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Assessment of the efficacy of some bio-rational pesticide formulations for the management of yellow stem borer, *Scirpophaga incertulas* Wlk. in paddy field

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ABSTRACT

Extent of suppression of paddy yellow stem borer population by eleven selected pesticide formulations (9 bio-pesticide + 2 synthetic pesticide) was studied in the field of paddy cultivar *Swarna mashuri* (MTU 7029) during three consecutive *kharif* crop seasons of 2007-2009 at Raiganj, Uttar Dinajpur, West Bengal, India. Experiment was done following complete randomized block design and had three replications for each year. All treatments were significantly effective in checking stem borer infestation causing the decrease of both dead heart (DH) and white head (WH) number. Numerically, least damage was noted for monocrotophos 36 WSC. This was followed by carbofuran 3G, nimbecidine - 2.5%, neem seed kernel extract (NSKE) - 5%, *B. thuringiensis*-2ml/L, neem leaf extract (NLE)- 2%, neem oil-2%, karanja seed kernel extract (KSKE)-5%, mahua oil-2%, *Vitex negundo* extract in ascending order. The control plot has registered maximum DH and WH. In consideration of yield increase over control, maximum efficacy was registered for monocrotophos respectively followed by carbofuran, nimbecidine, *B.thuringiensis* ,NSKE ,NLE, mahua oil, neem oil, KSKE, *V. negundo* and plant mixture in descending order. Significant differences in the number of effective tillers/m^2, panicle/m^2 leaf area index and dry matter production/ m^2 in consideration of different treatment formulation was noted. But plant height, panicle length, and 1000 seed grain weight differed insignificantly.

Key words: Population suppression, paddy yellow stem borer, biopesticide, yield loss

INTRODUCTION

One of the main causes of low yields of rice in the tropical Asian countries is due to damages by the insect pests (Matteson, 2000). About 128 species of insects have been reported to ravage the paddy field. Out of these, in consideration of crop damage, 15 to 20 insect species are economically important (Kalode, 2005). Stem borers (SBs) are key group of insect pests of rice (Dhaliwal *et al.*, 1996). Among the borers, yellow stem borer (YSB), *Scircophaga incertulas* Walker is distributed throughout India and is regarded as the most dominating and destructive pest species (Mahar *et al.*, 1985). Severe infestation by YSB often results in complete crop failure (Kushwaha, 1995). Experiments on the efficacy of synthetic pesticides of different newer brands have been carried out by several authors like Khan and Khaliq (1989); Kushwaha (1995); Saljoqi *et al.* (2002); Prasad and Prasad (2006); Sasmal *et al*.(2007), but no definite plant protection schedule applicable for all the agro-ecological zones could be evolved. In spite of that synthetic insecticides are still the primary way to control YSB menace. Such over reliance on synthetic pesticides causes ecological adversity and health related problems (Kushwaha 1995, Wakil 2001). In such a back drop bio-pesticides are reported to be safer to human health imparting no ecological toxicity (Ketkar, 1976; Khan and Khan, 1989). Though the efficacy of neem derivatives and a few other bio-pesticides on YSB incidence have been tested elsewhere, it has resulted only in a variable range of success (Ganguli and Ganguli, 1998). The neem seed kernel extract (NSKE) is known to suppress the feeding, growth and reproduction of insects due to its biochemicals (Natarajan and Sundaramurthy, 1990). Neem products can be recommended for many programmes on integrated pest management (Juan *et al*., 2000; Calvo and Molina, 2003). *Vitex negundo* L. (Verbenaceae) has shown a promising pesticidal activity against insects and is widely used for its pest control properties (Hern´andez *et al.*, 1999). *Bacillus thuringiensis* (Bt) with allelochemicals are used for developing natural resistance to insects (Senthil *et al*.,1999). Ahmed *et al*. (1980) have reported that *V.negundo* effectively suppresses rice weevil (*Sitophilus oryzae*). Miranpuri *et al*. (1993) have also reported the efficacy of some bio-pesticides for pest suppression. In this consideration efficacy of different pesticide formulation on the YSB incidence in diverse agro-ecological zone is needed to be explored (Dent, 1993;

Kushwaha, 1995). In view of this and to evaluate the relative efficacy of 11 selected insecticide formulations against YSB incidence, a study was undertaken for three consecutive years (2007-2009) where no such experiment even of preliminary in nature was carried out earlier.

