Determination of the Leaf Consumption by Different Larval Stages of Defoliating Major Tea-pest Hyposidra talaca Walker (Lepidoptera: Geometridae), under the Treatment of a Chemical Pesticide, Emamectin Benzoate and a Biopesticide, Bacillus thuringiensis on the Basis of Leaf Area Parameters

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Determination of the Leaf Consumption by Different Larval Stages of Defoliating Major Tea-pest *Hyposidra talaca* Walker (Lepidoptera: Geometridae), under the Treatment of a Chemical Pesticide, Emamectin Benzoate and a Biopesticide, *Bacillus thuringiensis* on the Basis of Leaf Area Parameters

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ABSTRACT

Lopper stages of *Hyposidra talaca*, the major tea-pest infests the tea leaves in large scale in the tea plantations of Darjeeling-Terai region of West Bengal. This geometrid moth has five instars in their larval stage. In this present study the leaf consumption was measured for last three instar stages of this pest for three consecutive days. It was found that the final instar stage infests most vigorously comparing to other looper stages. The leaf consumption of this black inch looper was also calculated under the treatment of two pesticides- the most widely used chemical pesticide, Emamectin Benzoate and the potential biopesticide for this lepidopteran pest, *Bacillus thuringiensis* at their field concentrations. Though both the pesticides effectively decrease the pest infestation, however, the chemical pesticide showed better effect on the leaf consumption. But considering the adverse effect of the chemical pesticides on the ecosystem, the equally effective and ecologically safe biopesticide can be an alternative better choice to control this major defoliating pest in the tea plantations.

Key words: Tea, Pesticide, *Hyposidra talaca,* Leaf consumption, Leaf area, *Bacillus thuringiensis,* Emamectin benzoate

Tea (*Camelia sinensis*), the most popular beverage in India, is the economic life line of a large section of people from the northern part of West Bengal and the north-east India. But it is regularly attacked by huge number of tea pests that are injurious or potentially injurious to economy of this region. Tea plantations are infested by about 167 insect species in the north-eastern tea growing regions of India [1]. Of these, six species have attained major pest status causing 11-55% crop loss [2]. *Hyposidra talaca* (Walker 1860) (Lepidoptera: Geometridae) is reported as one of the most destructive defoliator of tea plantations [3-4]. The looper caterpillar stage of this species may occur in large numbers on tea (more than 200 per bush) [5]. It has been reported that a cohort of advanced stage caterpillars, normally surviving from a single clutch of eggs (n=500) may consume on an average 12,690 cm^2 of the leaf area during its development [6]. The caterpillar of this species prefers to feed upon the pluckable leaves. But at the unavailability of these leaves, they also consume mature maintenance leaves.

In this present study, laboratory-based experiments were undertaken to compare the leaf consumption by the looper stage of *Hyposidra talaca* under the treatment of one mostly used chemical pesticide, emamectin benzoate and one most potential bio-pesticide for this lepidopteran pests, *Bacillis thuringiensis*. For this purpose, the crop loss was calculated on the basis of leaf area at different developmental stages under the treatment of Emamectin Benzoate and *Bacillus thuringiensis*.

MATERIALS AND METHODS

Insect rearing

The gravid females of *Hyposidra talaca* (Walker 1860) collected from the tea gardens in the Terai region of Darjeeling District, West Bengal were released in the laboratory in rearing containers made of transparent plastic (11 cm height × 12 cm diameter) in 2:2 or 2:3 female to male ratio to lay eggs. After hatching, neonates were released in a plastic container (11 cm height × 11 cm diameter) containing single tea twigs in water filled micro-centrifuge tubes for the development of the first two instars. From the third instar onward, they were reared in a large cylindrical bucket (45 cm

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height × 30 cm diameter) whose mouth was covered by autoclaved cotton cloths and secured by rubber bands, to avoid the escape of larvae. The bucket was provided with 7-8 tea leaf twigs immersed in the water-filled 100 ml conical flask [5]. Tea leaves of TV26 (Tocklai variant) clone were collected from the experimental plot of the organically maintained Tea Garden in University of North Bengal, Siliguri-13 (26° 71' N and 88° 35' E). The twigs being provided ad-libitum were replaced daily or alternate days, before being consumed totally by the larvae or before getting dried. Rearing was done in a BOD incubator (CHM-10 PLUS, REMI, India: Make) at a temperature of 27 ± 2°C, L:D 13:11h and RH 75 ± 5% following the method of Prasad and Mukhopadhyay [6].

