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Research Article

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Evaluation of Efficacies of Some Insecticides against Major Insect Pests of Brinjal and Cabbage in Mid Hills of Meghalaya

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Abstract

The experiments were conducted at ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya, India to evaluate of some insecticides against major insect pests of brinjal and cabbage under field condition. All treatments viz. indoxacarb 14.5 SC (75 and 150 g a.i. ha^{-1}), chlorfenapyr 10 SC (100 and 200 g a.i. ha^{-1}), chlorpyrifos 20EC (200 and 400 g a.i. ha^{-1}) and control (water spray) were applied thrice in brinjal and twice in cabbage at 15 days intervals. Shoot infestation in brinjal was counted from randomly selected five tagged plants from each replication before spray and on 7 and 14 days after application of insecticides. Fruits infestations were counted during harvesting only. In cabbage, larval population was counted from five randomly selected tagged plants from each replication on 1 day before and on 1, 3, 7, 14 days of each spray. Results revealed that the mean shoot infestation of brinjal was lowest in indoxacarb at double the recommended dose (4.82%) followed by indoxacarb at recommended dose (6.65%) with 80.19 and 72.66% reduction respectively over control check. The lowest brinjal fruit infestation (8.25%) also recorded at double the recommended dose of indoxacarb followed recommended dose (11.48%) of same insecticide. In cabbage, pooled of two years results revealed that indoxacarb @ 150 g a.i. ha^{-1} was very effective treatment with lowest number of larvae (0.98 larvae plant^{-1}) followed by indoxacarb @ 75 g a.i. ha^{-1} (2.21 larvae plant^{-1}) with higher marketable yield at both these treatments.

Keywords: Brinjal, cabbage, chlorfenapyr, indoxacarb, *Leucinodes orbonalis*, *Pieris brassicae*

1. Introduction

Vegetables are the most vital constituents of our diet and power house of nutrients. They contain large quantity of minerals, vitamins, dietary fibers, folic acid and antioxidants. They are also rich in secondary metabolites and antioxidants which help in preventing diseases like cancer, cardiovascular diseases, diabetes and hypertension (Islam, 2006). It has been reported that intake of vegetables and fruits is inversely associated with the risk of many chronic diseases (Zhang et al., 2015). India produces a large number of vegetables every year to meet the huge nutritional need of its population (Patra et al., 2018). India stands second position in vegetables production after China with the production of 184.39 million mt from

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10.25 million ha area during 2017–2018 (Anonymous, 2018). Among the vegetables, solanaceous (brinjal) and cruciferous (cabbage and cauliflower) are widespread vegetables and fetch better return to the vegetable growers. Brinjal or eggplant (*Solanum melongena* L.) is an important solanaceous vegetable in India. It is also valued for medicinal properties as it is used in treatment of diseases like intestinal worm, cough and leucorrhoea. It is grown in different parts of India round the year except in regions of high altitudes. It produced 128.01 lakh mt from 7.30 lakh ha area with productivity of 17.53 mt ha^{-1} during 2017–2018 (Anonymous, 2018) in our country. Cabbage (*Brassica oleracea* var. *capitata*) is another popular cool-season crop cultivated throughout the country. In India, it is grown mainly during the winter season and in a few places during the rainy season (Ganguly et al., 2017). It is generally grown for its compactly leaved heads and consumed in many ways as cooked curries, salad and boiled vegetables. Fresh leafy cabbage is incredibly nutritious and very low in fat and calories. They have high nutritional value and are rich source of vitamin C and K. They also contain an adequate amount of minerals like potassium, manganese, iron and magnesium. Total cabbage production in India was 90.37 lakh mt from 3.99 lakh ha area with the productivity of 22.65 mt ha^{-1} (Anonymous, 2018). Major constraint for brinjal and cabbage production is heavy infestation of insect pests on these crops. Brinjal is attacked by many pests like shoot and fruit borer (BSFB), jassid, epilachna beetles, white fly and aphids (Patra et al., 2016a). Amongst, BSFB (*Leucinodes orbonalis* Guenee) is a serious insect pest of brinjal in all brinjal growing countries (Yousafi et al., 2015). Early larval instars feed exclusively on flower buds, flowers and tender shoots causing dead heart. While, later instars larva bore into fruits until they pupate and reducing their marketable value. It is reported that BSFB caused 26.3–62.5% fruit damage in Khasi hills of Meghalaya (Gangwar and Sachan, 1981; Patra et al., 2016a). It is found throughout the tropics in Asia and Africa, where it can reduce yield by as much as 70% (Srinivasan, 2009). Cabbage is also suffered by many dreaded insect pests such as, diamondback moth, cabbage borer, cabbage leaf webber, cabbage butterfly and aphids during different growth stages (Patra et al., 2017, Patra et al., 2020). The avoidable quantitative loss due to insect pests was estimated between 29.33-32.67% (Jat et al., 2017) in cabbage. Out of these, cabbage butterfly *Pieris brassicae* (L.) (Lepidoptera: Pieridae) is the most serious pest of cabbage, cauliflower and many crucifers found different regions of the world and it passes the winter in the plains and migrates to hilly regions during summer in India (Lytana and Firake, 2012). It is a key insect pest of cabbage in Meghalaya (Rangad et al*.,* 2014) and it alone can cause more than 40% of yield loss annually (Ali and Rizvi, 2007). This pest causes heavy damage to different growth stages of cole crops (Sachan and Gangwar, 1980; Younas et al., 2004; Lal and Ram, 2004). Caterpillars infest on leaves and defoliate the whole plant eventually results into yield loss and product deterioration. To combat these huge losses, farmers are frequently using over doses of pesticides that creates many problems in the environment. Hence, it is very much necessity to evaluate the frequently used insecticides with different doses against these pests. Keeping these views, the present studies were carried out to evaluate some insecticides with recommended (RD) and double the recommended (DRD) against shoot and fruit borer in brinjal and cabbage butterfly under mid hills of Meghalaya.

