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Research Article

Efficacy of commercial insecticides for cowpea pod borer (*Maruca vitrata* F.) management in Pokhara, Nepal

Lok Nath Aryal[1*], Rajendra Regmi[2], Santosh Lohani[1] and Yubaraj Bhusal[1]

[1]Nepal Agricultural Research Council, Horticulture Research Station, Malepatan, Pokhara, Nepal
[2]Agriculture and Forestry University, Rampur, Chitwan, Nepal
Correspondence: loknatharyal44@gmail.com
ORCID: https://orcid.org/0000-0001-5162-2051
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ABSTRACT

Cowpea (*Vigna unguiculata* Walp.) is a major grain legume used as vegetables and pulses. Among the several insect pest of cowpea, spotted pod borer is one of the most destructive pest. To evaluate the available chemical pesticides for pod borer management, a set of field experiments on cowpea variety Malepatan-1 were conducted at Horticulture Research Station, Malepatan, Pokhara in years 2019 and 2020. The experiments were laid out in Completely Randomized Block Design (RCBD) having seven treatments viz.Flubendiamide 39.35 % SC @ 0.3 mL/L, Chlorantraniliprole 18.5 % SC @ 0.2 mL/L, Emamectin benzoate 5 % SG @0.3 g/L, Spinosad 45 % SC @0.3 mL/L, *Bacillus thuringiensis* Kurstaki @2g/L, Azadirechtin 0.03%@ 5mL/L and Control with four replications. Flubendiamide 39.35 % SC @ 0.3 mL/L and Emamectin benzoate 5 % SG @0.3 g/L were found the most effective insecticides in lowering cowpea flower and pod damage with highest benefit cost ratio; however, considering environment, Chlorantraniliprole 18.5 % SC @ 0.2 mL/L and Spinosad 45 % SC @0.3 mL/L being next effective treatments could be viable option to manage spotted pod borer in cowpea production.

Keywords:Cowpea, insecticide, pod borer, treatment, yield

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INTRODUCTION

Cowpea (*Vigna unguiculata* Walp.) is a major grain legume used as vegetables and pulses. It is subtropical and tropical crop widely grown in the warmer parts of southeastern Asia and Africa (Srinives *et al.*, 2007). Its production is estimated to be 9186 metric tons from an area of 6752 ha in Nepal (MoAD, 2017). Its production is limited by several constraints, mainly biotic pressure from insect pests and diseases (Mahalakshmi *et al.*, 2016*).* There are about 21 insect pests of different groups which are recorded to damage cowpea crop from germination to maturity (Choudhary *et al.*, 2017; Dhakal *et al.*, 2018). There are two species of spotted pod

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borer prevalent in legumes i.e. *Maruca vitrata* Fabricious, major pest in cowpea, and lablab bean, and *Maruca testulalis* Geyer, major pest of black gram (Mia, 1998). The larvae web the leaves, inflorescence, flower, flower buds, pods and feeds inside the webbing. The flower bud stage is most preferred for ovi-position. The peak incidence of larvae was observed at flowering and pod development stage. The 1st and 2nd instar larvae injure the terminal shoots and flower buds whereas third to fifth instar prefer boring into the pods and consume the developing grains.

The pod borer larvae attack on flower buds, flowers, green pods and seeds of cowpea and damage them reducing overall production (Mahalakshmi *et al.,* 2016). Grain yield loss of legumes is estimated to be 20 to 60% in India due to *Maruca vitrata* Fabricious (Singh & Allen, 1980). In cowpea, it has been estimated to be 54.4% in Bangladesh (Ohno & Alam, 1989) and 72% in Nigeria in 1985 (Ogunwolu, 1990). An experiment conducted by Regmi *et.al,* 2012 in yardlong bean has estimated that the loss by spotted borer to be more than 50 % in Chitwan, Nepal. High temperatures, high relative humidity and rainfall favor the population build up which leads to severe infestation in cowpea and pigeon pea (Akhilesh & Paras, 2005).