Pesticide application

To study the pest infestation status of larval stages of *H. talaca* under one chemical and one biopesticide, pesticide application was done by the standard method (Method No. 7) recommended by Insecticide Resistance Action Committee (IRAC) [7]. The concentrations used for emamectin benzoate (EB) (chemical pesticide) and *Bacillus thuringiensis* (biopesticide) were the recommended field concentrations of the respective pesticides (0.4g/litre for EB and 2.5 ml/litre for BT) by tea-board [8] and TRA [9], respectively. According to IRAC method 7, the leaves were dipped in the pesticide for 5 s with gentle agitation and air-dried. For control, the leaves were dipped in distilled water. Second generation one–day old healthy larvae (n=10) of 3rd, 4th and 5th instar of *H. talaca* were released for 24 hours separately into each bucket (45 cm height × 30 cm diameter) whose mouth was covered by autoclaved cotton cloths and secured by rubber bands, to avoid the escape of larvae. The bucket was provided with 15 treated tea twigs with two leaves and a bud immersed in the water-filled 100 ml conical flask [5]. Only for 5th instar larvae 20 tea twigs were provided in control experiment. Three replicates were done for each pesticide as well as water treatment for each instar.

Measurement of pest infestation

Food consumed by the caterpillar was determined simply by deducting the area of remaining leaf from the initial area of the leaf [10]. The leaf was measured by drawing the leaves on the millimeter- graph paper.

Statistical analyses

All the statistical analyses were performed using computer software MINITAB (www. minitab.com). The significant differences between means of leaf consumptions under different treatment were calculated by 2-sample t-Test ($p \leq 0.001$). Differences among means in three different instars as well as in three different days of experiment were calculated by one way ANOVA ($p \leq 0.001$).

RESULTS AND DISCUSSION

Infestation of tea leaves by Hyposidra talaca at 3rd instar larval stage

Mass laboratory rearing of *Hyposidra talaca* on fresh tea leaves was done to measure the infestation of this major tea pest at 3rd instar larval stage under the chemical and bio-pesticide treatment over three days along with the water treatment.

Table 1 Leaf consumption by the 3rd, 4th and 5th instar larva of *Hyposidra talaca* (n=30) at definite intervals (24 hours) during the period of 72 hours under control condition and under the treatment of chemical-pesticide (Emamectin Benzoate, EB) and bio-pesticide (*Bacillus thuringiensis*, BT)

Instar	Treatment	Leaf Area (mm^2) at				Leaf consumption (mm^2)			Total leaf consumption (mm^2) during 72 hours	Proportion of total consumption (%)		
		0 Hrs.	24 Hrs.	48 Hrs.	72 Hrs.	Day 1	Day 2	Day 3		Day 1	Day 2	Day 3
		A	B	C	D	E= A-B	F= B-C	G= C-D	T=E+F+G	E/T* 100	F/T* 100	G/T* 100
III	Control	34602	34228	33662	32785	374±9	566±11	877±29	1818±34	21	31	48
	EB	34306	34202	34202	34202	104±8	0	0	104±8	100		
	BT	36050	35939	35882	35763	111±5	57±2	119±5	287±12	39	20	41
IV	Control	33961	30909	28944	16084	3052±139	1964±35	12861±663	17877±835	17	11	72
	EB	35696	35314	35314	35314	381±10	0	0	381±10	100		
	BT	35844	35257	34908	34274	587±36	349±16	634±86	1570±64	38	22	40
V	Control	62482	52673	32759	7709	9809±56	19915±1313	25050±2096	54774±3435	18	36	46
	EB	40554	39973	39768	39768	581±36	205±28	0	786±53	74	26	0
	BT	38972	38343	37652	36537	629±19	691±56	1115±74	2435±130	26	28	46

