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Bio-rational management of major lepidopterous pests and their influence on yield of cabbage crop under Manipur valley

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Abstract
A field trial was carried out in randomized block design with thirteen treatments including control during Rabi, 2010-11 at vegetables Research Farm, College of Agriculture, Central Agricultural University, Imphal to evaluate the efficacy of certain bio-rational insecticides against *Plutella xylostella* and *Pieris brassicae* on a crop variety "Pride of India" under Manipur valley. The studied revealed that due to the Diamondback moth pre-treatment mean extent of leaf damage reached 90.67 percent and whereas it reached 91.11 percent due to the cabbage butterfly, *Pieris brassicae*. Spinosad (*Saccharopolyspora spinosa)*2.5 SC @ 500 ml ha^{-1} was found most effective to control both these pests registering lower extent of mean leaf damage by 14.22 percent and 24.30 percent respectively. It was followed by myco-jaal (*Beauveria bassiana*) 10 SC @ 500 ml ha^{-1} with 15.11 percent and 26.59 percent and differs significantly from untreated control 69.18 percent. The yield harvested in the bio-rational treatment were spinosad 2.5 SC 24.77 t $ha^{-1,}$ myco-jaal 10 SC 23.70 t ha^{-1}, malathion 50 EC 22.97 t ha^{-1}, racer (*Beauveria bassiana*) 22.85 t ha^{-1}, achook (Azadirachtin 1500 ppm) 22.73 t ha^{-1}, lipel (*Bacillus thuringiensis* var. *kurstaki*) 22.60 t ha^{-1}, shakti (Azadirachtin 300 ppm) 20.13 t ha^{-1}, margosom(300 ppm) 20.10 t ha^{-1}, multineem (Azadirachtin 1500 ppm) 20.03 t ha^{-1}, Cow–urine + *Melia azedarach*19.97 t ha^{-1}, pestoneem (Azadirachtin 1500 ppm) 19.90 t ha^{-1}, pacer (*Metarhizium anisopliae*) 19.27 t ha^{-1} and untreated control 15.40 t ha^{-1}respectively.

Keywords: Bio-rational, Cabbage, *Plutella xylostella*, *Pieris brassicae* and Spinosad

Introduction
Cabbage (*Brassica oleracea* var. *capitata* Linn.) is one of the most important vegetables crop grown for nutritional and economical values for producers and consumer point of view. This crop plant is a native of West Europe and the Northern shores of the Mediterranean [11, 19]. It is grown over an area of 3.12 million ha in the world and 0.331 million ha in India and accounted 7.3 percent of total vegetables production of India is currently the second largest producer of vegetables worldwide [13]. West Bengal ranks first in cabbage production followed by Odisha, Bihar, Assam and Gujarat. In Manipur, the total area under cabbage is only 19.9 thousand hectares with a production of 221.8 thousand metric tonnes as against National production of 7281 metric tonnes [2].

In India, [20] recorded 37 insect pests in cabbage crop. Among them fourteen species were recorded in Manipur *viz*., diamondback moth, *Plutella xylostella* Linnaeus, cabbage butterfly, *Pieris brassicae* Linnaeus, Leaf webber, *Crocidolomia binotalis* Zeller, head borer, *Hellula undalis* Fabricius, cabbage semilooper, *Plusia orichalcea* Fabricius, cutworm,

Agrotis ipsilon Hufnagel, tobacco caterpillar, *Spodoptera litura* Fabricius, Bihar hairy caterpillar, *Spilosoma obliqua* Walker, pea leaf miner, *Phytomyza atricornis* Meigan, Flea beetle, *Phyllotreata cruciferae* Goeze and sucking pests such as cabbage aphids,

Brevicoryne brassicae Linnaeus, green aphids, *Myzus persicae* Sulzer, *Lipaphis erysimi* Kaltenbach and pentatomid bug, *Bagrada cruciferarum* Kirkaldy [17, 26]. Over the years, cabbage is cultivated more intensively, which in turn resulted in high pest infestations [8, 40].