2. Materials and Methods

The experiments were carried out at ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya, India to assess the efficacies of some insecticides against BSFB during kharif season and cabbage butterfly during *rabi* season of 2016–17 and 2017–18. The randomized block designs (RBD) were used for the present study with seven treatments and three replications. Brinjal (var: chhaya) was planted in 12 m^2 area with a spacing of 60×50 cm^2 whereas cabbage (var: wonder ball) was transplanted in same size of plot with a spacing of 50×50 cm^2. All treatments viz. indoxacarb 14.5 SC at recommended dose, RD (75 g a.i. ha^{-1}) and double the recommended dose, DRD (150 g a.i. ha^{-1}), chlorfenapyr 10 SC at RD (100 g a.i. ha^{-1}) and DRD (200 g a.i. ha^{-1}), chlorpyriphos 20 EC at RD (200 g a.i. ha^{-1}) and DRD (400 g a.i. ha^{-1}) and control (water spray) were applied thrice in brinjal and twice in cabbage at 15 days intervals. In brinjal, infested shoot and total shoot was observed from five randomly selected tagged plants from each replication on 1 day before the spray and on 7 and 14 days after application of treatments. Total marketable and damage fruits of brinjal were recorded after each harvesting only. In cabbage, larval population of cabbage butterfly was counted from five randomly selected tagged plants from each plot on 1 day before and on 1, 3, 7, 14 days of spray application. Then, mean data were subjected to suitable transformation for both the crops and analysed using Tukey's honestly significance test at five percent level of probability.

3. Results and Discussion

3.1. *Effect of insecticides against shoot infestation of brinjal*

Efficacies of insecticides against shoot infestation during 2016 and 2017 are illustrated in Table 1. During 2016, the experimental results revealed that the pretreatment shoot infestation ranged from (13.48–18.95%) and there was no difference among the treatments before spray. However, post application data showed that all insecticidal treatments were effective for suppressing shoot infestation over untreated control plots and there were significant differences among the treatments. The lowest shoot damage (4.79%) was found in indoxacarb at DRD followed by indoxacarb at RD (6.19%), chlorfenapyr at DRD (7.39%), chlorpyrifos at DRD (7.81%) whereas maximum shoot damage was found in untreated control plot (27.01%). During 2017, similar trend of shoot damage found as in previous year. The minimum shoot damage was found in indoxacarb at DRD (4.85%) followed

Table 1: Effect of insecticide treatments on shoot infestation in brinjal during 2016 and 2017