To reduce the crop loss, farmers are practicing indiscriminate use of chemical pesticides especially pesticides with long waiting period leading chemical residues in the food materials (Aryal *et al.,* 2016). Some of them are uneconomical and have serious impact on environment and human health (Bett *et al.,* 2017; Kamara *et al.,* 2007). So, the environment friendly and sustainable management of cowpea/legume pod borer is essential. This research aimed to evaluate the efficacy of some commercial insecticides available in Nepal with some ecofriendly measures for managing cowpea pod borer.

MATERIALS AND METHODS

Field experiments on management of spotted pod borer were conducted in Horticulture Research Station, Malepatan, Pokhara (28^{O}13' N to 83^{O}58' E and elevation of 838-848 masl) during April to August, 2019 and 2020. The cowpea variety Malepatan-1 which is fibreless even at the maturity and has bushy growth habit was used for study. The experiment was laid out in completely randomized block design (RCBD) with seven treatments (Table 1), which were replicated four times. Two seeds per hill was sown in April with the spacing of 60cm×30cm in 3mx3m plot size having 50 plants/plot. Fertilizers were applied at the rate of 40:60:40 kg NPK/ha along with 12 t/ha FYM. FYM applications were done at the time of second ploughing. Nitrogen was applied in two split dose. Data regarding flower damage and green pod infestation were collected along with green pod harvesting one day before subsequent insecticide application. Insecticide treatments were imposed thrice at 15 days interval starting from flowering to initial pod formation stage (40 days after sowing). Five plants were randomly selected from each plot to observe the damage caused by *M. vitrata* on flower and green pod. Percentage infestation were calculated by comparing the number of flower and green pod infested among existing number of flower and green pod on the sample plants. Effects of imposed treatment on seed yield were recorded from remaining plant population of the plot.

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Table 1: Treatment details

SN	Common name	Trade name	Formulation	Dose	WHO class
1	Flubendiamide	Fame 480 SC	39.35% SC	0.3 mL/L	II
2	Chlorantraniliprole	Allcora	18.5% SC	0.2 mL/L	U
3	Emamectin benzoate	Kingstar	5% SG	0.3 g/L	II
4	Spinosad	Tracer	45% SC	0.3 mL/L	III
5	*Bacillus thuringiensiskurstaki*	Lipel	SP	2 g/L	U
6	Azadirechtin	Neemraj	EC	5 mL/L	U
7	Control				

Observation on flower damage by borer, marketable and infested green pod yield, seed yield, cost and benefit from each treatment were taken and analyzed using statistical software Genstat Discovery 4. Average means were compared using DMRT (Duncan's Multiple Range Test). Mean comparison was carried out at $P < 0.01$, and $P < 0.05$ level of significance (Gomez & Gomez, 1984; Shrestha, 2019). Benefit cost ratio were calculated for each treatment to evaluate the economies of insecticide applications. The cost of cultivation and expected revenue were calculated with reference to the input used in the farm, average production and market price at Pokhara.

