leaf beetle over control (%)	Number of infested plant by leaf beetle /m^2	Reduction of infested plant over control (%)
Package 1	0.71	86.47	0.71	96.97
Package 2	0.78	85.14	0.93	96.04
Package 3	0.86	83.61	0.86	96.34
Package 4	0.86	83.61	0.78	96.68
Untreated control	5.25	-	23.50	-
LSD (0.5)	0.45	-	0.93	-
CV (%)	9.65	-	11.25	-

Package 1- Yellow sticky trap + Bio-neem Plus @ 1 ml/L of water
Package 2 - Yellow sticky trap + Nitro 505 EC @ 1 ml/ L of water
Package 3 - Bioneem Plus @ 1ml/ L of water + Nitro 505EC @ 1 ml/ L of water
Package 4 -Yellow sticky trap + Bioneem Plus @ 1ml/ L of water+ Nitro 505 EC @ 1 ml/ L of water
Untreated control

Infested plant by leaf beetle varied significantly and ranged from 0.71 to 24.25. The lowest number of infested plants by leaf beetle was observed in package 1 (Yellow stick trap + Bioneem Plus) and package 4 (0.71) treated plots followed by package 3 (0.73) and package 2 (0.86). The highest number of plant infestation per square meter was observed in untreated control plots (24.25 /square meter) which was statistically different from all other treatments. Accordingly, the highest percentage of plant infestation reduction (97.07%) over control was found in package 1 and package 4 treated plot followed by package 3 (96.98) and package 2 (96.45%) treated plot (Table 3).

Efficacy of different IPM packages on leaf beetle and its infestation on French bean: Effect of IPM packages on leaf beetle population, its reduction over control and leaf area damaged are presented in Table 4 and Plate 1. The mean number of leaf beetle varied significantly and it ranged from 1.05 to 5.00 leaf beetle/plant. The lowest mean number of leaf beetle (1.05/Plant) was observed in package 1 (Installing Yellow sticky trap + spraying Bio-neem plus 1 EC @ 1ml/L of water) followed

Table 3. Effect of different IPM packages on the incidence of leaf beetle on French bean at 58 DAS

IPM packages	Number of leaf beetle/ plant	Reduction of leaf beetle over control (%)	Number of infested plant by leaf beetle /m^2	Reduction of infested plant over control (%)
Package 1	0.71	89.85	0.71	97.07
Package 2	0.71	89.85	0.86	96.45
Package 3	0.86	87.71	0.73	96.98
Package 4	0.71	89.85	0.71	97.07
Untreated control	7.00	-	24.25	-
LSD(0.5)	0.56	-	0.66	-
CV (%)	8.32	-	7.86	-

Package 1- Yellow sticky trap + Bio-neem Plus @ 1 ml/L of water
Package 2 - Yellow sticky trap + Nitro 505 EC @ 1 ml/ L of water
Package 3 - Bioneem Plus @ 1ml/ L of water + Nitro 505EC @ 1 ml/ L of water
Package 4 -Yellow sticky trap + Bioneem Plus @ 1ml/ L of water+ Nitro 505 EC @ 1 ml/ L of water
Untreated control

by package 4 (1.15/plant), package 2 (1.17/Plant), and package 3 (1.22/Plant). The highest number of leaf beetle was observed in untreated control plots (5.00/Plant) which were significantly different from all other treatments. Accordingly, the highest percentage of leaf beetle population reduction (79.00%) over control was found in package1 treated plots followed by package 4 (77.00%), package 2 (76.60%) and package 3 (75.60%).

In case of leaf area damage, the percent leaf area damaged varied significantly and ranged from 2.19% to 22.94%. The lowest leaf area damaged (2.19%) was observed in package 1 treated plots followed by package 4 (2.42%), package 3 (2.45%) and package 2 (2.75%) while the highest (22.94%) was observed in untreated control plots which were statistically different from all other treatments. Accordingly, the highest percentage (90.45%) of leaf area damaged reduction over control was found in package 1 followed by package 4 (89.45%), package 3 (89.31%) and package 2 (88.01%) treated plot (Table 4).

