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M Balasubramamiam
SMS - Plant Protection,
ICAR - Krishi Vigyan Kendra,
Tirunelveli, Tamil Nadu, India

K Kumar
Professor and Head,
Department of Agricultural Entomology, PAJANCOA&RI,
Karaikal, Puducherry, India

Correspondence
M Balasubramamiam
SMS - Plant Protection,
ICAR - Krishi Vigyan Kendra,
Tirunelveli, Tamil Nadu, India

Bioefficacy of neem formulations against the rice yellow stem borer, *S. incertulas* (Walk.)

M Balasubramamiam and K Kumar

Abstract
Bioefficacy of neem formulations against the rice yellow stem borer, *S. incertulas* (Walk.) was evaluated with the help of two supervised field experiments conducted during *kharif* 2016 and *rabi* 2016-17 at PAJANCOA & RI. The experiment was laid out in RBD with eight treatments and three replications including control, the variety used was ADT 45. Two foliar applications were given for controlling rice stem borer. The results revealed that, the overall mean per cent damage was low in the treatment with dinotefuran 20 SG @ 200 g/ha (4.91,5.06%/hill) and (5.24,3.17%/hill) with a per cent reduction of 60.65,61.37 per cent and 56.26,80.11 per cent in the field experiments I and II respectively. Among the neem formulations, the treatment with multineem 1.0% EC @ 2500 ml/ha recorded lower yellow stem borer damage (7.89,6.73%/hill) and (6.96,5.46%/hill) with a per cent reduction of 36.77,48.62 per cent and 41.90,65.75 per cent as compared to the untreated check. The highest yield was observed in the treatment with dinotefuran 20 SG @ 200 g/ha (4.31 and 5.77 t/ha) and among the neem formulations, multineem 1% EC @ 2500 ml/ha recorded a highest yield (3.90 and 5.40t/ha) as compared to the untreated check (2.85 and 3.40 t/ha).

Keywords: Dinotefuran 20 SG, yellow stem borer, neem formulations and rice

Introduction
Rice (*Oryza sativa* L.) is the main source of food for more than half the world's population and its cultivation secures a livelihood for more than two billion people. Rice is the staple food in most of the Indian states and plays a major role in Indian economy. About 90 per cent of the rice produced is consumed within the country. One of the major constraints for low production of rice in Asia is insect pests and diseases. Among the insect pests, the yellow stem borer, *Scirpophaga incertulas* (Walk.) is the most devastating pest of deep water rice causing up to 76% damaged stem at late ripening stage and ultimately reducing yield to the tune of 27.3 % (Prasad *et al.*, 2007) [7]. Although both synthetic and natural pesticides are used extensively in the agricultural fields to control crop pests, it is well known that natural pesticides are eco-friendly and are safe to the nontarget organisms. Nearly 550 insect pest species are sensitive to Azadirachtin, an active compound extracted from the neem tree *Azardirachta indica* (L).
Now a days, pesticides from *A. indica* become very much popular because of their biodegradability, less persistence and least toxic to non-target organisms, economical and easy availability. In India, it was stated that the neem products are effective against various pests both in the field as well as in the stored grains like rice, wheat, corn, legumes, potato, tomato, etc.
(Mondal Debashri and Tamal, 2012) [3]. Botanical pesticides are the important alternatives to minimize or replace the use of synthetic pesticides as they possess an array of properties including toxicity to the pest, repellency, anti-feedancy, insect growth regulatory activities against the pests of agricultural importance (Prakash and Rao, 1986, Prakash *et al*., 1990) [5, 6]. Considering the effectiveness, the present investigation was taken up to evaluate the bioefficacy of neem formulations against the yellow stem borer incidence.

Materials and Methods
Two field experiments were conducted at the Eastern farm of PAJANCOA & RI, Karaikal, U. T. of Puducherry during *kharif"*2016 and *rabi'*2016-17 to evaluate the bioefficacy of neem formulations against the rice yellow stem borer, *S. incertulas* (Walk.). The experiment was laid out in a randomized block design (RBD) with three replications and eight treatments in a 4×4.5 square meter plot with a spacing of 20×15 cm and the variety used was ADT 45.

