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Infestation Status of Some Major Insect Pests of Soybean and Their Management

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The study was conducted to investigate the effective management of some major insect pests of soybean in the research field of Sher-e-Bangla Agricultural University, Dhaka during the period from December, 2020 to March 2021. The experiment was designed with Randomized Complete Block Design (RCBD) with three replications. During this experiment total six insecticides were tested viz., Lambda-Cyhalothrin @1ml/L of water Neemoil @1ml/L of water with 3g of detergent; Thiamethoxam @0.5g/L of water; Spinosad @0.5ml/L of water; Chlorantraniliprole @0.3ml/L of water; Emamectin Benzoate @1ml/L of water. Data on different pests populaton number and yield were collected and recorded. The lowest population per unit of whitefly and jassid was found in Emamectin Benzoate @1ml/L of water treated plots after consecutive three times application. Similarly, lowest unit of aphid was found in Chlorantraniliprole @0.3ml/L of water; treated plots. On the other hand, Thiamethoxam @0.5gl/L of water were found effective against whitefly, aphid, pod borer per plant, while the highest infestation was observed in control plots. The maximum yield was 1.68 t/ha, observed from Emamectin Benzoate @1ml/L of water, followed by (1.61 t/ha) Chlorantraniliprole @0.3ml/L of water Among the treatments, Emamectin Benzoate @1ml/L of water was more effective for the controlling of insect pests as well as yield of soybean.

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Keywords: Soybean; insecticide; yield; whitefly; aphid; pod borer; infestation.

1. INTRODUCTION

Soybean, *Glycine max* (L.) is one of the important oilseed cash crops of the world. It is the largest oilseed crop in the world accounting for more than 45% of the world oilseeds production. It ranks first in the world as edible oil. It is also used in manufacturing several antibiotics, varnishes, adhesives and lubricants and also valuable as protein supplement in human diet and animal feed (Alexander et al.1974). The processed soybean is the largest source of protein feed and second largest source of vegetable oil in the world. It has provided 40% protein, well balanced in essential amino acids; 20% oil, rich in polyunsaturated fats specially. Omega 6 and Omega 5 fatty acids; 6-7% total minerals; 5-6% crude fiber and 17-19% carbohydrates In Bangladesh, the present annual production of oilseed and edible oil stands about 373 thousand metric tons and 122 thousand metric tons, respectively. This can satisfy only about 20 percent of the present consumption at 2.9 g/day/head [1]. Therefore, 80 percent of the requirement of the country is being filled through import. Cultivation of soybean covered about 55,000 hectares of land and produced about 90,000 metric tons of seeds during the period 2009-2010 in Bangladesh [2]. About 380 species of insects have been reported on soybean crop from many parts of the world. About 65 insect species have been reported to attack soybean from cotyledon stage to harvesting stage [3]. Major insect pest in soybean of national importance are stem fly (*Melanagromyza sojae*), tobacco caterpillar (*Spodoptera litura*), green semiloopers (*Chrysodeixis acuta*), Mealy bug (*Pseudococcus sp.*), girdle beetle (*Obereopsis brevis* Gahan), pod borer (*Helicoverpa armigera*), white fly (*Bemisia tabaci*), leafhopper (*Empoasca kerri*), Aphid *(Aphis sp.)* and pod bug (*Riptortus pedestris*). The defoliators, *S. litura* and *C. acuta* are most damaging pest on soybean [4]. The full-grown caterpillars are most voracious feeders and cause extensive damage. Because of excessive and indiscriminate use of pesticide several problems like development of resistance in targeted species, resurgence of secondary pest, elimination of natural enemies and wild life [6-8]. One of the major problems to the successful oilseed production in Bangladesh is the pest infestation. Practical experiences demostrate that 15 - 20 percent of the total production is lost directly and indirectly by the attack of insect and mite every year. So, integrated management of pests of different oilseed crops is essential for reducing the loss caused by the attack of such pests [9,10]. Several insecticides present in the market to control pests of soybean, it is necessary to identify the best chemical to control the major insect pests of soybean at an affordable cost and also avoid pest resurgence [11,12]. Hence, this study was conducted for evaluating the effectiveness of six insecticides for the management of major insect pests of soybean crop. Besides, the current trends of modern society towards 'green consumerism' desiring fewer synthetic ingredients in food may favour plant-based products which are generally recognized as safe in eco-friendly management of plant pests as botanical pesticides [5].

2. MATERIALS AND METHODS

The experiment was carried out at the central farm of Sher-e-Bangla Agricultural University (SAU), Dhaka during the period from December 2020 to March 2021. The study was conducted with seven treatments with three (3) replications. The experiment was laid out in a Randomized Complete Block Design (RCBD). The field was divided into 3 equal sub-plots maintaining 3m x 2m plot size, 0.50 meter block to block distance. 0.75 meter plot to plot distance, where each block was used for each replication and each treatment was randomly assigned in each plot. Plant to plant distance was 20 cm and row to row distance was 30 cm. Each treatment was allocated randomly within the block and replicated three times. Urea, Triple super phosphate (TSP), Muriate of Potash (MP) and Gypsum,. Manures and fertilizers were used as a source of nitrogen, phosphorous, potassium and sulfur respectively with proper intercultural practices. The seven treatments for several soybean pests were, T_1- Lambda Cyhalothrin @ 1ml/L of water at the 15 days intervals;T_2- Neem oil @ 1ml/L of water with 3g of detergent at the 15 days intervals;T_3-Thiamethoxam @0.5g/L of water at the 15 days intervals; T_4- Spinosad @0.5 ml/L of water at the 15 days intervals,T_5-Chlorantraniliprole @0.3ml/L of water at the 15 days intervals;T_6 -Emamectin Benzoate 1ml/L of water at the 15 days intervals andT_7-Untreated Control The recorded data were Number of Whitefly after applying different treatments; Leaf infestation and reduction status of whitefly ;Number of Aphid after applying different treatments; Leaf infestation and reduction status

of aphid; Number of Pod borer after applying different treatments; Leaf infestation and reduction status of pod borer; Number of Jassid after applying different treatments; Leaf infestation and reduction status of jassid; Number of healthy leaves and plants; Number of pods per plant; Number of seeds per pod; Number of seeds per plant; Number of seed weight per plant; Yield per plot; Yield per hectare and Increase percentage of yield over control Statistical analysis of data was done with the help of computer software Statistics 10.

