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EFFICACY TESTING OF 'SOFT' PESTICIDES FOR THE MANAGEMENT OF CABBAGE BUTTERFLY (PIERIS BRASSICAE NEPALENSIS DOUBLEDAY) IN SALYAN, NEPAL

Biju Adhikari*
Faculty of Agriculture, Agriculture and Forestry University, Rampur, Chitwan, Nepal

Santosh Khadka
Department of Entomology, Agriculture and Forestry University, Rampur, Chitwan, Nepal

Santosh Kafle
Faculty of Agriculture, Agriculture and Forestry University, Rampur, Chitwan, Nepal

Niharika Chaudhary
College of Natural Resource Management, Agriculture and Forestry University, Nepal

Saroj Sapkota
Department of Agri-botany and Conservation Ecology, Agriculture and Forestry University, Rampur, Chitwan, Nepal

*E-mail: biju.adhikari13@gmail.com

ABSTRACT

Hit-or-miss use of chemical pesticides and benightedness on the long-term impacts of hard pesticides on plants, soil, human health, and environments in conjunction with the resurgence of cabbage butterfly are the major impediments to the production of cabbage across the globe. This study, thus, was executed to disinter the effective soft pesticides which can keep the *Pieris brassicae nepalensis* well below the economic injury level, minimize their resurgence or even eradicate them so as to surge the production and productivity of cabbage in Salyan district, Nepal from April to July 2022. The experiment was set down in one factorial randomized complete block design with soft pesticides: Neemix @5ml/l, Cow urine solution@ 1:10, Botanical extract fermented with cow urine (BEFCU)@1:5, Emamectin benzoate @2gm/l, Spinosad @0.3ml/l, Cypermethrin@2ml/l, and Control, were used as treatments and each treatment were replicated thrice. Mean larval population, percentage of infested leaves, average hole per infested leaves, head diameter, height, and yield of cabbage were the parameters that were documented during the entire experimental period. Spraying of soft pesticides unraveled significant sway in larval mortality as well as diminution in the damage. Zenithal reduction in the cabbage butterfly population was recorded on the application of Spinosad (80%) followed by Cypermethrin (71.29%), Emamectin benzoate (71.25%), and Neemix (67.22%). Similarly, the nadir percentage of damage on leaves was documented on the application of Spinosad and Cypermethrin followed by Emamection benzoate. Maximum head diameter (16.10 cm) and yield (23.44 Mt/ha) were obtained when cabbage was sprayed with Spinosad followed by Cypermethrin whereas minimum head diameter (13.37 cm) and yield (13.76 Mt/ha) was recorded with the control. Spinosad and Cypermethrin, thus, are superior soft pesticides for the management of cabbage butterfly relative to other treatments in Salyan district. Farmers, therefore, are suggested to exploit Spinosad and Cypermethrin for the control and management of cabbage butterfly in an attempt to boost the production and productivity of cabbage.

KEY WORDS

Bio-pesticides, pieris brassicae nepalensis, cabbage, spinosad, cypermethrin.

Cabbage (*Brassica oleracea var. capitata* L.), is one of the important winter leafy vegetables worldwide having large production and export potential (Talekar, 2000).

Cabbage, in terms of area and production, is an important cole crop of Nepal after cauliflower which is grown year-round at higher elevations whereas in tropical regions, it can be successfully grown in winter with an average annual production of 494,053 Mt and productivity of 16.67 Mt/ha (MoALD, 2021). Salyan district, having diverse climatic conditions ranging from tropical to temperate, offers year-round cultivation of off–season vegetables like tomato, cabbage, cauliflower, capsicum, etc. Among them, cabbage is cultivated on 183 ha of land with a production of 2838 Mt and productivity of 15.49 Mt/ha (MoALD, 2021).

Various insect pests such as cabbage butterfly (*Pieris brassicae nepalensis*), diamondback moth (*Plutella xyllostella*), aphids (*Brevicoryne brassicae*), cutworm (*Agrotis ipsilon)*, tobacco caterpillar (*Spodoptera litura*), semi looper (*Thysanoplusia orichalcea*), and others have been known to attack this crop. Among them, the cabbage butterfly (*Pieris brassicae nepalensis*) is a deleterious pest in late-season cultivars of cabbage and cauliflower in Nepal, engendering average annual output losses upto 80-100% (Joshi, 1994). The cabbage butterfly, belonging to the Pieridae family, is the most destructive pest causing damage at all growth stages: seedlings, vegetative, and flowering stages (Khalid, 2006) leading to over 40% yield loss (Ali & Rizvi, 2007). In Nepal, it passes winter in the plains and migrates to hilly regions during summer (Gupta, 2002). High temperatures and more sunshine hours, accompanied by low relative humidity and rainfall, favor population build-ups (Sood & Bhalla, 1996).