Table 4. Efficacy of different IPM packages on the incidence of leaf beetle and its infestation on French bean

Treatments	Number of leaf beetle/ plant	Reduction of leaf beetle population over control (%)	Leaf area damaged by leaf beetle (%)	Reduction of leaf area damaged over control (%)
Package 1	1.05 b	79.00	2.19	90.45
Package 2	1.17 b	76.60	2.75	88.01
Package 3	1.22 b	75.60	2.45	89.31
Package 4	1.15 b	77.00	2.42	89.45
Untreated control	5.00 a	-	22.94	
LSD (0.5)	0.12	-	0.98	-
CV (%)	4.11	-	9.70	-

Package 1- Yellow sticky trap + Bio-neem Plus @ 1 ml/L of water
Package 2 - Yellow sticky trap + Nitro 505 EC @ 1 ml/ L of water
Package 3 - Bioneem Plus @ 1ml/ L of water + Nitro 505EC @ 1 ml/ L of water
Package 4 -Yellow sticky trap + Bioneem Plus @ 1ml/ L of water+ Nitro 505 EC @ 1 ml/ L of water Untreated control

Relationship between leaf beetle incidence and yield of French bean: Total yield influenced by the incidence of leaf beetle per plant. The result revealed that there was a strong negative correlation between number of leaf beetle and total yield. It indicated that with the increase of leaf beetle there was progressive fall in the yield. A linear regression was fitted between leaf beetle abundance and total yield (Fig. 1). The correlation coefficient (r) was 0.929 and the contribution of the regression (R^2 = 0.863, when Y = - 1.369x + 15.41) was 86.30%.

Relationship between plant infestation by leaf beetle and yield of French bean: A negative relationship between percent plant infestation and total yield was found in different treatments, which indicated that with the increase of leaf beetle infestation there was progressive fall in the yield. A linear regression was fitted between leaf beetle infestation and total yield (Fig. 2). The correlation coefficient (r) was 0.924 and the contribution of the regression (R^2 = 0.853, when Y = - 0.287x + 23.92) was 85.30%.