3. RESULTS AND DISCUSSION

The present research work was conducted to investigate the effective management of some major insect pests of soybean crop. The management of insect pests of soybean in the fields was evaluated on the basis of the relative efficacy of some insecticides on the mortality and growth inhibition of major insect pests such as whitefly, aphid, pod borer, jassid. Treatments were applied individually with different selected doses. Their effects were evaluated on different parameters viz. unit of pests per plot and yield after applying treatments. The result of different treatments of this experiment has been presented and discussed under the following sub-headings.

3.1 Incidence of Whitefly after Applying Treatments (1st, 2nd and 3rd Spray of Selected Insecticides)

From Table 1, before spray, the unit for whitefly per unit in T_1 plot was 2.18, after 1st spray it became 2.01, then a bit decreased after 2nd spray (1.65) and after 3rd sprays (1.55).

For T_2, the unit per unit was 3.03, which decrease after 1st spray (2.83), then a bit reduced after 2nd spray (2.55) and gradually decreased after 3rd spray (2.33), which showed reduction overall for T_2 treatment.

For T_3, the number of whitefly per unit was 1.92 before spray, then the number decreased slightly to 1.67 after 1st spray, the gradually decreased after 2nd (1.32) spray, then became 1.18 due to 3rd spray.

For T_4 treated plots, the unit per unit was 2.65, then the number decreased to 2.42 after 1st spray, then decreased after 2nd (2.35) spray and 3rd (2.13) spray.

In case of T_5, the population was 3.69. After 1st spray, it showed the unit 3.33. The number gradually decreased after 2nd (2.97) and 3rd (2.62) spray.

For T_6, the unit was 1.67 before. The unit of whitefly was 1.45, 1.26 and 1.05 for 1st, 2nd and 3rd application respectively. This treatment showed significant reduction for population.

For T_7, the unit was 4.13 after 1st, 2nd and 3rd spray; it became 4.39, 4.53 and 4.69 respectively from Table 1.

Number of whitefly per unit was recorded and statistically significant variations were observed among the treatments applied for controlling major insect pests of soybean. Results showed that after 1st, 2nd,3rd spray, the lowest number of whitefly was recorded in T_6 treated plot, which was statistically similar with T_3 treatment; whereas the highest number was recorded in T_7 treatment and which was closely followed by T_5.

As a result, the order of rank of study the effect of different management on the incidence of major insect pest of soybean by number was T_6> T_3> T_1> T_4 > T_2> T_5> T_7. So, T_6-Emamectin Benzoate 1ml/L of water was considered best.

3.2 Leaf Infestation Status and Reduction over Control Percentage of Whitefly

A significant variation was also observed due to the effect of different chemicals and botanical management of insect pests on soybean plant in respect of number of whitefly per plant unit. The minimum infestation percentage was found at T_6 treated pot (9.6%), where the reduction over control percentage (61.6 %) was found the highest also. On the other hand, the maximum infestation percentage was recorded from control treatment (T_7) and the lowest % of reduction over control (40.76%) was observed in T_1 treated plot (Fig. 1).

3.3 Incidence of Aphid after Applying Treatments

From Table 2, in context of aphid, after 1st spray, the lowest number of aphid unit was recorded in T_5 (1.60) treated plot and closely followed by T_3 (1.93), T_1 (2.01), T_4 (2.57) T_6 (2.65), T_2 (2.73) treatments; whereas the highest number was recorded in T_7 (3.74). In this case, T_3 (1.93) was statistically similar with T_1 (2.01) treatment.

Table 1. Incidence of whitefly after applying treatments at the different spray times

Treatment	No. of whitefly per unit			
	Before spray	After 1st spray	After 2nd spray	After 3rd spray
T_1	2.18	2.01 de	1.65 cd	1.55 cd
T_2	3.03	2.83 c	2.55 b	2.33 bc
T_3	1.92	1.67 e	1.32 d	1.18 d
T_4	2.65	2.42 cd	2.35 bc	2.13 bc
T_5	3.69	3.33 b	2.97 b	2.62 b
T_6	1.67	1.45 e	1.26 d	1.05 d
T_7	4.13	4.39 a	4.53 a	4.69 a
CV	18.74	11.37	8.42	12.73
LSD (0.05)	-	0.48	0.79	0.92

In column, means containing same letter(s) indicate significantly similar under LSD at 5% level of significance. Values are the means of three replications

T_1- Lambda Cyhalothrin @ 1ml/L of water at the 15 days intervals; T_2- Neem oil @ 1ml/L of water with 3g of detergent at the 15 days intervals; T_3-Thiamethoxam @0.5g/L of water at the 15 days intervals; T_4- Spinosad @0.5 ml/L of water at the 15 days intervals; T_5- Chlorantraniliprole @0.3ml/L of water at the 15 days intervals; T_6- Emamectin Benzoate 1ml/L of water at the 15 days intervals and T_7-Untreated Control