The eight treatments namely, Neem Baan 1.0% EC @ 1000 ml/ha, Neemazal 1.0% EC @ 1000 ml/ha, Nimbecidine 0.03% EC @ 2500 ml/ha Multineem 1.0% EC @ 2500 ml/ha, Neem oil @ 2500 ml/ha, Dinotefuran 20 SG @ 200 g/ha, Rynaxypyr 20 SC @ 150 ml/ha as standard checks along with untreated check. The per cent damage of dead hearts was calculated as follows.

$$\text{Per cent damage} = \frac{\text{Number of dead hearts}}{\text{Total number of tillers}} \text{ x } 100$$

The percent damage was recorded in the field experiment I and II. Observations were recorded on ten randomly selected plants per plot leaving the border rows prior to treatment and also at 1, 3, 7 and 14 DAT. The observations recorded for per cent damage by the yellow stem borer was transformed in to corresponding angular transformation (Arc sine) and used for analysis. The data obtained from the field experiment was analysed in a simple randomized block design by "F" test for significance as described by Panse and Sukhatme (1958) [4]. Critical difference values were calculated at five per cent probability level and the treatment mean values of the experiment were computed using Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984) [1].

Results and Discussion

Field experiment I (*Kharif'2016*)

The effect of neem formulations against the rice yellow stem borer in *kharif* 2016 on rice variety ADT 45 are presented in Table 1. Before the first foliar application, the per cent dead heart damage ranged from 7.13 to 10.17 per cent/hill. After the application, the per cent dead heart damage ranged from 6.29 to 11.55, 4.19 to 12.05, 1.66 to 13.68 and 5.29 to 15.11 per cent/hill at 1,3,7 and 14 days after treatment (DAT) respectively. It was found that the treatment with dinotefuran 20 SG @ 200 g/ha recorded the lowest per cent dead heart damage which ranged from 1.66 to 6.29 per cent/hill followed by rynaxypyr 20 SC @ 150 ml/ha (3.03 to 7.36%/hill).

Among the neem formulations, the treatment with multineem 1.0% EC @ 2500 ml/ha recorded lowest per cent dead heart damage which ranged from 6.23 to 9.37 per cent/hill compared to the untreated check (11.55 to 15.11%/hill) at 1,3,7 and 14 DAT.

The overall mean per cent dead heart damage ranged from 4.91 to 12.48 per cent/hill. It was found that the per cent dead heart damage was low in the treatment with dinotefuran 20 SG @ 200 g/ha (4.91%/hill) which was on par with rynaxypyr 20 SC @ 150 ml/ha (6.18%/hill) followed by multineem 1.0% EC @ 2500 ml/ha (7.89%/hill). All the treatments were found to be superior as compared to the untreated check (12.48%/hill). It was found that the treatment with dinotefuran 20 SG @ 200 g/ha was superior with a per cent reduction of 60.65 per cent and among neem formulations the treatment with multineem 1% EC @ 2500 ml/ha was superior with a per cent reduction of 36.77 per cent as compared to the untreated check.

Before the second foliar application, the per cent dead heart damage ranged from 5.29 to 15.11 per cent/hill. After the application, the per cent dead heart damage ranged from 4.21 to 15.61, 3.63 to 16.05, 3.26 to 17.19 and 6.58 to 18.86 per cent/hill at 1,3,7 and 14 DAT respectively. The treatment with dinotefuran 20 SG @ 200 g/ha recorded the lowest per cent dead heart damage which ranged from 3.26 to 6.58 per cent/hill. Among the neem formulations the treatment with multineem 1.0% EC @ 2500 ml/ha recorded lowest per cent dead heart damage which ranged from 4.82 to 8.31 per cent/hill followed by neem baan 1.0% EC @ 1000 ml/ha (5.59 to 9.14%/hill) compared to the untreated check (15.61 to 18.86%/hill) at 1,3,7 and

14 DAT. In the case of the overall mean per cent dead heart damage and per cent reduction similar trend was observed as in the first foliar application. Since the pest population trend was low, third foliar application was not given.

