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EFFICACY OF ECO-FRIENDLY INSECTICIDES ON THE MANAGEMENT OF DIAMONDBACK MOTH (*PLUTELLA XYLOSTELLA* LINN.) ON CABBAGE

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ABSTRACT

Field experiment was conducted to study the relative efficacy of different eco-friendly insecticides comprising of four neem product (nimbecidine, agrineem, vijayneem and neemark), two Bt products (dipel and delfin), one entomopathogenic fungus, *B.bassiana* (biorin) and a chemical insecticide (nuvan) against diamondback moth (*Plutella xylostella* Linn.) vis-à-vis their effect on the predatory coccinellid, *Coccinella s eptempunctata* Linn. All the insecticides were superior in controlling the diamondback moth population in comparison to untreated control. Amongst the different treatments, Bt. (dipel) recorded the lowest larval population (0.21/plant) and proved to be the most effective treatment, followed by Bt (delfin) and nuvan with larval populations of 0.45 and 1.50/plant respectively, as against 8.88/plant in untreated control. Vijayneem was found to be the most inferior insecticide by recording the highest population of 3.06/plant. The mean yield ranged from 17.92 to 22.73t/ha in insecticidal treatments with the maximum yield in dipel as against 14.75t/ah in untreated control. Amongst all the tested compounds, agrineem and delfin proved to be the safest insecticide to the predatory beetle, *Coccinella septempunctata* with the highest population of 1.20/plant each against 1.28/plant in untreated control. The lowest beetle population (0.87/plant) was recorded in nuvan treated plots. However, all the insecticidal treatments were found to be safe to the predator as it was observed that there was no significant difference with untreated control after post applications counts.

INTRODUCTION

Cole vegetables grown mostly in winter season occupy an important position in meeting the dietary requirements of most of the people all over the world. Among the winter vegetables, cabbage *Brassica oleracea var. capitata* Linn. is a popular and extensively cultivated crop because of its nutritional and economical values. It is grown for its edible enlarged terminal buds, which is a rich source of Ca, P, Na, K, S Vitamin A, Vitamin C and dietary fibre. India is the second largest producer of cabbage in the world after China producing 68.70 lakh tonnes in an area of 3.1 lakh hactares with a productivity of 22.20 MT/ha (Anon., 2009). The productivity level of cabbage is much lower than its potential attributing to many causes and among them insect pests are major constraints. The cabbage crop is attacked by a number of different insect pests and among them cabbage caterpillar, *Pieris brassicae* Linnaeus; diamondback moth, *Plutella xylostella* Linnaeus; cabbage semi-looper, *Thysanoplusia orichalcea* Fabricius and *Autographa nigrisigna* Walker; tobacco caterpillar, *Spodoptera litura* Fabricius ; cabbage leaf webber, *Crocodolomia binotalis* Zeller ; cabbage borer, *Hellula undalis* Fabricius and cabbage flea beetles, *Phyllotreta cruciferae* Goeze., *P. chotanica* Duviv., *P. birmanica* Harold., *P. oncera* Maulik and *P. downesi* Baly are the pests of major importance (Atwal and Dhaliwal, 2002). Out of these, diamondback moth, *Plutella xylostella* (L.) is the most destructive pest (Mahla *et al*., 2005; Kumar *et al*., 2007) and is the limiting factor for the successful cultivation of cruciferous crops (Rai *et al*., 1992).

In India, diamondback moth has national importance on cabbage as it causes 50-80% annual loss in the marketable yield (Devjani and Singh, 1999 and Ayalew, 2006) and a loss of US $ 16 million every year (Mohan and Gujar, 2003).

Hence, farmers are compelled to use chemical insecticides in order to cultivate lucratively, as traditional and cultural practices alone cannot not give satisfactory control over the pest menace. Frequent use of chemical insecticides at higher doses results in depredation of natural enemies (Haseeb *et al*., 2004) and development of insecticide resistance in *P. xylostella* against a range of insecticides in different parts of India (Talekar *et al*., 1990 and Vastrad *et al*., 2003). This has necessitated the use of alternative eco-friendly insecticides to sustain the management of diamondback moth. The efficacy of neem products and microbial insecticides like *Bacillus thuringiensis* has been reported by several workers (Panigrahi, 2010; Nethravathi and Hugar, 2010; Raut and Simon, 2010 and Meena *et al*., 2011). Due to their efficacy in controlling the target pests without adversely affecting their natural enemies, bio-pesticide ensures effectiveness, safety and acceptability to mankind. Amongst the bio-pesticide, neem and microbial insecticides are the most common and easily available pesticides in the market. Neem based insecticides have been recognized as the potential insecticides due to its azadirachtin content It has insecticidal properties like repellent, feeding and oviposition deterrent, reducing fecundity, insect growth inhibitor, low mammalian toxicity and very less persistence in the environment (Schmutter, 1990 and Lal, 1996). Hence the present study was undertaken for assessment of commercially available neem formulations and microbial products with one conventional insecticide in managing the pest, their effect on yield parameters and on the predatory coccinelid population under field conditions.