Under water treatment

Without the treatment of any pesticide, all 10 1-day-old second generation 3rd instar loopers in each of the three replicates fed on negligible amount of tea leaves in terms of leaf area consumed. The leaf area, measured on graph, was decreased steadily due to leaf consumption. The average leaf area for three replicates was measured at 0 hour (34602 mm^2), 24 hours (34228 mm^2), 48 hours (33662 mm^2) and 72 hours (32785 mm^2). Then the consumption of tea leaves was calculated. It was found that the average consumption in three replicates each having 10 loopers under water treatment was increased steadily over 3 consecutive days: 374 ± 9 mm^2 at day 1, 566 ± 11 mm^2 at day 2 and 877 ± 29 mm^2 at day 3 and the total consumption of the group of 10 loopers for 3 days under experiment was found 1818 ± 34 mm^2. It means, at this stage the loopers consume 21%, 31% and 48% of total consumption over 3 consecutive days of treatment respectively (Table 1). The average consumption of tea leaves without any pesticide treatment in 3 replicates, each having 10 blank inch looper stage larvae of *Hyposidra talaca* in 3rd instar, when compared among three consecutive days of experiment by one-way ANOVA testing using Minitab, it was found that there is a significant variation in day-wise consumption [F=186.52, df= 8 (between groups=2, within groups=6), p<0.001] (Table 2).

Under the treatment of chemical pesticide

When emamectin benzoate (EB) (chemical pesticide) was used at field concentration (400 mg/l) on second generation 1 day-old 3rd instar larvae the leaf area was decreased abruptly at day 1 but remain same for the subsequent two days as all larvae were responded against the pesticide within 24 hours and there was no live loopers during next two days. At 0 hour, the average leaf area was 34306 mm^2 which was decreased to 34202 mm^2 at 24 hours. Thus, under the treatment of EB the black inch looper consume on average 104 ± 8 mm^2 in three replicates at day 1 i.e., consume 100% of total consumption for 24 hours duration (Table 1).

Under the treatment of biopesticide

When *Bacillus thuringiensis* (BT) (biopesticide) was applied at the field concentration (2.5 ml/l), the average leaf area for all three replicates (36050 mm^2) was gradually decreased into 35939 mm^2, 35882 mm^2 and 35763 mm^2 due to consumption in 1st, 2nd and 3rd day after pesticide treatment respectively. The average consumption in three replicates was calculated as 111 ± 5 mm^2, 57 ± 2 mm^2 and 119 ± 5 mm^2 at 1st, 2nd and 3rd day of pesticide exposure respectively i.e., total 287 ± 12 mm^2 for 72 hours of experiment. Thus, it was found that under the treatment of biopesticide, 3rd instar stage of loopers consume 39% of total consumption for 3 days in the 1st day whereas 20% and 41% of total consumption in 2nd and 3rd day of exposure, respectively (Table 1). Significant variation among 3 day's consumption under the treatment of BT, the biopesticide, was found when comparison was done by one-way ANOVA [F=63.58, df= 8 (between groups=2, within groups=6), p<0.001] (Table 2).

The total consumption of tea leaves for 3 consecutive days by 3rd instar larvae significantly decreases by the application of the chemical pesticide (EB) (t=49.63, df=4, p<0.001) as well as by the use of biopesticide (BT) (t=42.98, df=4, p<0.001). When the total consumption under the treatment of EB and BT for 3 days by the 3rd instar stage of looper, was compared by unpaired t-test, significant variation was found (t= -13.25, df=4, p<0.001) (Table 3).