Treatments	Dose (g a.i. ha^{-1})	Shoot infestation (%) before and after spray during two consecutive seasons											
		2016					2017					MSI	POC
		Before spray	Spray I	Spray II	Spray III	Mean	Before spray	Spray I	Spray II	Spray III	Mean		
Indoxacarb	75	16.52^{a} (24.68)	10.79^{a} (20.06)	5.25^{a} (14.40)	2.55^{ab} (10.72)	6.19^{ab} (15.55)	9.85^{a} (19.21)	9.10^{ab} (18.52)	7.69^{ab} (17.13)	4.54^{ab} (13.60)	7.11^{b} (16.55)	6.65^{ab} (16.06)	72.66
Indoxacarb	150	18.95^{a} (26.48)	9.09^{a} (18.37)	3.75^{a} (12.53)	1.52^{a} (9.12)	4.79^{a} (13.85)	10.84^{a} (20.10)	7.13^{a} (16.54)	4.57^{a} (13.57)	2.87^{a} (11.32)	4.85^{a} (13.98)	4.82^{a} (13.92)	80.19
Chlorfenapyr	100	13.48^{a} (22.35)	12.09^{a} (21.13)	7.64^{ab} (17.04)	5.79^{c} (15.10)	8.50^{c} (17.92)	9.60^{a} (18.98)	10.21^{abc} (19.54)	11.34^{bc} (20.53)	8.56^{cd} (18.00)	10.04^{cd} (19.39)	9.27^{cd} (18.67)	61.90
Chlorfenapyr	200	14.39^{a} (23.08)	10.54^{a} (19.78)	6.88^{ab} (16.24)	4.76^{bc} (13.66)	7.39^{ab} (16.77)	10.61^{a} (19.85)	9.07^{ab} (18.45)	10.42^{bc} (19.73)	5.75^{bc} (15.04)	8.41^{bc} (17.86)	7.90^{bc} (17.35)	67.52
Chlorpyrifos	200	17.42^{a} (25.39)	12.92^{a} (21.86)	10.26^{b} (19.53)	6.83^{c} (16.24)	10.00^{c} (19.36)	11.76^{a} (20.87)	12.89^{cd} (21.87)	15.15^{c} (23.67)	11.69^{d} (20.82)	13.24^{e} (22.17)	11.62^{d} (20.81)	52.23
Chlorpyrifos	400	18.15^{a} (25.93)	10.41^{a} (19.66)	6.70^{ab} (16.11)	6.32^{c} (15.69)	7.81^{ab} (17.24)	9.58^{a} (18.88)	11.82^{bcd} (20.97)	12.89^{c} (21.82)	11.85^{d} (20.95)	12.19^{de} (21.27)	10.00^{cd} (19.35)	58.92
Control	-	15.35^{a} (23.82)	21.64^{b} (28.38)	27.08^{c} (31.96)	32.32^{d} (35.25)	27.01^{d} (31.94)	8.79^{a} (18.21)	15.22^{d} (23.73)	24.09^{d} (30.05)	25.64^{e} (31.07)	21.65^{f} (28.42)	24.33^{e} (30.22)	-
SEm±	-	-	0.51	1.03	0.92	0.51	-	0.65	0.90	0.80	0.48	0.38	-
CD*	-	NS	1.57	3.17	2.84	1.57	NS	1.99	2.78	2.45	1.48	1.16	-

MSI: Mean shoot infestation (%) (Pooled of two years); POC: Protection over control (%); CD*: CD (p=0.05); Figures in parentheses are angular transformed value; Difference in mean values was determined by Tukey's honestly significance test. Means sharing the same letter in a column are not significantly different at 5% level of significance

by indoxacarb at RD (7.11%). The pooled results of two years data showed that lowest shoot damage was found in DRD of indoxacarb (4.82%) followed by RD of same insecticide (6.65%) with 80.19 and 72.66% reduction of shoot damage over control (Table 1).

3.2. *Effect of insecticide treatments on fruit infestation and yield of brinjal*

The data pertaining to fruit infestation and yield of brinjal during 2016 and 2017 are presented in Table 2. Though, all insecticidal treatments showed effectiveness for reducing fruit infestation over control plots with significant differences in efficacies. During 2016, indoxacarb at DRD showed the lowest mean fruit infestation (7.50%) followed by RD of same insecticides (10.05%), chlorfenapyr at DRD (10.07%) and chlorpyrifos at DRD (10.56%) whereas the highest fruit damage was found in control plot (35.89%). During 2017, the lowest fruit damage was recorded in double dose of indoxacarb (9.01%) followed by single dose of same insecticide (12.92%). The pooled results of two years data revealed that minimum fruit infestation was also found in DRD of indoxacarb (8.25%) followed by RD of same insecticide (11.48%) with 77.64 and 68.89% reduction respectively over control plots. The chlorfenapyr at DRD (12.51%) was also effective treatment and it was statistically at par with other insecticidal treatments. During 2016, the highest marketable yield was observed in indoxacarb at DRD treated plots (256.23 q ha^{-1}) which was statistically at par with RD of indoxacarb (245.37 q ha^{-1}) followed by chlorfenapyr at DRD (231.78 q ha^{-1}). In the second season (2017), almost the similar trend of results of yield was observed as found in previous year. Pooled of two years results also revealed the similar trend of yield in all treatments. The highest marketable yield was found in double dose of indoxacarb (252.98 q ha^{-1}) followed by single dose of same insecticide (243.50 q ha^{-1}) with 56.22 and 54.52% increase over control plots (110.76 q ha^{-1}).