Early instars larvae/caterpillars (damage-causing stage) feed gregariously and indiscriminately on foliage, scraping the leaf lamina and then biting making round holes that ultimately skeletonize leaving intact the main veins (Younas et al., 2004; Khalid, 2006). Leaves may be riddled thereby making them unfit for consumption which sometimes bores into the head causing significant damage to the crop which in extreme cases, usually during March-April, results in crop collapse (USDA, 1984).

Pieris brassicae has already been introduced in Nepal and is spreading throughout the country and it is now seen in Salyan district. The complete eradication of this pest is impossible; however, many control measures are being discovered to control this pest. As a sole means of plant protection, 80% of the farmers are using chemical pesticides while the remaining 20% use them in conjunction with other protective measures (Rijal et al., 2006). Nepalese farmers, having a paucity of knowledge or even nescient, normally regard pesticides as a weapon of pest management (Yassin et al., 2002). The use of pesticides in Nepal has been waxing rapidly at @10-20% per year with an eye to boost up the crops yield (Adhikari, 2018). The current application, arbitrary use of pesticides, has numerous negative consequences for humans and the environment (Thapa, 2003). Chemical pesticides have been found to have long-term impacts on soil, the environment, human health, groundwater contamination, pesticide resistance, pest resurgence, and other ecological effects (Thapa & GC, 2000). Therefore, as an alternative to it, plant and animal extracts such as neem leaf extract, cow urine, garlic extract, BECFU, and other soft pesticides can be used for the management of cabbage butterfly (Giri et al., 2006). Soft pesticides are benign and environmentally friendly for stepping down and controlling key insect pests which are commonly known as biopesticides. Bio-pesticides, made from natural products of living organisms such as bacteria, viruses, and fungi in conjunction with plants, are exploited to manage pest populations (Thakore, 2017).

Farmers are in desperate need of precise and reliable information regarding the efficacy of different soft pesticides to minimize infestation by cabbage butterfly. This research will galvanize or enable farmers to switch and demonstrate propensity from chemical management practices to eco-friendly practices though owing slow but long-lasting effect on the quality, production, and productivity of cabbage through the application of effective soft pesticides for controlling *the P.brassicae nepalensis*. With due regard to all IPM-related technologies, the study regarding the pertinent eco-friendly management practices of *P. brassicae nepalensis* is an utmost necessity and hence this study emphasized evaluating the efficacy of market-accessible soft pesticides against cabbage butterfly control with an attempt to disinter the most effective bio-pesticides.

MATERIALS AND METHODS OF RESEARCH

The field trial was performed in Triveni rural municipality-06, Luham, Salyan (Figure 1) located within the line of latitude of 28.30ºN and longitude of 82.23ºE at an altitude of 1009 m above the main sea level. The soil of the study area had a pH of 6.1, organic matter (5.4%), Nitrogen (0.27%), Phosphorous (99 kg/ha), Potassium (168 kg/ha), and Boron (0.591 ppm). The experiment was executed from April to July 2022 during which the average temperature, relative humidity, and precipitation are presented in Figure 2.

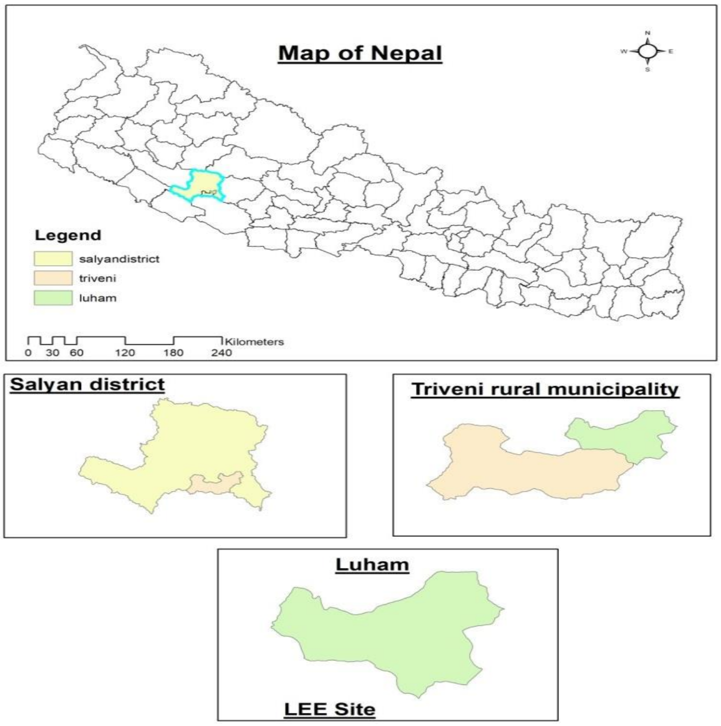

Figure 1 – Location of the site of study (Source: ArcGIS)