Infestation of tea leaves by H. talaca at 4th instar larval stage

Mass in-house rearing of *H. talaca* on fresh tea leaves was done to measure the infestation of this major tea pest at 4th instar larval stage under the same pesticide treatment used for 3rd instar larval stage over three days along with the water treatment.

Table 2 Showing the significance of day-wise and instar-wise differences of leaf consumption by control, EB and BT treated larvae of *Hyposidra talaca* using one way ANOVA

		Control	EB	BT
Instar III	F among Day 1, 2 & 3	186.52	-	63.58
	P	< 0.001		< 0.001
Instar IV	F among Day 1, 2 & 3	234.60	-	7.87
	P	< 0.001		0.021
Instar V	F among Day 1, 2 & 3	29.48	125.96	23.24
	P	0.001	< 0.001	0.001
	F among Instar III, IV & V	176.99	119.86	166.35
	P	< 0.001	< 0.001	< 0.001

Under water treatment

All 1-day-old second-generation 4th instar looper stage of *H. talaca* feed more vigorously the fresh tea leaves in comparison to the earlier stage. Initially 33961 mm^2 tea leaves on average were provided to the 10 loopers in each of the three replicates. Due to heavy infestation of the pest, the average leaf area reduced to 30909 mm^2, 28944 mm^2 and 16084 mm^2 at the consecutive 3 days of water treatment. From the average leaf area for each day, the average consumption of 10 healthy loopers of 4th instar stage in each of the three replicates was calculated. During day 1 the average consumption was 3052 ± 139 mm^2, which was reduced slightly into 1964 ± 35 mm^2 in day 2 but during 3rd day the consumption increases massively to 12861 ± 663 mm^2 i.e., total 17877 ± 835 mm^2 for 3 days of experiment. Therefore, the 4th instar larvae in the 1st day of experiment consume only 17% of total consumption for 3 days. Strangely, the proportion of total consumption reduced to 11% in the 2nd day. So, the rest 72% consumption occurs in the 3rd day of experiment (Table 1). The average consumption of tea leaves without any pesticide treatment by the larvae of *Hyposidra talaca* in 4th instar, when compared among three consecutive days of experiment by one-way ANOVA testing using minitab, it was found that there is a significant variation in day-wise consumption [F=234.6, df= 8 (between groups=2, within groups=6), p<0.001] (Table 2).

Under the treatment of chemical pesticide

When emamectin benzoate (EB) (chemical pesticide) was used at field concentration (400 mg/l) on second generation 1 day-old 4th instar larvae the average leaf area was decreased from 35696 mm^2 to 35314 mm^2 due to leaf consumption during 1st day but for the subsequent two days the average leaf area remained unchanged as like the 3rd instar stage, all 4th instar larvae of *H. talaca* died by the application of the field concentration of emamectin benzoate (EB) within 24 hours of application. Thus, under the treatment of EB the black inch looper consume on average 381 ± 10 mm^2 for three replicates at day 1 i.e., consume 100% of total consumption (Table 1).

Under the treatment of biopesticide

When field concentration of BT was applied to the 4th instar larvae, the average leaf area for all three replicates

(35844 mm^2), gradually decreased into 35257 mm^2, 34908 mm^2 and 34274 mm^2 due to consumption in 1st, 2nd and 3rd day of pesticide treatment respectively. The average consumption for three replicates was calculated as 587 ± 36 mm^2, 349 ± 16 mm^2 and 634 ± 86 mm^2 at 1st, 2nd and 3rd day of pesticide exposure respectively i.e., 1570 ± 64 mm^2 in total for 3 days. Therefore, like the water treatment leaf consumption surprisingly reduced in the 2nd day of pesticide application from the 1st day, but in the 3rd day massive increase in the consumption was not found like the healthy loopers. Thus the 4th instar loopers were found to cause 38% of infestation in day 1, 22% in day 2 and 40% in the 3rd day of the pesticide application (Table 1). Less significant variation among 3 day's consumption of 4th instar larvae under the treatment of BT was found when comparison was done by one-way ANOVA [F=7.87, df= 8 (between groups=2, within groups=6), p=0.02] (Table 2).