According to present findings, indoxacarb at both RD and DRD were promising against *Leucinodes orbonalis* in brinjal. The findings of the present experiments are in conformity with the results of Singh (2010) who exhibited the good results of indoxacarb against *L. orbonalis*. Indoxacarb belongs to oxydiazinon, a new chemical group and has a unique mode of action to counterbalance the resistance problem (Gunning and Moores, 2002). The present results are in agreement with the findings of many workers (Patra et al., 2009; Mahata et al., 2014; Tripura et al., 2017a) who demonstrated that indoxacarb found very effective for managing *L. orbonalis*. The results of chlorfenapyr in the present experiments were also effective against *L. orbonalis*. The results of chlorfenapyr are in the similar line of findings of Hunt and Treacy (1998) who revealed that chlorfenapyr, specifically a pro-insecticide and considered as best insecticide against *L. orbonalis*. Foliar

Table 2: Effect of insecticide treatments on fruit infestation of brinjal during 2016 and 2017

Treatments	Dose (g a.i. ha^{-1})	Mean fruit infestation (%)			Reduction over control (%)	Marketable yield (q ha^{-1}) of brinjal			Increase yield over control (%)
		2016	2017	Mean (Pooled of two years)		2016	2017	Mean (Pooled of two years)	
Indoxacarb	75	10.05[ab] (19.38)	12.92[bc] (21.89)	11.48[abc] (20.69)	68.89	245.37[ab]	241.63[ab]	243.50[ab]	54.52
Indoxacarb	150	7.50[a] (16.92)	9.01[a] (18.44)	8.25[a] (17.70)	77.64	256.23[a]	249.72[a]	252.98[a]	56.22
Chlorfenapyr	100	12.99[bc] (21.92)	15.36[cd] (23.84)	14.18[bc] (22.92)	61.59	223.15[b]	217.79[c]	220.47[c]	49.76
Chlorfenapyr	200	10.07[ab] (19.31)	14.96[cd] (22.75)	12.51[bc] (20.71)	66.10	231.78[ab]	226.45[bc]	229.12[bc]	51.66
Chlorpyrifos	200	15.09[c] (23.64)	17.40[d] (25.39)	15.64[c] (24.53)	57.62	222.16[b]	211.05[c]	216.61[c]	48.87
Chlorpyrifos	400	10.56[ab] (19.78)	15.26[cd] (23.78)	12.91[bc] (21.88)	65.01	225.27[b]	213.24[c]	219.25[c]	49.49
Control	-	35.89[d] (37.36)	37.93[e] (38.60)	36.91[d] (37.99)	-	113.65[c]	107.86[d]	110.76[d]	-
SEm±	-	0.92	0.46	0.59	-	4.94	3.06	2.79	-
CD (*p*=0.05)	-	2.83	1.42	1.81	-	15.22	9.43	8.61	-

Figures in parentheses are angular transformed value; Difference in mean values was determined by Tukey's honestly significance test. Means sharing the same letter in a column are not significantly different at 5% level of significance

applications of chlorfenapyr was demonstrated by Miller et al. (1990) and reported that chlorfenapyr was found effective for control of more than 70 insect pests and mites in different crops. However, the conventional insecticide, chlorpyrifos significantly reduced the brinjal fruit and shoot borer incidence as compared to untreated control, but its effectiveness was not as good as newer insecticides. Analogous findings of chlorpyrifos against *L. orbonalis* was exhibited by (Singh and Sachan, 2015) who stated that chlorpyrifos was relatively less effective against *L. orbonalis* as compared to new generation insecticide like spinosad.

