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Dina Bhandari
Department of Entomology, College of Horticulture, VCSG UUHF, Bharsar, Uttarakhand, India

Dr. Vijay Kumar
Department of Plant Pathology, College of Horticulture, VCSG UUHF, Bharsar, Uttarakhand, India

Dr. Pankaj Bahuguna
Department of Basic Science & Humanities, College of Horticulture, VCSG UUHF, Bharsar, Uttarakhand, India

Correspondence
Dina Bhandari
Department of Entomology, College of Horticulture, VCSG UUHF, Bharsar, Uttarakhand, India

Bioefficacy of insecticides and botanicals against cabbage butterfly, *Pieris brassicae*

Dina Bhandari, Dr. Vijay Kumar and Dr. Pankaj Bahuguna

Abstract
In order to determine the selected botanicals, bio-pesticides and synthetic pyrithroids *viz.*, Cow urine + *Azadiracta indica*, Cow urine + *Eupatorium adenophorum*, Cow urine + *Lantana camara*, Cow urine + *Melia azedarach*, *Bacillus Thuringiensis* var. *Kurstaki*, *Beaveria bassiana*, Spinosad 45% SC, Emamectin Benzoat5% SG, Deltamethrin 2.8% EC, respectively, against Cabbage butterfly *P. brasssicae*. The Field trial was conducted during *Rabi* season 2017-18 at Bharsar, Pauri. The insecticides were used as per recommended dose along with an untreated control. Each insecticide was sprayed twice at 14 days interval. The larval count per plant was taken one day before and 3, 7, 11 and 14 days after each spray. All the insecticides tested significantly reduced the pest population compared to control. Spinosad 45% SC 3ml/lit was the most effective on the basis of pest population per plant and increased the yield over untreated control. The maximum yield per ha was recorded in Spinosad 45% SC (214.87q/ha) followed by Emamectin benzoate 5% SG (203.08q/ha), Deltamethrin 2.8% EC (200.66q/ha), *Bacillus thuringiensis var. kurstaki* (195.95q/ha), *Beaveria bassiana* (187.92q/ha), Cow urine+*Azadiracta indica* (172.21q/ha), Cow urine + *Eupatorium adenophorum* (167.55q/ha) and Cow urine +*Lantana camara* (160.45q/ha). The minimum yield per ha recorded in control (145.07q/ha).

Keywords: Botanicals, bio-pesticides, *Brassica oleracea* var. *Capitata*, *P brassicae*

1. Introduction
Cabbage (*Brassica oleracea* var. *capitata* L.) is one of the most important winter vegetable in India and is commercially grown as leafy vegetable. In India, it is grown extensively in tropical and temperate regions and believed to have originated from Western Europe and Mediterranean region (khan *et al*., 2017) [11]. India is the second largest producer of cabbage in the world after china, accounting for 16.55 per cent of the world area and 12.79 per cent of the world production. Country wise, it is grown in an area of 407 hectare with an annual production of 8971 million tonnes and productivity of 22.6 t/ha, ranking second to cabbage in area but topping in production among cole crops (Anonymous, 2016) [3]. It is grown for its edible enlarged terminal buds known as head, and rich in many phytonutrients like vitamin A (2000 I.U.), B1 (50 I.U.) and C (124 mg/100gm) (Singh *et al*., 2015) [19]. In Uttarakhand, cabbage is grown in summer (high hills) and winter (low-mid hills) and occupies an area of 0.38 hectare with a production of 4.62 million tonnes (Anonymous, 2016) [3]. A large number of insect- pest are associated with this crop. These are the cabbage butterfly *Pieris brassicae*, diamondback moth (DBM), *Plutella xylostella*, cabbage semilooper *Trichoplusia ni*, head borer *Hellula undalis*, Tobacco caterpiller, *Spodoptera litura*, Cabbage aphid, *Brevicorneae brassicae* and green peach aphid *Myzus persicae.* Out of these, the cabbage butterfly, *Pieris brassicae* L. (Lepidoptera: Pieridae) and diamond back moth, *Plutella xylostella* L. are the major constraints for profitable cultivation of this crop (Sachan and Gangwar, 1980) [16]. *P. brassicae* is commonly known as the large white butterfly causing damage to seedlings or to the plants at vegetative and flowering stages (Ali and Rizvi, 2007) [2]. This caterpillar feeds only on glucosinolate-releasing plant which is characteristic feature of Brassicaceae family and includes cabbages, cauliflower and mustards etc. (Hopkins *et al*., 2009) [9]. Young larvae of *P. brassicae* graze on lower epidermis of the leaves whereas the older larvae cause extensive defoliation. They often reduce the plants to a skeleton of stems, veins and finally may kill the plants (Lin *et al*., 2001) [12]. The time of planting of cabbage, which is a season bound crop, has profound effect on the incidence of cabbage butterfly and diamond back moth (Dey *et al*., 2017) [5]. As a result of the above problems there is the need to find alternative and suitable methods for the control of these pests to bring about increased crop production.