MATERIAL AND METHODS

Field layout and experimental protocol

Field experiments were conducted with transplanted 35-day old seedlings of widely cultivated variety *Swarna mashuri* (MTU 7029) during three consecutive *kharif* seasons (winter crop) of 2007-2009 at Raiganj [26°35´15´´(N) – 87°48´37´´(W)], Uttar Dinajpur, West Bengal. The soil of the experimental field was sandy loam with PH value 6.5 and EC value 0.29mmhs/cm. Field N, P_2O_5 and K_2O was 315, 58 and 349 kg/ha respectively. Experiments were conducted by randomized block design with the transplanted seedlings at 15x10 cm spacing. There were eleven treatments, each with three replications for each year. Each plot was 10x10 m in size and separated from the nearby plot by a distance of 5m. Pesticide formulations in the plots were applied twice during 35 and 75 days after seedling transplantation (DAT) respectively. Fertilizer inputs and other necessary field management were done in due course of time following the national protocol with befitting modifications.

Preparation of pesticide formulation

Different grades of pesticide formulations were prepared. 150 gm of 3 month - old neem kernel was finely smashed and subsequently pounded in 1 litre of water to prepare neem seed kernel extract (NSKE) formulation (T1). Similarly, 1 kg green neem leaves were soaked overnight in 5 litres of water, grinded and the leaf extract was filtered to prepare neem leaf extract (NLE) formulation (T2). In the same manner *karanja* formulation was also prepared (T3). Neem oil formulation was prepared after adding 2 ml of oil to 1 litre of water. The mixture was stirred well, emulsified and stored as working solution (T4). Desired formulation grade of commercially available market sample of Nimbecidine was prepared (T5). Commercially available concentrate formulation of *Bacillus thuringiensis* was used as *Bt* formulation (T6). The preparation was added with the required amount of water to make appropriate conidial suspension. 300 liter of spray suspension/ acre was applied by high volume sprayer. To prepare plant mixture solution, extract from five plant parts reported to have pest suppression quality was used. These were Nerium (*Nerium* sp.), *Parthenium* sp. , *Vinca rosea*., *Pongamia* sp. and *Carica papaya* . 350 gm of each of the plant sample was at first surface sterilized with 2% sodium hyochloride solution for 5 minutes and subsequently watched and crushed in pure water (1:1 w/v). The pulp was then squeezed and the aliquot properly filtered. The clear extract was then stored. 0.5 kg cow dung and 0.5 litre of cattle urine were properly mixed with it. The mixture was then diluted with 20 litres of water and kept undisturbed for about 30 days for complete fermentation and for subsequent field application (T7). The filtrate was again re-diluted and used as @ 5 ml/L water. Sundried brown coloured *Mahua* kernels were smashed and the extracted oil was filtered to remove suspended materials. The oil was stored in brown coloured bottle at room temperature and from that desired concentration grade was prepared (T8). 75 g of *V. negundo* leaves were washed and oven-dried to get constant weight at 55 °C. The dried sample was then grinded into powder. The powder was then mixed with 150 ml of water to prepare a stock solution. From the stock solution required concentrations grade were prepared using water (T9). The standard synthetic formulations were monocrotophos 36 WSC, 1125ml/ha (T10) and carbofuran 3 G, 30kg/ha (T11).

Assessment on pest incidence

The infestation by YSB was recorded in terms of the number of DH and WH produced during vegetative and reproductive stages respectively in each plot. The percentage of DH and WH of individual plot was calculated by using the following formula described by Singha and Pandey (1997).

$$\text{DH and WH \%} = \frac{\text{Number of DH / WH}}{\text{Total number of tillers}} \times 100$$

Assessment on yield attributing characters

Average plant height(cm), panicle length (cm), panicle number/ m^2, number of effective tillers/ m^2, Leaf area index and dry matter production (gm/m^2) were measured from fifty randomly selected hills from each of the plots at maximum growth stage of paddy. Grains were sun dried, threshed, cleaned thoroughly and the produce from each plot was weighed (q/ha). From the threshed product of each plot, thousand grains were separately counted, dried and weighed (in gm.).