Field experiment II (*Rabi*'2016-17)

The effect of neem formulations against the rice yellow stem borer in *rabi'* 2016-17 on rice variety ADT 45 are presented in Table 2. Before the first foliar application, the per cent dead heart damage ranged from 7.71 to 10.62 per cent/hill. After the application, the per cent dead heart damage ranged from 6.51 to 11.01, 4.35 to 11.86, 2.43 to 12.79 and 4.68 to 13.60 per cent/hill. at 1,3,7 and 14 DAT respectively. The treatment with dinotefuran 20 SG @ 200 g/ha recorded the lowest per cent dead heart damage which ranged from 2.43 to 6.51 per cent/hill. Among the neem formulations the treatment with multineem 1.0% EC @ 2500 ml/ha recorded the lowest per cent dead heart damage which ranged from 4.51 to 8.33 per cent/hill followed by neem baan 1.0% EC @ 1000 ml/ha (5.27 to 8.27%/hill) compared to the untreated check (11.01 to 13.60%/hill) at 1,3,7 and 14 DAT.

The overall mean per cent dead heart damage ranged from 5.24 to 11.98 per cent/hill. It was found that the per cent dead heart damage was low in the treatment with dinotefuran 20 SG @ 200 g/ha (5.24%/hill) and was on par with rynaxypyr 20 SC @ 150 ml/ha (5.78%/hill) followed by multineem 1.0% EC @ 2500 ml/ha (6.96%/hill) and neem baan 1.0% EC @ 1000 ml/ha (7.45%/hill). All the treatments were found to be superior as compared to the untreated check (11.98%/hill). It was found that the treatment with dinotefuran 20 SG @ 200 g/ha was superior among the treatments with a per cent reduction of 56.26 per cent and among the neem formulations the treatment with multineem 1.0% EC @ 2500 ml/ha was superior with a per cent reduction of 41.90 per cent compared to the untreated check.

Before the second foliar application, the per cent dead heart damage ranged from 4.68 to 13.60 per cent/hill. After the application, the per cent dead heart damage ranged from 3.14 to 14.10, 2.31 to 15.11, 1.34 to 17.05 and 4.37 to 19.83 per cent/hill at 1,3,7 and 14 DAT respectively and similar trend was observed as in the first foliar application.

Table 1: Effect of neem formulations against the yellow stem borer, *Scirpophaga incertulas* (Walker) during *kharif*' 2016 in rice after first and second foliar application (Field experiment I)