The total consumption of tea leaves for 3 consecutive days by 4th instar larvae significantly decreases by the application of the chemical pesticide (EB) (t=20.95, df=4, p<0.001) as well as by the use of biopesticide (BT) (t=19.47, df=4, p<0.001) when compared to the untreated larvae. When the total consumption under the treatment of EB and BT for 3 days on the 4th instar stage of looper, was compared by unpaired t-test, significant variation was found (t=-18.51, df=4, p<0.001) (Table 3).

Table 3 Showing the significance of treatment-wise differences of leaf consumption by 3rd, 4th and 5th instar larvae of *Hyposidra talaca* using 2-sample *t*-test

	III	IV	V
t-between			
C & EB	49.63	20.95	15.72
p	< 0.001	< 0.001	< 0.001
C & BT	42.98	19.47	15.23
p	< 0.001	< 0.001	< 0.001
EB & BT	-13.25	-18.51	-11.75
p	< 0.001	< 0.001	< 0.001

Infestation of tea leaves by Hyposidra talaca at 5th instar larval stage

To measure the infestation of this major tea pest at 5th instar larval stage applying the same chemical & biological pesticide used for 3rd and 4th instar stage, mass rearing of *H. talaca* on fresh tea leaves was done along with the water treatment for 3 consecutive days in laboratory condition.

Under water treatment

All 1-day old 5th instar looper stage of *H. talaca* feed much more vigorously the fresh tea leaves in comparison to the earlier stages. Initially 62482 mm^2 tea leaves on average were provided to the 10 loopers in each of the three replicates. Due to heavy infestation of the pest, the average leaf area reduced to 52673 mm^2, 32759 mm^2 and 7709 mm^2 at the consecutive 3 days of water treatment. From the average leaf area for each day, the average consumption of 10 healthy loopers of 5th instar stage in each of the three replicates was calculated. During day 1 the average consumption was 9809 ± 56 mm^2, which was increased greatly into 19915 ± 1313 mm^2 in day 2 and during 3rd day the consumption reaches up to 25050 ± 2096 mm^2 i.e., total 54774 ± 3435 mm^2 fresh tea leaves was consumed by the group of 10 5th instar larvae for 3 days of experiment. Therefore, the 5th instar larvae in the 1st day of experiment consume only 18% of total consumption for 3 days. But the proportion increased dramatically in the 2nd day into 36% and in the 3rd day into 46% (Table 1). The average consumption of tea leaves without any pesticide treatment by the larvae of *Hyposidra talaca* in 5th instar, when compared among three consecutive days of experiment by one-way ANOVA testing using Minitab, it was found that there is a significant variation in day-wise consumption [F=29.48, df= 8 (between groups=2, within groups=6), p=0.001] (Table 2).

Under the treatment of chemical pesticide

During the first 24 hours after the treatment with the chemical pesticide the average leaf area was decreased from 40554 mm^2 to 39973 mm^2 and during the second 24 hours the average leaf area drops down to 39973 mm^2 due to leaf consumption but in the last day of the experiment the average leaf area remained unchanged due to the absence of live loopers. Thus, under the treatment of EB the black inch loopers consume on average 581+ 36 mm^2 for three replicates at day 1 and 205 + 28 mm^2 i.e., total 786 + 53 mm^2 for 3 days and thus consume 74% of total consumption in the 1st day and rest 26% in the 2nd day of the chemical pesticide treatment (Table 1). When emamectin benzoate was used as chemical pesticide, consumption of tea leaves occurs only in 1st and 2nd day of experiment as in the 3rd day all 5th instar larvae under treatment were died. It was found significant variation among 3 day's consumption under the treatment of EB was found when comparison was done by one-way ANOVA [F=125.96, df= 8 (between groups=2, within groups=6), p<0.001] (Table 2).