Statistical analysis

Data obtained from field experiment was statistically analyzed by INDOSTAT- ANOVA and accordingly CD value was determined (Chandel, 1984).

RESULTS AND DISCUSSION

Efficacy of different pesticide formulations was determined in consideration of DH and WH formation (Table 1). On the whole, the magnitude of incidence under different treatments ranged from 3.11 to 8.90 % DH and 1.53 to 5.96 %WH. Least pest infestations with 3.11% DH and 1.53% WH was recorded

Table1. Impact of different biopesticide formulation on the incidence of DH (%) and WH (%)

Treatment	Insecticide formulation	Extent of Infestation (%)										Yield (q/ha)				Application Efficacy % (in respect of yield increase over control)
		DH%				Decrease of incidence over control %	WH(%)				Decrease of incidence over control %					
		2007	2008	2009	Mean		2007	2008	2009	Mean		2007	2008	2009	Mean	
T1	NSKE (5%)	3.89 (2.10)	4.01 (2.05)	3.72 (2.05)	3.87 (2.09)	56.48	2.42 (1.71)	2.33 (1.68)	2.18 (1.64)	2.31 (1.68)	61.22	31.91	31.78	31.92	31.87	29.62
T2	NLE (2%)	4.62 (2.26)	4.79 (2.30)	3.89 (2.10)	4.43 (2.22)	50.19	2.72 (1.79)	2.68 (1.78)	2.79 (1.81)	2.73 (1.80)	54.17	29.76	29.41	29.81	29.66	20.63
T3	KSKE (5%)	5.27 (2.40)	5.35 (2.42)	5.21 (2.39)	5.28 (2.40)	40.71	3.51 (2.00)	3.59 (2.02)	3.47 (1.99)	3.52 (2.01)	40.85	27.11	26.37	26.34	26.61	8.22
T4	*Neem oil* (2%)	5.32 (2.41)	4.97 (2.34)	5.07 (2.36)	5.12 (2.37)	42.47	3.13 (1.91)	3.49 (2.00)	3.32 (1.95)	3.31 (1.95)	44.38	28.82	28.42	30.13	29.12	18.45
T5	Nimbecidine (2.5%)	4.10 (2.14)	3.01 (1.87)	3.18 (1.92)	3.43 (1.98)	61.46	2.03 (1.59)	2.44 (1.71)	2.31 (1.68)	2.26 (1.66)	62.06	33.51	33.70	33.98	33.73	37.19
T6	*B. thuringiensis* (2 ml/l)	3.67 (2.04)	3.61 (2.03)	3.75 (2.06)	3.68 (2.04)	58.69	2.56 (1.75)	2.35 (1.69)	2.17 (1.63)	2.36 (1.69)	60.38	31.06	32.96	33.57	32.53	32.31
T7	Plant mixture (1.12 ml/l)	8.14 (2.94)	8.57 (3.01)	8.02 (2.92)	8.24 (2.96)	7.38	4.91 (2.34)	5.54 (2.46)	5.87 (2.52)	5.44 (2.44)	8.67	25.12	25.45	25.23	25.27	2.77
T8	Mahua oil (2%)	6.73 (2.69)	6.32 (2.61)	6.46 (2.64)	6.50 (2.65)	26.93	4.59 (2.26)	4.25 (2.18)	3.97 (2.11)	4.27 (2.18)	28.32	28.32	28.09	27.94	28.12	14.36
T9	*V. negundo* (5%)	7.47 (2.82)	7.23 (2.78)	7.82 (2.88)	7.51 (2.83)	15.66	4.89 (2.32)	5.41 (2.43)	5.56 (2.46)	5.29 (2.41)	11.25	26.11	26.27	26.87	26.42	7.44
T10	Monocrotophos 36 WSC (1125 ml/ha)	3.12 (1.90)	3.18 (1.92)	3.02 (1.88)	3.11 (1.90)	65.09	1.52 (1.42)	1.67 (1.47)	1.41 (1.38)	1.53 (1.43)	74.26	34.67	35.11	35.37	35.05	42.56
T11	Carbofuran (3 G) 30 kg/ha	3.06 (1.89)	3.20 (1.92)	3.71 (2.05)	3.32 (1.96)	62.66	1.87 (1.54)	1.98 (1.57)	1.79 (1.51)	1.88 (1.54)	68.44	33.56	33.87	34.09	33.84	37.64
T12	Control	8.92 (3.07)	9.16 (3.11)	8.62 (3.02)	8.90 (3.07)	-	5.95 (2.24)	6.11 (2.57)	5.81 (2.51)	5.96 (2.54)	-	24.57	24.09	25.10	24.59	-
	CD(P=0.05)	0.12	0.19	0.21	0.27	-	0.15	0.18	0.14	0.21	-	1.34	1.53	1.74	1.26	-

