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Research Article

Efficacy and Cost Economics of Bio-Pesticides and Botanical Extracts Against Cabbage Butterly *Pieris Brassicae Nepalensis* Doubleday in Cauliflower Crop in Ilam, Nepal

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Abstract

A field experiment was conducted to compare the efficacy and profitability of using bio-pesticides and locally available botanical extracts for the management of cabbage butterfly *Pieris Brassicae Nepalensis* Doubleday for cauliflower production. The management study was established in farmer's field in Barhabasti, Ilam, Nepal. Eight different types of management treatments were deployed in a randomized complete block design (RCBD) with three replications. The treatments were i) *Bacillus thuringensis* var *kurstaki* (2 gm /lt) ii) *Metarhizium Anisopliae* (2.5 ml /lit) iii) *Beauveria Bassiana* (3 ml /lit) iv) *Acorus calamus* (1:5) v) *Lantana camara* (1:5) vi) Neem oil (1.5 ml /lt) vii) Cow urine (1:4) viii) Control. Results showed that bio-pesticides and botanical extracts were significantly superior over control. *L. camara* treated plots contained the lowest larval population compared to all other treatments. The order of effectiveness of the treatments based on the population reduction was *L. camara* > *A. indica* > *A. calamus* > Cow urine > *M. Anisopliae* > *B. thuringiensis* > *B. Bassiana* > control. The above treatments were also safe to natural enemies since there was non-significant mortality effect of bio-pesticides on natural enemies. The highest benefit cost ratio (2.36) was recorded in neem oil treated plots that was superior to all other treatments. To summaries, this study can help to develop an IPM protocol for the sustain able management of cabbage butterfly in crucifer field.

Keywords: *Pieris Brassicae Nepalensis* Doubleday, Botanicals, Bio-pesticides, Efficacy

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Introduction

Cauliflower (*Brassica oleracea* L. var. *botrytis)* is a popular winter season vegetable widely grown throughout the world. It is also one of the most important vegetable crops grown in terms of area in Nepal. While 35,974 ha of the total area is occupied by cauliflower cultivation, it also has one of the highest shares in terms of productivity which is 14.8 mt /ha (MOALMC, 2018). Although the Terai region produces and sells more vegetables, the vegetables grown in the hilly region have better value as they produce during rainy reasons when prices are relatively higher (Prasain, 20ll). In most of the mid-hills, cauliflower is planted almost all round the year but there are some limiting factors to its qualitative and quantitative production.

One of the major constraints behind the low yield of crucifers is the damage caused by insect pests commonly attacking at various stages of the crop growth (Bondada et al., 2009). Prasad (1963) revealed that the combined infestation brought about by the pest complex arrives at the degree of 14 to 100 percent with the consequent decrease in the yield from 42 to 97 percent. Cabbage butterfly *Pieris Brassicae Nepalensis* Doubleday alone causes more than 40% yield loss in vegetable crops (Ali & Rizvi, 2007). It is the most destructive pest found wherever the crucifer vegetables are grown (Younas & Naeem et al., 2004). The larvae feeds on the leaves by biting and chewing them and causes loss of foliage which ultimately causes retardation of growth resulting in undersized cauliflower head. It is responsible for causing serious damages at all the growing stages of the plant from seedling to vegetative and flowering stages (Bhandari et al., 2009).

In Nepal, the use of chemicals is in increasing but the loss induced by pests is on the rise despite the increasing usage of pesticides. The realization of the negative effects of these chemicals has forced to shift to other safer alternatives that can fit into the cropping systems (Ansari et al., 2013). This has developed an interest in the pest control agents that are bio-active and ecologically safe. The recent advancements in science are deliberately providing a breakthrough in pest management by providing bio-pesticides. These have high target selectivity, environmental compatibility, economic viability, a novel mode of action, and are considered much safer to the environment and other beneficial organisms as well as a rational approach in the long run. To overcome the negative effect of pesticides and to deliver non-pesticidal management practices, it is essential to manage the pests through ecologically safe, environmentally sound, and economically viable methods.

Materials and Methods

Experimental Site

The experiment was conducted in Rabi season (from September to January 2021) in the farmer’s field in Ilam. Ilam is a hilly district situated at 26.9094° N latitude and 87.9282° E longitude and an altitude of 1020 m from the mean sea level. The weather of the research site was warm temperate. The place received a rainfall of 6.3 cm and recorded the maximum temperature of 21.8°c and a minimum temperature of 3.8°c during the research period. The topography of the field was uniform with a gentle slope.