Plutella xylostella can caused 100 percent marketable yield loss of cabbage [7], whereas [44] reported that more than 90 percent yield loss in South East Asia and [6] also reported 50-80 percent yield loss. The losses due to *Pieris brassicae* have been estimated to range from 8.16 to 31.69 percent in Uttarakhand [35] whereas [29] reported 10-100 percent yield loss in Meghalaya and Uttarakhand. A single larva of *Pieris brassicae* can consumes 74-80 sq.cm. leaf area [3]. The young caterpillars feed gregariously on leaves, resulting in defoliation of the plants [16, 18, 46].

Chemical toxicity causes several health hazards and leads to pollution to the environment and misbalance the ecology. It is reported that one percent of the chemical used in the pest control reached the target remaining 99 percent causes hazards to the environment. We should not forget Rachel Carson "Silent spring" where she mentioned ill effects of DDT (dichlorodiphenyltrichloroethane) and its impact on the environments. Concerning, the ill effects of chemicals the present studies was aimed to find out alternate strategies and hence bio-rational insecticides were chosen to evaluate against major pests in Manipur valley.

Materials and Methods

A field experiment was carried out in randomized block design (RBD) with 13 treatment including control during *Rabi*, 2010-11 at the College of Agriculture, Central Agricultural University, Iroisemba, Imphal, in cabbage crop variety "Pride of India**"**. The seed bed was prepared well and the seeds are sown in the beds followed by light irrigation to facilitate better germination. The experimental field was thoroughly ploughed with the help of tractor followed by three cross ploughed by power tiller and the soil was pulverized and leveled properly to ensure better growth. The thirty days old seedlings was transplanted in the main field with a spacing of 45 × 45 cm followed by life saving irrigations to ensure better establishment of seedlings and to maintain good crop stand. After transplanting, the field was irrigated at weekly intervals to facilitate proper vegetative growth of the seedlings and thus enlarged the head of cabbage. The NPK was applied @ 100: 80: 60 Kg/ha. The field was kept weed free with two hands weeding at 30 and 60 days after transplanting.

The experiment was carried out at latitude of 24^0 45'N and 93^0 56' E with an elevation of 790 m above Mean Sea Level, where the soil was clay loam and shows acidic 5.5 reaction.

Percent leaf damaged was calculated by using the following formulae

$$\text{Leaf damage percent} = \frac{\text{No. of infested leaves/5plants}}{\text{Total no. of leaves/5plants}} \times 100$$

Percent yield increased over control was calculated by using the following formulae

$$\text{Percent yield increased over control} = \frac{T - C}{C} \times 100$$

Where, T= Yield in respected treatment
C= Yield in control

Results and Discussions

Effects of bio-rational insecticides against *Plutella xylostella* Linnaeus

The results of the bio-rational insecticides against diamondback moth, *Plutella xylostella* is presented in (Table 1 and Fig. 1). The pre-treatment mean extent of leaf damage of diamondback moth varied from 52.00 to 90.67 percent. The pooled means of thrice spray revealed that spinosad 2.5 SC@ 500 m ha^{-1} treated plot registered lower leaf damage of 14. 22 percent and differs from untreated control where 69.18 percent leaf damaged was recorded. The efficacy of others bio-rational insecticides were such as myco-jaal 10 SC @ 500 ml ha^{-1} 15.11 percent, lipel @ 1000 g ha^{-1} 16.59 percent and racer @1000g ha^{-1} 17.63 percent but differ significantly from each others. Pacer @ 1000g ha^{-1} was registered to be less effective against diamondback moth with a maximum leaf damage of 32.59 percent. The leaf damage registered in botanicals treatment were *viz*., achook @ 1500 ml^{-1} 26.67 percent, margosom @ 2500ml ha^{-1} 28.30 percent and shakti @ 2500ml ha^{-1} 29.33 percent, multineem @1500ml ha^{-1} 29.63 percent, pestoneem @ 1500ml ha^{-1} 29.78 percent, Cow-urine + *Melia azedarach* @ 12500 ml ha^{-1} 32.30 percent and malathion 50 EC @ 500 ml ha^{-1} 21.33 percent. The excellence performance of spinosad in the present findings for management of *Plutella xylostella* were similar to the findings of [23, 25, 31, 41, 43]. Spinosad was reported effective against range of arthropod pests and especially effective against the order Lepidoptera [39]. Safety of spinosad to non-target beneficial organisms was proved [22, 32, 37, 42]. Spinosad was reported having low mammalian toxicology [9] and classified as bio-insecticides [10]. However, phytotoxicity of spinosad was reported [15]. The results of the *B. bassiana* formalations (myco-jaal and racer) in suppressing the *Plutella xylostella* conform to the findings of [1, 36]. Effectiveness of neem to *Plutella xylostella* was reported [21].