(-): not applicable, Figure in the parenthesis is the square root transformed values from monocrotophos 36 WSC treated plots. Carbofuran 3G ranked next resulting 3.32% DH and 1.88 % WH. This was followed by nimbicidine 2.5ml/litre with 3.43 DH and 2.26 WH. Formulation of NSKE 5% was evicted as the fourth best pesticide resulting 3.87 % DH and 2.31 %WH. *B. thuringiensis* (2g/ litre), NLE 2%, mahua oil, neem oil, KSKE 5%, *V. negundo*, plant mixture and control formulation respectively in ascending order. Though numerically variation in the abundance of DH and WH was noted between carbofuran and *B. thuringiensis* treatment, in consideration of pest suppression efficiently both the treatments differed moderately. Application of plant extract formulation resulted in maximum range of infestation and it was on a par with the field of no pesticide application.

Maximum YSB population suppression was noted for monocrotophos. The second best result was noted for Carbofuran 3G DH and WH), nimbecidine 6 %, NSKE 5%, *B. thuringenensis* 1ml/L DH and WH, NLE 2%, neem oil 2% , KSKE 5%, mahua oil 2%, *V. negundo* 5% DH and WH) and plant mixture DH and WH in descending order.

Application efficacy in percentage of each of the formulations was assessed in terms of the yield increase capacity over the control plots. Maximum benefit was scored for monocrotophos 36 WSC (42.56%), The second best result was noted for carbofuran 3G (37.64%). Nimbecidine- 2.5% ,NSKE 5% , *B. thuringiensis* 2ml/L, NLE 2%, neem oil 2%, mahua oil 2%, KSKE 5% , *V.negundo* 5% and plant mixture-5% ranked in descending order.

Efficacy of different pesticide formulation was assessed in terms of some selected yield attributing characters (Table 2). Significant differences in the number of effective tillers/m^2, leaf area index and dry matter production/m^2 in consideration of different formulation was noted. But plant height, panicle length, panicle/m^2 and 1000 seed grain weight differed insignificantly.

Plant height (cm): No significant variation of plant height in consideration of different treatment was noted. However, maximum number of plant height was noted in T10 .This was followed by T11, T6 , T1, T2 , T5 , T8 , T3 , T4 , T9 , T7 and T12 respectively in descending order.

Panicle length (cm): Length of the panicle under different treatments differed insignificantly. However, maximum panicle length was noted in T10 , T11 , T6 , T1 , T2 , T5 , T8 , T3 , T4 , T9, T7 and T12 in descending order. *Panicle number/m^2*: Variation of panicle number/m^2 under different treatment was significant. Highest number of panicles/m^2 was noted in T10. The next one was T11. T6, T1, T2, T5, T8, T3, T4, T9, T7 and T12 ranked afterward in descending order.

Number of effective tillers/m^2: Maximum number of effective tillers/m^2 was noted in T10. T11 scored the second highest number of tillers. T6 , T1 , T2 , T5 , T8 , T3 , T4 , T9 , T7 and T12 respectively ranked afterwards.