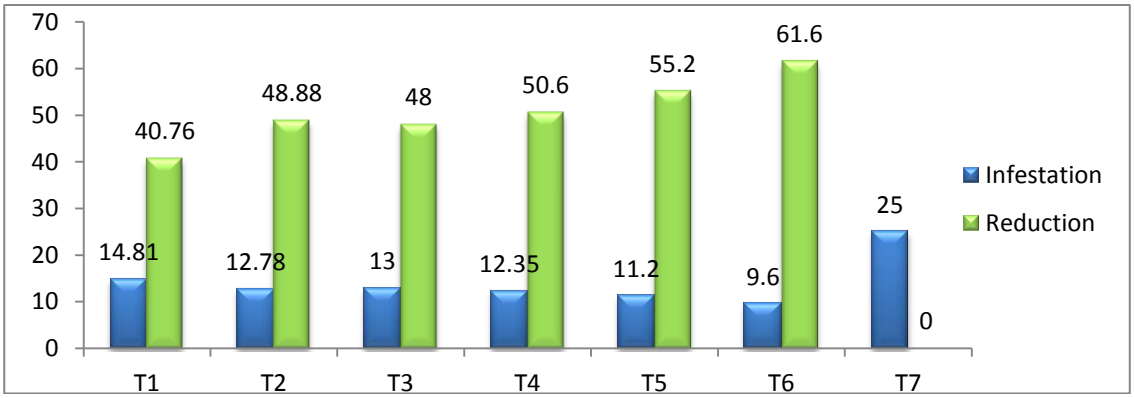

Fig. 1. Effect of different management practices on the leaf infestation and reduction over control percentage of whitefly

In case of 2nd spray, the unit per unit was lowest in T_5 (1.45) treated plot, which was statistically similar with T_3 (1.68) and T_1 (1.78) treatments. The highest unit was in T_7 (3.98) and closely followed by T_2 (2.58) treatment.

After final spray, the lowest population per unit was found in the plot treated with T_5 (1.34), which was statistically similar with T_3 treatment and the unit was 1.49; whereas the highest number was recorded in T_7 (4.03) treatment and closely followed by T_2 (2.41) treatment.

Before spray, the unit for T_1 plot was 2.19, which reduced after 1st spray (2.01) and decreased after 2nd spray (1.78) and 3rd spray (1.57).

For T_2, the unit was 3.12, which increase after 1st spray (2.73), then reduced after 2nd spray (2.58) and gradually decreased after 3rd spray (2.41), which showed reduction overall for T_2 treatment.

For T_3, the number of aphid was 2.18 before spray, then the number decreased slightly to 1.93 after 1st spray, the gradually decreased after 2nd (1.68) spray and 3rd spray. (1.49)

For T_4 treated plots, the unit was 2.73 before. The unit of aphid was 2.57, 2.38 and 2.14 for 1st, 2nd and 3rd application respectively.

In case of T_5, the unit was 1.85, then the number decreased to 1.60 after 1st spray, then also decreased after 2nd (1.45) spray and 3rd (1.34) spray.

For T_6, the population was 2.97. After 1st spray, unit was 2.65. The number gradually decreased after 2nd (2.43) and 3rd (2.27) spray.

For T_7, the unit was 3.45. After 1st, 2nd and 3rd spray, it became 3.74, 3.98 and 4.03 respectively in Table 2.

As a result, the order of rank of study the effect of different management on the incidence of major insect pest of soybean by number was T_5> T_3> T_1> T_4 > T_6> T_2> T_7.

3.4 Leaf Infestation Status and Reduction over Control Percentage of Aphid

A significant variation was also observed due to the effect of different chemicals and botanical management of pest on soybean plant in respect of number of aphid per leaf. The minimum infestation percentage was found at T_5 treated pot (9.7%), where the reduction over control percentage (65.35 %) was found the highest also. On the other hand, the maximum infestation percentage (28%) was recorded from control treatment (T_7) and the lowest % of reduction over control (50 %) was observed in T_2 treated plot (Fig. 2).

3.5 Incidence of Jassid after Applying Treatments at the Different Spray Times

From Table 3, the results of treatments showed that after 1st spray, the lowest number of jassid was recorded in T_6 (1.46) treated plot, which was statistically similar with T_1 (1.57). The highest number was recorded in T_7 (3.34) treatment and closely followed by T_5 (2.62).

Table 2. Incidence of aphid after applying treatments at the different spray times

Treatment	No. of aphid per unit			
	Before spray	After 1st spray	After2nd spray	After 3rd spray
T_1	2.19	2.01 c	1.78 c	1.57 c
T_2	3.12	2.73 b	2.58 b	2.41 b
T_3	2.18	1.93 c	1.68 c	1.49 d
T_4	2.73	2.57 b	2.38 b	2.14 bc
T_5	1.85	1.60 d	1.45 c	1.34 d
T_6	2.97	2.65 b	2.43 b	2.27 b
T_7	3.45	3.74 a	3.98 a	4.03 a
CV	13.45	11.53	12.96	11.82
LSD (0.05)	-	0.32	0.45	0.63

In column, means containing same letter indicate significantly similar under LSD at 5% level of significance. Values are the means of three replications

T_1- Lambda Cyhalothrin @ 1ml/L of water at the 15 days intervals; T_2- Neem oil @ 1ml/L of water with 3g of detergent at the 15 days intervals; T_3-Thiamethoxam @0.5g/L of water at the 15 days intervals; T_4- Spinosad @0.5 ml/L of water at the 15 days intervals; T_5- Chlorantraniliprole @0.3ml/L of water at the 15 days intervals; T_6- Emamectin Benzoate 1ml/L of water at the 15 days intervals and T_7-Untreated Control