3.3. *Effect of insecticide treatments against Pieris brassicae and on marketable yield of cabbage*

Effect of insecticide treatments against *Pieris brassicae* on cabbage for 2017 and 2018 is illustrated in Table 3. The population of *P. brassicae* was non-significant before spraying among the treatments in 2017 and 2018. During 2017, the pretreatment counts of larval population varied from 15.40 to22.23 larvae $plant^{-1}$. Mean of two (first and second) spray revealed that all the insecticidal treatments proved effectively superior over control plot against larval population of *P. brassicae*. Among the treatment, indoxacarb at DRD recorded the lowest number of larvae $plant^{-1}$ (1.20 larvae $plant^{-1}$) which was at par with chlorpyrifos at DRD (2.44 larvae $plant^{-1}$) and indoxacarb at RD (3.15 larvae $plant^{-1}$) with 95.25, 90.34 and 87.55% reduction over control treatments (25.27 larvae $plant^{-1}$), respectively. In the second season (2018), the pretreatment data varied from 5.47 to7.73 larvae $plant^{-1}$. Mean of two spray revealed that minimum number of larvae recorded in indoxacarb at DRD (0.77 larvae $plant^{-1}$) which was significantly at par with chlorfenapyr at DRD (1.02 larvae $plant^{-1}$) and indoxacarb at RD (1.28 larvae $plant^{-1}$) with 92.47, 90.01 and 87.43% decrease over control treatment (10.18 larvae $plant^{-1}$), respectively. The pooled of two years results also showed that indoxacarb at DRD recorded lowest larval population (0.98 larvae $plant^{-1}$) with 94.45% reduction over control treatments (17.72 larvae $plant^{-1}$) while all remaining treatments showed at par each other's.

The marketable yield of cabbage for 2017 and 2018 is depicted in Figure 1. During 2017, the higher yield obtained from the both doses of indoxacarb (19.05 and 18.24 t ha^{-1}, respectively). Chlorpyrifos at DRD was the next treatment for recording good yield (16.01 t ha^{-1}) followed by chlorfenapyr at RD (12.87 t ha^{-1}). During 2018, indoxacarb at both doses recorded maximum

Table 3: Effect of insecticide treatments against *Pieris brassicae* on cabbage during 2017 and 2018

Treatments	Dose (g a.i. ha^{-1})	No. of larvae plant^{-1} during two consecutive years											
		2017					2018					CMLP	ROC
		Before spray	First spray	Second spray	Mean	PROC	Before spray	First spray	Second spray	Mean	PROC		
Indoxacarb	75	17.17^{a} (4.18)	5.18^{ab} (2.37)	1.12^{ab} (1.24)	3.15^{abc} (1.89)	87.55	6.20^{a} (2.56)	1.63^{abc} (1.46)	0.93^{ab} (1.20)	1.28^{ab} (1.33)	87.43	2.21^{ab} (1.65)	87.53
Indoxacarb	150	15.40^{a} (3.97)	2.18^{a} (1.63)	0.22^{a} (0.84)	1.20^{a} (1.30)	95.25	5.67^{a} (2.48)	0.85^{a} (1.16)	0.68^{a} (1.09)	0.77^{a} (1.12)	92.47	0.98^{a} (1.22)	94.45
Chlorfenapyr	100	20.93^{a} (4.57)	7.70^{b} (2.86)	3.83^{c} (2.08)	5.77^{c} (2.50)	77.18	6.33^{a} (2.58)	1.93^{bc} (1.56)	1.92^{b} (1.55)	1.93^{bc} (1.56)	81.08	4.30^{b} (2.08)	75.75
Chlorfenapyr	200	22.23^{a} (4.76)	5.53^{ab} (2.40)	2.07^{bc} (1.59)	3.80^{bc} (2.04)	84.98	6.60^{a} (2.66)	1.10^{ab} (1.26)	0.93^{ab} (1.20)	1.02^{ab} (1.23)	90.01	3.21^{ab} (1.69)	81.90
Chlorpyrifos	200	16.30^{a} (4.09)	6.58^{b} (2.66)	1.08^{ab} (1.25)	3.83^{bc} (2.08)	84.85	5.47^{a} (2.43)	2.75^{c} (1.80)	2.15^{b} (1.62)	2.45^{c} (1.71)	75.92	3.14^{b} (1.91)	82.29
Chlorpyrifos	400	19.11^{a} (4.42)	4.08^{ab} (2.13)	0.80^{ab} (1.13)	2.44^{ab} (1.71)	90.34	7.33^{a} (2.78)	2.17^{bc} (1.63)	1.83^{ab} (1.52)	2.00^{bc} (1.58)	80.34	2.22^{ab} (1.65)	87.47
Control	-	18.83^{a} (4.37)	26.15^{c} (5.16)	24.40^{d} (4.98)	25.27^{d} (5.07)	-	7.73^{a} (2.86)	8.97^{d} (3.07)	11.38^{c} (3.44)	10.18^{d} (3.26)	-	17.72^{c} (4.26)	-
SEm±	-	-	0.20	0.14	0.16	-	-	0.09	0.09	0.08	-	0.11	-
CD*	-	NS	0.61	0.43	0.49	-	NS	0.27	0.28	0.25	-	0.34	-