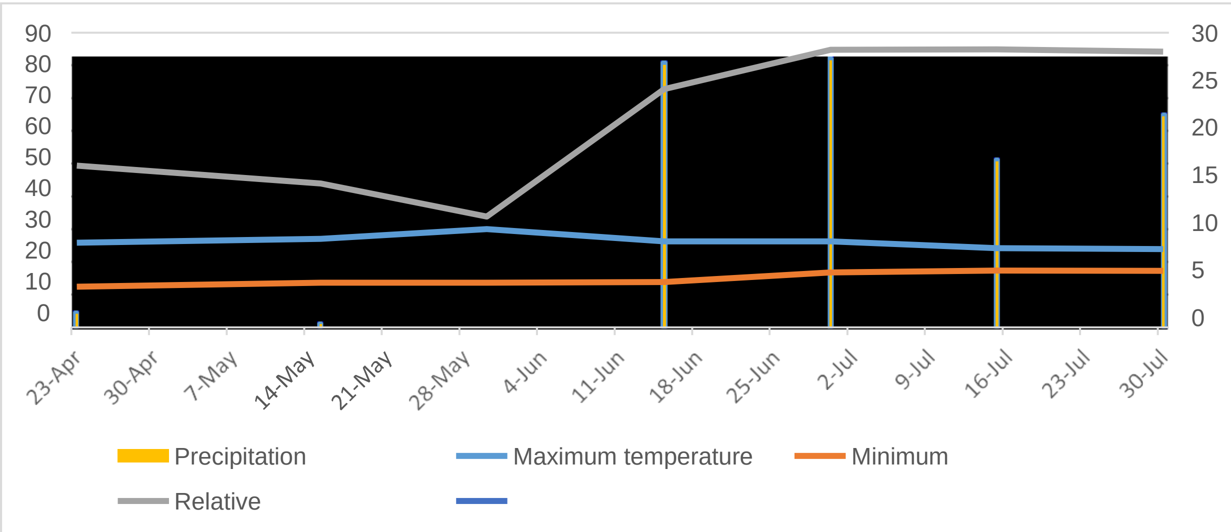

Figure 2 – Meteorological conditions during the experimental period (Source: NASA-Power, 2022)

Entire experimental setup constituted seven treatments viz: Neemix, Cow urine solution, Botanical extract fermented with cow urine solution (BEFCU), Spinosad 45% SC, Emamectin benzoate 5 % SC, Cypermethrin 10% EC, and control, where each treatment was replicated thrice. Details of each treatment are mentioned in Table 1.

Table 1 – Details of each treatment to evaluate their efficacy on management of cabbage butterfly

Treatment Number	Treatments	Trade name	Recommendation dose	Group of insecticide
T1	Neem based pesticide	Neemix	5ml/l	Botanicals
T2	Cow urine solution	-	1:10	Animal origin
T3	BEFCU	-	1:5	Botanicals
T4	Spinosad	Tracer	0.3ml/l	Spinosyns
T5	Cypermethrin	Superkiller-10	2ml/l	Synthetic pyrethroid
T6	Emamectin benzoate	Kingstar	2gm/l	Avermectin
T7	Control	-	-	-

The trial was laid out by utilizing the “T-621” hybrid variety of cabbage in a randomized complete block design having three replications of each treatment. There were altogether 21 plots where plot size was maintained at 4m^2 (2m×2m) with a total of 25 plants per plot in 5 rows and 5 columns. Row-to-row spacing as well as plant-to-plant spacing was kept at a distance of 40cm while the distance between the replication and treatment was maintained at 1m and 50cm respectively with a field margin of 50cm each on all sides.