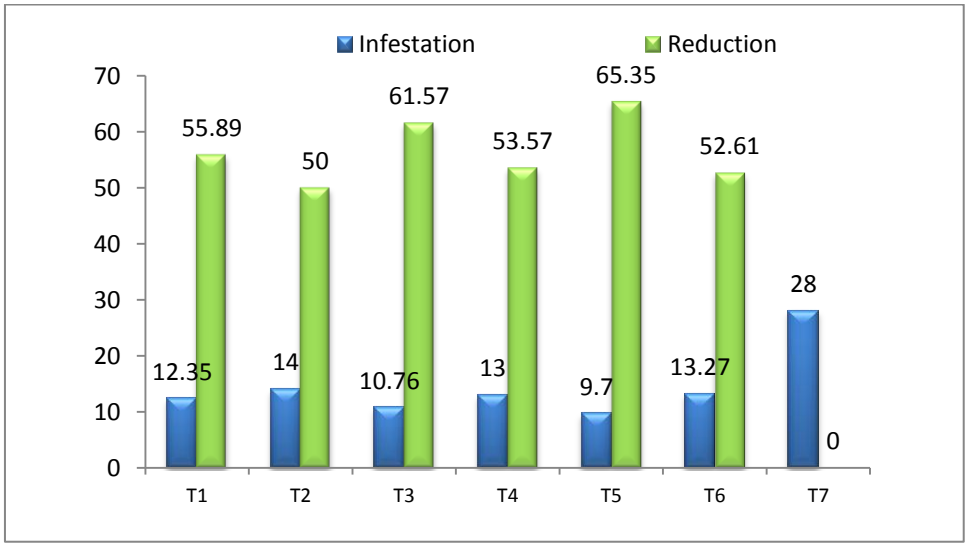

Fig. 2. Effect of different management practices on the leaf infestation and reduction over control percentage of aphid

In case of 2nd spray, the unit was lowest in T_6 (1.33) treated plot and closely followed by T_1 (1.35), T_3 (1.58), T_2 (1.74), T_4 (2.09) and T_5 (2.35) treatments. The highest unit was in T_7 (3.67). Here, T_1 (1.35) and T_3 (1.58) both were statistically similar.

After final spray, the lowest population was found in the plot treated with T_6 treatment and the unit was 1.10 and closely followed by T_1 (1.26), T_3 (1.37), T_2 (1.67), T_4 (1.89) and T_5 (2.07). The highest number was recorded in T_7 (3.79) treatment.

Before spray, the unit for T_1 plot was 1.87, which decreased after 1st spray (1.57), a bit fell after 2nd spray (1.35) and 3rd spray (1.26).

For T_2, the unit was 2.29, which increase after 1st spray (2.11), then reduced after 2nd spray (1.74) and gradually decreased after 3rd spray (1.67).

For T_3, the number of jassid was 2.06 before spray, then the number decreased slightly to 1.89 after 1st spray, the gradually decreased after 2nd (1.58) spray and 3rd spray (1.37).

For T_4 treated plots, the unit was 2.48, then the number decreased to 2.26 after 1st spray, then increased after 2nd (2.09) spray and decreased drastically after 3rd (1.89) spray.

In case of T_5, the population was 2.97. After 1st spray, it showed reduction of unit 2.62. The number decreased after 2nd (2.35) and 3rd (2.07) spray.

For T_6, the unit was 1.82 before. The unit of jassid was 1.46, 1.33 and 1.10 for 1st, 2nd and 3rd application respectively.

For T_7, the unit was 3.19. After 1st, 2nd and 3rd spray, it became 3.34, 3.67 and 3.79 respectively in Table 3.

As a result, the order of rank of study the effect of different management on the incidence of major insect pest of soybean by number was T_6> T_3> T_1> T_2 > T_4> T_5> T_7.

3.6 Leaf Infestation Status and Reduction over Control Percentage of Jassid

A significant variation was also observed due to the effect of different chemicals and botanical management of pest on soybean plant in respect of number of whitefly per leaf. The minimum infestation percentage was found at T_6 treated pot (9.9 %), where the reduction over control percentage (65.35 %) was found the highest also. On the other hand, the maximum infestation percentage was recorded from control treatment (T_7) and the lowest % of reduction over control (50 %) was observed in T_6 treated plot (Fig. 3).

3.7 Incidence of Pod Borer after Applying Treatments

From Table 4, Considering pod borer, before and after 1st spray, there was no sign of this pest, as it is only available in the reproductive stage.

Table 3. Incidence of Jassid after applying treatments at the different spray times

Treatment	No. of jassid per unit			
	Before spray	After 1st spray	After 2nd spray	After 3rd spray
T_1	1.87	1.57 d	1.35 de	1.26 de
T_2	2.29	2.11 bcd	1.74 cd	1.67 c
T_3	2.06	1.89 cd	1.58 de	1.37 d
T_4	2.48	2.26 bc	2.09 bc	1.89 bc
T_5	2.97	2.62 b	2.35 b	2.07 b
T_6	1.82	1.46 d	1.33 e	1.10 e
T_7	3.19	3.34 a	3.67 a	3.79 a
CV	13.63	7.55	8.34	6.46
LSD (0.05)	-	0.68	0.39	0.24

In column, means containing same letter(s) indicate significantly similar under LSD at 5% level of significance. Values are the means of three replications

T_1- Lambda Cyhalothrin @ 1ml/L of water at the 15 days intervals; T_2- Neem oil @ 1ml/L of water with 3g of detergent at the 15 days intervals;T_3-Thiamethoxam @0.5g/L of water at the 15 days intervals; T_4- Spinosad @0.5 ml/L of water at the 15 days intervals; T_5- Chlorantraniliprole @0.3ml/L of water at the 15 days intervals; T_6- Emamectin Benzoate 1ml/L of water at the 15 days intervals and T_7-Untreated Control

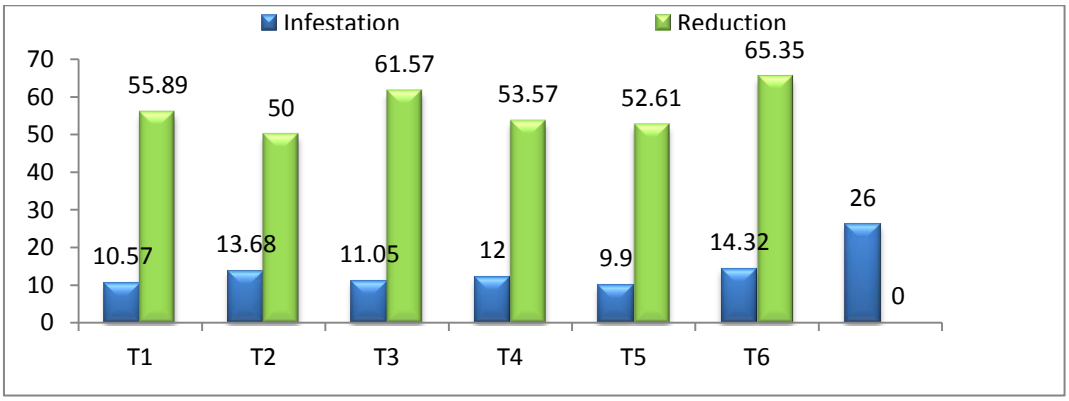

Fig. 3. Effect of different management practices on the leaf infestation and reduction over control percentage of jassid

In case of 2nd spray, the unit was lowest in T_1 (1.19) treated plot, which was statistically similar with T_4 (1.42) treatment. The highest unit was in T_7 (2.19) and closely followed by T_6 (2.04) treatment.