Effects of bio-rational insecticides against *Pieris brassicae* Linnaeus

The results of the bio-rational insecticides against cabbage butterfly, *Pieris brassicae* is presented in (Table 2 and Fig. 1). The pre-count mean extent of leaf damage due to Cabbage butterfly ranged from 80.00 to 91.11 percent. Among the treatments, spinosad 2.5 SC@ 500 ml ha^{-1} performed significantly better than the rest of the treatments and recorded lowest leaf damage of 24.30 percent as against 87.38 percent in untreated control. The excellent performance of spinosad to manage the cabbage butterfly is similar to the findings of [4, 14, 27, 28, 30]. It was closely followed by myco-jaal 10 SC @ 500 ml ha^{-1} 26.59 percent, Lipel @ 1000 g ha^{-1} 29.33 percent and racer@1000g ha^{-1} 29.89 percent but differ significantly from each other except between Lipel and Racer. The treatment comprising of malathion 50 EC and achook also recorded comparatively lower leaf damage of 30.50 percent and 30.67 percent which are par. The mean percent leaf damage recorded in botanicals treatments were margosom@2500 ml ha^{-1} 35.04 percent followed by multineem@1500 ml ha^{-1} 35.70 percent, pestoneem@1500 ml ha^{-1} 36.03 percent, shakti@2500 ml ha^{-1} 36.47 percent, Cow-urine + *Melia azaderach*@12500 ml ha^{-1} 36.80 percent and pacer @1500g ha^{-1} 37.47 percent. The effectiveness of *Bacillus thuringiensis* was similar to the findings of [37]. The effectiveness of botanicals insecticides against *Pieris brassicae* was similar to the findings of [5, 24, 33, 34].

Effect of bio-rational insecticides on the yield of cabbage crop

Yield of a crop is the interaction product of Genetic potential of the variety, effect of prevailing environment and crop management practices including pest management system adopted. It is expected that the treatment providing good protection of pests will give higher yield under uniform ecological and crop management system. In present investigation, there was clear evidence that all the bio-rational insecticidal treatment register significant reduction of *Plutella xylostella* and *Pieris brassicae* incidence which results in significantly higher yield in comparison to untreated control.

The yield registered in the microbial treatment were such as spinosad 2.5 SC @ 500ml ha^{-1} 24.77 tonnes ha^{-1} followed by myco-jaal 10 SC 23.70 tonnes ha^{-1}, racer @1000 g ha^{-1} 22.85 tonnes ha^{-1}, lipel @1000 g ha^{-1} 22.60 tonnes ha^{-1} and pacer 1000 g ha^{-1} 19.27 tonnes ha^{-1}.

The yield harvested in botanicals insecticides were such as achook 1500 ppm @ 1500 ml ha^{-1} 22.73 tonnes ha^{-1} followed by shakti 300 ppm @ 2500 ml ha^{-1} 20.13 tonnes ha^{-1}, margosom 300 ppm @ 2500 ml ha^{-1} 20.10 tonnes ha^{-1}, multineem 1500 ppm @ 1500 ml ha^{-1} 20.03 tonnes ha^{-1}, in cow-urine + *Melia azedarach*@12500 ml ha^{-1} 19.97 tonnes ha^{-1} and pestoneem 1500 ppm 1500 ml ha^{-1} register lower yield of 19.90 tonnes ha^{-1}.

The yield harvested in malathion 50 EC was 22.97 tonnes ha^{-1} whereas it was recorded 15.40 tonnes ha^{-1} in untreated control (Table 3 and Fig. 2). The higher yields in spinosad in present investigation were comparable with the findings of [12, 45].