SL. No.	Treatments	Conc. ml/g/ha	Per cent dead heart # I Foliar application							Per cent dead heart # II Foliar application					
			Pre-count	1 DAT	3 DAT	7 DAT	14 DAT ##	Overall mean	Per cent reduction	1 DAT	3 DAT	7 DAT	14 DAT	Overall mean	Percent reduction
1.	Neem Baan 1.0% EC	1000	9.13 (17.58)^{bc}	8.15 (16.59)^{cd}	8.03 (16.45)^{d}	6.82 (15.13)^{cd}	8.28 (16.72)^{d}	8.08 (16.50)^{b}	35.25	8.13 (16.57)^{d}	6.91 (15.24)^{cd}	5.59 (13.68)^{d}	9.14 (17.59)^{d}	7.61 (15.96)^{cd}	41.90
2.	Neemazal 1.0% EC	1000	9.64 (18.09)^{de}	8.74 (17.20)^{de}	8.90 (17.35)^{e}	7.22 (15.58)^{de}	8.58 (17.04)^{d}	8.62 (17.05)^{b}	30.92	8.81 (17.27)^{e}	7.73 (16.15)^{de}	6.31 (14.54)^{de}	10.03 (18.47)^{e}	8.29 (16.69) ^{de}	36.71
3.	Nimbecidine 0.03% EC	2500	10.17 (18.59)^{ab}	8.04 (16.47)^{c}	9.20 (17.65)^{ef}	7.85 (16.27)^{ef}	8.21 (16.65)^{d}	8.69 (17.13)^{b}	30.36	9.65 (18.09)^{f}	8.52 (16.97)^{ef}	7.01 (15.35)^{ef}	11.00 (19.37)^{f}	8.77 (17.18) ^{ef}	33.05
4.	Multineem 1.0% EC	2500	9.37 (17.82)^{de}	9.37 (17.82)^{e}	7.20 (15.56)^{c}	6.23 (14.45)^{c}	7.26 (15.63)^{c}	7.89 (16.26)^{b}	36.77	7.07 (15.42)^{c}	6.18 (14.39)^{c}	4.82 (12.67)^{c}	8.31 (16.75)^{c}	6.73 (14.98) ^{bc}	48.62
5.	Neem oil	2500	9.30 (17.75)^{a}	10.53 (18.93)^{f}	9.91 (18.35)^{f}	8.42 (16.87)^{f}	9.71 (18.15)^{e}	9.57 (18.01)^{b}	23.31	10.56 (18.96)^{g}	9.31 (17.76)^{f}	7.80 (16.22)^{f}	11.77 (20.06)^{f}	9.64 (18.06) ^{f}	26.41
6.	Dinotefuran 20 SG	200	7.13 (15.48)^{ab}	6.29 (14.52)^{a}	4.19 (11.80)^{a}	1.66 (7.39)^{a}	5.29 (13.29)^{a}	4.91 (12.51)^{a}	60.65	4.21 (11.83)^{a}	3.63 (10.98)^{a}	3.26 (10.40)^{a}	6.58 (14.86)^{a}	5.06 (12.92) ^{a}	61.37
7.	Rynaxypyr 20 SC	150	9.01 (17.46)^{e}	7.36 (15.73)^{b}	5.13 (13.08)^{b}	3.03 (10.03)^{b}	6.38 (14.63)^{b}	6.18 (14.19)^{a}	50.48	5.35 (13.37)^{b}	5.43 (13.47)^{b}	4.07 (11.62)^{b}	7.53 (15.92)^{b}	5.99 (14.09) ^{b}	54.27
8.	Untreated check	-	10.01 (18.44)^{d}	11.55 (19.87)^{g}	12.05 (20.31)^{g}	13.68 (21.70)^{f}	15.11 (23.12)^{f}	12.48 (20.64)^{c}	-	15.61 (23.37)^{h}	16.05 (23.61)^{g}	17.19 (24.49)^{g}	18.86 (25.74)^{g}	13.10 (21.17) ^{g}	-
	S. Ed	-	0.416	0.322	0.409	0.437	0.393	0.952		0.361	0.425	0.407	0.377	0.484	-
	CD (P=0.05)	-	0.894**	0.691**	0.877**	0.938**	0.845**	1.95**		0.774**	0.912**	0.873**	0.808**	0.992**	-

** - Significant at P=0.01
In a column mean followed by a common letter are not significantly different by DMRT (P=0.05)
- Mean of 10 hills
Values in parentheses are arc sine transformed values
Mean of 3 replications
DAT – Days after treatment
- Second spray pre-count

Table 2: Effect of neem formulations against the yellow stem borer, *Scirpophaga incertulas* (Walker) during *rabi'* 2016-17 in rice after first and second foliar application (Field experiment II)