All the insecticides were applied on their respective plots with a knapsack sprayer. The first application was made 15 days after transplanting of cabbage and repeated at 15 days intervals where the field efficacy of selected soft pesticides viz. Neemix, Cow urine solution, Botanical extract fermented with cow urine solution (BEFCU), Spinosad 45% SC, Emamectin benzoate 5 % SC, and Cypermethrin 10% EC were compared with untreated control respectively. All the respective spray fluids were sprayed thoroughly to cover each plant in every treatment.

BEFCU was prepared from locally accessible materials viz: 3kg botanical plants (Asuro, Titepati, Lantana), 25 liters cow urine, 50gm chilly, 25gm cardamom, 10gm garlic, 25gm onion, 250gm turmeric powder, and 25 liters water. It was fermented for 4 weeks which was then thoroughly mixed with water in a ratio of 1:5 and the entire mixture of 555ml/liter was sprayed.

For nursery bed preparation, the experimental plot was thoroughly ploughed, and well-decomposed FYM was incorporated into the soil. The hybrid variety of cabbage: T-621 was used for the study. The nursery bed was kept 3m in length and 1m in width where seeds were sown in March 2022, under protected conditions, at a depth of about 2cm in lines 5cm apart. Regular watering was carried out as per the requirement. After complete germination of the seed and seedling growth, they were transplanted to the main field.

The field was thoroughly ploughed twice with a mini tiller followed by leveling. Well-decomposed FYM was incorporated into the soil @20ton/ha. Pits with dimensions of 20cm in width and 15cm in depth were made for transplantation of cabbage seedlings wherein the chemical fertilizers viz: Urea (46:0:0), DAP (18:46:0) and MOP (0:0:60) were used @120:90:40 kg NPK/ha were mixed well in the soil. Seedlings that were 28 days old with 3-4 true leaves were transplanted. Half of the recommended dose of Nitrogen was applied as basal dose while the remaining half dose was given in two equal split doses as a top dressing by ring method at 30 DAT and 45 DAT respectively. To overcome the deficiency of boron, 15 kg/ha was applied (MOALD, 2021).

Pre-counting was made prior to each spray while post-treatment counting was executed at 3 and 7 days after each treatment application. The number of Cabbage butterfly larvae was determined from 5 randomly selected plants of each plot through visual counting by opening the leaves from the head of the cabbage usually in the morning. The percentage of infested leaves and the number of holes per leaf were documented at the 7th day of spraying whereas the head height, diameter, and yield were recorded at the time of harvesting. Diminution in the pest population through the use of different treatments over control was calculated by exploiting the modified Abbott’s formula used by Fleming and Ratnakaran (1985).

Microsoft Excel and GenStat version 14.2 were used to carry out statistical analysis of amassed data. One-way ANOVA was used to test the impact of different soft pesticides over control on larval population, number of infested leaves and holes per leaf, head height, diameter, and yield of cabbage. With an eye to disinter the significant divergence among the different parameters that were considered, one-way ANOVA with Duncan's Multiple Range Test (DMRT) was executed. Data were also transformed by using square root transformation [SQR(x+0.5)] as and when required (Gomez & Gomez, 1984).

RESULTS OF STUDY

Application of soft pesticides after 15 days of transplanting unleashed a substantial difference in abating the larval population count of *P. brassicae nepalensis* clearly visible from Table 2. The nadir larval population (0.26) was documented from the application of Spinosad subsequently followed by Cypermethrin (0.33) whereas the apical larval count was documented with control (1.06). Likewise, at 7 days after the first spray, the lowest larval population was recorded from spraying of Spinosad and Cypermethrin each displaying the figure of 0.2 subsequently followed by Emamectin benzoate (0.26). Larval population, however, was documented as the highest with control exhibiting the figure of 0.86.

Similarly, Spinosad was unveiled to be pre-eminently superior pesticide in subsiding the larval population displaying a reduction of 74% and 71.67% at 3 and 7 days after application respectively which is subsequently followed by Cypermethrin (60% and 71.29%) while cow urine was disinterred to the least effective pesticide exhibiting the reduction of 35.33% and 28.67% at 3 and 7 days after application respectively.

