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Evaluation of Poison Baits and *Bacillus thuringiensis* var. *kurstaki* Against *Spodoptera litura* in Tomato

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Abstract

Spodoptera is a polyphagous and most destructive pest of most of crops including tomato. The bioefficacy of poison baits with Methomyl and *Bt* formulations was observed along with male flight activity of the tobacco caterpillar in tomato open field crops. The study was conducted in three villages of Chamba district viz. Sahu, Bhanauta and Kiri during 2019-2020. Tomato is one of the important cash crops in many parts of district Chamba and a source of livelihood of small and marginal farmers of the district. It is cultivated in an area of about 294 hectares with the annual production of 11,410 MT. Tobacco caterpillar, *Spodoptera litura* (Fab.) (Lepidoptera: Noctuidae) is a polyphagous and sporadic pest and is nocturnal pest in nature. The bioefficacy results revealed that the % mortality of baits with insecticide (ranging from 10.24% to 83.24%), baits with *BT* formulation (15.64% to 81.06%) and spray of *Bt* formulations (14.10% to 85.60%) in fields did not differ significantly at the respective days. It was also observed that the peak activity was observed in the months of June and July (maximum 20 adult trapped trap^{-1}) and hence capturing the male adults this time resulted in fewer larval population of the insect-pest. Thus, these practices could be included in IPM of the insect pest and confirmed the importance of eco-friendly methods against lepidopteron species.

Keywords: Adult traps, bio-efficacy, *Bt* formulations, poison bait, tobacco caterpillar, tomato

1. Introduction

Spodoptera litura (Fab.) (Lepidoptera: Noctuidae), commonly known as tobacco caterpillar is a polyphagous pest of many economically important crops such as cotton, groundnut, soybean tomato, sweet potato etc. (Senrung et al., 2014). It is a major pest of many crops because of its polyphagous feeding habit, high reproductive potential, overlapping generations, year round availability of host plants, ability of adults to migrate over long distances and frequent control failures with most of the commonly used insecticides (Muddassar et al., 2017). It is a nocturnal pest and can completely wither away the leaves from the plant. Furthermore, its broad host range also includes many vegetable crops such as tomato, *Solanum lycopersicum* L. (Solanaceae), which are often consumed fresh (Sobhy et al., 2015). These pests affect the crop yield and quality of fruits thereby reducing its market value (Mahapatra et al., 2018a). It is a most devastating pest of cotton, groundnut, chillies, tobacco, castor, lady finger, pulses and many vegetables (Armes et al., 1997; Kranthi et al., 2002). Out of 112 globally recorded host plants of *S. litura* (Moussa et al., 1960 and CABI, 2014), 60 are known only from India (Garad et al., 1984).

India is the third largest producer of tomato in the world after USA and China. Tomato is one of the most important protective food crops of India having an area of 880 thousand hectares with an annual production to the tune of 18227 thousand metric tonnes, contributing to 9.4% of total vegetable area and 11.5% of total vegetable production (Mahapatra et al., 2018b). Tomato is one of the important cash crop in many parts of district Chamba and a source of livelihood of small and marginal farmers of the district. It is cultivated in an area of about 294 hectares with the annual production of 11,410 MT. Insect pest act as a limiting factor in harvesting high yields of healthy and quality tomato fruits. Because of its fleshy nature about sixteen insects and other pest species cause damage to the tomato crop in India resulting in use of large volume of pesticides which leave their toxic residues (Bhutani, 1977).

The pressing global food crisis boosts the necessity for novel strategies to drastically increase crop productivity (Godfray et al., 2010). Effective management of insect pests should be part of such strategies as these pests cause enormous losses to crops (Bruce, 2010). Currently, chemical pesticides are being used to control this pest; however, they are not ideal because they cause environmental pollution (Gui-lan et al., 2002). Therefore, it is necessary to use methods that will not pollute the environment (Da-yong and Yong-man, 2010; Da-yong et al., 2012). Effective management of *S. litura* using poison bait consisting of rice bran, jaggery and monocrotophos was reported in groundnut and potato (Basavaraju et al., 2010). The use of pheromone traps for mass trapping has routinely lowered the *Bacillus thuringiensis* applications by 30-70%, which was otherwise required to maintain larval population at economically acceptable levels. While pheromone lures for *S. sunia* consistently gave high performance under field conditions, lures for *S. frugiperda* gave erratic field results (Dunkelblum et al., 1995).