Design and Layout of the Experiment

The experiment was established in randomized complete block design (RCBD) with eight treatments and three replications. There were altogether twenty-four plots with 24 plants in each plot. The area of a single plot was 3m* 1.8 m with a spacing of 0.5 m between each plot and 1.0 m between each block. Crop Geometry was 60 cm row to row and 45 cm plant to plant. The cauliflower seedlings (7 leaves and 45 days old) cv. Super White Top grown in nursery were transplanted in a main research field. The seedlings were not treated by any chemicals before transplantation. The sample plants were five in number selected following a standard “W” transect pattern for each plot. The details of the treatment are given in Table 1.

Table 1. Treatment details

Treatment	Treatment name	Trade name	Dose	Group of insecticides
T1	*Bacillus thuringiensis* var *kurstaki*	Maha-astra	2 gm / lit water	Bio-pesticide
T2	*Metarhizium Anisopliae*	Kalichakra	2.5 ml /lit water	Bio-pesticide
T3	*Beauveria bassiana*	Daman	3 ml /lit water	Bio-pesticide
T4	*Acorus calamus*	Home made	1:5(1part *Acorus* extract and 5-part water)	Botanical
T5	*Lantana camara*	Home made	1:5(1part *Lantana* extract and 5-part water)	Botanical
T6	*Azadirachta indica* (oil)	Nimbecidine	1.5ml /lit water	Botanical
T7	Cow urine	Collected locally and mixed with water during spray	1:4(1part cow urine and 4-part water)	Animal waste
T8	Control		Water	

Preparation of Botanical Extract

Fresh rhizomes of *A. calamus* and leaves & flowers of *L. camara* were brought to the laboratory. They were pulverized and crushed. 200 gm of the crushed products were added in one-liter water and left overnight (about 14 hours). The extract was filtered and applied as a treatment. Some other treatment materials were also collected from the periphery of research sites. The doses of the treatments were applied as foliar spray within the research plots with the help of a hand sprayer during evening hours. These treatments were applied 3 times in the plot at an interval of 10 days. Care was taken to properly clean the sprayer after the application of one treatment and before applying another.

Sampling and Data Observation

Sampling was done as follows:

- Before the first spray of treatments and three samplings after its spray in 3 days interval.
- Before the second spray of treatments and three samplings after its spray in 3 days interval.
- Before the third spray of treatments and three samplings after its spray in 3 days interval.

The weather parameters of the research site were taken from the Department of Hydrology and Meteorology, Dhankuta. Weather parameters include temperature (minimum and maximum), relative humidity, and rainfall. Considering *P. brassicae nepalensis* as the target pest, the number of *P. brassicae nepalensis* larvae associated with the plant in the field was counted from 5 selected sample plants. Data was recorded at - 1 day before spray and 3, 6, and 9 days after application of treatments. Assessment of natural enemies was done where the number of ladybird beetle and spiders associated with the plant in the field were counted from 5 selected sample plants at all sampling times.

The fresh weight of the curd was also recorded immediately after the harvest using a weighing balance and the average yield per plot was recorded after harvesting the experimental plot plants and converted them into per hectare.

Efficacy of treatments in yield

All the harvestable yields from each plot were kept separately leaving the affected plants. Cauliflower yield was recorded from all treatment plots. The yield per plot was extrapolated into yield per hectare.

While comparing the efficacy of treatments in terms of yield, an increase in yield over control was calculated using the formula (Pradhan, 1969).

$$\text{Increase in yield over control (\%)} = \left(\frac{T-C}{C}\right) * 100$$

Where,

T= yield from the treated plot

C= yield from the control plot

Economic Analysis

The research goal was to find out the suitable management strategy with the most favorable benefit: cost ratio. The additional yield obtained in treated plots over control was recorded and total returns from each treatment were worked out. Benefit: cost ratio for all treatments were calculated considering the prevailing market price of necessary inputs, the market rate of the curd, etc.

Statistical Analysis

Abnormal data on insect population count were transformed into square root value to get normal data. The data were subjected to analysis using analysis of variance (ANOVA) and pair of means were separated by using Duncan's Multiple Range Test (DMRT) at 5% and 1% level of significance (Gomez & Gomez, 1984). Data were analyzed using Microsoft Excel and Minitab statistical packages.