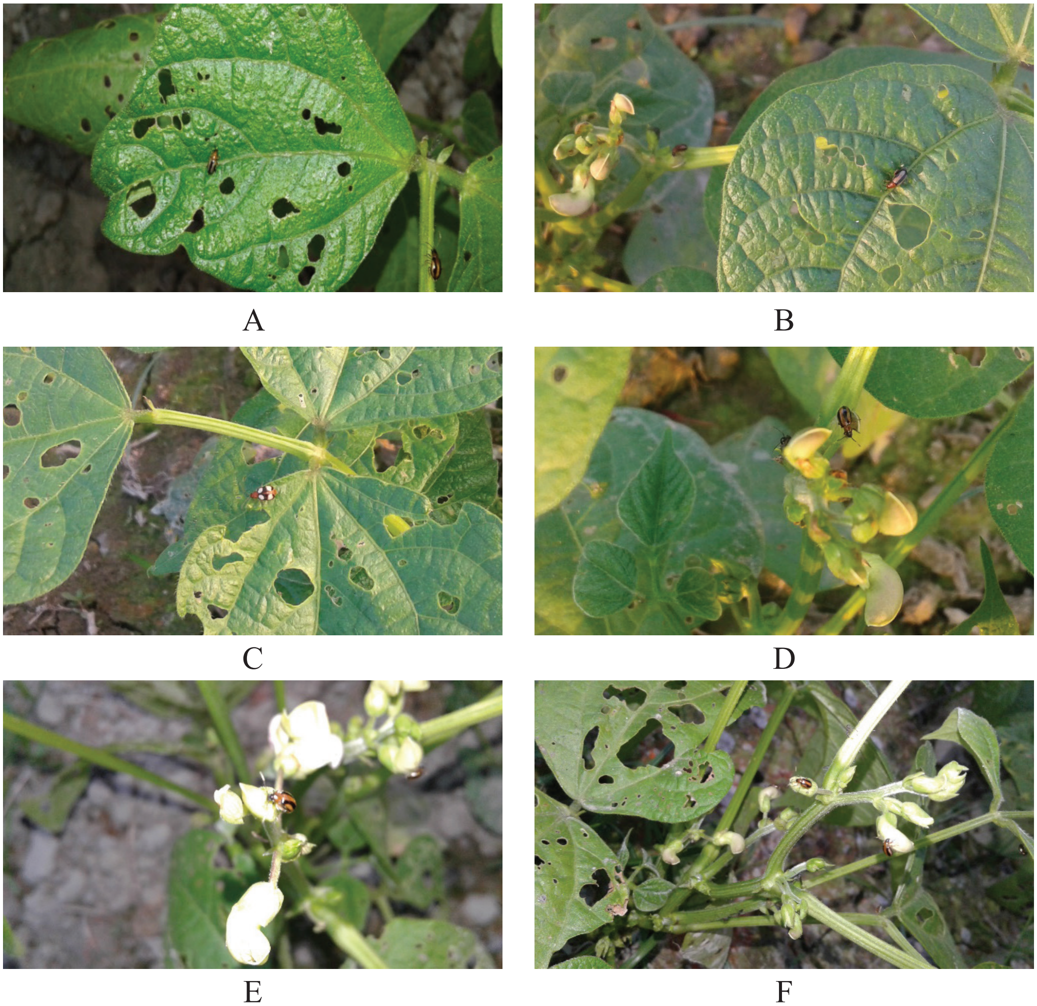

Plate 1. Leaf and flower area damaged by leaf beetle on French bean leaves (A-C) and flowers (D-F)

Relationship between leaf area damage and yield of French bean: A negative relationship between percent leaf area damage and total yield was found in different treatments, which indicated that with the increase of leaf beetle infestation there was progressive fall in the yield. A linear regression was fitted between leaf beetle infestation and total yield (Fig. 3). The correlation coefficient (r) was 0.925 and the contribution of the regression ($R^2 = 0.856$, when $Y = -0.256x + 14.47$) was 85.60%.

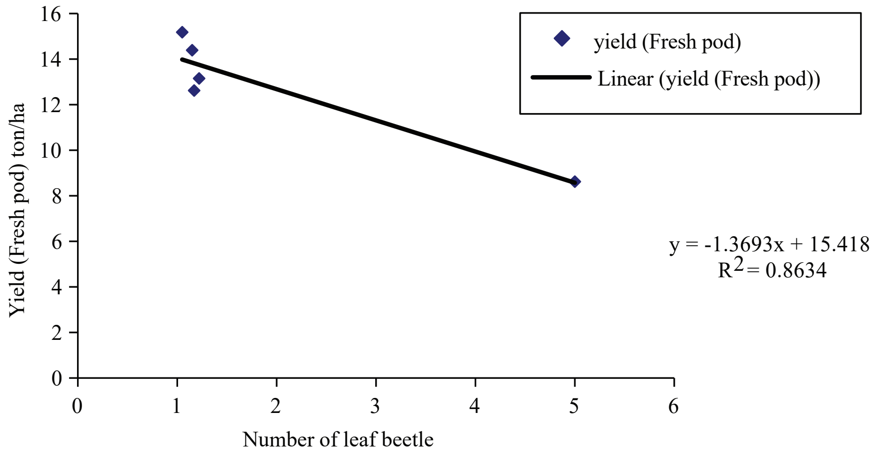

Fig. 1. Relationship between leaf beetle incidence and yield of French bean during growing season 2018-2019