2. Materials and Methods

2.1. Layout of trial

The trials were conducted during 2019-2020. Three villages of Chamba district viz. Kiri, Sahu and Bhanauta were selected for conducting the trials. Farmers of these villages were growing tomato in open fields. The mean annual rainfall of the study area was 1000 to 1200 mm. The mean annual temperature lied between 14.2-22.1 °C. The agro climatic zone was sub temperate, sub humid, mid hills and cereals, pulses, fruits and vegetables based cropping systems were predominant in this zone (Table 1). The varieties or hybrids grown in these villages and other crop plantation details are mentioned in Table 2. The seeds were sown in late March and/or early April. The flowering started in the month of Late May and early June and farmers took several harvests till the month of August or in some parts the crop was harvested till late November.

2.2. Preparation of poison baits

Baiting is a technique that comprises an attractive food along with an insecticide to lure insect pests. Baiting tends to be more selective and less environmentally disruptive than conventional pesticide applications. Poison bait was made with these ingredients - 1 kg rice or wheat flour (as per farmers availability) + 1.2 kg jaggery + Methomyl 40SP or *Bt* formulation.

For the preparation of these baits 100 g of jaggery was

Table 1: Agro-climatic details of three villages of Chamba district selected for the study

Sl. No.	Name of village	Agro-climatic zone	Altitude (amsl)	Latitude longitude	Cropping system
1.	Bhanauta	Sub tropical- Sub mountain & low hills	890 m	32° 36.89'N 76° 04.23'E	Wheat- Maize- vegetables
2.	Kiri	Wet temperate & high hills	1560 m	32° 34.12'N 76° 15.21E	Wheat- Maize- vegetables- pulses -fruits
3.	Saho	Sub temperate & high hills	1370 m	32° 35.79'N 76° 13.12'E	Wheat- Maize- pulses- fruits-vegetables

Table 2: Crop specifications and details of plots in selected villages

Sampling sites	Number of surveyed plots	Plant Variety or hybrid	Distance between rows (m)	Distance between plants (m)	Cropping period
Kiri	2 open fields	Abhilash (early crop)	0.9	0.30	20-Apr-2019 to 01-Sep-2019
Bhanauta	3 open fields	Himsona (mid-season)	0.9	0.30	18-Apr-2019 to 10-Sep-2019
Saho	3 open fields	Abhilash (early crop)	0.9	0.30	25-Apr-2019 to 28-Aug-2019

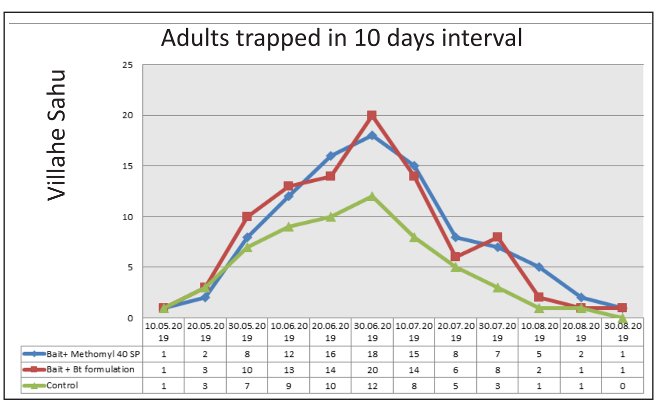


Figure 1: Adults trapped in Sahu village at 10 days interval

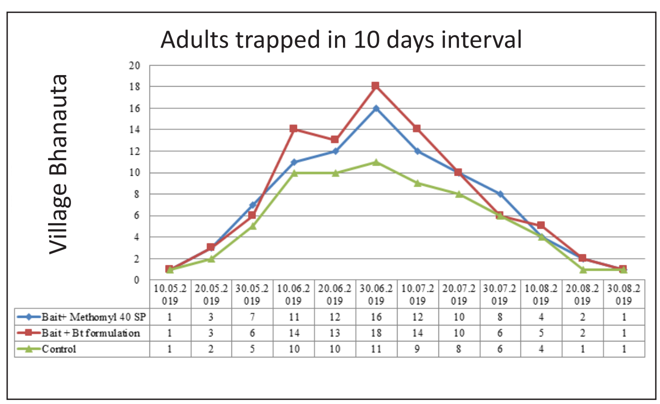


Figure 2: Adults trapped in Bhanauta village at 10 days interval

dissolved in 500ml of water then poured on to rice or wheat flour (100g). The material is mixed thoroughly and kept for 24 hours for fermentation under dark condition. Three different treatments were made with this jaggery mixture. Chemical insecticide Methomyl 40 SP (50 g acre^{-1}) is used in one treatment and in other *Bt* formulation is used as insecticide for killing the trapped larvae of insect pest. These treatments have been used to evaluate the bio-efficacy studies. Total number of larvae was counted at 10 days interval. Out of which, the number of died larvae were counted and were removed from the baits. Larval mortality (%) was recorded at 2,4,6,8 and 10 days interval. Larval mortality (%) has been calculated with Abbott's formula (Fleming and Arthur, 1985):