Table 2 – Effect of different treatments against cabbage butterfly after 1st spray

Treatments	Pre-treatment	3DAS	PROC (%)	7 DAS	PROC (%)
Neemix @5ml/l	0.86	0.40^{b}	57.67	0.26^{b}	67.22
Cowurine@1:10	0.86	0.66^{c}	35.33	0.53^{c}	28.67
BEFCU@1:5	0.66	0.53^{bc}	51.11	0.33^{bc}	61.67
Emamectin benzoate@2gm/l	1.13	0.40^{b}	60.00	0.26^{b}	71.25
Spinosad@0.3ml/l	0.86	0.26^{a}	74.00	0.20^{a}	71.67
Cypermethrin@2ml/l	1.13	0.33^{ab}	60.00	0.20^{a}	71.29
Control	1.0	1.06^{d}		0.86^{d}	
F-test	Ns	***		***	
P-value		<0.001		<0.001	
SEm(+-)		0.015		0.018	
LSD(0.05)		0.42		0.51	

*Note: Means with the same letter in the column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01), *** Significant at 0.1% (P<0.001), and NS: not significantly different at 5% (P >0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance, DAS = Day after spraying and figure in the parenthesis indicate [SQR(x+0.5)] transformation value.*

Three days after the first spray, the highest population reduction of cabbage butterfly was recorded with Spinosad (74.00%) and Cypermethrin (60.00%) as well as Emamectin benzoate (60.00%) followed by Neemix (57.67%) and BEFCU (51.11%) while the lowest reduction percentage was found with cow urine solution (35.33%). Similarly, Spinosad was found continuously superior at reducing the larval population at 7 days after the first spray with a 71.67% reduction rate which was followed by Cypermethrin and Emamectin benzoate with a reduction rate of 71.29% and 71.25% respectively. Likewise, the population reduction of larvae with Cow urine (28.67%) was found to be the least among all treatments at 7 days after the first spray.

During the second spray, different insecticides were found significantly efficacious in forestalling the increase in the larval population of cabbage butterfly as evinced from Table 3. Spinosad was disinterred to be extremely effective in stepping down the larval population exhibiting the lowest population of 0.13 at three days after 2nd spray whereas the highest larval population was documented with control (1.13). Likewise, at 7 days after the second spray, the nadir larval count was recorded with Spinosad (0.13) which is statistically compatible with the application of Cypermethrin (0.13) whereas the zenithal larval population was noted with control (1.06).

In addition to this, Spinosad was disinterred to be the pre-eminently superior pesticide in waning the larval population displaying a reduction of 71.91% and 74% at 3 and 7 days after application respectively followed by Cypermethrin (64.75% and 60%) whereas cow urine was disinterred to the least effective pesticide exhibiting the reduction of 30.41% and 35.33% at 3 and 7 days after application respectively.

Table 3 – Effect of different treatments against cabbage butterfly after 2ndspray in Salyan, Nepal 2022

Treatments	Pre-treatment	3DAS	PROC (%)	7DAS	PROC (%)
Neemix @5ml/l	0.66	0.26^{bc}	61.98	0.26^{b}	57.67
Cowurine@1:10	0.66	0.40^{c}	30.41	0.40^{c}	35.33
BEFCU@1:5	0.46	0.33^{bc}	45.27	0.33^{bc}	51.11
Emamectin benzoate@2gm/l	0.86	0.25^{b}	63.54	0.26^{b}	60.00
Spinosad@0.3ml/l	0.73	0.13^{a}	71.91	0.13^{a}	74.00
Cypermethrin@2ml/l	0.66	0.20^{a}	64.75	0.13^{a}	60.00
Control	1.43	1.13^{d}		1.06^{d}	
F-test	Ns	***		***	
P-value		<0.001		<0.001	
SEm(+-)		0.07		0.02	
LSD (0.05)		0.18		0.20	

*Note: Means with the same letter in the column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01), *** Significant at 0.1% (P<0.001), and NS: not significantly different at 5% (P>0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance, DAS = Day after spraying and figure in the parenthesis indicate [SQR(x+0.5)] transformation value.*

The application of insecticides produced a significant difference in controlling the larval population of cabbage butterfly as evidenced by Table 4. 3 days after the third spray, the lowest larval population was documented with Spinosad (0.13) followed by Cypermethrin and Emamectin benzoate each displaying the value of 0.2 whereas the highest larval population was noted with control (1.2). Similarly, the lowest larval population of 0.13 was noted with the application of Spinosad at 7 days after the third spray which is statistically at par with Cypermethrin (0.13) while the highest larval population was noted with control (1.26).

In addition to this, Spinosad was unraveled to be pre-eminently superior pesticide in dwindling the larval population displaying a reduction of 80% followed by Cypermethrin (76.67% and 70%) at 3 and 7 days after application respectively whereas cow urine was disinterred to the least efficacious pesticide exhibiting the reduction of 26.67% and 30% at 3 and 7 days after application respectively.