The use of plant derivatives as an alternative to chemical insecticides has been studied throughout the world. The neem tree, *Azadirachta indica*, has been demonstrated to possess insecticidal properties. This is because several chemicals in its leaves and seeds have been shown to be effective against many agricultural insect pests (Schmutterer *et al.*, 1981) [18]. The application of botanicals and bio-pesticides along with synthetic pyrethroids in the management of insect pests has received more attention because they offer a more environmentally friendly and sustainable alternative to synthetic insecticides.

2. Materials & methods

The study on bioefficacy of Insecticides and Botanicals against cabbage butterfly, *Pieris brassicae* was conducted at Vegetable Research and Demonstration block, VCSG, Uttarakhand University of Horticulture and Forestry, Bharsar, Pauri Garhwal, Bharsar is situated in Pauri Garhwal under the mid- hill zone of Uttarakhand. The trial were laid out in a randomized block design having plot size of 1.8 m x 1.35 m and spacing 60 cm x 45 cm with Cabbage cv. Golden Acre. All the treatments were replicated thrice. The dose used for different treatments are given in the (Table 1). Treatment wise application of insecticide was given when pest level crossed the Economic threshold level *i.e.*, 2-3 larvae per plant by using high volume sprayer (knapsack) with required concentration. The first spray was applied as soon as the the second spray was given after 14 days respectively. The field efficacy of selected botanicals and biopesticides and synthetic pyrithroids *viz*., Cow urine+*Azadiracta indica*, Cow urine +*Eupatorium adenophorum*, Cow urine+*Lantana camara*, Cow urine +*Melia azedarach*, *Bacillus Thuringiensis* var. *Kurstaki*, *Beaveria bassiana*, Spinosad 45% SC, Emamectin Benzoat5% SG, Deltamethrin 2.8% EC, respectively was compared with untreated control. All the respective spray fluids were sprayed thoroughly to cover each plant in every treatment. The population count of Cabbage butterfly larvae was recorded five plants randomly selected each plots one day before every spray which served as pre-treatment observation and the subsequent counts were taken on 3rd, 7th, 11th and 14th days after each spray. Observation on the larval population will be recorded during morning hours.

The spray solution of a desired concentration will prepare by adopting the following formula.

$$V = \frac{C \times A}{\%\ a.\ i}$$

Where,
V= Volume / weight of commercial insecticide ml or g.
C = Concentration required.
A = Volume of solution to be prepared.
% a.i. = Percentages of active ingredient in commercial formulation.

2.1 Preparation of Plants extract in cow urine

The test plants parts were collected from different location, whereas, Cow urine was collected from desi breed cow. The plants collected from various families were washed with dechlorinated water, shade dried under room temperature for 7-9 days and then the plant materials were powdered individually using an electric blender. 10gm of each powdered plant material weight separately by using a top separately balance and dissolve in 90 ml of cow urine to get 1:9 w/v (Rani *et al.*, 2009) [15] were sieved using a kitchen strainer. The prepared solution were kept for fermentation for 15 days then the extracts filtered by using muslin cloth after that it was kept in refrigerator at 4 ^{0}C and working solutions of the desired concentrations were prepared afresh prior to application.

