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Field efficacy of a novel ready-mix molecule Novaluron (5.25% SC) + Emamectin (0.9% SC) against Diamondback moth (*Plutella xylostella* L.) on cabbage (*Brassica oleracea* var. Capitata)

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Abstract
Field efficacy of different Novaluron (5.25% SC) + Emamectin (0.9% SC) treatment schedules was assessed against diamondback moth on cabbage during *rabi* season in 2014-15 at "In Check Farm", C-Block, B.C.K.V., Kalyani, Nadia, West Bengal. After three rounds of sprays, Novaluron (5.25% SC) + Emamectin (0.9%SC) @925ml/ha registered 93.10% mortality followed by Novaluron 10%SC@ 750ml/ha and Novaluron (5.25% SC) + Emamectin (0.9% SC) @875ml/ha with 87.01% mortality and 81.18% mortality respectively. Highest yield (18.33t/ha that was 30.95% increase over control) was recorded in Novaluron (5.25% SC) + Emamectin (0.9% SC) @925ml/ha followed by Novaluron 10% SC@ 750ml/ha (17.67t/ha) and Novaluron (5.25% SC) + Emamectin (0.9% SC) @ 875ml/ha (16.67t/ha). Hence Novaluron (5.25% SC) + Emamectin (0.9% SC) @925ml/ha was found to be most effective in reducing population of diamondback moth on cabbage and also gave the highest cost: benefit ratio.

Keywords: Novaluron (5.25% SC) + Emamectin (0.9% SC), cabbage and diamondback moth

Introduction
In world market India is the second highest cabbage producing country (Anonymous, 2013) [1]. In India the major cabbage producing states are Uttar Pradesh, Odisha, Bihar, Assam, West Bengal, Maharashtra and Karnataka. In India the area under cabbage cultivation is 0.372 million hectares and production 8.534 million tonnes with an average productivity of 22.9 MT/ha as well as 5.3% share to the total national vegetable production during 2012-13. A wide number of insect pests have been reported to infest cabbage of which Diamond back moth, *Plutella xylostella* is the most serious. Actually all most all the cruciferous crops are attacked by this pest. It has become the most destructive insect pest of crucifer plants throughout the world and annual cost of managing it is estimated to be US 1 billion dollar (Talekar and Shelton, 1993) [8]. In India, Krishnamoorthy (2004) [5] reported a 52% yield loss on cabbage due to diamond back moth. Ghosh *et al*. (2002) [3] reported that 26.11% yield loss of cabbage is due to insect pests attack in Terai Region of West Bengal. In India it has gained the status of national pest with resistance to almost all the insectides. In India, resistance to different insectides has reported from several states like Punjab, Haryana, Tamil Nadu, Karnataka and Andhra Pradesh (Mehrotra and Phokela, 2000) [6].

Materials and Methods
The field trial was laid out at "In Check Farm", C-Block, B.C.K.V., Kalyani, Nadia, West Bengal in Randomized Block Design (RBD) with seven treatments including an untreated control, each with three replications. The cabbage cultivar "Royal ball" was selected. Seedlings were ready within 4-5 weeks with 5 to 6 leaves were transplanted in the well prepared field. Light irrigation immediately after transplanting and then at an intervals of 1-2 days were given for proper establishment of young seedlings. The plot size was 2m x 2m and the spacing between rows and plants was maintained at 45 and 45cm, respectively. Six insecticides i.e Novaluron (5.25% SC) + Emamectin (0.9% SC) @925ml/ha, Novaluron 10%SC@ 750ml/ha (92.28%), Novaluron (5.25% SC) + Emamectin (0.9% SC) @ 875ml/ha Emamectin Benzoate 5% SG @ 200ml/ha, Novaluron (5.25%SC) + Emamectin(0.9%SC) @ 825ml/ha, Fipronil 5%SC@ 1000ml/ha were used in this experiment. The first spray was applied as soon as the pest level crossed the ETL i.e. 4-5 larvae per plant and the second and third sprays were given at 15 days interval. All the respective spray fluids were sprayed thoroughly to cover each plant in every treatment. Spraying was done with the help of a knapsack sprayer.

Observations on diamondback moth, *Plutella xylostella* on cabbage and its population counts were recorded by randomly selecting 5 plants. The population count of diamondback moth larvae was recorded on the day before every spray which served as pre-treatment observation and the subsequent counts were taken on three, five, seven and ten days after each spray. From these data the percentage reduction of diamondback moth population was worked out and the data was subjecting to statistical analysis following the formula of Henderson and Tilton, 1955.

$$P = 1- (C_b \times T_a / T_b \times C_a) \times 100$$

Where

P = Per cent reduction in the population of pest.
Cb= Number of larvae on untreated check before treatment
Ta= Number of larvae on treated plot after treatment
Tb=Number of larvae on treated check after treatment
Ca=Number of larvae on untreated check after treatment