RESULTS AND DISCUSSION

The results from the experiment in 2019 and 2020 showed that there was significant difference (Table 2) on the effect of insecticides' treatment in numbers of flower damage. In the year of 2019, the highest number of floral damage was found from the control (2.95) which was at par with the treatments *Bacillus thuringiensisKurstaki* @2 g/L and Azadirechtin 0.03 @5 mL/L while the lowest number of floral damage was found from the treatment Flubendiamide 39.85 SC @0.3 mL/L(1.08). Similarly in the year of 2020, the highest number of floral damage was found from the control (2.48) which was at par with the treatments *Bacillus thuringiensis Kurstaki* @2 g/L and Azadirechtin 0.03 @5 mL/L while the lowest number of floral damage was found from the treatment Flubendiamide 39.85 SC @0.3 mL/L(1.06). The pooled results from both years revealed that, the number of flower damage was observed the lowest (1.07) when crop was treated with Flubendiamide which was at par with Emamectin benzoate (1.35), Chlorantraniliprole (1.45), and Spinosad (1.57) treated ones and the highest (2.71) damage were found in control plot. The combined result of two years also showed that there was significantly higher numbers of non-infested green pod per plant in Flubendiamide (33.74), Emamectin benzoate (33.62), Spinosad (32.50), and Chlorantraniliprole (31.95) sprayed plot followed by Azadirechtin (27.60) and *Bacillus thuringiensis Kurstaki* (26.61) treated plot. The present result agrees somehow with the findings of Patel *et al.* (2012) who reported that the Emamectin benzoate 5 SG @ 3 g/ L (2.70%) significantly reduced the spotted pod borer damage. Swamy *et al.* (2010) found that Flubendiamide provided good protection and less pod damage among newer insecticides viz., Flubendiamide, Spinosad, and Emamectin benzoate. Grigolli *et al.* (2015) also observed the similar findings in context to management of *Maruca vitrata* through Flubendiamide in soyabean. Sreekanth and Maha Lakshmi (2012) reported that the percent inflorescence damage due to legume pod borer is the lowest in Spinosad 45% SC @ 73 g a.i/ha treated plots (4.74%) followed by *Bacillus thuringiensis* @ 1.5 kg/ha (10.52 %)

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which is highest in control (24.79%) in pigeonpea.

Table 2: Effect of different treatments in reducing number of damaged flowers and number of pod per plant in cowpea in Pokhara, Nepal, 2019 and 2020

Treatments	No. of floral damage per plant			Number of pod/plant		
	2019	2020	Combined	2019	2020	Combined
Flubendiamide 39.85 SC @0.3 mL/L	1.08[a]	1.06[a]	1.07[a]	34.19[a]	33.30[a]	33.74[a]
Chlorantraniliprole 18.5 SC @0.2 mL/L	1.35[ab]	1.55[a]	1.45[a]	32.35[ab]	31.55[a]	31.95[a]
Emamectin benzoate 5 SG @0.3 g/L	1.35[ab]	1.35[a]	1.35[a]	35.19[a]	32.05[a]	33.62[a]
Spinosad 45 SC @ 0.3mL/L	1.65[abc]	1.49[a]	1.57[a]	34.25[a]	30.75[ab]	32.50[a]
Bacillus thuringiensisKurstaki @2 g/L	2.50[cd]	2.40[b]	2.45[b]	26.31[bc]	26.90[bc]	26.61[b]
Azadirechtin 0.03 @5 mL/L	2.23[bcd]	2.38[b]	2.30[b]	28.50[bc]	26.70[bc]	27.60[b]
Control	2.95[d]	2.48[b]	2.71[b]	22.69[c]	23.60[c]	23.14[c]
Grand mean	1.87	1.81	1.84	30.50	29.26	29.88
SEM ±	0.37	0.20	0.18	15.33	7.44	7.40
P value	0.005	<0.001	<0.001	<0.001	0.001	<0.001
F test	**	**	**	**	**	**
CV (%)	34.4	24.2	30.5	10.5	9.7	10.9

*** and * denotes significant at 1 % and 5% level of significance, respectively;* CV: Coefficient of Variation; SEM: Standard error with mean value