SL. No.	Treatments	Conc. ml/g/ha	Per cent dead heart # I Foliar application							Per cent dead heart # II Foliar application					
			Pre count	1 DAT	3 DAT	7 DAT	14 DAT ##	Overall mean	Per cent reduction	1 DAT	3 DAT	7 DAT	14 DAT	Overall mean	Percent reduction
1.	Neem Baan 1.0% EC	1000	8.47 (16.92)^{abc}	8.27 (16.72)^{c}	7.70 (16.10)^{d}	5.27 (13.27)^{d}	7.52 (15.91)^{d}	7.45 (15.79) ^{cd}	37.81	6.74 (15.05)^{d}	5.52 (13.59)^{d}	4.35 (12.03)^{d}	7.77 (16.18)^{d}	6.38 (14.56) ^{cd}	59.98
2.	Neemazal 1.0% EC	1000	9.60 (18.05)^{bcd}	9.77 (18.22)^{d}	8.44 (16.89)^{e}	6.06 (14.25)^{e}	8.57 (17.02)^{e}	8.49 (16.89) ^{de}	29.13	7.68 (16.09)^{e}	6.24 (14.46)^{e}	5.08 (13.02)^{e}	8.65 (17.10)^{e}	7.25 (15.54) ^{de}	54.51
3.	Nimbecidine 0.03% EC	2500	9.66 (18.10)^{cd}	9.89 (18.33)^{d}	9.52 (17.97)^{f}	6.74 (15.05)^{f}	8.41 (16.85)^{e}	8.84 (17.26) ^{de}	26.21	8.57 (17.02)^{f}	7.38 (15.76)^{f}	5.98 (14.15)^{f}	9.46 (17.91)^{f}	7.96 (16.34) ^{ef}	50.06
4.	Multineem 1.0% EC	2500	8.17 (16.61)^{ab}	8.33 (16.78)^{c}	7.07 (15.42)^{c}	4.51 (12.26)^{c}	6.73 (15.03)^{c}	6.96 (15.22) ^{bc}	41.90	5.91 (14.07)^{c}	4.55 (12.31)^{c}	3.51 (10.79)^{c}	6.60 (14.89)^{c}	5.46 (13.42) ^{c}	65.75
5.	Neem oil	2500	9.77 (18.21)^{cd}	9.78 (18.23)^{d}	9.97 (18.40)^{f}	7.10 (15.45)^{f}	9.21 (17.67)^{f}	9.17 (17.52) ^{e}	23.45	9.33 (17.78)^{g}	8.37 (16.82)^{g}	6.80 (15.11)^{g}	10.26 (18.68)^{g}	8.79 (17.21) ^{f}	44.85
6.	Dinotefuran 20 SG	200	8.21 (16.62)^{ab}	6.51 (14.77)^{a}	4.35 (12.04)^{b}	2.43 (8.97)^{a}	4.68 (12.49)^{a}	5.24 (12.99) ^{a}	56.26	3.14 (10.20)^{a}	2.31 (8.74)^{a}	1.34 (6.62)^{a}	4.37 (12.06)^{a}	3.17 (10.03) ^{a}	80.11
7.	Rynaxypyr 20 SC	150	7.71 (16.06)^{a}	7.25 (15.62)^{b}	5.30 (13.31)^{a}	3.26 (10.40)^{b}	5.37 (13.40)^{b}	5.78 (13.77) ^{ab}	51.75	3.94 (11.44)^{b}	3.42 (10.65)^{b}	2.20 (8.50)^{b}	5.39 (13.42)^{b}	4.06 (11.49) ^{b}	74.52
8.	Untreated check	-	10.62 (19.02)^{d}	11.01 (19.38)^{e}	11.86 (20.14)^{g}	12.79 (20.95)^{h}	13.60 (21.64)^{g}	11.98 (20.23) ^{f}	-	14.10 (22.06)^{h}	15.11 (22.87)^{h}	17.05 (24.39)^{h}	19.83 (26.44)^{h}	15.94 (23.48) ^{g}	-
	S. Ed	-	0.676	0.265	0.237	0.150	0.231	0.735	-	0.231	0.256	0.442	0.254	0.657	-
	CD (P=0.05)	-	1.45**	0.568**	0.510**	0.322**	0.688**	1.505	-	0.496**	0.549**	0.949**	0.546**	1.346**	-

** - Significant at P=0.01
In a column mean followed by a common letter are not significantly different by DMRT (P=0.05)
- Mean of 10 hills
Values in parentheses are arc sine transformed values
Mean of 3 replications
DAT – Days after treatment
- Second spray pre-count

The overall mean per cent dead heart damage ranged from 3.17 to 15.94 per cent/hill. It was found that the per cent dead heart damage was low in the treatment with dinotefuran 20 SG @ 200 g/ha (3.17%/hill) followed by rynaxypyr 20 SC @ 150 ml/ha (4.06%/hill). Among the neem formulations, the treatment with multineem 1.0% EC @ 2500 ml/ha (5.46%/hill) recorded a lower per cent dead heart damage and was on par with neem baan 1.0% EC @ 1000 ml/ha (6.38%/hill). All the treatments were found to be superior as compared to the untreated check (15.94%/hill). It was found that the treatment with dinotefuran 20 SG @ 200 g/ha was superior among the treatments with a per cent reduction of 80.11 per cent and among the neem formulations the treatments with multineem 1.0% EC @ 1000 ml/ha recorded a per cent reduction of 65.75 per cent as compared to the untreated check. Singh *et al.* (2012) [11] reported that among the botanicals nimbecidine @ 300 ppm @ 3l/ha recorded lower dead heart in the vegetative stage and white ears in the reproductive damage with increased yield of 5.30t/ha asncompared to the untreated check (Prasad *et al*., 2009) [8].