Table 1: Details of insecticides used in the experiment

Treatments	Insecticides	Concentration used for field experiment (g a.i./ha)	Formulation (ml/ha)	Mode of Action
T_1	Novaluron (5.25%SC) + Emamectin (0.9%SC)	43.31+7.43	825	Neuromuscular poison and chitin synthesis inhibitor
T_2	Novaluron (5.25%SC) + Emamectin (0.9%SC)	45.94+7.88	875	Neuromuscular poison and chitin synthesis inhibitor
T_3	Novaluron (5.25%SC) + Emamectin (0.9%SC)	48.56+8.33	925	Neuromuscular poison and chitin synthesis inhibitor
T_4	Novaluron 10% SC	75	750	Chitin synthesis inhibitor
T_5	Emamectin Benzoate 5% SG	10	200	Chloride channel activator
T_6	Fipronil 5% SC	50	1000	Chloride channel activator
T_7	Control	-	-	

Results and discussions

The data pertaining to the efficacy of some insecticides against diamondback moth on cabbage has been pooled and presented in table-2. There was a non significant reduction in pre treatment population at 1 day before spray and average percent mortality ranged from 27.22% to 28.44% per 5 plants. After the first round spray it was found that the highest (92.28%) mortality was observed in the plots treated with Novaluron (5.25% SC) + Emamectin (0.9% SC) @925ml/ha i.e., followed by Novaluron 10% SC@ 750ml/ha (92.28%), Novaluron (5.25% SC) + Emamectin (0.9% SC) @ 875ml/ha (80.29%), Emamectin Benzoate 5% SG @ 200ml/ha (68.41%), Novaluron (5.25% SC) + Emamectin (0.9% SC) @ 825ml/ha (61.4%), Fipronil 5% SC@ 1000ml/ha (56.99%) over control. However, after the second round spray with the same treatments, it was observed that maximum (93.73%) mortality was observed in the plots treated with Novaluron (5.25% SC) + Emamectin (0.9% SC) @ 925ml/ha followed by Novaluron 10% SC @ 750ml/ha (87.88%), Novaluron (5.25% SC) + Emamectin (0.9% SC) @ 875ml/ha (81.33%), Emamectin Benzoate 5% SG @ 200ml/ha (71.23%), Novaluron (5.25% SC) + Emamectin (0.9% SC) 825ml/ha (64.46%), Fipronil 5% SC @ 1000ml/ha (60.01%) over control. The results after the third round of spray revealed that the plots treated with Novaluron (5.25% SC) + Emamectin (0.9% SC) 925ml/ha shows highest (93.28%) mortality followed by Novaluron 10% SC @ 750ml/ha (87.2%), Novaluron (5.25% SC) + Emamectin (0.9% SC) @ 875ml/ha (81.94%), Emamectin Benzoate 5%SG @ 200 ml/ha (69.52%), Novaluron (5.25%SC) + Emamectin(0.9%SC) 825ml/ha (62.45%), Fipronil 5% SC @ 1000ml/lit (57.77%) over control.

The present finding was found to be at par with the findings of Chatterjee *et al.*, 2012 [2] who found that Emamectin benzoate, methoxyfenozide, and *Bacillus thuringiensis*, also performed well in reducing damage of diamondback moth and increasing yield. Seal *et al.,* 1995 [7] also revealed that Emamectin benzoate alone or in rotation with *Bacillus thuringiensis* var. *kurstaki* (Dipel 2x) or *B. thuringiensis* var. *aizawai* (*Xentari*) reduced *P. xylostella* populations significantly. Simultaneously Harish *et al.,* 2003 [4] tested the efficacy of novaluron (Rimon 10EC) and other insecticides against *Plutella xylostella* (L.). Novaluron @ 0.75 ml/lit resulted in 90% larval mortality. Wavare *et al.,* 2008 [9] evaluated the efficacy of novaluron against two stages of egg development *viz*., freshly laid prior to hatching, larvae and pupae of diamondback moth, *Plutella xylostella* (L.). As both these insecticides are effective in controlling lepidopteran pests, hence the combination product must be effective against these pests.

A separate observation was taken on yields from each treatment and percentage increase in yield over control was

calculated All the treatments showed significant increase in yield over control (table 3). Highest yield (18.33t/ha that was 30.95% increase over control) was recorded in Novaluron (5.25% SC) + Emamectin (0.9% SC) @925ml/ha treated plot closely followed by plots treated with Novaluron 10% SC @ 750ml/ha (17.67t/ha), Novaluron (5.25%SC) + Emamectin (0.9% SC) @ 875ml/ha (16.67t/ha), Emamectin Benzoate 5% SG @ 200ml/ha (16.33t/ha), Novaluron (5.25% SC) + Emamectin (0.9% SC) 825ml/ha (15.67t/ha), Fipronil 5% SC @ 1000ml/lit (14.33t/ha) and control (14t/ha).

Table 2: Effect of insecticides on yield of cabbage

Treatment	Yield (t/ha)	Per Cent Increase over Control [%]
T1	15.67	11.90
T2	16.67	19.05
T3	18.33	30.95
T4	17.67	26.19
T5	16.33	16.67
T6	14.33	2.38
Control	14.00	0.00

Table 3: Effect of insecticidal spray on the population reduction of diamondback moth, *Plutella xylostella* (L.)