Results and Discussion

Effect on *P. Brassicae Nepalensis* Larvae

The pre-count of larvae was non-significant showing uniform distribution of population in all plots. After the first spray of the treatments on the sixth DAS, *A. indica* oil and *A. calamus* treated plot showed a significant reduction in the control of larval population over control. Ninth day after the spray, *A. indica* proved efficacy against the *P. brassicae nepalensis* larva as it caused a significant reduction in the population. The antifeedant and toxic effects of *A. indica* on *P. brassicae nepalensis* caused the population reduction (Sharma & Gupta, 2009). However, considering the mean reduction over 9 days of the first spray, a significant reduction of the larval population was observed in the *A. calamus* treated plot (Figure 1). The findings were similar with the study conducted by Bajpai and Chandel (2009) who reported that the plant extract of *A. calamus* gave the maximum larval mortality killing 80.87% of *P. brassicae nepalensis* compared to ten other indigenous plant extracts considering its insecticidal effects. *A. indica* oil-treated plot was at par with the *A calamus* treated plot on the sixth DAS of treatments. On a ninth day, *A. indica* oil-treated plot showed high effectiveness over control with a subsequent reduction in the larval population.

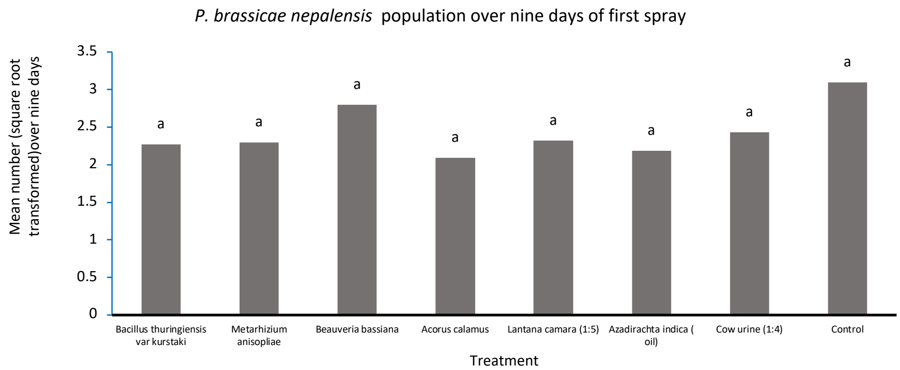

Fig. 1. Mean larval population (square root transformed) in various treatments over nine days after the first spray.

Similar was the result of the second spray (Figure 2). The mean over nine days of the second spray showed the lowest larval population in the *A. indica* oil-treated plot. This is due to the oviposition deterrence, antifeedant and toxic effects of *A. indica* based products among which the oil-based formulations reduced the survival of larvae by 51%. Direct contact with the eggs also reduced their survival (Hasan et al. 2010). The key insecticidal element responsible for its antifeedant and toxic effects in insects is azadirachtin, a steroid-like tetranortriterpenoid (Mordue (Luntz) & Nisbet, 2000).

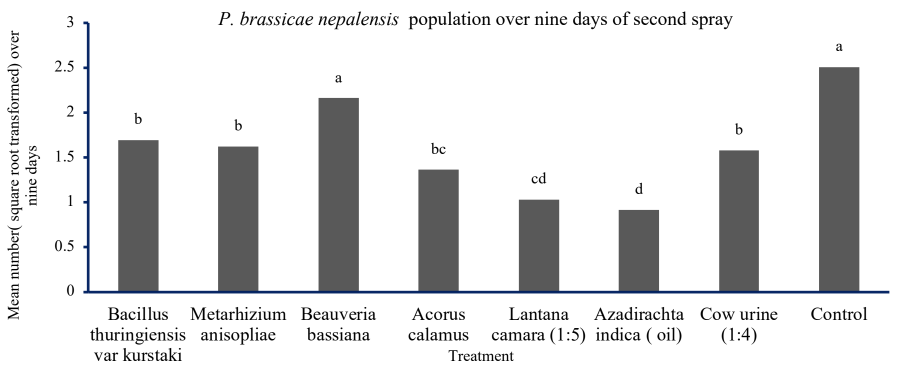

Fig. 2. Mean *P. brassicae nepalensis* population (square root transformed) in various treatments over nine days after the second spray.