Table 1: Details of treatments and their doses used *in vivo* condition

T. No.	Treatments	Dose Per cent or ml/lit/g	Manufacture by	Group of insecticides
T_1	Control			
T_2	Cow urine+*Azadiracta indica*	5	Home made	Botanicals
T_3	Cow urine +*Eupatorium adenophorum*	5	Home made	Botanicals
T_4	Cow urine+*Lantana camara*	5	Home made	Botanicals
T_5	*Bacillus Thuringiensis* var. *Kurstaki*	0.20	Greenlife Biotech Laboratory	Microbials
T_6	*Beaveria bassiana*	0.19	Greenlife Biotech laboratory	Microbials
T_7	Cow urine+ *Melia azedarach*	5	Home made	Botanicals
T_8	Spinosad 45% SC	0.30	Biostadt India Ltd.	Spinosyns
T_9	Emamectin Benzoate 5% SG	0.50	Crop life Science Ltd	Avermectin
T_{10}	Deltamethrin 2.8% EC	0.35	Bayer Crop Science Ltd.	Synthetic Pyrethroid

2.2 Observations

Pre- count was made prior to each spray. The post treatment counts were made at three, seven and eleven and fourteen days after each spray. Number of *P. brassicae* larvae associated with cabbage plants in field will be examined visually and recorded before and after 2nd spray at an interval of 3,7 11 and 14 days. Number of larvae were recorded from five randomly selected plants in each treatment through visual counting by opening leaves from heath cabbage plants.

The per cent reduction in pest population in different treatments over untreated control was calculated by modified Abbott's formula by (Fleming and Ratnakaran. 1985) [6] as given below:

$$\text{PROC\%} = \left(1 - \frac{Ta \times Cb}{Tb \times Ca}\right) \times 100$$

The avoidable yield loss was computed in each treatment by using the formula suggested by (Pawar *et al.*, 1984) [13].

$$\text{Increase in Yield (\%)} = \frac{\text{Yield in treatment} - \text{Yield in control}}{\text{Yield in control}} \text{X100}$$

2.3 Statistical analysis

The data obtained from the different treatments were computed to determine the mean values. The mean values after suitable transformation were subjected to statistical

analysis to test significance as per (Gomez and Gomez. 1984) [8] for interpretation of the results.

3. Results

All the insecticidal application proved to be significantly superior over control in reducing larval population of cabbage butterfly (Table-2 and 3). The efficacy of Spinosad against larval population of *Pieris brassicae* on cabbage was observed highest as the least larval population (11.18 larvae per plant) was counted at 3 days interval after first spray followed by Emamectin benzoate, Deltamethrin, *Beaveria bassiana, Bacillus thuringiensis* var. *kurstaki*, Cow urine+ *Azadiracta indica*, Cow urine+ *Melia azedarach.* Highest reduction in caterpillar population (10.05 larvae per plant) was recorded with Emamectin benzoate 7 DAS of first spray followed by Spinosad, Deltamethrin, Cow urine+*Azadiracta indica, Bacillus thuringiensis* var. *kurstaki*, Cow urine+ *Melia azedarach, Beaveria bassiana.* The minimum larval count (9.11 larvae per plant) was recorded in Cow urine+ *Melia azedarach* after first spray of 11 days interval followed by Spinosad, Emamectin benzoate, Deltamethrin. The least larval count (8.89 larvae per plant) was recorded with Spinosad 14 days interval after first spray followed by Emamectin benzoate, Deltamethrin, Cow urine+ *Melia azedarach, Bacillus thuringiensis* var. *kurstaki*, Cow urine+*Azadiracta indica* and *Beaveria bassiana.* The population reduction over control was significantly higher in Spinosad 45% SC (48.56) after first spray followed by Emamectin benzoate 5% SG (46.03), Deltamethrin 2.8% EC (40.86).

Spinosad was found effective among all the treatments in controlling the insect after 3, 7, 11 and 14 days after spray, after second spray followed by Emamectin benzoate, Deltamethrin in 3, 7, 11 and 14 days after spray.