MATERIALS AND METHODS

Field experiment was conducted with cabbage *var.* "Pride of India" in the experimental field of Department of Entomology, Central Agricultural University, Imphal during *rabi* season of 2009-10 and 2010-11.The experiment was laid out in a randomized block design (RBD) with 9 treatments including untreated control and replicated 3 times. The crop was raised with recommended agronomic practices with a plot size of 20sq.m (4x5m) at 40 x 50cm spacing. The insecticides evaluated were four neem-based insecticides i.e., nimbecidine (azadirachtin 0.03%) @1.5L/ha), agrineem (azadirachtin 0.03%) @1.0 L/ha), vijayneem (azadirachtin 0.15%) @1.0 L/ ha), neemark (azadirachtin 0.03%) @1.0 L/ha) ; three microbials *i.e.*, dipel - 8L (*Bacillus thuringiensis* var. kurstaki) @ 1.0 L/ha, delfin –WG (*Bacillus thuringiensis* var. kurstaki) @ 1.0 L/ha and biorin (*Beauveria bassiana*) @ 1.0 L /ha along with one conventional insecticide, nuvan as check. The appearance of diamondback moth was keenly monitored and when the population was almost evenly distributed, the test insecticides were applied as foliar spray (500 L/ha) by a high volume knapsack sprayer twice at 10 days interval. Water was sprayed in the untreated control plots. Observations on the larval population of diamondback moth and predator, *Coccinella septempunctata* were recorded at 24 hours before application (pre-treatment count) and 3rd, 7th and 10th days after application (post-treatment count) on five randomly selected plants in each plot. To estimate the larval population of diamondback moth, direct visual counting method was used (Lal, 1998). The cabbage head harvested from each plot was recorded and computed to tonnes/ha.

Statistical analysis

The data obtained from the different treatments were computed to determine the mean values. The mean values after suitable transformation were subjected to statistical analysis to test significance as per Gomez and Gomez (1984) for interpretation of the results.

RESULTS AND DISCUSSION

Effect of the insecticidal treatments on larval population of diamondback moth

The mean diamondback moth population data recorded after the post treatment counts (3, 7 and 10 DAA) revealed that dipel was the most effective treatment with 0.24 and 0.18/ plant and was closely followed by delfin (0.48 and 0.42/plant), which were at par with each other while the maximum population was recorded from vijayneem and agrineem (3.36 and 2,88/plant) as against 9.03 and 8.72/plant in untreated control during the *rabi* seasons of 2009-10 and 2010-11, respectively. It was revealed that all the insecticidal treatments resulted in significant reduction of the diamondback moth population over control (Table 1).

The pooled mean data of two years presented in Table 2 revealed that dipel @ 1.0 L/ha proved to be the most effective insecticide in suppression of diamondback moth population with lowest mean population of 0.21/plant against 8.88/plant in untreated control. It was followed by delfin @ 1.0 L/ha and nuvan @ 500g a.i./ha with their corresponding mean population of 0.45 and 1.50/plant, respectively but showed a significant difference from one another. The maximum population (3.06/plant) was recorded in plots treated with vijayneem @ 1.0 L/ha.

Among the insecticides evaluated, the two Bt products namely dipel and delfin showed superior effect in reducing the larval population of diamondback moth. The effectiveness of all the neem-based insecticides was found to be significantly inferior to that of the Bt products and synthetic chemical nuvan. But among the neem products, the maximum protection was given by neemark @ 1.5 L/ha with minimum population of 1.94/

Table 1: Effect of eco-friendly insecticides on the larval population of diamondback moth on cabbage during 2009-10 and 2010-11 at Imphal