Abbott Corrected Mortality=(T–C)/(100-C)×100

where, T = % mortality in treatment

C= % mortality in control

These baits were used in the fields to trap or lure the larvae. Two poison baits acre^{-1} were used. Direct spray of *Bacillus thuringiensis* was also used as one treatment for the control of insect pest. Open fields of tomato in different villages were selected for conducting trails. Untreated plots with only rice or wheat flour and jaggery were used as control. The treatments were replicated thrice. Each experimental unit comprised of 30 tomato plants. The details of the treatments are as under:

T_1: Poison Bait (1 kg rice or wheat flour + 1.2 kg jaggery + Methomyl 40 SP @ 50 g acre^{-1}

T_2: Spray of *Bacillus thuringiensis* formulation @70 g l^{-1}

T_3: Poison Bait (1 kg rice or wheat flour + 1.2 kg jaggery +5 g l^{-1})

T_4: Control (untreated plots: Rice or wheat flour + Jaggery)

Poison baits were also used for the trapping of adults. Adult count was taken from 10 May to 30 August, 2019, at 10 days interval. For this, separate baits were kept in each field and only adults were counted in these traps irrespective of the fact that the larvae were also attracted to these baits and were also killed. Care was taken to install these traps higher in the fields at minimum 5feet height from the ground so that larvae could not reach these traps with ease. But, these baits have been used only for counting the adults trapped. The baits were replaced after 20 days. Funnel shaped traps were used for trapping these adults in which the bait mixture was placed. Adult count was taken at 10 days interval and each time the traps were cleaned and the trapped adults were removed.

3. Results and Discussion

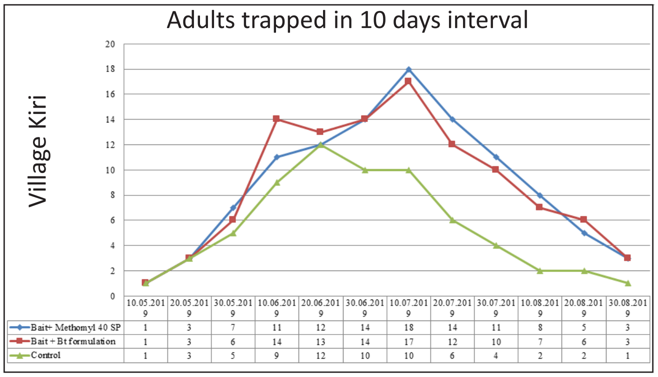
3.1. Bio-efficacy of baits and Bt formulations

Results of bio- efficacy studies with baits and *Bt* formulations have been tabulated in Table 3. Results showed that there was no significant difference in larval mortality between the treatments at 2,4,6,8 and 10 days interval in selected three villages. But since the larval mortality ranged from 10.24 % observed at day two to maximum of 85.60 % at day 10, it could be assumed that all the treatments were effective for

Table 3: Effect of different treatments on larval mortality

Village and treatment	Larval Mortality (%)				
Kiri	Day 2	Day 4	Day 6	Day 8	Day 10
Poison bait- Insecticide	15.87(3.98)*	28.32 (5.32)	42.65(6.53)	62.12(7.88)	78.27(8.85)
Bt	18.65(4.32)	34.05(5.84)	51.74(7.19)	72.08(8.49)	82.32(9.07)
Poison bait + Bt	15.64(3.95)	32.95(5.74)	46.17(6.79)	76.3(8.73)	79.4(8.91)
Control (flour + jaggery	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Bhanauta					
Poison bait- Insecticide	12.56(3.54)	26.32(5.13)	45.01(6.71)	68.25(8.26)	83.24(9.12)
Bt	14.10(3.75)	30.75(5.55)	59.28(7.70)	78.03(8.83)	85.60(9.25)
Poison bait + Bt	18.74(4.33)	24.86(4.99)	62.70(7.92)	74.05(8.61)	81.06(9.25)
Control (flour + jaggery	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Sahu					
Poison bait- Insecticide	10.24(3.20)	21.37(4.62)	38.20(6.18)	63.54(7.97)	74.28(8.62)
Bt	14.25(3.77)	30.20(5.50)	44.25(6.65)	70.06(8.37)	80.5(8.97)
Poison bait + Bt	21.30(4.62)	30.60(5.53)	40.90(6.40)	74.20(8.61)	80.60(8.98)
Control	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
SEm±	1.30	0.50	1.82	0.47	1.64
CD (*p*=0.05)	N.S	1.76	N.S	1.64	N.S