Table 4 – Effect of different treatments against cabbage butterfly after 3rd spray in Salyan, Nepal 2022

Treatments	Pre- treatment	3DAS	PROC (%)	7DAS	PROC (%)
Neemix@5ml/l	1.13	0.33^{b}	43.33	0.20^{b}	56.67
Cowurine@1:10	0.86	0.53^{c}	26.67	0.46^{c}	30.00
BEFCU@1:5	0.86	0.33^{b}	35.55	0.20^{b}	40.00
Emamectin benzoate@2gm/l	1.13	0.20^{ab}	60.00	0.20^{b}	62.22
Spinosad@0.3ml/l	0.86	0.13^{a}	80.00	0.13^{a}	80.00
Cypermethrin@2ml/l	0.66	0.20^{ab}	76.67	0.13^{a}	70.00
Control	1.0	1.20^{d}		1.26^{d}	
F-test	**	***		***	
P –value	<0.01	<0.001		<0.001	
SEm(+-)	0.081	0.013		0.026	
LSD(0.05)	0.29	0.10		0.24	

*Note: Means with the same letter in the column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01), *** Significant at 0.1% (P<0.001), and NS: not significantly different at 5% (P >0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance, DAS = Day after spraying and figure in the parenthesis indicate [SQR(x+0.5)] transformation value.*

Significant difference was observed in the proportion of infested leaves at each spray of insecticides which is pellucid from Table 5. From the scrutinization of the table, it is evident that cabbage plants that were sprayed with Spinosad displayed the minimum percentage of infested leaves (13.48%) seven days after the third spray which is statistically compatible with the application of Cypermethrin exhibiting 13.83% of infested leaves. Quite the contrary, the maximum proportion of infested leaves (45.71%) were documented from those cabbage plants which were not applied with insecticides followed by the application of cow urine solution displaying the maximum percentage of infested leaves (36.33%).

Table 5 – Effects of different treatments on the percentage of infested leaves at all sprays in Salyan, Nepal 2022

Treatments	First spray 3DAS 7DAS		Second spray 3DAS 7DAS		Third spray 3DAS 7DAS	
Neemix@5ml/l	27.26^{bc}	29.68^{bc}	28.72^{b}	32.84^{b}	28.11^{b}	24.43^{b}
Cow urine@1:10	29.98^{c}	33.99^{c}	33.89^{b}	35.79^{b}	36.33^{c}	34.56^{c}
BEFCU@1:5	29.79^{bc}	33.41^{c}	31.94^{b}	34.73^{b}	30.26^{bc}	25.79^{bc}
Emamectin benzoate@2gm/l	21.14^{ab}	25.23^{ab}	27.21^{b}	29.95^{b}	19.58^{ab}	17.22^{ab}
Spinosad@0.3ml/l	17.77^{a}	18.35^{a}	18.73^{a}	17.41^{a}	15.08^{a}	13.48^{a}
Cypermethrin@2ml/l	19.19^{a}	20.22^{a}	19.76^{a}	18.93^{a}	16.58^{a}	13.83^{a}
Control	34.36^{c}	37.71^{c}	41.65^{c}	45.71^{c}	37.94^{c}	37.88^{d}
F-test	***	***	***	***	***	***
LSD (0.05)	6.962	7.810	7.403	6.855	7.135	6.533
SEm(+-)	2.260	2.535	2.403	2.225	2.322	2.038
P-value	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

*Note: Means with same letter in column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (P< 0.05), ** Significant at 1% (P< 0.01), *** Significant at 0.1% (P<0.001), and NS: not significantly different at 5% (P >0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance, DAS = Day after spraying and figure in the parenthesis indicate [SQR(x+0.5)] transformation value.*

Although there was a substantial reduction in the larval population through the application of soft pesticides, there was no considerable difference in the number of holes on leaves on any day even after all sprays which is evinced from Table 6.