At 3 days interval of second spray, the effective microbials insecticides after chemical insecticides, was *Beaveria bassiana* followed by *Bacillus thuringiensis* var. *kurstaki, Bacillus thuringiensis* var. *kurstaki.* After chemical insecticides the effective botanical was Cow urine+ *Melia azedarach* followed by Cow urine+*Azadiracta indica* after 3, 7, 11 and 14 days after spray of second spray. The population reduction over control was higher in Spinosad 45% SC (52.43) followed by Emamectin benzoate 5% SG (36.13), Deltamethrin 2.8% EC(34.36) after second spray. Where in control plot the larvae number decreased due to maturity or the environmental condition, there was less number of reduction of larvae compared to other plot.

3.1 Yield of cabbage

The data presented in (Table 4) revealed that all treatments were found statistically significant with control in respect to yield per ha. The maximum yield per ha was recorded in Spinosad 45% SC (214.87 q/ha) followed by Emamectin benzoate 5% SG (203.08 q/ha), Deltamethrin 2.8% EC (200.66 q/ha), *Bacillus thuringiensis var. kurstaki* (195.95 q/ha), *Beaveria bassiana* (187.92q/ha), Cow urine+*Azadiracta indica* (172.21 q/ha), Cow urine + *Eupatorium adenophorum* (167.55 q/ha) and Cow urine +*Lantana camara* (160.45 q/ha). The minimum yield per ha recorded in control (145.07 q/ha). Yield increased over control was highest in spinosad 45% SC (48.11%) followed by Emamectin benzoate 5% SG (39.99%), Deltamethrin 2.8% EC (38.32%) and *Bacillus thuringiensis var. kurstaki* (35.07%) while minimum yield increased over control was found in Cow urine +*Lantana camara* (10.60%). The above finding show a close resemblance with the research carried out by (Stanikzi and thakur.2016) [20] who reported the highest yield with treatments of Spinosad 45% SC (187.60 q/ha) followed by Indoxacarb 14.5% SC(178.25 q/ha), Emamectin benzoate 5% SG(173.75 q/ha), as compared to control (80.24 q/ha) in checking the infestation of lepidopterans.

The present findings of effectiveness of Spinosad are in conformity with those of in accordance with the reports were observed by (Khan *et al.,* 2017) [11] who studied the mortality of 3rd instar larvae of *Pieris brassicae* (Linn.) and maximum mortality was observed with Spinosad. (Satpathy *et al*., 2007) [17] Confirm our findings and reported that Spinosad is a broad spectrum insecticide used against a range of agricultural insect pests like *Helicoverpa armigera*, *Pieris rapae, Plutella xylostella and Trichopulsia nia*. The judicious use of chemicals with novel mode of action needs to be implemented to manage this insect pest. On large commercial cabbage farms, growers primarily use pyrethroids, neonicotinoids, and other insect nerve poisons to kill the larvae while organic growers tend to rely on Spinosad (Precheur *et al*., 2012) [14]. The next effective treatment were Emamectin benzoate 5% SG, Cow urine+ *M. azedarach, Bacillus thuringiensis* var. *kurstaki* The present finding are in a close proximity with the research conducted by (Kanna *et al*., 2005) [10] who concluded that Emamectin benzoate was highly effective in reducing the larval population of *P. brassicae* L. on cabbage. (Sunitha and Mohite. 2016) [21] also noticed that the Emamectin benzoate showed more effectiveness on cabbage diamond back moth. Another effective treatment was Cow urine+ *M. azedarach* @5ml/lit where similar studies were conducted by (Alexander *et al*., 2012) [1] who studied bioefficacy of indigenous products such as neem leaf and seed extracts in Cow urine against the larvae of lepidopterans on cabbage and revealed that the efficacy of indigenous products could be enhanced. Plants are rich sources of natural substances that can be utilized in the development of environmentally safe methods for insect control. Numbers of workers uses the plant materials and cow urine for the control of insect pests of field crops (Geetanjaly and Tiwari, 2014) [7]. Microbial control was also effective and this was also reprted by (Bhattarai *et al*.,2016) [4] who also reported that highest mortality percentage i.e. 37.92%, 46.25% and 46.42% of cabbage butterfly larvae were found in first, second and third spray of *Bacillus thuringiensis* var. *kurstaki* @ 2ml/lit.