Under the treatment of biopesticide

However, the field concentration of BT when applied to the 5th instar larvae, the average leaf area for all three replicates gradually decreased from 38972 mm^2 into 38343 mm^2, 37652 mm^2 and 36537 mm^2 due to consumption in 1st, 2nd and 3rd day of pesticide treatment respectively. Then the average consumption for three replicates was calculated as 629 ± 19 mm^2, 691 ± 56 mm^2 and 1115 ± 74 mm^2 at 1st, 2nd and 3rd day of pesticide exposure respectively i.e., total 2435 ± 130 mm^2 for 3 days. Therefore, like the water treatment leaf consumption gradually increases over the consecutive three days of experiment. Thus the 5th instar loopers were found to cause 26% of infestation in day 1, 28% in day 2 and 46% in the 3rd day of the pesticide application (Table 1). However, significant variation among 3 day's consumption by 5th instar larvae under the treatment of BT was found when comparison was done by one-way ANOVA [F=23.24, df= 8 (between groups=2, within groups=6), p=0.001] (Table 2).

The total consumption of tea leaves for 3 consecutive days by 5th instar larvae significantly decreases by the application of the chemical pesticide (EB) (t=15.72, df=4, p<0.001) as well as by the use of biopesticide (BT) (t=15.23, df=4, p<0.001). When the total consumption under the treatment of EB and BT for 3 days on the 5th instar stage of looper, was compared by unpaired t-test, significant variation was found (t=-11.75, df=4, p<0.001) (Table 3).

The infestation of tea leaves in terms of leaf infestation varies significantly in different developmental stages using water [F=176.99, df= 8 (between groups=2, within groups=6), p<0.001], EB [F=119.86, df= 8 (between groups=2, within groups=6), p<0.001] as well as BT [F=166.35, df= 8 (between groups=2, within groups=6), p<0.001] (Table 2).

The looper species, *Hyposidra talaca*, has become dominant pest on tea, causing heavy foliage loss [11-12]. The effect of crop loss caused by defoliation can be evaluated by measuring leaf mass consumed per unit of land area, timing of leaf consumption and location of the defoliation [13]. Before calculating the economic injury level, one major step is to estimate the loss per insect by food consumption experiment. Though the 3rd instar larvae of *H. talaca* feed on negligible amount of leaf in terms of leaf area less than even 100 mm2 in 24 hours on average, which is much less in comparison to the advanced stages, i.e., 4th and 5th instar stage. In 4th and 5th instar larvae the average consumption for 24 hours increases about 3 times and 12 times respectively in comparison to 3rd instar larval stage of *H. talaca* [6]. Leaf area consumed by 5th instar Cassava defoliator larvae, is 6.4 times higher than that of 4th instar [10]. In this present study similar trends were found for 1-day old larvae of 3rd, 4th and 5th instar of *H. talaca* for 3 consecutive days. A 4th instar can consume about 10 times more than a 3rd instar larva of *H. talaca* and the 5th instar consume about 3 times more than 4th instar. As the developmental period for a 4th instar is about 3 days, it does not result in huge crop loss, but the developmental period of 5th instar is around 7 days, so the last larval stage is responsible for huge crop loss in terms of yield and in terms of photosynthetic area [5-6]. Therefore, the advanced stages are major defoliator of tea crop.

Pest control in tea is largely dependent on broad spectrum chemical pesticides. However, often the planters experience that, in spite of adopting control measures with synthetic insecticides, considerable amount of crop loss is incurred every year due to looper attack. It was also found that *H. talaca* has developed increased tolerance towards synthetic pyrethroids, such as cypermethrin [5]. Tea Board of India recommended some other group of chemical pesticides for killing the looper stage of *H. talaca* to combat against the development of resistance against particular pesticide. Among several pesticides Emamectin Benzoate 5% SG is mostly used to control the looper caterpillars in the tea gardens. It was found in my earlier study that the field concentration recommended by TRA [9] was much lesser than LC99 [14]. However, the field concentration recommended in PPC (version 9) [8] is much higher than the LC99 [14]. It can cause the development of resistance against this pesticide also. Moreover, large scale and injudicious application of these synthetic pesticides over the years has not only upset the natural ecosystem by enhancing secondary pest outbreak, pest resurgence, and variation in susceptibility but also created problems of pesticide residue in tea.