Treatment	Dose	Larval population per 5 plants at 2009-10					2010-11				
		1DBA	3DAA	7DAA	10 DAA	*Mean	1DBA	3DAA	7DAA	10\DAA	*Mean
Nimbecidine (Azadirachtin 0.03%)	1.5 L/ha	8.13(2.93)	2.93(1.85)	1.83(1.52)	2.37(1.66)	2.38(1.68)	7.53(2.83)	2.60(1.76)	1.60(1.45)	2.13(1.61)	2.11(1.61)
Agrineem (Azadirachtin 0.03%)	1.0 L/ha	7.53(2.82)	3.18(1.91)	2.43(1.70)	2.90(1.84)	2.84(1.82)	7.47(2.82)	3.13(1.90)	2.60(1.76)	2.90(1.84)	2.88(1.83)
Vijayneem (Azadirachtin 0.15%)	1.0 L/ha	7.40(2.81)	4.00(2.12)	2.80(1.81)	3.27(1.94)	3.36(1.96)	7.60(2.84)	3.27(1.94)	2.23(1.65)	2.80(1.81)	2.77(1.80)
Neemark (Azadirachtin 0.03%)	1.0 L/ha	8.40(2.97)	2.47(1.72)	1.45(1.39)	1.93(1.56)	1.95(1.56)	7.40(2.81)	2.30(1.67)	1.45(1.39)	2.03(1.59)	1.93(1.55)
Dipel (*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	7.67(2.85)	0.35(0.92)	0.13(0.79)	0.23(0.85)	0.24(0.85)	7.87(2.89)	0.27(0.87)	0.13(0.79)	0.13(0.79)	0.18(0.82)
Delfin ((*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	7.60(2.84)	0.63(1.04)	0.35(0.92)	0.47(0.97)	0.48(0.98)	7.33(2.80)	0.47(0.97)	0.35(0.92)	0.43(0.96)	0.42(0.95)
Biorin (*Beauveria bassiana*)	1.0 L/ha	8.47(2.98)	3.27(1.94)	2.00(1.56)	2.80(1.81)	2.69(1.77)	8.07(2.92)	2.73(1.80)	2.00(1.56)	2.63(1.77)	2.44(1.71)
Nuvan (Dichlorvos 76 EC)	500g a.i/ha	7.80(2.87)	2.00(1.56)	1.23(1.31)	1.45(1.39)	1.56(1.42)	7.27(2.78)	1.80(1.50)	1.07(1.25)	1.45(1.39)	1.44(1.38)
Control	-	7.87(2.89)	8.73(3.04)	9.43(3.15)	8.93(3.07)	9.03(3.09)	7.50(2.83)	8.37(2.98)	9.00(3.08)	8.80(3.05)	8.72(3.04)
S.E.m(±)		0.08	0.16	0.12	0.14	0.06	0.01	0.13	0.10	0.08	0.06
CD (p = 0.05)		0.17	0.35	0.24	0.30	0.13	0.20	0.28	0.22	0.17	0.13

Figures in parenthesis are √Actual population + 0.5, DBA = Days before application , DAA = Days after application, * Means refers to post count observations

Table 2: Effect of eco friendly insecticides on the larval population of diamondback moth on cabbage at Imphal (pooled data of 2009-10 and 2010-11)

Treatment	Dose	Larval population per 5 plants at				
		1DBA	3DAA	7DAA	10 DAA	*Mean
Nimbecidine (Azadirachtin 0.03%)	1.5 L/ha	7.83(2.88)	2.77(1.80)	1.72(1.48)	2.25(1.64)	2.24(1.64)
Agrineem (Azadirachtin 0.03%)	1.0 L/ha	7.50(2.82)	3.16(1.91)	2.52(1.73)	2.90(1.84)	2.86(1.83)
Vijayneem (Azadirachtin 0.15%)	1.0 L/ha	7.50(2.83)	3.63(2.03)	2.52(1.73)	3.03(1.88)	3.06(1.88)
Neemark (Azadirachtin 0.03%)	1.0 L/ha	7.90(2.89)	2.38(1.69)	1.45(1.39)	1.98(1.57)	1.94(1.55)
Dipel (*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	7.77(2.87)	0.31(0.89)	0.13(0.79)	0.18(0.82)	0.21(0.84)
Delfin ((*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	7.47(2.82)	0.55(1.01)	0.35(0.92)	0.45(0.97)	0.45(0.96)
Biorin (*Beauveria bassiana*)	1.0 L/ha	8.27(2.95)	3.00(1.87)	2.00(1.56)	2.72(1.79)	2.57(1.74)
Nuvan (Dichlorvos 76 EC)	500g a.i/ha	7.53(2.83)	1.90(1.53)	1.15(1.28)	1.45(1.39)	1.50(1.40)
Control	-	7.68(2.86)	8.55(3.01)	9.22(3.12)	8.87(3.06)	8.88(3.06)
S.E.m(±)		0.06	0.10	0.08	0.08	0.04
CD (P= 0.05)		0.13	0.21	0.17	0.17	0.08