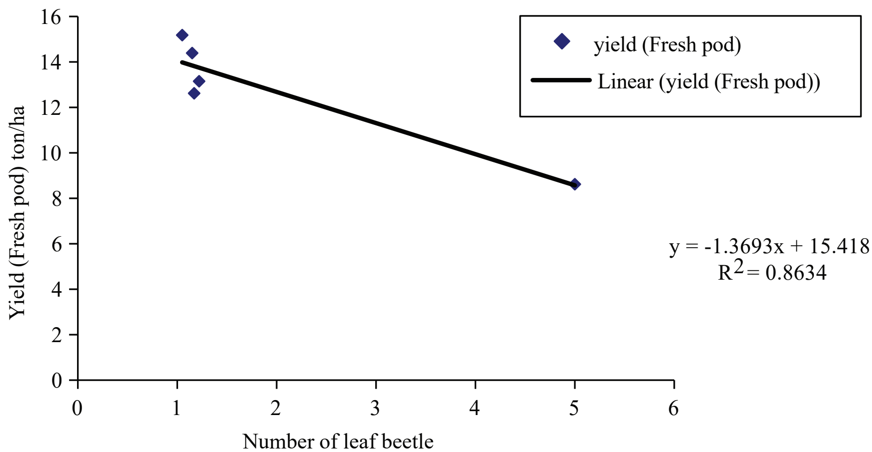

Fig. 2. Relationship between plant infestation by leaf beetle and yield of French bean during growing season 2018-2019

Return and marginal benefit cost ratio (MBCR): Return and marginal benefit cost ratio are presented in Table 5. The net return and marginal benefit cost ratio was varied depending on the cost of treatment application. As a fresh pod, the highest net return (Tk.156397/ha) was recorded from package 1 (Yellow sticky trap + Bio-neem plus) treated plots followed by package 4 (Tk. 13997/ha), package 3 (Tk.109878/ha) and package 2 (Tk. 92487/ha). But, the highest marginal benefit cost ratio (MBCR

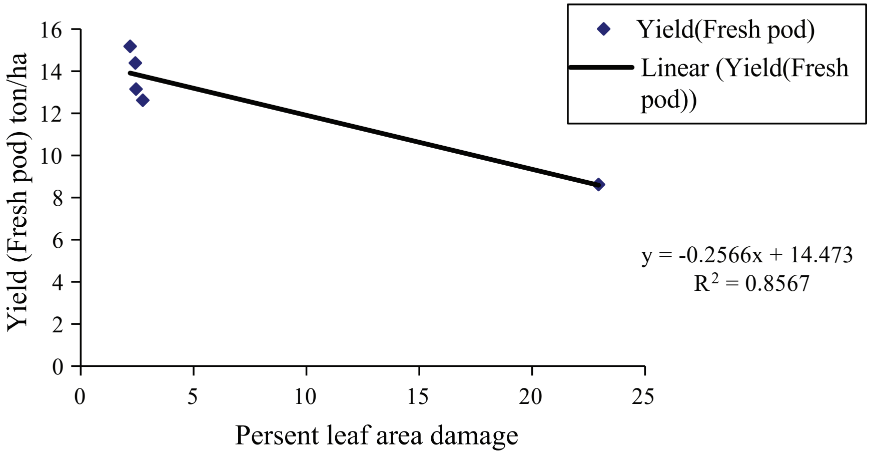

Fig. 3. Relationship between leaf area damage and yield of French bean during growing season 2018-2019

Table 5. Effect different IPM packages on net return and marginal benefit cost ratio in French bean yield as a fresh pod.