Table 1: Efficacy of certain bio-rational insecticides against, *Plutella xylostella* Linnaeus in cabbage var. "Pride of India" during *Rabi*, 2010-11

Treatment	Dose (ha^{-1})	[1]Mean percent leaf damage due to *P. xylostella* recorded during			Pooled Mean	DBA	[2]Days after applications		
		1st spray	2nd spray	3rd spray			3	5	7
Margosom (Azadirachtin 300 ppm)	2500 ml	35.56 (5.99)	28.00 (5.33)	21.33 (4.65)	28.30 (5.33)	68.00 (8.27)	26.34 (5.18)	22.67 (4.81)	19.87 (4.51)
Shakti (Azadirachtin300 ppm)	2500 ml	36.89 (6.11)	31.56 (5.66)	19.56 (4.47)	29.33 (5.42)	64.00 (8.03)	26.86 (5.23)	25.01 (5.05)	22.22 (4.77)
Pestoneem (Azadirachtin 1500 ppm)	1500 ml	30.22 (5.53)	33.33 (5.81)	25.78 (5.11)	29.78 (5.48)	64.00 (8.03)	25.61 (5.11)	23.27 (4.88)	20.49 (4.58)
Multineem (Azadirachtin 1500ppm)	1500 ml	34.22 (5.89)	30.22 (5.54)	24.44 (4.99)	29.63 (5.49)	56.00 (7.51)	25.49 (5.10)	23.64 (4.91)	20.84 (4.62)
Achook (Azadirachtin 1500 ppm)	1500 ml	27.11 (5.25)	28.44 (5.38)	24.44 (4.99)	26.67 (5.21)	68.00 (8.27)	23.72 (4.92)	20.00 (4.53)	17.21 (4.21)
Cow-urine +*Melia azedarach*	12500 ml	30.22 (5.53)	35.11 (5.96)	31.56 (5.65)	32.30 (5.50)	60.00 (7.78)	26.57 (5.20)	23.75 (4.92)	20.97 (4.63)
Myco-jaal 10SC (*Beauveria bassiana*)	500 ml	15.11 (3.95)	17.78 (4.28)	12.44 (3.60)	15.11 (3.95)	84.00 (9.19)	15.83 (4.04)	12.07 (3.55)	9.24 (3.12)
Lipel (*Bacillus thuringiensis* var. *kurstaki*)	1000 g	17.78 (4.28)	19.11 (4.43)	12.89 (3.66)	16.59 (4.13)	68.00 (8.27)	17.20 (4.21)	13.46 (3.74)	10.63 (3.34)
Racer (*Beauveria bassiana*)	1000 g	23.56 (4.88)	18.22 (4.29)	11.11 (3.35)	17.63 (4.17)	64.00 (8.03)	19.43 (4.46)	14.74 (3.90)	11.90 (3.52)
Pacer (*Metarhizium anisopliae*)	1000 g	36.89 (6.11)	32.00 (5.69)	28.89 (5.41)	32.59 (5.74)	52.00 (7.24)	27.35 (5.27)	25.01 (5.05)	22.22 (4.77)
Spinosad 2.5 SC	500 ml	14.67 (3.89)	16.89 (4.17)	11.11 (3.41)	14.22 (3.84)	90.67 (9.55)	16.27 (4.10)	11.13 (3.41)	8.29 (2.96)
Malathion 50 EC	500 ml	21.78 (4.71)	21.78 (4.71)	20.44 (4.57)	21.33 (4.67)	83.56 (9.16)	18.58 (4.37)	15.78 (4.03)	13.90 (3.79)
Control	Water	69.33 (8.36)	68.89 (8.33)	69.33 (8.36)	69.18 (8.35)	69.33 (8.36)	46.73 (6.87)	48.54 (7.00)	51.28 (7.2)
SEm (±)		0.14	0.15	0.22	0.10	0.19	0.11	0.23	0.26
CD(P=0.05)		0.30	0.31	0.46	0.20	NS	0.22	0.47	0.53

Figures in parentheses are $\sqrt{X + 0.5}$ transformed values; DBA= Day before application;
NS=Non-Significant
[1]Composite means of three post treatment observations recorded at 3, 5 and 7 days after application
[2]Mean of 3 replications based on 3 applications data.