Table 3: Effect of eco-friendly insecticides on yield of cabbage during *rabi* season of 2009-2010 and 2010-2011

Treatments	Dose	Yield (t/ha)		
		2009-10	2010-11	Pooled mean
Nimbecidine (Azadirachtin 0.03%)	1.5 L/ha	19.11	19.00	19.06
Agrineem (Azadirachtin 0.03%)	1.0 L/ha	18.22	17.78	18.00
Vijayneem (Azadirachtin 0.15%)	1.0 L/ha	17.83	18.00	17.92
Neemark (Azadirachtin 0.03%)	1.0 L/ha	19.50	18.61	19.06
Dipel (*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	23.13	22.33	22.73
Delfin ((*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	22.11	21.17	21.64
Biorin (*Beauveria bassiana*)	1.0 L/ha	18.56	18.17	18.36
Nuvan (Dichlorvos 76 EC)	500g a.i/ha	20.76	19.94	20.35
Control	-	14.83	14.67	14.75
S.E.m(±)	-	0.46	0.44	0.32
CD (P= 0.05)	-	0.98	0.93	0.64

* Cabbage yield t/ha is the mean of 3 replications

Table 4: Effect of eco friendly insecticides on the population of *Coccinella septempunctata* on cabbage during 2009-10 and 2010-11 at Imphal

Treatment	Dose	Adult population per 5 plants at									
		2009-10					2010-11				
		1DBA	3DAA	7DAA	10 DAA	*Mean	1DBA	3DAA	7DAA	10\DAA	*Mean
Nimbecidine (Azadirachtin 0.03%)	1.5 L/ha	0.93(1.19)	0.80(1.12)	1.10(1.26)	1.23(1.31)	1.04(1.23)	0.93(1.19)	0.97(1.19)	1.03(1.23)	1.13(1.26)	1.04(1.23)
Agrineem (Azadirachtin 0.03%)	1.0 L/ha	0.80(1.13)	0.93(1.18)	1.07(1.24)	1.33(1.35)	1.11(1.26)	1.07(1.25)	1.07(1.25)	1.10(1.26)	1.70(1.48)	1.29(1.33)
Vijayneem (Azadirachtin 0.15%)	1.0 L/ha	0.80(1.12)	1.00(1.20)	1.17(1.29)	0.97(1.21)	1.05(1.23)	1.00(1.22)	1.17(1.26)	1.30(1.32)	1.33(1.33)	1.27(1.30)
Neemark (Azadirachtin 0.03%)	1.0 L/ha	0.87(1.16)	0.80(1.14)	1.00(1.21)	1.10(1.26)	0.97(1.20)	0.93(1.19)	1.00(1.22)	1.07(1.24)	1.10(1.28)	1.06(1.24)
Dipel (*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	0.80(1.14)	0.87(1.16)	1.10(1.26)	1.13(1.26)	1.03(1.23)	1.00(1.22)	1.00(1.22)	1.07(1.25)	1.17(1.28)	1.08(1.25)
Delfin ((*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	1.00(1.22)	1.00(1.20)	1.17(1.29)	1.17(1.28)	1.11(1.26)	1.13(1.27)	1.20(1.29)	1.27(1.32)	1.40(1.37)	1.29(1.33)
Biorin (*Beauveria bassiana*)	1.0 L/ha	1.00(1.22)	1.00(1.20)	1.23(1.31)	1.07(1.25)	1.10(1.25)	1.00(1.22)	1.10(1.26)	1.30(1.33)	1.27(1.26)	1.22(1.28)
Nuvan (Dichlorvos 76 EC)	500g a.i/ha	1.00(1.22)	0.60(1.05)	0.83(1.15)	1.07(1.23)	0.83(1.14)	0.97(1.20)	0.67 (1.05)	0.93(1.19)	1.13(1.27)	0.91(1.17)
Control	-	0.80(1.14)	1.23(1.31)	1.30(1.32)	1.10(1.26)	1.21(1.29)	0.97(1.20)	1.30(1.32)	1.33(1.33)	1.40(1.37)	1.34(1.34)
S.E.m(±)		0.13	0.20	0.08	0.14	0.08	0.07	0.17	0.14	0.16	0.08
CD (P= 0.05)		0.27	0.32	0.17	0.30	0.18	0.16	0.36	0.30	0.35	0.17