Table 2: Effects of Insecticides and plant extracts on the larval population of cabbage butterfly after first spray

T. No.	Treatments	Dose (%)	Mean larval Population of *P. brassicae* after first spray					ROC%
			Pre-count	3DAS	7DAS	11DAS	14DAS	
T_1	Control (water spray)	-	18.55 (4.19)	19.40 (4.46)	21.40 (4.68)	22.40 (4.78)	24.07 (4.95)	-
T_2	Cow urine+ *A. indica*	5	17.48* (4.17)	13.76* (3.78)	12.13* (3.55)	12.33* (3.58)	10.79* (3.35)	33.28
T_3	Cow urine+ *E. adenophorum*	5	24.93* (5.04)	21.35 (4.67)	19.35* (4.45)	18.61* (4.37)	18.75* (4.39)	25.24
T_4	Cow urine+ *L. camara*	5	24.93*	22.05	20.35*	21.48	21.54*	22.35

			(5.04)	(4.75)	(4.56)	(4.69)	(4.69)	
T_5	*Bacillus thuringiensis* var. *kurstaki*	0.20	20.52* (4.58)	13.17* (3.69)	12.63* (3.62)	10.23* (3.27)	10.09* (3.25)	43.06
T_6	*Beaveria bassiana*	0.19	17.16* (4.20)	13.07* (3.68)	13.28* (3.71)	12.98* (3.67)	12.25* (3.56)	29.73
T_7	Cow urine+ *M. azedarach*	5	22.28* (4.77)	15.16* (3.95)	13.22* (3.70)	9.11* (3.09)	9.12* (3.10)	45.76
T_8	Spinosad 45% SC	0.30	20.95* (4.63)	11.18* (3.41)	10.42* (3.29)	09.99* (3.23)	8.89* (3.06)	48.56
T_9	Emamectin benzoate 5% SG	0.50	19.98* (4.39)	11.93* (3.52)	10.05* (3.24)	10.49* (3.31)	9.1* (3.08)	46.03
T_{10}	Deltamethrin 2.8% EC	0.35	19.28* (4.32)	12.82* (3.65)	12.30* (3.58)	11.57* (3.48)	9.04* (3.08)	40.86
	Range		17.16~ 24.95	11.18~22.05	10.05~21.40	9.11~22.40	8.89~24.07	
	SE(d)	-	-	0.16	0.14	0.12	0.18	
	C.D. (0.05)	-	NS	0.34	0.30	0.25	0.38	

( ) = Values in parenthesis are square root transformed, DAS- Days after Spray, NS= No significant,* Significant at 5% level of significance compared with control.

Table 3: Effects of Insecticides and plant extracts on the larval population of cabbage butterfly after second spray

T. No.	Treatments	Dose (%)	Mean larval Population of *P. brassicae* after Second spray					ROC%
			Pre-count	3DAS	7DAS	11DAS	14DAS	
T_1	Control (water spray)	-	19.82 (4.48)	20.16 (4.54)	22.80 (4.77)	23.83 (4.93)	23.48 (4.90)	-
T_2	Cow urine + *A. indica*	5	14.35* (3.76)	11.36* (3.44)	10.43* (3.30)	10.09* (3.25)	08.83* (3.05)	32.63
T_3	Cow urine + *E. adenophorum*	5	17.35* (4.10)	15.85* (4.04)	14.56* (3.88)	13.49* (3.74)	12.65* (2.62)	26.57
T_4	Cow urine + *L. camara*	5	17.53* (4.16)	16.15* (4.08)	15.12* (3.95)	13.96* (3.80)	13.07* (3.68)	24.12
T_5	*Bacillus thuringiensis* var. *kurstaki*	0.20	12.09* (3.54)	10.03* (3.24)	08.96* (3.07)	08.43* (2.99)	07.45* (2.80)	31.87
T_6	*Beaveria bassiana*	0.19	12.25* (3.56)	10.49* (3.31)	09.27* (3.12)	08.01* (2.90)	07.63* (3.84)	31.77
T_7	Cow urine + *M. azedarach*	5	12.56* (3.61)	11.23* (3.42)	09.89* (3.22)	09.57* (3.17)	08.43* (2.99)	27.82
T_8	Spinosad 45% SC	0.30	14.89* (3.92)	9.05* (3.08)	6.29* (2.60)	5.48* (3.44)	04.67* (2.23)	52.43
T_9	Emamectin benzoate 5% SG	0.50	11.45* (3.45)	08.64* (3.02)	07.61* (2.83)	07.79* (2.87)	06.20* (2.58)	36.13
T_{10}	Deltamethrin 2.8% EC	0.35	11.83* (3.47)	09.35* (3.13)	08.01* (2.90)	07.95* (2.90)	07.13* (2.75)	34.36
	Range		11.45~19.82	8.64~20.16	6.29~22.80	5.48~23.83	4.67~23.48	-
	SE(d)	-	-	0.16	0.12	0.15	0.24	-
	C.D. (0.05)	-	NS	0.34	0.26	0.32	0.51	-