On the sixth day after the third spray of the treatments, *L. camara* showed significant control of the larvae in comparison to other plots. The data recorded nine days after the spray also showed a similar result (Figure 3). *L camara* was superior compared to other treatment plots. This finding agrees with Sharma (2016) who evaluated some plant derivatives for the management of *P. brassicae nepalensis*. The result revealed that among other plant derivatives. *L. camara* resulted in significantly higher toxicity to the caterpillars. The study conducted by Bhattarai et al. (2016) reported a Percentage Reduction Over Control (PROC) of 27.50% and a mortality percentage of 33.37 of the larval population of *P. brassicae nepalensis on* the application of *L.camara*. The mean population over nine days of the third spray recorded the lowest population presence in *L. camara* (1:5) treated plot followed by *A. indica* oil and then by *A. calamus* treated plots.

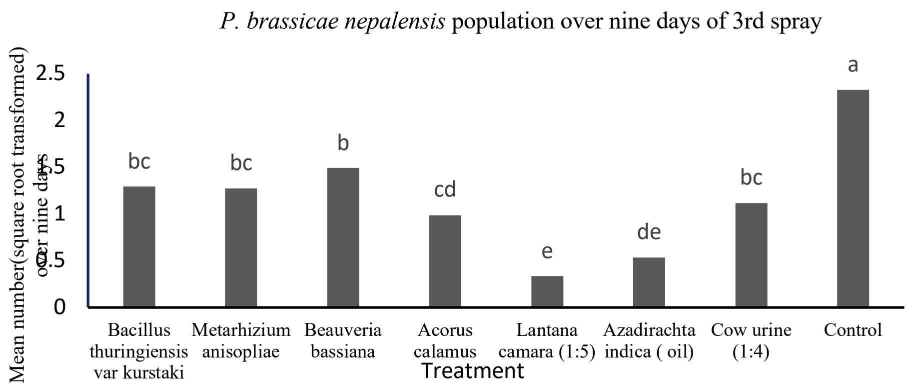

Fig. 3. Square root transformed mean *P. Brassicae Nepalensis* population in various treatments over nine days after the third spray.

B. thuringiensis and *B. bassiana* and were less effective in controlling the larval population as compared to *A. indica* and *L. camara* though they were significantly better over control. This could be due to the decrease in toxicity with time (Chaterjee & Chowdhary, 2003). The poor performance of the microbial insecticides could also be related to the concentration since the efficacy of the microbial pesticides is concentration dependent (Dhawan & Joshi, 2017; Hussain et al., 2003). Garcia-Gutierrez et al. (2010) also reported that the native isolate of *B. bassiana* recorded higher mortality of *P. brassicae nepalensis* than the commercial formulations of *B. bassiana* and *M anisopliae.*

Effect on Natural Enemies

The number of natural enemies was slightly increased in number as compared to the pre-spray of the treatments for Ladybird beetle and spider. This could be because the botanicals are effective against a limited number of target species, they degrade rapidly, are therefore highly eco-friendly and are also less likely to kill the beneficial insects in nature (Guleria & Tiku, 2009). There was no significant difference between the treatments even after all three sprays. However, there was a significant difference between the population of spiders in *B. thuringiensis* var *kurstaki* and *M. anisopliae* treated plot which were statistically similar and showed an increment in the number of spider population after the third spray. The population was highest in the untreated control. The findings agree with Vanlaldiki et al. (2013) who, on the study of the effect of eco-friendly insecticides on the predatory coccinellid reported that *A. indica* products and *B thuringiensis* proved to be the safest to the predatory beetle. Dutta et al. (2016) reported that *A. indica* is the safest to Coccinellid beetles and foraging honeybees, recording 7.50 beetles/ plant, and 9.64 honeybees/plot/five minute. Similarly, Maxwell & Fadamiro (2006) reported that *B thuringiensis* had no significant effects on the number of spiders and ladybird beetles.