After final spray, the lowest population was found in the plot treated with T_1 (0.78), which was statistically similar with T_4 (0.92) treatment. The highest unit was in T_7 (1.64), which was statistically similar with T_6 (1.56) treatment.

As a result, the order of rank of study the effect of different management on the incidence of major insect pest of soybean by number was T_4> T_1> T_3> T_5 > T_2> T_6> T_7.

3.7.1 Pod infestation status and reduction over control percentage of pod borer

A significant variation was also observed due to the effect of different chemicals and botanical management of pest on soybean plant in respect of number of Pod borer/Plant. The minimum infestation percentage was found at T_1 treated pot (10.62%), where the reduction over control percentage (55.75%) was found the highest. On the other hand, the maximum infestation percentage was recorded from control treatment (T_7) and the lowest % of reduction over control (47.75 %) was observed in T_6 treated plot (Fig. 4).

3.8 Effect of Different Spray Times of Selected Insecticides on Healthy and Infested Leaves/Plant, % of Infestation Due to Insect Pests of Soybean

From Table 5, results showed that the highest percentage of leaves per plants infestation was recorded in T_7 (83.9) treated plot and closely followed by T_2 (25.18), T_1 (22.52), T_3 (18.39), T_4 (17.97) and T_5 (9.05) treatments, whereas the lowest number was recorded in T_6 (6.83) treatment. The percent reduction over control was maximum in T_6 (91.86 %) and minimum in case of T_1 (68.28%).

3.9 Effect of Different Spray Times of Selected Insecticides on Healthy and Infested Plants/ Plot, % of Infestation Due to Insect Pests of Soybean

Results showed that the highest percentage of plants infestation per plot was recorded in T_7 (75.39) treated plot, which was statistically similar with T_2 (49.94); whereas the lowest number was recorded in T_6 (23.07) treatment and closely followed by T_4 (33.64) treatments. The percent reduction over control was maximum in T_6 (69.40 %) and minimum in case of T_2 (33.76 %) from Table 6.

3.10 Effect of Treatments on Soybean Yield after Applying Treatments at the Different Spray Times (1st, 2nd and 3rd Spray of Selected Insecticides)

In Table 7, results showed that the highest number of pod per plant (39.41) was recorded in T_6 treated plot, which was statistically similar with T_5 (37.33). On the other hand, the lowest number was recorded in T_7 (29.81) treatment and closely followed by T_2 (31.43).The highest number of seed per pod (3.00) was recorded in T_6 treated plot, whereas the lowest number was recorded in T_7 (2.7) treatment. The highest number of seed per plant (118.23) was recorded in T_6 treated plot, whereas the lowest number was recorded in T_7 (80.49) treatment.The highest number of seed weight per plant (15.42) was recorded in T_6 treated plot, whereas the lowest number was recorded in T_7 (9.06) treatment.

3.10.1 Yield of soybean per plot

Yield of soybean per hectare was significantly affected by the application of different insecticide. As a result Emamectin Benzoate @1ml/L of water showed the highest yield (1.01 kg/plot). On the other hand, the lowest yield (0.53 kg/plot) was found control treatment (Fig. 5). From the above results, it was found that the among all applied insecticide treatments in this study, Emamectin Benzoate @1ml/L of water showed the better performance in reducing the pest as well as on increasing yield of soybean.

3.10.2 Yield of soybean per hectare

Yield of soybean per hectare was significantly affected by the application of different insecticide. As a result Emamectin Benzoate @1ml/L of water showed the highest yield (1.68 t/ha). On the other hand, the lowest yield (0.88 t/ha) was found control treatment (Fig. 6). From the above results, it was found that the among all applied insecticide treatments in this study, Emamectin Benzoate @1ml/L of water showed the better performance in reducing the pest as well as on increasing yield of soybean.

3.10.3 Correlation between yield (ton/ha) and % Infestation due to insect pests of soybean

Correlation study was done to establish the relationship between percent of plant infestation/treated plot and healthy fruit yield (ton/ha) among different management practices. From the Fig. 7, it was revealed that positive correlation was observed between the parameters. It was evident that the equation y = --0.015x + 2.036 gave a good fit to the data and the co-efficient of determination (r^2 = 0.829) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the healthy fruit yield was strongly as well as negatively correlated with percent of plant infestation/treated plot. Fruit yield (ton/ha) was decreased due to increase of the percent of plant infestation/treated plot.

3.10.4 Correlation between yield (ton/ha) and % Increase over control due to insect pests of soybean

Correlation study was done to establish the relationship between percent (%) increase yield over control of soybean /treated plot and healthy fruit yield (ton/ha) among different management practices. From the Figure 8, it was revealed that positive correlation was observed between the parameters. It was evident that the equation y = 0.009x + 0.839 gave a good fit to the data and the co-efficient of determination (r^2 = 0.945)) fitted regression line had a significant regression co-efficient. It may be concluded from the figure that the healthy fruit yield was strongly as well as positively correlated with percent (%) increase yield over control of soybean /treated plot. Fruit yield (ton/ha) was decreased due to increase of the percent of plant infestation/treated plot.