Leaf area index: Significant variation in consideration of leaf area index under treatment was noted. Maximum leaf area indexwas estimated in T10 and T11 ranked second. The third

Table 2. Assessment of the impact of different pesticide formulation of different yield attributing characters of the paddy cultivar *Swarna mashuri* (MTU 7029)

Treatment	Plant Height (cm)	Panicle length (cm)	Panicle number/ m^2	Number of effective tillers/m^2	Leaf area index	Dry matter production gm/m^2	1000 seed grain weight (gm)
T1	98.19	22.41	139.21	440.92	4.40	602.56	24.85
T2	98.11	22.19	132.67	432.47	4.35	592.53	24.79
T3	97.85	21.58	118.45	408.56	4.12	563.73	24.41
T4	97.79	21.62	115.23	411.07	4.15	559.34	24.35
T5	98.01	22.03	127.73	425.34	4.29	583.89	24.67
T6	98.25	22.47	144.78	425.09	4.47	614.71	24.90
T7	97.62	21.47	101.45	401.63	3.92	550.45	24.21
T8	97.93	21.87	121.32	419.72	4.21	571.26	24.58
T9	97.71	21.49	108.21	396.02	4.03	541.22	24.28
T10	98.45	22.56	155.67	457.23	4.55	642.12	24.98
T11	98.37	22.51	151.03	451.22	4.50	631.76	24.94
T12	97.32	21.45	98.78	389.45	3.86	529.78	24.12
CD(P=0.05)	**2.45**	**1.92**	**1.21**	**1.67**	**0.56**	**1.02**	**1.76**

position was occupied byT6 than T1 , T2 , T5 , T8 , T3 , T4 , T9 , T7 and T12 in descending order.

Dry matter production (gm/m²): Production of dry matter under different treatment differed significantly. Maximum leaf area indexwas noted in T10 than T11. T6 , T1 , T2 , T5, T8 , T3, T4, T9, T7 and T12 ranked in descending order.

Thousand seed grain weight (gm): Insignificant variation of seed weight under different treatment was noted. Maximum grain weight (gm) was noted in T10 .This was followed by T11. T6 was the third best treatment in consideration of seed weight. The values of T1 , T2 , T5, T8, T3, T4, T9, T7 and T12 were in descending order.

Carbofuran 3G and monocrotophos 36 WSC were found superior in respect to the per cent yield increase over untreated control. Among different biopesticide formulation so evaluated, yield increase over untreated control was the maximum for nimbecidine followed by NSKE (5%). However, moderate variation in consideration to yield generation was noted between carbofuran and nimbecidine application.

The application of biological control is encouraging due to the popularization of environment awareness. Day by day conventionally applied synthetic chemicals become ineffective due to the generation of gradual resistance in insect pests (Dent, 1993). The relevance of bio-pesticides in modern agriculture is thus increasing due to the post application ecological adversity of synthetic pesticides (Ali *et al*., 1983, Khan *et al*., 1989). In the present experiment all the treatments were found superior to suppress YSB population in consideration of control. YSB covers nearly two generations in a crop cycle. Application of bio-pesticides during the first phase at 35 DAT brings about the mortality of the early YSB larval brood. This may be due to the anti-feedant activity of bio-formulations against larval broods (Ganguli *et al.,* 1998). Thus the canopy is protected from larval damage. Neem seed kernel extracts (NSKEs) have been found to suppress the feeding, growth, and reproduction of insect pests (Ascher *et al*., 1984). Consequently the field symptoms of DH and WH are reduced. Bhanukiran *et al*. (2000) have noted that in in-vitro condition neem products could effectively control the activity of maize stalk borer, *Chilo partellus* larvae. In field condition , as the insecticide treated larvae became sluggish they might have been picked up by the birds which were present in the nearby fields and could easily invade the crop field due to low canopy compactness at early stages of paddy growth. Ahmed *et al*. (2002) have concluded that neem formulations were economically prudent to suppress stem borer menace. Ali *et al*. (1983) have reported that neem oil at 1 ml/100 g seed effectively killed all the pulse beetle grubs and adults. Ketkar (1976) also reported from Pune, India that 8 ml neem oil when added with 1 kg of grains reduced the infestation to almost zero in Bengal gram.

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