PROC: Percent reduction over control; CMLP: Cumulative mean larvae plant^{-1} (Pooled of two years); Figures in parentheses are square root transformed √(x+0.5) value; Difference in mean values was determined by Tukey's honestly significance test. Means sharing the same letter in a column are not significantly different at 5% level of significance

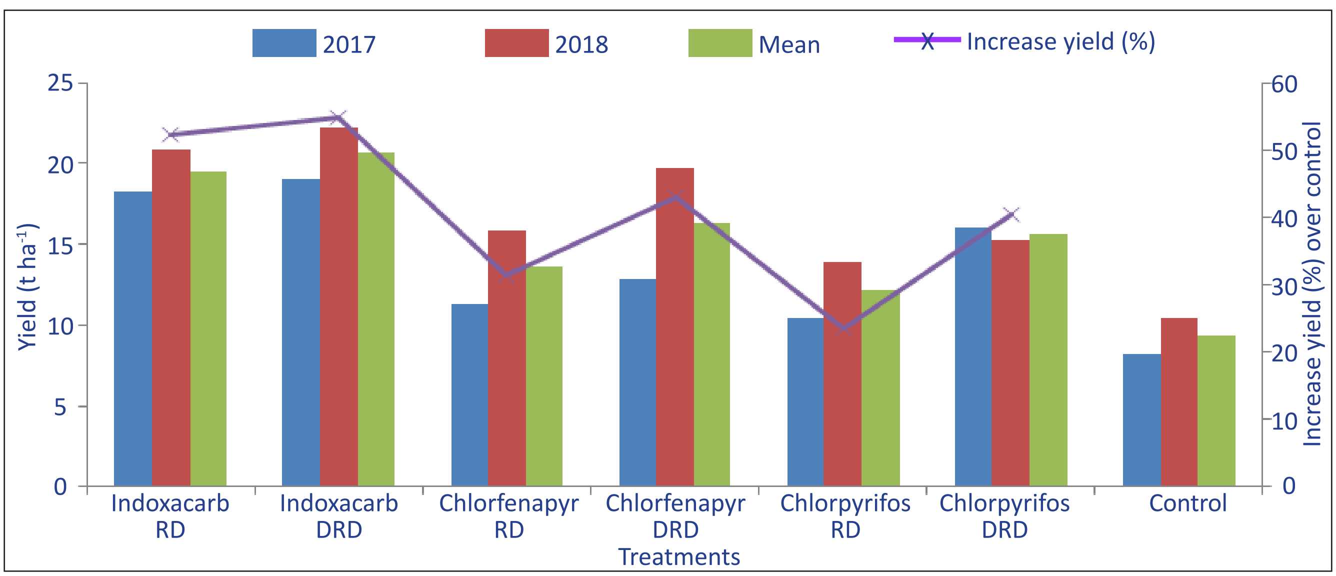

Figure 1: Effect of insecticide treatments on yield of cabbage during 2017–2018

yield (22.22 and 20.83 t ha^{-1}, respectively) followed by both doses of cholorfenapyr (19.72 and 15.83 t ha^{-1}, respectively). The pooled of two years yield also showed that indoxacarb at both doses recorded higher yield (20.64 and 19.54 t ha^{-1}, respectively) with 54.89 and 52.35% increase in yield over control plots (9.31 t ha^{-1}).