Considering the results of the experiments the efficacy of different treatments for the management of major insect pests in soybean as controlling components were in order as:

Emamectin Benzoate 1ml/L of water > Chlorantraniliprole @0.3ml/L of water > -Spinosad @0.5 ml/L of water **>** Lambda Cyhalothrin @ 1ml/L of water **>** Thiamethoxam @0.5g/L of water **>** Neem oil @ 1ml/L of water

Table 4. Effect of define treatments on the number of Pod borer, number of healthy and infested pods/Plant due to pod borer of soybean

Treatment	No. of pod borer per unit				
	60 DAS	75 DAS	Mean	No. of healthy pods/Plants	No. of infested pods/Plant
T_1	1.42 c	0.92 c	1.17 d	30.19 c	3.2 d
T_2	1.89ab	1.31 b	1.6 bc	26.32 d	5.11 b
T_3	1.72 b	1.17 b	1.45c	31.15 c	4.17 c
T_4	1.19 c	0.78 c	0.99 e	32.75 b	2.15 e
T_5	1.78ab	1.15 b	1.47 c	33.05 b	4.28 c
T_6	2.04 a	1.56 a	1.8 ab	34.28 a	5.13 b
T_7	2.19 a	1.64 a	1.92 a	23.47 d	6.34 a
CV	0.32	0.13	0.16	1.18	0.69
LSD	8.14	5.18	5.34	12.72	8.45

In column, means containing same letter indicate significantly similar under LSD at 5% level of significance. Values are the means of three replications

T_1- Lambda Cyhalothrin @ 1ml/L of water at the 15 days intervals; T_2- Neem oil @ 1ml/L of water with 3g of detergent at the 15 days intervals;T_3-Thiamethoxam @0.5g/L of water at the 15 days intervals; T_4- Spinosad @0.5 ml/L of water at the 15 days intervals; T_5- Chlorantraniliprole @0.3ml/L of water at the 15 days intervals; T_6-Emamectin Benzoate 1ml/L of water at the 15 days intervals and T_7-Untreated Control

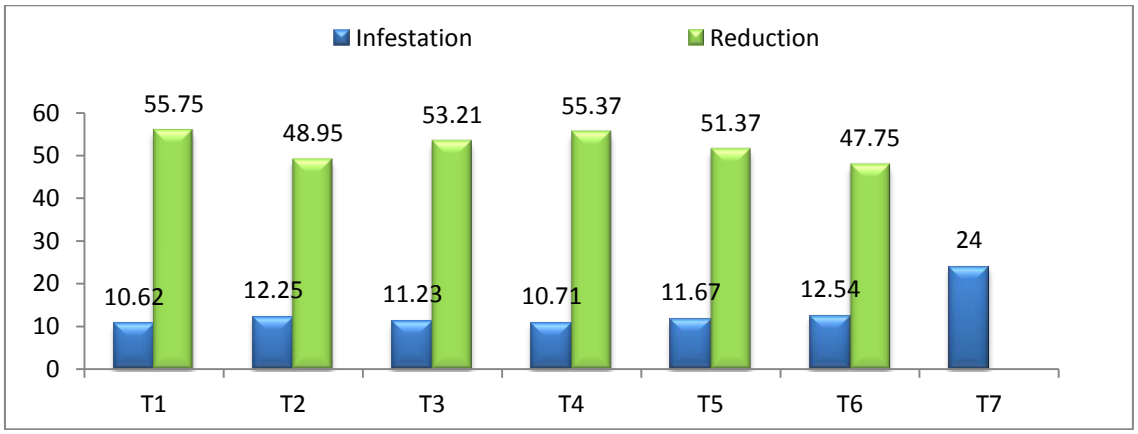

Fig. 4. Effect of different management practices on the pod infestation and reduction over control percentage of pod borer

Table 5. Effect of different spray times of selected insecticides on healthy and infested leaves/plant, % of Infestation due to insect pests of soybean

Treatment (s)	Healthy leaves	Infested leaves	%Leaf infestation	%Reduction over control
T_1	21.67 d	4.8ab	22.52 c	73.16
T_2	21.33cd	5.37 a	25.18 b	69.99
T_3	23.3 bc	4.29 b	18.39 d	78.08
T_4	24.15 a	4.34 b	17.97 d	78.58
T_5	25.42ab	2.30 c	9.05 e	89.21
T_6	27.07 a	1.85 c	6.83 f	91.86
T_7	13.56 d	11.3 a	83.9 a	--
LSD (0.05)	2.45	0.78	0.83	
CV	12.61	11.11	1.27	

In column, means containing same letter(s) indicate significantly similar under LSD at 5% level of significance. Values are the means of three replications

T1- Lambda Cyhalothrin @ 1ml/L of water at the 15 days intervals; T2- Neem oil @ 1ml/L of water with 3g of detergent at the 15 days intervals;T3-Thiamethoxam @0.5g/L of water at the 15 days intervals; T4- Spinosad @0.5 ml/L of water at the 15 days intervals; T5- Chlorantraniliprole @0.3ml/L of water at the 15 days intervals; T6-Emamectin Benzoate 1ml/L of water at the 15 days intervals and T7-Untreated Control

Table 6. Effect of different spray times of selected insecticides on healthy and infested plants/plot, % of Infestation due to insect pests of soybean

Treatment (s)	Healthy plants	Infested plants	Plant infestation	%Reduction over control
T_1	19.19 b	7.44ab	38.77 cd	48.57
T_2	16.28 d	8.13ab	49.94 b	33.76
T_3	18.60 c	7.78abc	41.88 bc	44.52
T_4	19.50 a	6.56 a	33.64 d	55.38
T_5	20.62 bc	5.87abc	28.47 d	62.24
T_6	22.84 b	5.27 bc	23.07 d	69.40
T_7	13.41 e	10.11 c	75.39 a	-
LSD (0.05)	1.47	0.98	8.11	-
CV	9.14	7.86	13.64	-

In column, means containing same letter(s) indicate significantly similar under LSD at 5% level of significance. Values are the means of three replications