IPM packages	Yield (kg/ha) As a fresh pod	Addl. yield over control (kg/ha)	Addl. Income over control (Tk/ha)	Cost of insecticide appl. (Tk/ha)	Net return (Tk/ha)	Marginal benefit cost ratio
Package 1	15180.50 a	6553.50	163837.50	7440	156397.50	21.02
Package 2	12622.50 d	3995.50	99887.50	7400	92487.50	12.49
Package 3	13151.75 c	4524.75	113118.75	3240	109878.75	33.91
Package 4	14396.50 b	5769.5	144237.50	8240	135997.50	16.50
Untreated control	8627.00 e	-	-	-	-	-
Level of significance	**	-	-	-	-	-
CV (%)	1.03	-	-	-	-	-

Addl. = Additional, appl. = application ** Significant at p=0.01

Means within column followed by the same letter are not significantly different from one another by CD (critical difference) values. Values are average of three replications.

Package 1- Yellow sticky trap + Bio-neem Plus @ 1 ml/L of water

Package 2 - Yellow sticky trap + Nitro 505 EC @ 1 ml/ L of water

Package 3 - Bioneem Plus @ 1ml/ L of water + Nitro 505EC @ 1 ml/ L of water

Package 4 -Yellow sticky trap + Bioneem Plus @ 1ml/ L of water+ Nitro 505 EC @ 1 ml/ L of water

Untreated control

For calculating income and benefit the following market prices were used: French bean as vegetables =Tk. 25/ kg, Yellow sticky trap = Tk. 50/trap, Bioneem plus 1% EC = Tk. 210/100 ml, Nitro 505 EC = Tk. 200/100 ml, Labor wages for spraying pesticides =Tk. 400/day/labour (8 hours day).

33.91) was recorded from package 3 (Bio-neem plus + Nitro 505EC) treated plots followed by package 1 (MBCR 21.02), package 4 (MBCR 16.50) and package 2 (MBCR 12.49). This was mainly due to incurring costs of these treatments.

Considering the efficacy and benefit, spraying of Bioneem plus 1 EC is the most profitable insecticidal management approach against insect pests of French bean followed by Nitro 505 EC and yellow sticky trap. The efficacy of different treatments of this experiment are in conformity with the reports of Wambua (2004) and Pest Control Products Board (2014) where they reported that use of conventional insecticides is the most frequently used method to suppress insect pests of French beans in Kenya. Roy *et al.* (2014) conducted an experiment to study the efficacy of some insecticides against whitefly and aphid insect pests of French bean. They found that Chlorpyriphos 20 EC @ 3 ml/L of water performed best to suppress the whitefly and aphid of French bean followed by Foratap 50 SP @ 3g/l of water. The lowest number of whitefly plant^{-1} (3.28 at 60 DAS) and aphid plant^{-1} (4.82 at 60 DAS), the lowest infestation intensity by whitefly (5.92%) and aphid (14.25%), the lowest infested bean yield plant^{-1} (52.80 at 60 DAS), highest healthy bean yield plant^{-1} (166.40 g at 60 DAS), highest total healthy yield (11.28 t ha^{-1}), lowest total infested yield (0.64 t ha^{-1}) and highest gross return (Tk. 232000.00 ha^{-1}) were obtained from the use of Chlorpyriphos. They also reported that lowest infested fruits, highest total healthy fruit yield and highest gross return were obtained by the application of Chlorpyriphos. Sharmah and Rahman (2017) reported four IPM modules including the control treatment were tested against major insect and mite pests of French bean and out of which IPM module –I with seed treatment by Captan @ 3gm/kg seed, weeding frequency (3 times at 15 days interval), yellow sticky trap @ 20nos./ha, mechanical destruction(removing by hand picking and destroying them), intercrop with coriander (2:1 ratio), release of *C. transversalis* of aphid and TSSM was found to be most effective as compared to the other IPM modules tested. Chandrashekara *et al*. (2022) reported that among different insect pest management strategies under field conditions, cartap hydrochloride and batain seed extract registered low sucking bug (*Chauliops choprai*) population. Integrated approaches including bio-agents, botanicals along with chemicals for managing these diseases and insect-pests were found appropriate options.

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