So, there is an urgent need of some alternate eco-friendly insecticides against loopers for successful cultivation of tea. Early larval instars of *Helicoverpa armigera*, *Plutella xylostella* and *Pieris brassicae* were more susceptible to *Btk* and with progressive advancement of larval instars; the insects became less susceptible to bio- pesticides [15]. Higher percentage of mortality of early instar caterpillars of *Pieris brassicae* due to different doses of *Bt* as compared to older instars [16]. There was a drastic reduction in looper population from 3 days to 7 days after first spraying when the loopers were in early instars and the effectives was found to decrease gradually [9]. In my unpublished study also, the LC50 was found to increases gradually with the advancement of the developmental stages.

When the effectiveness of these two pesticides were compared in terms of decrease in leaf consumption, it was found that there were no significant differences in the reduction of leaf consumption when Emamectin Benzoate (EB) and *Bt* was applied for 24 hours on 3rd instar larval stage of *H. talaca*. However, during this 24-hours all larvae were responded against the fast-acting pesticide EB, whereas only 40% larvae were died by the application of *Bt*. EB causes paralysis by acting on the nervous system of the larvae causing death, whereas *Bt* stop feeding by acting on the digestive tract. On the next day, leaf consumption further reduces under the treatment of *Bt*. But surprisingly on the 3rd day, consumption increases, probably due to the advancement in the larval stage. Therefore, on the basis of total consumption EB is much more effective and fast acting to kill the 3rd instar larvae of *H. talaca* as well as to reduce food consumption.

In the 4th instar, EB showed slightly better performance in reducing leaf consumption in comparison to *Bt*, when the pesticides were applied for 24 hours to the 4th instar stage of *H. talaca*. During that period, all larvae were killed by the activity of EB, however, under the treatment of biopesticide all larvae remained alive. But due to the activity of *Bt* on the feeding of larvae the leaf consumption decreases from the healthy larvae without any pesticide treatment. Surprisingly, on the second day the leaf consumption decreases both in control and BT treatment, probably at that time the 4th instar larvae prepare themselves for moulting into 5th instar stage which is responsible for the massive food consumption on the 3rd day. However, when total consumption for 3 consecutive days was considered, EB showed better performance over BT treatment.

In the final instar stage, two pesticides showed equally good performance on the reduction of leaf consumption during 24 hours exposure. But from the 2nd day of exposure, EB showed better performance over BT treatment. On the basis of lethality, however, EB was far better effective than BT. EB was found to be a fast-acting pesticide with higher lethality due to nervous degeneration through different stages of development. But *Bt* act on the digestive tract and stop feeding which leads to the death of the larvae. The effectiveness to kill the looper stages decreases from the early to the late instar stages. But, as the leaf consumption in advanced stages in untreated condition rises steeply, so the reduction in leaf consumption increases gradually through the progression of larval stages in spite of lesser effectiveness of both pesticides to kill the larvae of advanced instars. But in terms of total consumption for 3 consecutive days, EB showed better performance over BT treatment.

CONCLUSION

From this present study it was found that though EB decreases the population size much more efficiently than the application of *Bt* at field concentration in all three developmental stages, however, both these pesticides efficiently decrease the pest infestation, particularly at the advanced stages. However, the chemical pesticide showed slightly better performance over the biopesticide. In spite of this, instead of using the chemical pesticide, particularly in field concentration which is much higher than its LC99, the ecologically safe biopesticide can be considered as an alternative choice to control the attack of *Hyposidra talaca* on the tea crop.

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