Treatment	Dose ml/ac	First Spray						Second Spray						Third Spray						Oamadads
		Ptmcbs	Mean corrected Per cent Mortality				Oamadas	Ptmcbs	Mean corrected Per cent Mortality				Oamadas	Ptmcbs	Mean corrected Per cent Mortality				Oamadas	
			3DAS	5DAS	7DAS	10DAS			3DASP	5DASP	7DASP	10DAS			3DAS	5DAS	7DAS	10DAS		
T1	825	27.78a	58.12 (49.70)c	64.31 (53.40)c	61.22 (51.51)bc	61.97 (51.98)b	61.4 (51.65)b	26.37ab	60.8 (51.27)c	66.98 (55.00)bc	62.82 (52.55)b	67.23 (55.24) b	64.46 (53.51)c	26.53a	59.49 (50.50)c	65.15 (53.92)b	61.9 (51.95)b	63.26 (52.82) b	62.45 (52.30)c	62.77 (52.49)c
T2	875	28.44a	78.98 (62.75)d	74.48 (59.87)c	82.86 (65.62)d	84.81 (67.14)cd	80.29 (63.85)d	26.76ab	81.89 (64.85)e	76.73 (61.43)d	82.84 (65.62) d	83.86 (66.60) cd	81.33 (64.63)e	26.97a	80.99 (64.21)d	75.68 (60.78)c	84.34 (66.89)d	86.74 (68.93) d	81.94 (65.20)e	81.18 (64.56)e
T3	925	27.67a	88.69 (70.42)f	90.46 (74.23)e	93.74 (75.77)f	96.23 (79.50) e	92.28 (74.98)f	26.06a	92.06 (73.69)g	94.4 (76.40)f	93.59 (75.39)f	94.88 (77.04) e	93.73 (75.63)g	26.37a	92.56 (74.22)f	92.5 (74.38)e	93.47 (75.28)e	94.57 (76.71) e	93.28 (75.15)g	93.10 (75.25)g
T4	750	27.22a	82.4 (65.33)e	84.13 (66.91)d	87.03 (69.36)e	90.21 (73.73)de	85.94 (68.83)e	26.35ab	86.65 (68.65)f	88.38 (70.39)e	88.14 (70.35)e	88.36 (70.32) d	87.88 (69.92)f	26.58a	85.76 (67.98)e	86.79 (69.27)d	87.41 (69.52)d	88.83 (70.75) de	87.2 (69.38)f	87.01 (69.38)f
T5	200	27.33a	60.85 (51.29)c	68.09 (55.72)bc	68.47 (55.90)c	76.21 (61.02)c	68.41 (55.98)c	26.06a	63.89 (53.10)d	70.54 (57.27)c	73.04 (58.95)c	77.46 (62.12) c	71.23 (57.86)d	26.18a	62.55 (52.31)c	69.09 (56.43)bc	68.98 (56.32)c	77.45 (62.24) c	69.52 (56.83)d	69.72 (56.89)d
T6	1000	27.78a	53.51 (47.04)b	60.73 (51.25) b	56.58 (48.81)b	57.12 (49.13)b	56.99 (49.06)b	26.2ab	55.59 (48.24)b	62.35 (52.22)b	62.39 (52.27)b	59.71 (50.65) b	60.01 (50.84)b	26.57a	54.53 (47.63)b	61.33 (51.63)b	56.9 (49.02)b	58.31 (49.86) b	57.77 (49.53)b	58.26 (49.81)b
T7	-	28a	0.01 (0.54)a	0.01 (0.54) a	0.01 (0.54) a	0.01 (0.54) a	0.01 (0.54)a	28.33b	0.01 (0.54) a	0.01 (0.54) a	0.01 (0.54) a	0.01 (0.54) a	0.01 (0.54)a	28.44a	0.01 (0.54) a	0.01 (0.54) a	0.01 (0.54) a	0.01 (0.54) a	0.01 (0.54)a	0.01 (0.54)a
S.Em			0.66	2.08	1.11	2.35			1.69	3.86	4.58	5.12			2.52	4.71	4.27	6.36		
CD			2.02	6.42	3.42	7.24			0.55	1.25	1.49	1.66			0.82	1.53	1.39	2.06		

PTMCBS=Pre-treatment Mean Count Before spray, OASP=Over All Significance of Pesticides, CD at 5 per cent level of significance, OAMADAS= Over All Mean across Different Days after Spraying, OAMADADS = Over All Mean across Different Days across Different Spraying

Conclusion

It is evident from the present investigation that the yield in all treatments was significantly higher than untreated control. The plot treated with Novaluron 5.25% + Emamectin Benzoate 0.9% SC @ 925 ml/ha gave good control of pest with an 30.95% increase in yield over control. Hence it could be recommended for safe and economic use in cabbage for effective control of diamondback moth.

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