T_1- Lambda Cyhalothrin @ 1ml/L of water at the 15 days intervals; T_2- Neem oil @ 1ml/L of water with 3g of detergent at the 15 days intervals; T_3-Thiamethoxam @0.5g/L of water at the 15 days intervals; T_4- Spinosad @0.5 ml/L of water at the 15 days intervals; T_5- Chlorantraniliprole @0.3ml/L of water at the 15 days intervals; T_6- Emamectin Benzoate 1ml/L of water at the 15 days intervals and T_7-Untreated Control

Table 7. Effect of different spray times of selected insecticides on yield attributes and yield of Soybean

Treatment	Pod/ Plant	No. of seed / pod	No. seeds /plant	Wt. of seeds/ plant	Wt. of 100 seeds (g)
T_1	33.39 cd	3.0 a	100.17 c	12.25 d	12.23 b
T_2	31.43 d	2.9 a	91.15 d	10.72 e	11. 76 c
T_3	35.32 abc	2.8 a	98.90 c	12.20 d	12.34 b
T_4	34.9bcd	2.9 a	101.21 c	12.91 c	12. 76 a
T_5	37.33 a	3.0 a	111.99 b	14.35 b	12. 82 a
T_6	39.41 a	3.0 a	118.23 a	15.42 a	13. 04 a
T_7	29.81 e	2.7 b	80.49 e	9.06 f	11.26 d
Lsd	5.47	0.26	3.39	0.45	0.38
CV	8.88	6.94	11.41	6.01	3.89

In column, means containing same letter indicate significantly similar under [In column, means containing same letter(s) indicate significantly similar under LSD at 5% level of significance. Values are the means of three replications

T_1- Lambda Cyhalothrin @ 1ml/L of water at the 15 days intervals; T_2- Neem oil @ 1ml/L of water with 3g of detergent at the 15 days intervals;T_3-Thiamethoxam @0.5g/L of water at the 15 days intervals; T_4- Spinosad @0.5 ml/L of water at the 15 days intervals; T_5- Chlorantraniliprole @0.3ml/L of water at the 15 days intervals; T_6- Emamectin Benzoate 1ml/L of water at the 15 days intervals and T_7-Untreated Control

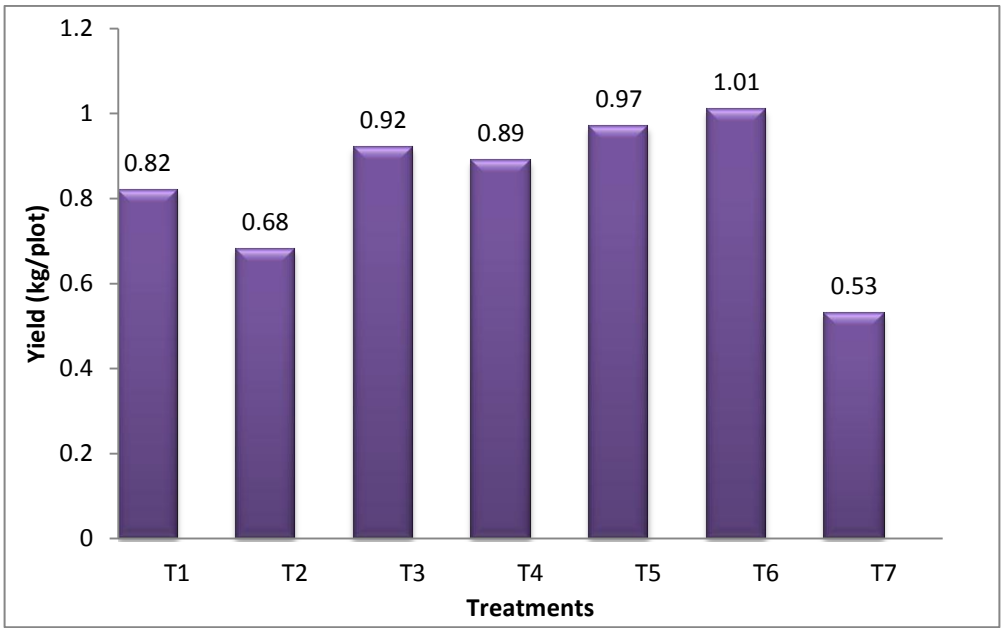

Fig. 5. Effect of different management practices on the yield (kg/plot) of soybean