Higher marketable green pod yield was recorded from Flubendiamide, Emamectin benzoate, Chlorantraniliprole, Spinosad treated plot, respectively as 9.68 t/ha, 9.05 t/ha, 8.65 t/ha and 8.53 t/ha (Table 3) which were at par in 2019 similar trends of result was observed in 2020, where higher marketable green pod yield were obtained as 8.48 t/ha, 8.45 t/ha, 7.89 t/ha and 7.65 t/ha respectively in Emamectin benzoate, Flubendiamide, Chlorantraniliprole and Spinosad treated plot. The pooled analysis from both years also showed that there was significantly higher green pod yield in Flubendiamide (9.57 t/ha) and Emamectin benzoate (8.77 t/ha) treatment followed by Chlorantraniliprole (8.27 t/ha) and Spinosad (8.09 t/ha) which were found at par. The lowest yields were observed in control plot followed by *Btkurstaki* and Azadirechtin application. The combined analysis also showed that the lowest unmarketable green pod yield was observed from Flubendiamide (0.97 t/ha), Emamectin benzoate (1.17 t/ha), and Chlorantraniliprole (1.26 t/ha) treatment. The highest unmarketable green pod yield was found from control plot (2.87 t/ha). This finding is in line with the result of Mallikarjuna *et al.* (2009) who recorded the highest larval reduction of pod borers with spraying Flubendiamide 480SC followed by Emamectin benzoate 55G in Dolichos bean. Regmi *et al.* (2012) found that the highest green pod yield in Emamectin benzoate sprayed plot (18.45 t/ha). They also found that the fresh green pod produced at Lipel (14.34 t/ha), and Margosom (12.96 t/ha) treatment is higher than control (11.29 t/ha). Chlorantraniliprole20 % SC at 20 g a.i./ha can be used against legume pod borer as an alternative for conventional insecticides (Maha Lakshmi *et al.*, 2013). Rao *et al.* (2007) observed that the Spinosad 45 EC @0.4 mL/L recorded the lowest pod damage by spotted pod borer in pigeon pea.

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Table 3: Effect of different insecticides treatments against cowpea pod borer on marketable and infested green pod yield of cowpea in Pokhara, Nepal, 2019 and 2020

Treatments	Marketable green pod yield (t/ha)			Unmarketable green pod yield (t/ha)		
	2019	2020	Combined	2019	2020	Combined
Flubendiamide 39.85 SC @0.3 mL/L	10.68[a]	8.45[a]	9.57[a]	1.05[a]	0.88[a]	0.97[a]
Chlorantraniliprole 18.5 SC @0.2 mL/L	8.65[ab]	7.89[ab]	8.27[b]	1.18[a]	1.34[ab]	1.26[a]
Emamectin benzoate 5 SG @0.3 g/L	9.05[ab]	8.48[a]	8.77[a]	1.10[a]	1.25[ab]	1.17[a]
Spinosad 45 SC @ 0.3mL/L	8.53[ab]	7.65[ab]	8.09[b]	1.83[b]	2.05[bc]	1.94[b]
Bacillus thuringiensisKurstaki @2 g/L	6.77[cd]	5.97[abc]	6.37[c]	2.18[b]	2.23[bc]	2.21[b]
Azadirechtin 0.03 @5 mL/L	7.49[cd]	6.72[abc]	6.86[bc]	1.88[b]	2.10[bc]	1.99[b]
Control	5.42[d]	5.51[c]	5.57[c]	2.86[c]	2.89[c]	2.87[c]
Grand mean	8.08	7.23	7.64	1.72	1.82	1.77
SEM ±	2.86	1.70	1.20	0.13	0.32	0.16
P value	0.014	0.029	<0.001	<0.001	0.002	<0.001
F test	*	*	**	**	**	**
CV (%)	21.8	18.9	20.9	15	32.7	28.10

*** and * denotes significant at 1 % and 5% level of significance, respectively;* CV: Coefficient of Variation; SEM: Standard error with mean value

The seed yields were significantly high when crop was sprayed with any of four insecticides i.e. Flubendiamide, Chlorantraniliprole, Emamectin benzoate and Spinosad in both years (Table 4). The combined analysis of two years showed that significantly high cowpea seed yield was obtained from Flubendiamide (938.05 kg/ha), Emamectin benzoate (931.40 kg/ha), Spinosad (923.31 kg/ha) and Chlorantraniliprole (918.28 kg/ha) treated plot. The lowest seed yield were obtained from control (686.29 kg/ha) followed by *Bacillus thuringiensis Kurstaki* (781.04 kg/ha) and Neemraj (804.02 kg/ha) treated plot.