( ) = Values in parenthesis are square root transformed, DAS- Days after Spray, NS= No significant,* Significant at 5% level of significance compared with control

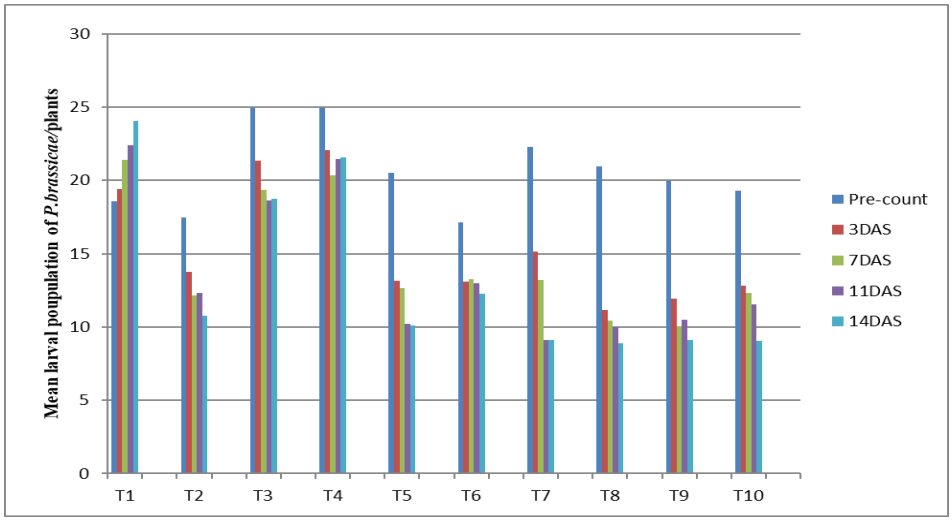

Fig 1: Effects of treatments against *P. brassicae* after first spray

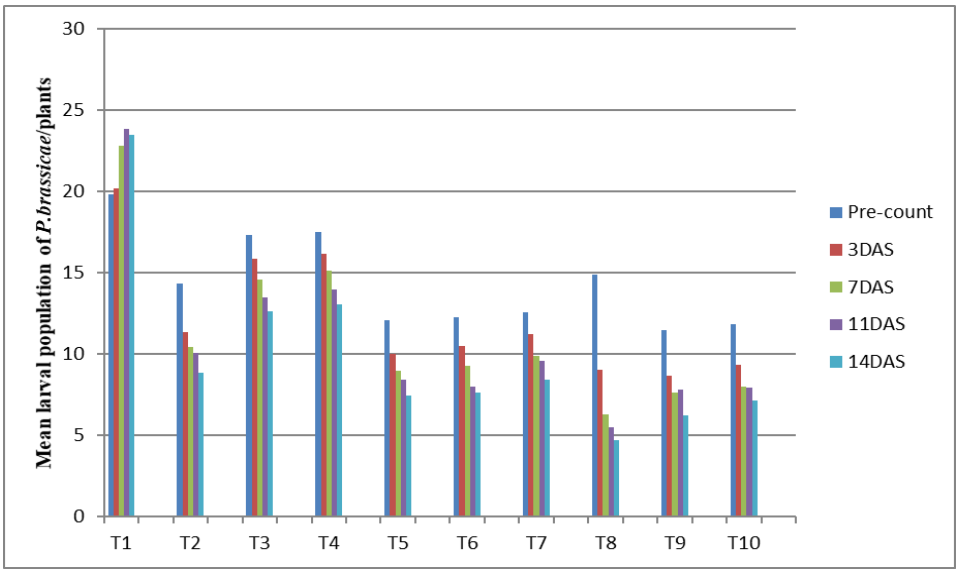

Fig 2: Effects of treatments against *P. brassicae* after second spray

Table 4: Effect of different treatments on yield of cabbage and yield increased over control