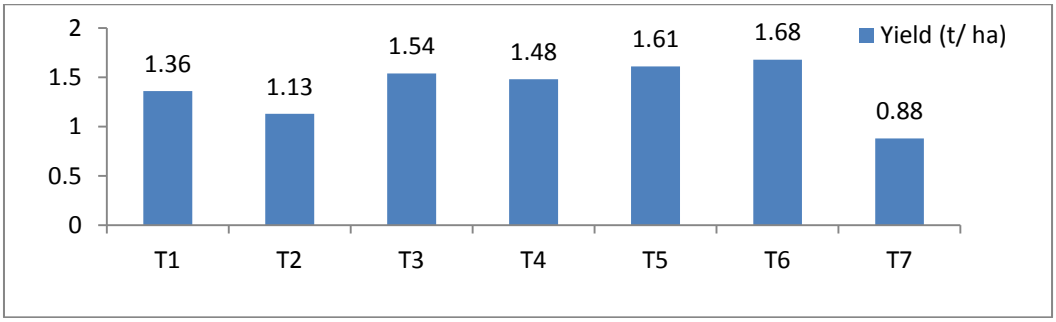

Fig. 6. Effect of different management practices on the yield (t/ ha) of soybean

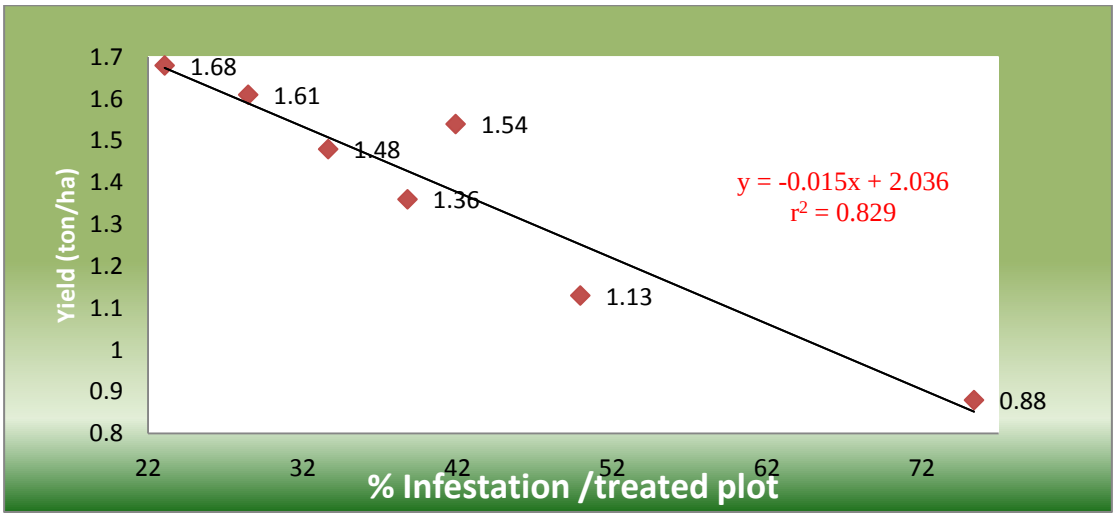

Fig. 7. Effect of different management practices on the correlation between yield and infestation of soybean

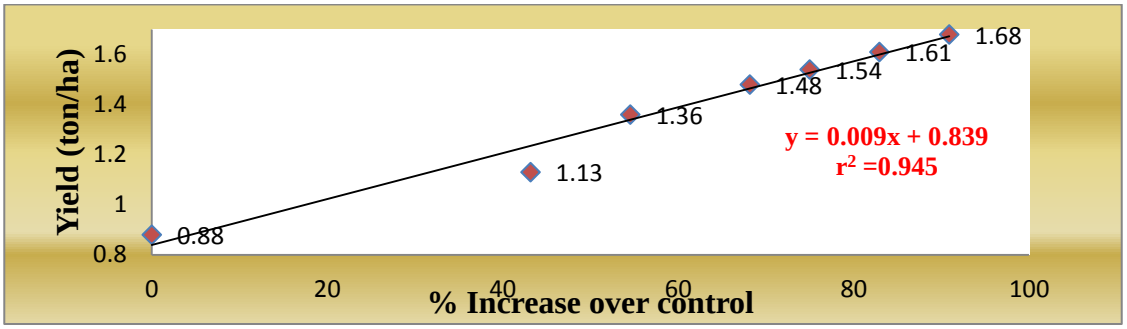

Fig. 8. Effect of different management practices on the correlation between yield and % increase yield over control of soybean

The effectiveness of different treatments obtained in the present investigation is in agreement with the results obtained by Venkataiah (2020), Wadnekar (2004), Joshi (2010), Patil (2015) and Thanushya (2011). According to Venkataiah et al. (2020) the chemical insecticide Emamectin benzoate 5% SG@ 0.5 g/l found effective in controlling population, to reduce leaf damage and pod infestation also produce the maximum grain yield. Wadnekar et al. (2004) reported that, unit of aphid (0.4, 0.83 and 1.17aphids/leaf after 2, 7 and 14 DAS, respectively) was found to be significantly low in thiamethoxam 25 WG @ 150 g a.i/ha. Emamectin benzoate @ 5 gm/10 litre were most effective for the control of jassid (Joshi et al. 2010). Lambda cyhalothrin and spinosad both are considered effective (Thanushya *et al.* 2011). Patil et al. (2015) also found that emamectin benzoate 1.9 EC at the rate of 200 ml per ha and indoxacarb 14.5 SC at the rate of 500 ml per ha obtained higher yield of soybean.

In the present study, the results obtained are very encouraging and there is a great potential for the use of emamectin benzoate 1ml/L of water as a toxic agent in soybean pests management systems in our country, although, the result obtained in this study may differed from those of the other workers.

4. CONCLUSION

The incidence of whitefly was found lowest in T_6 treated plot, which was statistically identical with T_3 treatment after different spray times. Besides, the infestation status and reduction control were also recorded most effective for T_6 treatment.

In context of aphid, after different spray times, the lowest number of aphid was recorded in T_5 treated plot, which was statistically identical with T_3 treatment. I also found that, the infestation status and reduction control were also recorded most effective for T_5 treatment. Considering the

incidence of pod borer was found lowest in T_4 treated plot, which was statistically identical with T_1 treatment after different spray times. Besides, the infestation status and reduction control were also recorded most effective for T_4 treatment. Now, the lowest jassid population was recorded in T_6 and T_1 after different spray times. Besides, the infestation status and reduction control were also recorded most effective for T_6 treatment. The minimum percent of both leaf and plant infestation were recorded in T_6 treated plots. In case of pod number, the highest number and lowest number was recorded in T_6 and T_7

Similarly, the maximum and minimum number of yield was recorded in T_6 (1.01 kg/ plot and 1.68 t/ha) and T_7 (0.53 kg/plot and 0.88 t/ha) respectively. Finally, the highest percentage of yield increase over control was found in T_6 (90.91 %) than other treatments.

From the study of the following conclusions may be drawn that, among the treatments, T_6 (Emamectin Benzoate @1ml/L of water) was more effective for the controlling of whitefly, Jassid as well as low infestation, highest pod number, seed number and yield of Soybean. On the other hand, the T_3 (Thiamethoxam @0.5g/L of water) treatment was effective for reducing the population of whitefly and aphid. Lastly, the T_1 (Lambda-Cyhalothrin @1ml/L of water) treatment was suitable for only pod borer.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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