Table 4: Effect of different treatments on seed yield of cowpea in Pokhara, Nepal, 2019 and 2020

Treatments	Seed yield (kg/ha)		
	2019	2020	Combined
Flubendiamide 39.85 SC @0.3 mL/L	926.7[a]	949.4[a]	938.05[a]
Chlorantraniliprole 18.5 SC @0.2 mL/L	933.7[a]	902.8[ab]	918.28[a]
Emamectin benzoate 5 SG @0.3 g/L	940.3[a]	922.5[ab]	931.40[a]
Spinosad 45 SC @ 0.3mL/L	954.8[a]	891.9[ab]	923.31[a]
Bacillus thuringiensisKurstaki @2 g/L	778.4[b]	783.6[bc]	781.04[b]
Azadirechtin 0.03 @5 mL/L	803.3[b]	804.7[abc]	804.02[b]
Control	700[b]	672.6[c]	686.29[c]
Grand mean	862.5	847	854.63
SEM ±	8202.84	8240.09	7507.01
P value	0.001	0.006	<0.001
F test	**	**	**
CV (%)	9.4	10.9	9.9

*** and * denotes significant at 1 % and 5% level of significance, respectively;* CV: Coefficient of Variation; *SEM: Standard error with mean value*

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These findings agree with the reports of Anusha *et al.*, (2014) who recorded the highest protection with Flubendiamide against pod borers (*M. vitrata*) followed by Emamectin benzoate 5 SG @ 0.2g/L and Spinosad 45 sc @ 0.1 mL/L in reducing the larval infestation in field bean. Ashok Kumar and Shivaraju (2009) reported that Flubendiamide 480 SC @ 48g a.i/ha is highly effective in controlling the pod borers in blackgram. Chyandrayudu*et al.* (2008) recorded the efficacy of commercial formulation of *Bacillus thuringiensis* @ 0.0025 % in suppression of pod damage due to spotted pod borer in cowpea.

The cowpea pod borer infestation was found less when crop was treated with Flubendiamide (6.71 %), Emamectin benzoate (6.88%), Chlorantraniliprole (7.68%) and Spinosad (8.26%). The highest percentage of pod infestation was observed in control plot (33.32 %) which was followed by *Bacillus thuringiensiskurstaki* (19.35 %) and Neemraj (16.59 %) application (Figure 1). The minimum effectiveness of *Bacillus thuringiensis* Kurstaki against pod borer (*Maruca vitrata*) might be due to improper storage and weather factors during application. The present result of investigations are in conformity with Singh *et al.* (2020) who found that significantly lower mean pod damage in number basis (4.79%) was recorded in flubendiamide 20 WG @ 1.0 g/L followed by spinosad 45 SC @ 0.3 mL/L, and emamectin benzoate 5 SG @ 0.5 g/L, with 7.99 %, 9.39 %, and 9.47 %, respectively, and the highest pod damage (13.46%) recorded in control plot. Craig *et al.* (1996) reported emamectin benzoate is effective for controlling Lepidopteran pest species on vegetable crops.