Table 5. Effect of eco friendly insecticides on the population of *Coccinella septempunctata* on cabbage at Imphal (pooled data of 2009-10 and 2010-11)

Treatment	Dose	Larval population per 5 plants at				
		1DBA	3DAA	7DAA	10 DAA	*Mean
Nimbecidine (Azadirachtin 0.03%)	1.5 L/ha	0.93(1.19)	0.88(1.15)	1.07(1.24)	1.18(1.29)	1.04(1.23)
Agrineem (Azadirachtin 0.03%)	1.0 L/ha	0.93(1.19)	1.00(1.21)	1.08(1.25)	1.52(1.41)	1.20(1.29)
Vijayneem (Azadirachtin 0.15%)	1.0 L/ha	0.90(1.17)	1.08(1.23)	1.23(1.30)	1.15(1.27)	1.16(1.27)
Neemark (Azadirachtin 0.03%)	1.0 L/ha	0.90(1.18)	0.90(1.18)	1.03(1.23)	1.10(1.26)	1.01(1.22)
Dipel (*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	0.90(1.18)	0.93(1.19)	1.08(1.25)	1.15(1.27)	1.06(1.24)
Delfin ((*Bacillus thuriengsis* var Kurstaki)	1.0 L/ha	1.07(1.25)	2.20(1.25)	1.22(1.31)	1.28(1.33)	1.20(1.29)
Biorin (*Beauveria bassiana*)	1.0 L/ha	1.00(1.22)	1.05(1.23)	1.27(1.32)	1.17(1.29)	1.16(1.27)
Nuvan (Dichlorvos 76 EC)	500g a.i/ha	0.98(1.21)	0.63(1.05)	0.88(1.17)	1.10(1.25)	0.87(1.16)
Control	-	0.88(1.17)	1.27 (1.32)	1.32 (1.33)	1.25 (1.32)	1.28(1.32)
S.E.m(±)	-	0.08	0.13	0.08	0.10	0.03
CD (P= 0.05)	-	0.17	0.28	0.23	0.21	0.20

Figures in parenthesis are √Actual population + 0.5, DBA = Days before application , DAA = Days after application, * Means refers to post count observations plant which was at par with the population of 2.24/plant recorded in the plots treated with nimbecidine @ 1.5 L/ha.

The results obtained in this experiment confirms the superiority of dipel for the control of diamondback moth population as it has also been consistently found by a number of other researchers (Leibee and Savage, 1992; Seal,1995 and Asokan *et al.*,1996.). Moreover, delfin - another Bt product along with dipel is also another insecticide which is superior to other insecticides for the control of the larval population of diamondback moth (Garcia, 1991; Kulkarni *et al.*, 1999; Malathi *et al.*1999; Malathi and Sriramulu, 2000; Kalra and Sharma, 2000; Biradar and Dhanorkar, 2001 and Elzen and James, 2002). The effectiveness of dipel and delfin against diamondback moth might be due to their inherent toxicity to the diamondback moth. The better performance of the Bt products than dichlorvos (nuvan) is in agreement with the findings of Shang *et al.* (2001) who reported that among 8 different insecticides tested nuvan was the least effective. The effectiveness of neem products against DBM was also observed by Facknath (1993) who described the strong antifeedant action of neemark in suppressing insect damage. The findings of other researchers like Malathi *et al.* (1999); Saucke *et al.* (2000); Shankar and Raju (2002); Vastrad *et al.*(2003) and Liang *et al.* (2003) are also in agreement with our present findings. There was further revealation from the results that biorin, a product of entomopathogenic fungus, *Beauveria bassiana* also provided significant effect in suppressing the larval population as compared with the untreated control but inferior to the two Bt products, nuvan and two neem products i.e., nimbecidine and neemark but performed better than agrineem and vijayneem. Some of the past researchers (Ibrahim and Low, 1993; Masuda, 1998; Shelton *et al.*, 1998; Yoon *et al.*, 1999; Jun *et al.*, 1999 and Alverez and Chirinos, 2001) have also reported the effectiveness of *B. bassiana* against DBM and our results confirm their findings.