The present study showed that, indoxacarb and chlorpyrifos proved their superiority against *P. brassicae*. Efficacy of indoxacarb, chlorfenapyr and chlorpyrifos against *P. brassicae* are very scanty, therefore, the present findings may be compared with other lepidopteran insect pests of cole crops. The current results may be corroborated with Patra et al. (2016b) who stated the higher efficacy of indoxacarb was recorded against diamondback moth. Vaseem et al. (2014) showed that the indoxacarb treatment recorded maximum net return and the CB ratio against DBM in cabbage. Stanikzi et al. (2016) reported that the maximum percentage reduction of DBM was recorded in spinosad which was followed by indoxacarb. Chlorpyrifos was also proved its efficacy against cabbage butterfly in the present experiment. Literature regarding efficacy results of chlorpyrifos for *P. brassicae* is scanty. Therefore, present finding may be compared with other lepidopteran pests of cole crops. Walunj and Pawar (2004) reported that all insecticides including chlorpyrifos (Dursban 20% EC) at 400 g a.i. ha^{-1} significantly reduced the larvae of *P. xylostella* and increased yield as compared to control plots. The spinosad treatments showed great potential for the effective protection of cabbage against *P. xylostella*. The present finding of chlorfenapyr against *P. brassicae* may be comparable with other lepidopteran insect pests of cole crops as well as other crops. Findings of current experiments may be analogous with the results of Xueyan et al. (2001) who showed effectiveness of chlorfenapyr against third instar larvae of diamondback moth.

4. Conclusion

Though, indoxacarb at double dose was superior against *L. orbonalis* and *P. brassicae* throughout the experiments but recommended dose of indoxacarb also found effective against both the insect pests. Hence, the studies conclude that indoxacarb at recommended dose may be useful in IPM programme for management of these insect pests.

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6. References

Ali, A., Rizvi, P.Q., 2007. Developmental response of cabbage butterfly, *Pieris brassicae* L. (Lepidoptera: Pieridae) on different cole crops under laboratory and field condition. Asian Journal of Plant Science 6, 1241–1245.

Anonymous, 2018. http://nhb.gov.in/statistics/State_Level/2017-18-(Final).pdf. Area and Production of Horticulture Crops - All India, accessed on 30.05.2019

Gangwar, S.K., Sachan, J.N., 1981. Seasonal incidence and control of insect pests of brinjal with special reference to shoot and fruit borer, *Leucinodes orbonalis* (Guen) in Meghalaya. Journal of Research Assam Agricultural University 2, 187–192.

Ganguly, P., Barik, S.R., Patra, S., Roy, S., Bhattacharyya, A., 2017. Persistence of chlorfluazuron in cabbage under different agro-climatic conditions of India and its risk assessment. Environmental Toxicology and Chemistry 36, 3028–3033.

Gunning, R.V., Moores, G.D., 2002. Chlorfenapyr rersitance in *Helicoverpa armigera* in Australia. In: Pests and diseases 2002. Proceedings of the British Crop Protection Council Conference. British Crop Protection Council, United Kingdom, 793–798.

Hunt, D.A., Treacy, M.F., 1998. Pyrrole insecticides: a new class of agriculturally important insecticides functioning as uncouplers of oxidative phosphorylation. In: Insecticides with novel modes of action. Springer Berlin Heidelberg, 138–151.

Islam, S., 2006. Sweetpoptato (*Ipomoea batatas* L.) Leaf: Its potential effect on human health and nutrition. Journal of Food Science. 71, R13–R21.

Jat, G.C., Lekha, R., Jat, S.K., Yadav, P.C., 2017. Assessment of quantitative losses due to insect pests of cabbage. International Journal of Agriculture Sciences 9, 4087–4090.

Lal, M.N., Ram, B., 2004. Cabbage butterfly, *Peries brassicae* (L.) an upcoming menace for brassicae oilseed crops in Northern India. Cruciferae Newsletter 25, 679–707.

Lytana, D., Firake, D.M., 2012. Effects of different host plants and rearing atmosphere on life cycle of large white cabbage butterfly, *Pieris brassicae* (Linnaeus). Archives of Phytopathology and Plant Protection 45, 1819–1825.

Mahata, S., Das, B.C., Patra, S., Biswas, A.K., Chatterjee, M.L., Samanta, A., 2014. New diamide insecticides against fruit and shoot borer (*Leucinodes orbonalis* Guen.) in brinjal. Pesticide Research Journal 26, 197–201.

Miller, T.P., Treacy, M.F., Gard, I.E., Lovell, J.B., Wright Jr, D.P., Addor, R.W., Kamhi, V.M., 1990. AC 303, 630-summary of 1988-89 field trial results. In: Brighton crop protection conference, pests and diseases. British Crop Protection Council, United Kingdom 1, 43–48.