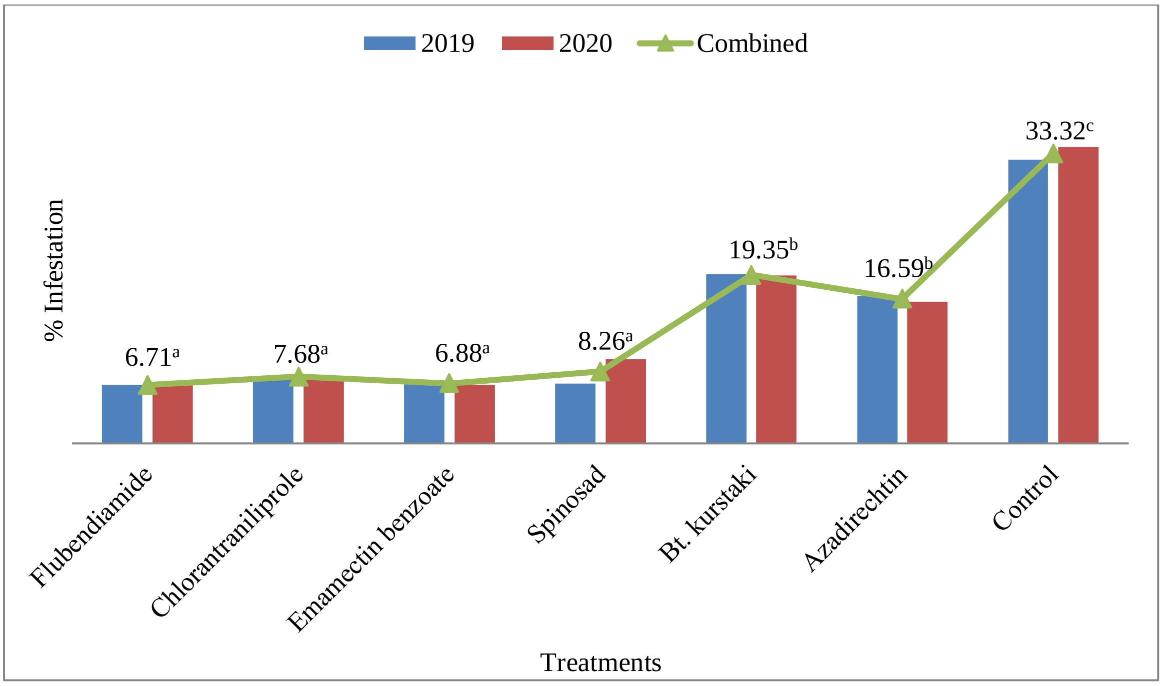

Figure 1: Effect of different treatments on percentage infestation of pod (on pod number basis) in Malepatan, Pokhara during 2019 and 2020

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Cost-benefit calculation of different treatments

The cost of cultivation per hectare without insecticide was found NRs. 203,833 (Table 5). The highest cost of insecticide application was found in Spinosad (NRs. 55,500/ha) followed by Flubendiamide (NRs. 36600/ha), Neemraj (NRs. 31,500/ha), Chlorantraniliprole (NRs. 19,500 per ha), *Bacillus thuringiensis*kurstaki (NRs. 9,000/ha) and Emamectin benzoate (NRs. 8,700).

Table 5: Cost of cultivation without considering plant protection measures in unit area (1 ha) in Pokhara, 2019

S.N	Particulars	Unit	Quantity	Rate (NRs.)	Total (NRs.)
A.	Variable cost				
1	Seed	Kg	30	500	15000
2	Fertilizer				
2.1	FYM	Kg	12000	4	48000
2.2	Urea	Kg	35.87	40	1434.8
2.3	DAP	Kg	130.44	50	6522
2.4	MOP	Kg	67	40	2680
3	Tractor for cultivation	hr	2	1200	2400
4	Labour for sowing seed	Person	8	517	4136
5	Labour for weeding, hoeing, top dressing and irrigation	Person	80	517	41360
6	Labor for harvesting and bundling	Person	100	517	51700
B.	Fixed cost				
1	Land rent	ha	1	30000	30000
2	Spade	No.	2	300	600
	Total cost of cultivation				203,833

Table 6: Cost of spraying of different insecticides against cowpea pod borer, *Maruca vitrata* in Pokhara, Nepal, during 2019 and 2020

Treatments	Quantity of insecticides (ml or g/ha)	Total cost of insecticides (NRs./ha)	Labor + Sprayer cost (NRs./ha)	Total cost of treatment (NRs./ha)	Total cost of cultivation (NRs./ha)	Grand total
Flubendiamide 39.85 SC @0.3 mL/L	300	35100	1500	36600	203833	240433
Chlorantraniliprole 18.5 SC @0.2 mL/L	200	18000	1500	19500	203833	223333
Emamectin benzoate 5 SG @0.3 g/L	300	7200	1500	8700	203833	212533
Spinosad 45 SC @ 0.3mL/L	300	54000	1500	55500	203833	259333
Bacillus thuringiensisKurstaki @2 g/L	2000	7500	1500	9000	203833	212833
Azadirechtin 0.03 @5 mL/L	5000	30000	1500	31500	203833	235333
Control		0	0	0	203833	203833