T. No.	Treatment	Yield (q/ha)	Total increase in yield over control (q/ha)	Per cent increased in yield over control
T_1	Control (water spray)	145.07*±1.76	-	-
T_2	Cow urine + *Azadiracta indica*	172.21*±1.79	27.14	18.71
T_3	Cow urine+ *Eupatorium adenophorum*	167.55*±1.70	22.48	15.50
T_4	Cow- urine + *Lantana camara*	160.45*±1.34	15.38	10.60
T_5	*Bacillus thuringiensis* var. *kurstaki*	195.95*±2.39	50.88	35.07
T_6	*Beaveria bassiana*	187.92*±1.82	42.85	29.54
T_7	Cow urine + *Melia azedarach*	182.72*±1.89	37.65	25.95
T_8	Spinosad 45% SC	214.87*±1.22	69.80	48.11
T_9	Emamectin benzoate 5% SG	203.08*±2.12	58.01	39.99
T_{10}	Deltamethrin 2.8% EC	200.66*±2.35	55.59	38.32
	SE(d)	2.79	-	-
	C.D. (0.05)	5.91	-	-

* Significant at 5% level of significance compared with control.

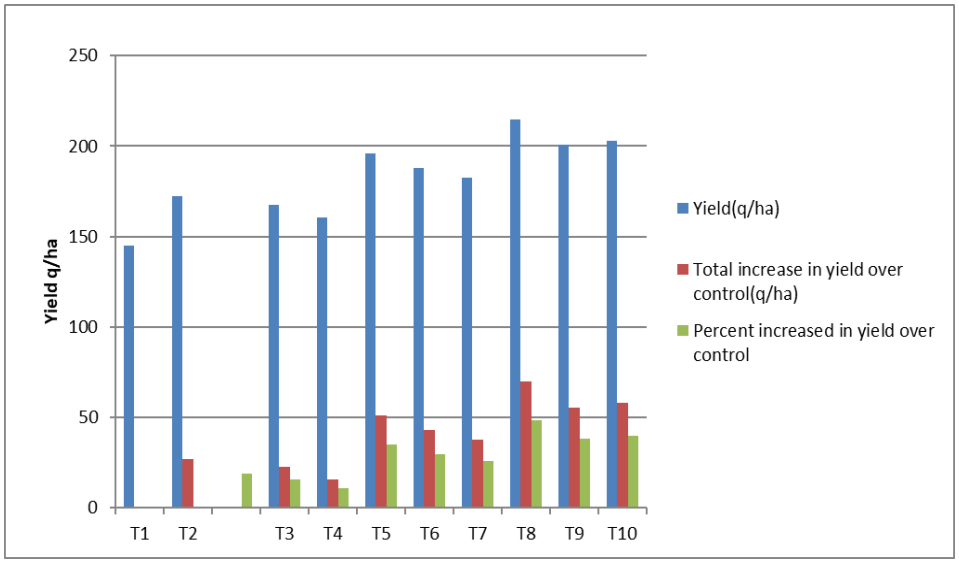

Fig 3: Yield performance of treatments

4. Conclusion

The analysis of the present findings revealed that Spinosad 45% SC was effective as per cent larval reduction of over control was 48.56% followed by Emamectin benzoate 5% SG (46.03%). In case of botanicals Cow urine + *Melia azedarach*, proved to be the best treatment in managing *Pieris brassicae* reduction as it reduces the population of insect 45.76%. In case of microbials *Bacillus thuringiensis* var. *kurstaki* was effective in which the percent larval reduction of over control was 43.06%. Therefore, insecticides of short residual effect and botanicals may be useful in devising proper integrated pest management strategy against Cabbage butterfly.

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