Patra, S., Thakur, N.S.A., Firake, D.M., 2016a. Evaluation of bio-pesticides and insecticides against brinjalshoot and fruit borer (*Leucinodes orbonalis* Guenee) in Meghalaya of North-Eastern India. International Journal of Bio-resource and Stress Management 7, 1032–1036.

Patra, S., Chatterjee, M.L., Mondal, S., Samanta, A., 2009. Field evaluation of some new insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guen.). Pesticide Research Journal 21, 56–60.

Patra, S., Das, B.C., Sarkar, S., Samanta, A., 2016b. Efficacy of newer insecticides against major lepidopteran pests of cabbage. Research on Crops 17, 144–150.

Patra, S., Dhote, V.W., Sarkar, S., Samanta, A., 2017. Evaluation of novel insecticides against diamondback moth and natural enemies in cabbage ecosystem. Journal of Environmental Biology 38, 1383–1389.

Patra, S., Ganguly, P., Barik, S.R., Samanta, A., 2018. Dissipation kinetics and risk assessment of chlorfenapyr on tomato and cabbage. Environmental Monitoring and Assessment 190, 71.

Patra, S., Ganguly, P., Barik, S.R., Goon, A., Mandal, J., Samanta, A., Bhattacharyya, A., 2020. Persistence behaviour and safety risk evaluation of pyridalyl in tomato and cabbage. Food Chemistry 309, 125711.

Rangad, R.W., Lytan, D., Waluniba, Firake, D.M., 2014. Bio-efficacy of eco-friendly Insecticides against cabbage butterfly, *Pieris brassicae* (L.) on cabbage in the mid altitudes hills of Meghalaya, north east India. Molecular Entomology 5, 1–3.

Sachan, J.N., Gangwar, S.K., 1980. Vertical distribution of important pests of cole crops in Meghalaya as influenced by the environmental factors. Indian Journal of Entomology 42, 414–421.

Singh, S.S., 2010. Comparative efficacy of certain bio-rational insecticides and *Bacillus thuringiensis* based bio-insecticides against *Leucinodes orbonalis* Guen. in brinjal. Indian Journal of Horticulture 67, 353–356.

Singh, M., Sachan, S.K., 2015. Comparative efficacy of some biopesticides against shoot and fruit borer, *Leucinodes orbonalis* Guenee in brinjal. Plant Archives 15, 805–808.

Srinivasan, R., 2009. Insect and mite pests on eggplant: a field guide for identification and management. AVRDC – The World Vegetable Center, Shanhua, Taiwan. AVRDC Publication No. 09-729, 64.

Stanikzi, R., Thakur, S., Simon, S., 2016. Comparative efficacy of insecticides and botanical extracts against diamondback moth (*Plutella xylostella*) in cabbage (*Brassica oleracea*var. *capitata* L.). Annals of Plant Protection Sciences 24, 283–285.

Tripura, A., Lalruatsangi, K., Chatterjee, M.L., Patra, S., 2017a. Seasonal incidence of shoot and fruit borer (*Leucinodes orbonalis* Guenee) of brinjal in midhills of Meghalaya. Indian Journal of Hill Farming 30, 335–340.

Vaseem, M., Singh, H., Kumar, K., Ali, M., 2014. Efficacy of newer insecticides against diamondback moth (*Plutella xylostella* Linn.) on cabbage under poly house condition. Journal of Experimental Zoology (India) 17, 487–489.

Walunj, A.R., Pawar, S.A., 2004. Evaluation of spinosad against diamondback moth (*Plutella xylostella* L.) on cabbage. Tests of Agrochemicals and Cultivars 25, 4–5.

Xueyan, Z., Zuo, H., Cuiyu, Y., Zuo, X., 2001. Monitoring on resistance of diamondback moth to abamectin and field control experiments in Yunnan, China. Journal of Huazhong Agricultural University, 426–430.

Younas, M., Naeem, M., Raquib, A., Masud, S., 2004. Population dynamics of *Peries brassicae* on five cultivars of cauliflower at Peshawar. Asian Journal of Plant Science 3, 391–393.

Yousafi, Q., Afzal, M., Aslam, M., 2015. Management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee, with selected insecticides. Pakistan Journal Zoology 47, 1413–1420.

Zhang, Y.J., Gan, R.Y., Li, S., Zhou, Y., Li, A.N., Xu, D.P., Li, H.B., 2015. Antioxidant phytochemicals for the prevention and preatment of phronic diseases. Molecules 20, 21138–21156.