Source: Average cost of cultivation based on field level retail price in Pokhara in 2019 and 2020

The highest benefit cost ratio of marketable green pod yield was found in Emamectin benzoate

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treatment (2.06) followed by Flubendiamide (1.99), Chlorantraniliprole (1.85), Spinosad (1.56), *Bacillus thuringiensisKurstaki* (1.49) and Neemraj (1.46). The control treatment (without any insecticide) gave the lowest benefit cost ratio (1.37) (Table 6). The result was supported by the finding of Anusha*et al.,* (2014) who observed that the highest benefit cost ratio (3.06) in Flubendiamide 480 SC @ 0.1 mL/L (2.96) followed by Emamectin benzoate 5 SG @ 0.2 g/L, and spinosad 45 SC @ 0.2 mL/L (2.32).

Table 7: Benefit-cost ratio of different insecticide treatments against cowpea pod borer, *Maruca vitrata* in Pokhara, Nepal, during 2019 and 2020

Treatments	Marketable green pod yield (t/ha)	Total return (NRs./ha)	Total cost of cowpea production (NRs./ha)	Net profit (NRs./ha)	Benefit-cost ratio
Flubendiamide 39.85 SC @0.3 mL/L	9.57	478500	240433	238067	1.99
Chlorantraniliprole 18.5 SC @0.2 mL/L	8.27	413500	223333	190167	1.85
Emamectin benzoate 5 SG @0.3 g/L	8.77	438500	212533	225967	2.06
Spinosad 45 SC @ 0.3mL/L	8.09	404500	259333	145167	1.56
Bacillus thuringiensisKurstaki @2 g/L	6.37	318500	212833	105667	1.49
Azadirechtin 0.03 @5 mL/L	6.86	343000	235333	107667	1.46
Control	5.57	278500	203833	74667	1.37

**In this time ,there was no difference in price of fresh cowpea between the organic production and inorganic production. The average selling price of cowpea green pod at farm gate price NRs.50 per kg in Pokhara, 2019 and 2020*

CONCLUSION

The spotted pod borer, *Maruca vitrata* Fabricious was major pest of cowpea production in Nepal. From the two year's experiment, Flubendiamide 39.35% SC @ 0.3 mL/L, Emamectin benzoate 5% SG @0.3 g/L, Chlorantrinilprole 18.5% SC @ 0.2 mL/L and Spinosad 45% SC @0.3 mL/L were the most effective insecticides in lowering cowpea flower and pod damage and protecting crop by increasing fresh green pod and seed yield. Safe treatments like Neemraj 0.03%@ 5mL/L and commercial *Bacillus thuringiensis* Kurstaki @2g/L were found effective for reducing the spotted pod borer infestation to some extent than control.The yield from the chemical pesticides were more than the bio pesticides. The highest benefit cost ratio were found with Emamectin benzoate 5 % SG @0.3 g/L followed by Flubendiamide 39.35 % SC @ 0.3 mL/L, Chlorantraniliprole 18.5 % SC @ 0.2 mL/L and Spinosad 45 % SC @0.3 mL/L (1.56). Among the treatments used for the research, Chlorantraniliprole 18.5 % SC and Spinosad 45 % SC being comparatively safe and may be viable option to manage spotted pod borer as compared to Flubendiamide 39.35 % SC @ 0.3 mL/L and Emamectin benzoate 5 % SG @0.3 g/L even if they had relatively more benefit cost ratio. Therefore, use of Chlorantraniliprole

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and Spinosad are recommended to manage spotted pod borer in cowpea field.

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Authors' Contributions
LN Aryal designated the research plan, conducted experiment and prepared manuscript. R. Regmi, S. Lohani, and YR Bhusal assisted in data analysis and manuscript preparation.

Conflict of Interest
The authors declare that there is no conflict of interest with present publication.

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