Table 2: Efficacy of certain bio-rational insecticides against the cabbage butterfly, *Pieris brassicae* Linnaeus in cabbage var. "Pride of India" during *Rabi*, 2010-11

Treatment	Dose (ha^{-1})	[1]Mean % leaf damage due to *P. brassicae* recorded during			PooledMean	DBA	[2]Days after applications		
		1st spray	2nd spray	3rd spray			3	5	7
Margosom (Azadirachtin 300 ppm)	2500 ml	31.11 (5.62)	32.22 (5.72)	41.78 (6.50)	35.04 (6.01)	83.11 (9.11)	39.56 (6.33)	34.44 (5.91)	31.11 (5.62)
Shakti (Azadirachtin300 ppm)	2500 ml	39.11 (6.92)	35.20 (5.97)	35.11 (5.97)	36.47 (6.08)	90.00 (9.51)	46.67 (6.87)	36.53 (6.09)	26.22 (5.17)
Pestoneem (Azadirachtin 1500 ppm)	1500 ml	25.78 (5.13)	38.76 (6.27)	43.56 (6.64)	36.03 (6.01)	80.00 (8.96)	41.78 (6.50)	35.2 (5.97)	31.11 (5.62)
Multineem (Azadirachtin 1500ppm)	1500 ml	27.11 (5.25)	34.67 (5.93)	45.33 (6.77)	35.70 (5.98)	90.22 (9.52)	43.11 (6.60)	34.67 (5.93)	29.33 (5.46)
Achook (Azadirachtin 1500 ppm)	1500 ml	31.5 (5.66)	32.00 (5.70)	28.44 (5.38)	30.67 (5.58)	83.33 (9.12)	36.44 (6.08)	28.89 (5.42)	26.67 (5.21)
Cow-urine +*Melia azedarach*	12500 ml	35.11 (5.97)	36.62 (6.09)	38.67 (6.26)	36.80 (6.11)	84.44 (8.21)	42.67 (6.57)	35.73 (6.02)	32.00 (5.70)
Myco-jaal 10SC (*Beauveria bassiana*)	500 ml	23.11 (4.86)	26.00 (5.15)	30.67 (5.58)	26.59 (5.20)	81.56 (9.05)	35.11 (5.97)	24.67 (5.02)	20.00 (4.53)
Lipel (*Bacillus thuringiensis* var. *kurstaki*)	1000 g	25.33 (5.08)	29.78 (5.50)	32.89 (5.78)	29.33 (5.45)	89.78 (9.50)	34.22 (5.89)	28.44 (5.38)	25.33 (5.08)
Racer (*Beauveria bassiana*)	1000 g	28.44 (5.38)	27.78 (5.32)	33.33 (5.82)	29.89 (5.50)	91.11 (9.57)	38.67 (6.26)	29.56 (5.48)	21.33 (4.67)
Pacer (*Metarhizium anisopliae*)	1000 g	24.44 (4.99)	43.93 (6.67)	44.04 (6.67)	37.47 (6.11)	88.44 (9.43)	45.78 (6.80)	34.64 (5.93)	32.00 (5.70)

Spinosad 2.5 SC	500 ml	23.56 (4.90)	24.00 (4.95)	25.33 (5.08)	24.30 (4.98)	90.67 (9.55)	32.89 (5.78)	23.56 (4.90)	16.44 (4.12)
Malathion 50 EC	500 ml	29.33 (5.46)	31.96 (5.70)	30.22 (5.54)	30.50 (5.57)	83.56 (9.16)	41.33 (6.47)	28.84 (5.42)	21.33 (4.67)
Control	Water	84.89 (9.24)	85.69 (9.28)	91.56 (9.59)	87.38 (9.37)	89.73 (9.48)	90.58 (9.54)	86.89 (9.35)	84.67 (9.23)
SEm(±)		0.14	0.15	0.22	0.10	0.29	0.11	0.23	0.26
CD(P=0.05)		0.30	0.31	0.46	0.20	NS	0.22	0.47	0.53

Figures in parentheses are $\sqrt{X + 0.5}$ transformed values; DBA= Day before application; NS=Non-Significant
[1]Composite means of three post treatment observations recorded at 3, 5 and 7 days after application
[2]Mean of 3 replications based on 3 applications data.