Table 6 – Effects of different treatments on the average number of holes per infested leaf at all sprays in Salyan, Nepal 2022

Treatments	First spray 3DAS 7DAS		Second spray 3DAS 7DAS		Third spray 3DAS 7DAS	
Neemix@5ml/l	3.56	2.70	1.89	1.53	1.40	1.30
Cowurine@1:10	4.19	3.43	1.97	1.49	1.57	1.14
BEFCU@1:5	3.84	2.97	1.84	1.423	1.54	1.38
Emamectin benzoate@2gm/l	3.86	3.12	1.68	1.553	1.36	1.08
Spinosad@0.3ml/l	3.71	2.86	2.03	1.37	1.50	0.74
Cypermethrin@2ml/l	3.60	3.24	2.01	1.72	1.22	0.74
Control	3.66	2.83	2.12	1.59	1.22	1.64
Grand mean	3.77	3.04	1.93	1.52	1.46	1.14
F-test	Ns	Ns	Ns	Ns	Ns	Ns

*Note: Means with the same letter in the column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (P< 0.05),** Significant at 1% (P< 0.01), *** Significant at 0.1% (P<0.001), and NS: not significantly different at 5% (P >0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance, DAS = Day after spraying and figure in the parenthesis indicate [SQR(x+0.5)] transformation value.*

Table 7 – Effects of different treatments on cabbage yield, head diameter, and height

Treatments	Yield (mt/ha)	Head diameter (cm)	Head height (cm)
Neemix @5ml/liter	18.19^{c}	14.77^{bc}	12.30^{b}
Cow urine @1:10	16.33^{d}	14.06^{c}	12.06^{c}
BEFCU @1:5	17.04^{d}	14.17^{c}	13.97^{a}
Emamectin benzoate@ 2 gm/l \	19.29^{c}	14.47^{c}	13.30^{ab}
Spinosad@0.3ml/l	23.44^{a}	16.10^{a}	13.54^{a}
Cypermethrin@2ml/l	22.02^{b}	15.06^{ab}	13.46^{ab}
Control	13.76^{e}	13.37^{d}	11.02^{d}
Grandmean	17.46	14.58	12.82
F-test	**	**	*
P-value	<0.01	<0.01	<0.05
SEm (±)	1.057	0.230	0.027
LSD (0.05)	3.25	0.71	0.08
CV (%)	12.10%	3.16%	1.49%

*Means with the same letter in the column are not significantly different at p = 0.05 by DMRT. *Significant at 5% (P< 0.05),** Significant at 1% (P< 0.01), *** Significant at 0.1% (P<0.001), and NS: not significantly different at 5% (P >0.05). SEM = Standard error of mean, LSD = Least significant difference, CV = Coefficient of variance, DAS = Day after spraying and figure in the parenthesis indicate [SQR(x+0.5)] transformation value.*

From the perusal of Table 7, it is unraveled that there was a significant impact of soft pesticides on the yield, head diameter in conjunction with height. Maximum head yield (23.44 Mt/ha) was obtained through the application of Spinosad whereas minimum yield (13.76 Mt/ha) was recorded from the control. Similarly, cabbage plants in Spinosad-treated plots gave a maximum head diameter of 16.10 cm whereas the minimum head diameter (13.37 cm) was recorded from plots where no treatments were applied. In addition to this, the maximum head height (13.97 cm) was documented from the plots where they were sprayed with BEFCU which is statistically analogous (13.54 cm) with the application of Spinosad; however, head height was the lowest (11.02 cm) in those cabbage plants where no any pesticides were applied.

DISCUSSION OF RESULTS

Soft pesticides were found to be substantial, efficacious, and consistent in waning the cabbage butterfly population thereby precluding their resurgence to reach the economic injury level. Spinosad proved to be superior relative to others as a result of the zenithal stepping-down of the larval population of *P. brassicae nepalensis* over control all the time. We obtained maximum PROC (80%) on 3rd and 7th days after the third spray of Spinosad which is in conformity with the findings of Muthukumar et al (2007) who recorded the highest PROC of 78.7% against cabbage butterfly (Figure 3). Cypermethrin was disinterred as another promising bio-pesticides in our study which exhibited a 76.67% of dwindling of *P. brassicae nepalensis* after 3 days of third spray which is compatible with the inference drawn by Legwaila et al (2014), Khan &Kumar (2017), Dhawan et al (2010) and Tomlin (1994).