* Figures in parenthesis are square root transformation values; NS= Non-significant



	10.05.2019	20.05.2019	30.05.2019	10.06.2019	20.06.2019	30.06.2019	10.07.2019	20.07.2019	30.07.2019	10.08.2019	20.08.2019	30.08.2019
Bait+ Methomyl 40 SP	1	3	7	11	12	14	18	14	11	8	5	3
Bait + Bt formulation	1	3	6	14	13	14	17	12	10	7	6	3
Control	1	3	5	9	12	10	10	6	4	2	2	1

Figure 3: Adults trapped in Kiri Village at 10 days interval

the control of the insect pest. Minimum larval mortality (10.24 %) was observed in village Sahu at day 2 with treatment of bait with chemical insecticide and maximum larval mortality (21.30 %) with poison bait and *Bt* formulation at Sahu village, but there was no significant difference between larval mortality. Similar results were also obtained on day 6 and day 10. The $CD_{p=0.05}$ value of 1.76 and 1.64 was observed at day 4 and day 8, but the % larval mortality did not differ significantly among the treatments. Minimum (21.37 %) and maximum larval mortality (34.05 %) were observed at day 4 but were statistically at par with each other. Similar results were obtained at Day 8 where minimum larval mortality (62.12 %) and maximum larval mortality (78.03 %) were obtained. The results revealed that all the treatments, though, resulted in larval mortalities above 70 % at 10 days interval but all treatments were statistically at par with each other. These results are in accordance with the results obtained by Duraimurugan and Srinivas (2017) who reported that poison bait of wheat bran + sugarcane jaggery + chlorpyriphos 20EC was effective and resulted maximum larval mortality of 51.1 to 53.3% and 43.3 to 56.7% as compared to 45.6 to 50% and 42.2 to 52.2% mortality in standard check (rice bran + sugarcane jaggery + monocrotophos 36SC) against *S. litura* in castor.

3.2. Trapping of adults

Poison bait with insecticide and *Bt* formulations were also used to assess the number of adults trapped in these baits. The number of adults trapped in these baits have been shown in figure 1 to 3 for each selected village. Figure 1 depicts the adults trapped in village Sahu. The data was collected at 10 days interval starting from 10th May till 30th August 2019. It was observed that the trapping peak was observed in the months of June and July. Maximum number of adults were trapped on 30th July 2019 in both types of traps. Baits with *Bt* formulations recorded maximum of 20 adults whereas that of Methomyl insecticide recorded 18 adults. Thereafter, there was decline in the number of adults trapped. Maximum of 12 adults were also trapped in the control treatment with rice or wheat flour and jaggery. The results thus revealed that the insect adults were attracted to the mixture of jaggery and flour. The reason for less count in control was due to the fact that in the baits with insecticide and *Bt* formulations, were killed and were thus trapped in the traps, but in control since there was no insecticide and some of the adults attracted to the jaggery mixture might have flew back to the fields. Similar results were also observed in village Bhanauta where peak activity of the pest was observed at the end week of June when maximum 18 adults were trapped in baits with *Bt* formulations and 16 adults with baits having chemical insecticide Methomyl. Maximum of 11 adults were also trapped in control traps. Thus, peak activity of insect-pest was recorded at the end of June and after that the activity of the pest decreased. Thus, these traps were useful tool for trapping and monitoring the insect pest.

Maximum activity of the pest at Kiri village was observed in the first week of July with maximum number of 18 and 17 adults were trapped in baits with insecticide and *Bt* formulations, respectively. Maximum adult count of 10 was observed in control at the end of June and in the beginning of July month. The results in this study are well supported by the results of Ivan et al (2012) with the use of sex pheromone traps against *S. frugiperda* in maize. They reported that 54 adults were captured during 64 consecutive days with the use of pheromone traps and insecticides.

4. Conclusion

From the present study it could be concluded that poison baits can help in trapping of males which hinders mating and reproduction. Further these baits and *Bt* formulations can be effective in killing larvae (with maximum larval mortality of 83.24 % with poison baits and 85.60% with *Bt* sprays) as reported under this study. Use of *Bt* formulations in agriculture should be promoted for the management of the insect pest as these are safer to honey bees and pollinators, too.

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