Effect on Yield

The yield was comparatively higher in all sprayed treatments than unsprayed ones (Table 2). Among sprayed, *A. indica* oil-treated plot produced the highest yield which was significantly higher than all the other treatments. This was followed by *L. camara* (1:5). Baidoo and Adam (2012) also reported that the use of *A. indica* and *L. camara* increased the yield by 37.05% and 25.80% respectively. The effect of *L. camara* on cauliflower yield was statistically like *A. calamus* and cow urine. Among the treatments sprayed, *B. thuringiensis* treated plot gave the lowest yield, but it was significantly higher than the control plot. The reason for the low yield could be the damaged plants showing stunted growth because of the destruction of leaves by the larval feeding (Wawrzyniak, 1996). The cultivar selected and the proper balance of fertilizers along with the recommended cultivation practices followed timely could also be the supporting factors in the yield increase besides the effective control of pests by the treatments resulting in less destruction of plant foliages.

Table 2. Mean number (square root transformed) value of yield.

Treatment details	Mean
Bacillus thuringiensis var *kurstaki*	25.6 ± 1.54 ^{bc} (655.36)
Metarhizium anisopliae	25.79 ± 2.01 ^{bc} (665.12)
Beauveria bassiana	27.172 ± 0.91 ^{bc} (738.21)
Acorus calamus	27.792 ± 0.68 ^{ab} (772.40)
Lantana camara (1:5)	31.188 ± 0.56 ^{ab} (972.69)
Azadirachta indica (oil)	33.92 ± 1.11^{a} (1150.57)
Cow urine (1:4)	28.8 ± 1.42 ^{ab} (829.44)
Control	20.95 ± 1.74^{c} (438.90)
Mean	27.65
SEM (±)	0.861
CV (%)	15.25
p value	0.00

SEM = Standard Error of Mean, CV = Coefficient of Variance

Cost Economics

The maximum increase in yield over control was recorded in *A. indica* oil-treated plot giving the highest net profit and benefit-cost ratio of 2.36. The next best cost-effective treatment was *L. camara* with the benefit-cost ratio of 1.94 which showed a significant increase in yield over control. This was followed by cow urine (1.64), *A. calamus* (1.53), and *B. bassiana* (1.41) with the increase in yield over control of 66.6%, 61.11%, and 52.78% respectively. *B. thuringiensis* and *M. anisopliae* recorded the low benefit-cost ratio of 1.31 and 1.32 which was also significantly higher as compared to the control plot which was 1.01 (Table 3). The higher benefit-cost ratio obtained because of higher yield could also be influenced by the cultivar selected, balanced fertilizers and cultivation practices followed timely besides the proper pest control in treated plots. Ghanasambandhan et al. (2000) reported that botanicals are eco-friendly and have a higher benefit-cost ratio along with being safer to mammals and no risk of developing pest resistance.

Table 3. Economics of different insecticides applications against *P. Brassicae Nepalensis* Doubleday

Treatment details	Head weight (mt/ha)	Increase in yield over control. (%)	Total return (Rs/ha)	Cost of cultivation (Rs/ha)	Net profit (Rs/ha)	B:C ratio
Bacillus thuringiensis var *kurstaki*	28.74	34.71	2011644.44	1534814.81	476829.63	1.31
Metarhizium anisopliae	29.93	40.28	2094804.44	1592592.59	502211.85	1.32
Beauveria bassiana	32.59	52.78	2281471.11	1614814.81	666656.30	1.41
Acorus calamus (1:5)	34.37	61.11	2405915.56	1570370.37	835545.19	1.53
Lantana camara (1:5)	43.56	104.16	3048888.89	1570370.37	1478518.52	1.94
Azadirachta indica (oil)	51.26	140.28	3588137.78	1521481.48	2066656.30	2.36
Cow urine (1:4)	35.56	66.66	2488888.89	1514814.81	974074.08	1.64
Control	21.33	0.00	1493333.33	1481481.48	11851.85	1.01

Conclusion

On the evaluation of the various bio-pesticides and locally available botanical extracts, based on their efficacy in terms of control and cost effectiveness, *Azadirachta indica* oil and *Lantana camara (*1:5) showed the best result with decrease in the pest population and increased yield over control. However, all the treatments were significantly better over control. Furthermore, excellent repellency showed by the azadirachtin present in oil formulation could be tested at different concentrations and different formulations for the increased efficacy. The locally available materials like *Lantana camara, Acorus calamus* or cow urine and different bio-pesticides like *Bacillus thuringiensis, Beauveria Bassiana, Metarhizium Anisopliae* could be encouraged among farmers as well as further researched at different formulations and different concentrations for their improved efficacies.

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