Effect of eco-friendly insecticidal treatments on the yield of cabbage

During *rabi* 2009-10, the highest yield 23.13 t/ha was obtained from the plots treated with dipel, followed by delfin (22.11) and nuvan (20.76). All the treatments showed significant difference from each other (Table 3). The lowest yield of 17.83 t/ha was recorded in the vijayneem treated plots, which was at par with agrineem and biorin. Significant lowest yield of 14.83 t/ha was observed in the untreated control plots. A more or less similar trend was also observed during *rabi* season of 2010-11 with maximum yield of 22.33 t/ha in dipel treatment which was followed by delfin (21.17 t/ha) and nuvan (19.94 t/ha). The minimum yield of 17.78 t/ha was recorded in the plots treated with agrineem, which was followed by vijayneem, biorin and neemark. However, the yield obtained from all the insecticidal treatment plots was significantly higher than that recorded in untreated control plots.

The pooled mean data indicated that the minimum yield (14.75 t/ha) was obtained from untreated control, which was significantly lower that the yields harvested from the other insecticidal treatments (17.92 to 22.73 t/ha), the highest being recorded in dipel treatment and lowest in vijayneem treatment. The yield of dipel was followed by delfin and nuvan with a mean yield of 21.64 and 20.35 t/ha, respectively. The cabbage yield recorded in the plots treated with vijayneem, agrineem, biorin, nimbecidine and neemark were significantly higher to that of untreated control plots, but were inferior to other insecticidal treatments. Shankar and Raju (2002) have also compared the efficacy of different insecticides comprising Bt products, botanicals, conventional, pyrethroid, insect growth regulator against DBM and observed that significantly highest yield was obtained from the Bt treatments. Several earlier researchers have also recorded effective control of diamondback moth with substantial yield increase in cabbage with the use of Bt and neem products, (Seal, 1995; Asokan *et al.*, 1996; Tambe *et al.*, 1997; Kulkarni *et al.*, 1999; Monnerat *et al.*, 2000; Javaid *et al.*, 2000; Loganathan *et al.*, 2000 and Biradar and Dhanorkar, 2001). Ibrahim and Low (1993) have also found that *B. bassiana* treated plots showed significant reduction of larval population as well as in increasing the yield when compared with alternating sprays of cypermethrin 0.1 % and phenthoate 0.1 %.

Field toxicity of the test insecticides to the coccinellid predator, *Coccinella septempunctata*

In 2009-10, out of all the insecticidal treated plots the maximum population of coccinellid beetle was recorded from vijayneem and delfin (1.11/plant each) as against 1.21/plant in untreated control. Nuvan recorded the minimum beetle population of 0.83/plant. A more or less similar trend was observed in the second year also. However, all the treatments did not show significant difference with one another and with the untreated control (Table 4).

The results of the pooled mean data on the toxic effect of eco-friendly insecticides on the population of *C. septempunctata* revealed that vijayneem @ 1.0 L/ha and delfin 1.0 L/ha proved to be the safest insecticide with the highest population of 1.20/plant in each. The lowest beetle population was recorded in nuvan @ 500g a.i./ha treated plots with a population of 0.87/plant which was at par with neemark @ 1.0L/ha recording the mean population of 1.01/plant. The mean number of adult population in the rest of the insecticidal treatments ranged from 1.04 to 1.16/plant and 1.28/plant in untreated control. However, since all the insecticidal treatments were found to be at par with untreated control in all the post treatment counts, it clearly indicates that they were all found to be safe to the predatory coccinellid beetle (Table 5).

The results on the safety of Bt and neem products on the population of *C. septempunctata* are also reported by Kaethner (1991); Malathi *et al.* (1999) and Singh *et al.* (2007) who determined the toxic effect of Bt product and neem product and observed that all the tested insecticides were found to be safe and did not show any adverse effect on the coccinellid population. Sonkar and Desai (1998) also observed that the neem product, nimbitor (2 %) was found to be a less toxic insecticide to the predator as compared to other insecticides tested. The safety of Bt formulations was also reported by Jayanthi and Padmavathamma (1996) and Sharma *et al.* (2000) who observed that all Bt formulations were found to be safe and helped in conserving the coccinellid predators. Akmal *et al.* (2013) reported that the entomopathogenic fungus, *B. bassiana* showed little or no detrimental effects to *C.*

septempunctata which is in conformity with the present findings. The less or marginal toxicity of Bt, neem products and biorin (*B. bassiana*) on *C.septempunctata* population might be due to their low inherent contact toxic action and minimum residual toxicity, while the higher toxic effect of nuvan may be attributed to its systemic nature translocating into the plant tissue system thereby causing maximum residual toxic effect on *C. septempunctata*.

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