Table 3: Effect of bio-rational insecticides on yield parameters of cabbage var. "Pride of India" during *Rabi*, 2010-11

Treatment	Dose (ha^{-1})	Yield tonne ha^{-1}	Increased over control	Percent increased
Margosom (Azadirachtin 300 ppm)	2500 ml	20.10	4.70	30.52
Shakti (Azadirachtin300 ppm)	2500 ml	20.13	4.73	30.71
Pestoneem (Azadirachtin 1500 ppm)	1500 ml	19.90	4.50	29.50
Multineem (Azadirachtin 1500ppm)	1500 ml	20.03	4.63	30.06
Achook (Azadirachtin 1500 ppm)	1500 ml	22.73	7.33	47.60
Cow-urine +*Meliaazedarach*	12500 ml	19.97	4.57	29.67
Myco-jaal 10SC (*Beauveria bassiana*)	500 ml	23.70	8.30	53.89
Lipel (*Bacillus thuringiensis* var. *kurstaki*)	1000 g	22.60	7.20	46.75
Racer (*Beauveria bassiana*)	1000 g	22.85	7.45	48.37
Pacer (*Metarhizium anisopliae*)	1000 g	19.27	3.87	25.12
Spinosad 2.5 SC	500 ml	24.77	9.37	60.84
Malathion 50 EC	500 ml	22.97	7.57	49.15
Control	Water	15.40		
SEm(±)		0.11		
CD= (P0.05)		0.23		

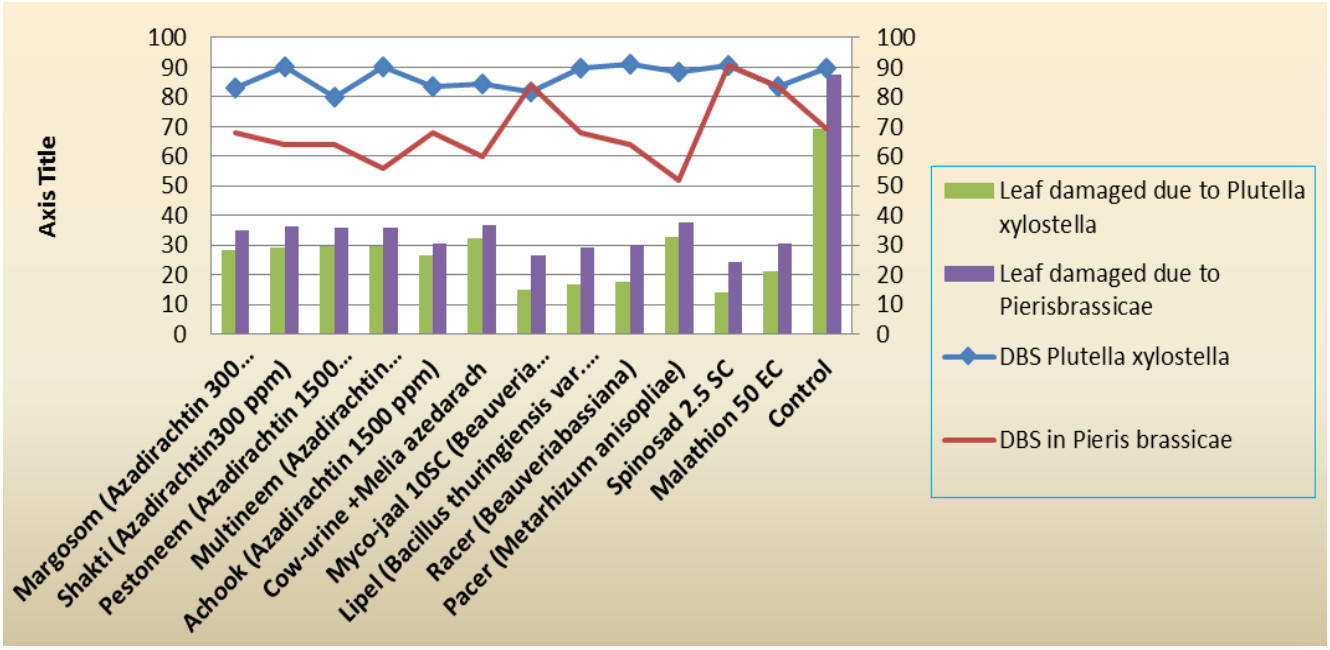

Fig 1: Pre- count extent of mean leaf damaged, Efficacy of Bio-rational insecticides against Major lepidopterous pests in cabbage crop during 2010-11