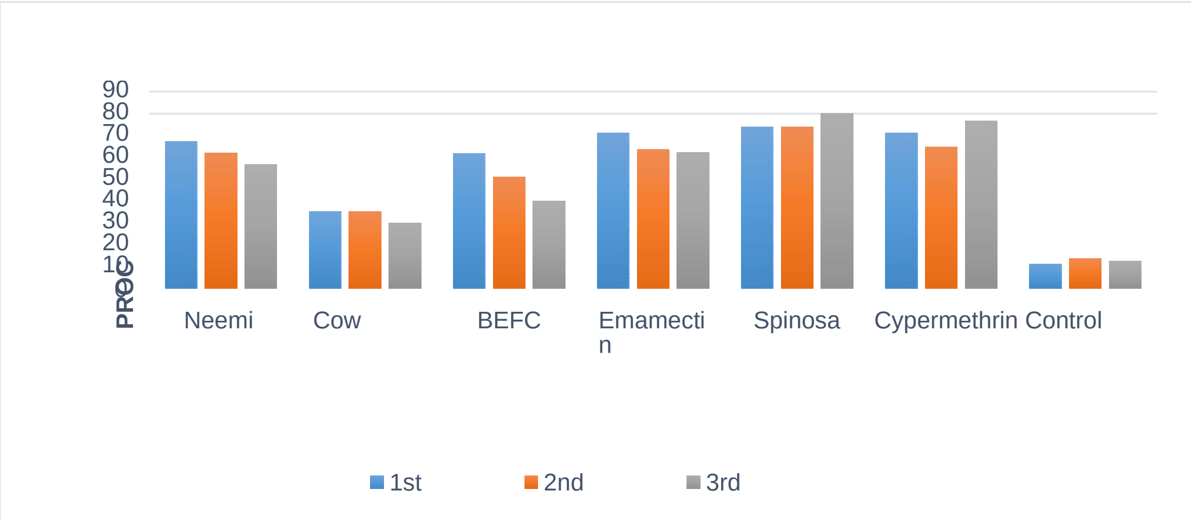

Figure 3 – Impact of spraying of different insecticides on PROC (%) of cabbage butterfly population

Emamectin benzoate was found nearly as efficacious as Cypermethrin in dwindling larval population of cabbage butterfly exhibiting a reduction of 71.25 % after 7 days of the first spray. This contention is in harmony with the assertion of Singh, Rai and Singh (2010) and Youha & Hongemi (2009) who reported a step-down of 80-90% over the control on lepidopteran pests. Neemix gave poor performance compared to other insecticides giving a maximum PROC of 56.67 % (seven days after the third spray) which is in line with the contention of Temurade, Deshmukh, and Nemade (1992). Sharma and Gupta (2009), however, reported neem-based pesticides to be effective rendering up to 88% of reduction over control against *P. brassicae* which contradicts our assertion.

Application of Spinosad divulged least percentage of leaves (13.48%) infested by *P. brassicae* seven days after the third spray relative to others whereas the highest percentage of damaged leaves were recorded with control at 3rd and 7th days after all spraying followed by cow urine solution displaying the minimum percentage of infested leaves (29.98%) three days after the first spray. These findings are in accordance with the inferences drawn by Bajracharya et al., (2016) who reported that Cypermethrin and Spinosad were effective for waning the leaves damage and achieving higher larval population control in the field condition.

Despite the reduction in the larval population by the use of soft pesticides, there is a non-significant difference in the number of holes per leaf. This might be due to the infestation of the field by *P. brassicae* even before the application of pesticides. Sallam, Soliman and Khodary (2015) results accorded strong ground to warrant our findings who reported that the post-infestation application of chemical insecticides doesn't have a significant effect on mining percent reduction.

Maximum head yield of 23.44 Mt/ha was obtained with the application of Spinosad whereas the lowest was recorded from the control (13.76 Mt/ha) followed by cow urine solution and BEFCU. Similar results were also documented by Gautam (2022). Cabbage in Spinosad treated plots gave a maximum head diameter of 16.10 cm which was followed by the application of Cypermethrin and Emamectin benzoate. In addition to this, a maximum head height of 13.97 cm was obtained from the use of BEFCU, however, the lowest height was obtained from the plants that were applied with cow urine solution. These inferences are corroborative with the assertion drawn up by Singh and Bhandari (2015) who reported that Spinosad is one of the effective pesticides to control cabbage butterfly thereby resulting in higher crop yield.

CONCLUSION

Deep insights on the efficacy of soft pesticides for the management of cabbage butterfly (*Pieris brassicacae nepalensis*) galvanize the farmers to forestall the rampant application of chemical pesticides which have untoward consequences on plants, soil, human health in conjunction with the environment. From the experiment, it was unveiled that a maximum reduction in cabbage butterfly population and head yield was found through the application of Spinosad followed by Cypermethrin and Emamection benzoate. Neemix and BEFCU were disinterred as considerable soft pesticides in abating the pest population via frequent application. All in all, Spinosad and Cypermethrin were found to be cost-effective pesticides in securing the superior yield by thwarting the cabbage butterfly population to reach economic injury level thereby subsiding the damage to the leaves and plant as a whole.

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