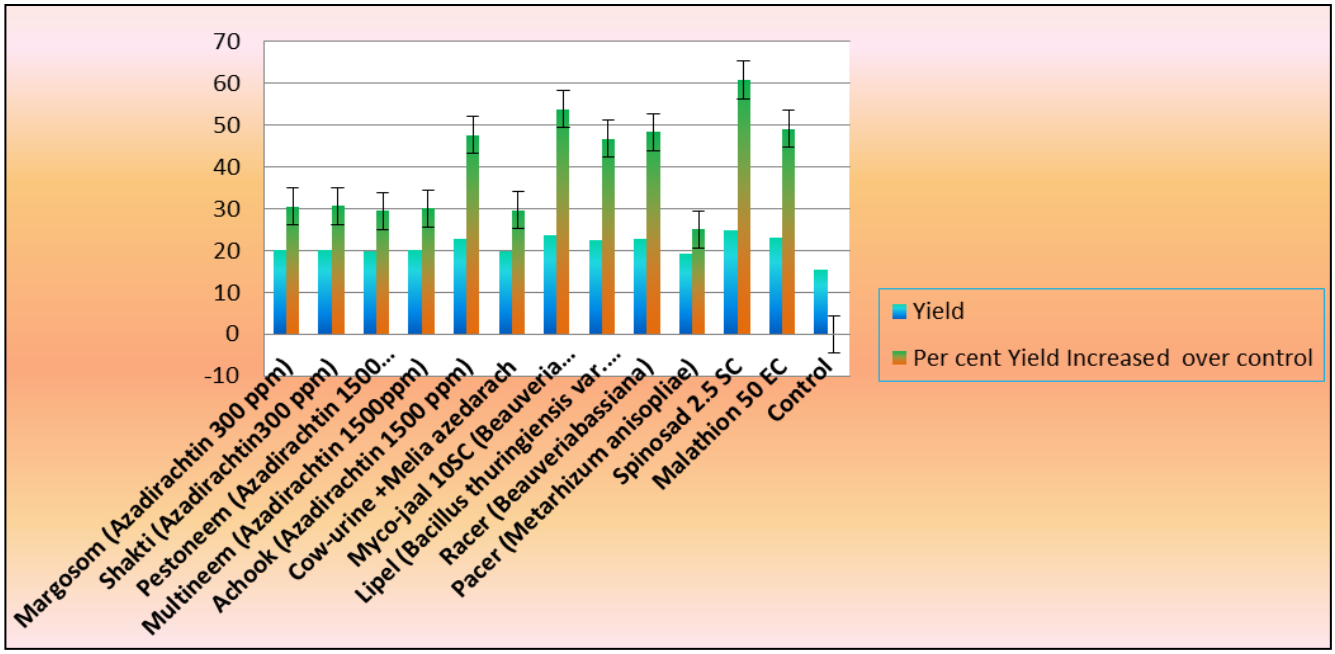

Fig 2: Effect of bio-rational insecticides on yield parameters of cabbage var. "Pride of India" during *Rabi*, 2010-11

Conclusions

The bio-rational evaluated against major pests *viz*., *Plutella xylostella* and *Pieris brassicae* in cabbage crop under Manipur valley were significantly effective than the untreated control. However, the pooled mean of leaf damaged of thrice spray suggests that the treatment spinosad 2.5 SC registered best for managing both these pests and thus returning to higher yields. This was followed by myco-jaal 10 SC, these bio-rational used in the present studies were eco-friendly and may be further recommended for the management of these major pests of cabbage in Manipur valley in the farmer's fields whenever necessary.

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