Singh *et al.* (2015) [12] stated that neemarin 1500 ppm @ 3lit/ha recorded lower percentage of white ears (5.60%) caused by yellow stem borer, *S. incertulas* in rice. Prasad (2016) [9] reported that dinotefuran 20 SG @ 200 g/ha was found to be effective against yellow stem borer,

S. incertulas with increased grain yield on semi deep-water rice variety. All the earlier findings are in conformity with the present findings.

Yield and Benefit cost ratio

The yield of rice variety (ADT 45) and benefit cost ratio from the field experiment I and II was recorded and are given in the Table 3. It was found that the yield of rice was higher in the treatment with dinotefuran 20 SG @ 200 g/ha (4.31 and 5.77 t/ha) followed by rynaxypyr 20 SC @ 150ml/ha (4.16 and 5.43 t/ha) and among the neem formulations, multineem 1% EC @ 2500 ml/ha recorded a higher yield (3.90 and 5.40t/ha) as compared to the untreated check (2.85 and 3.40 t/ha) in the field experiment I and II respectively. From the field experiments I and II, it was found that the benefit cost ratio was higher in the treatment with dinotefuran 20 SG @ 200 g/ha (1:1.48 and 1:1.99) followed by rynaxypyr 20 SC @ 150 g/ha (1:1.42 and 1:1.98) and multineem 1% EC @ 1000ml/ha (1:1.37 and 1:1.90) over the untreated check.

Sachan *et al.* (2006) [10] found that insecticides gave maximum C:B ratio. Nimbecidine and neemarin (neem formulation), aflamethrin were found to be effective as well as economical in reducing the incidence of *S. incertulas.* Kalita *et al*. (2009) [2] found that higher yield was observed in the treatment with monocrotophos 36 SL @ 1ml/l (43.94 q/ha) followed by nimbecidine 0.03 % EC @ 3 ml/lit (39.70 q/ha), multineem 0.03% EC @ 3ml/l (37.68 q/ha) and achook 0.15% EC @ 3ml/l (38.84 q/ha) in rice. Visalakshmi *et al*. (2016) [13] reported that chloratraniliprole 18.5% SC @ 150 ml/ha was recorded a higher yield of 5.40 and 6.20 t/ha in both the *kharif* and *rabi* season. All the earlier findings are in conformity with the present findings. From the present study, it was concluded that application of neem formulations multineem 1.0% EC @ 2500 ml/ha, neembaan 1.0% EC @ 1000 ml/ha and need based application of dinotefuran 20 SG @ 200 g/ha, rynaxypyr 20 SC @ 150 ml/ha can be recommended against the rice yellow stem borer in rice ecosystem.

Table 3: Yield and Benefit cost ratio of rice variety ADT 45

Sl. No	Treatments	Conc. ml/g/ha	Mean yield (t/ha)		BCR	
			Field experiment I (*kharif*)	Field experiment II(*rabi*)	Field experiment I (*kharif*)	Field experiment II (*rabi*)
1.	Neem Baan 1.0% EC	1000	3.85^{bc}	5.13^{c}	1:1.36	1:1.82
2.	Neemazal 1.0% EC	1000	3.64^{cd}	4.23^{d}	1:1.29	1:1.50
3.	Nimbecidine 0.03% EC	2500	3.63^{d}	4.23^{d}	1:1.28	1:1.49
4.	Multineem 1.0% EC	2500	3.90^{b}	5.40^{bc}	1:1.37	1:1.90
5.	Neem oil	2500	3.35^{e}	3.83^{e}	1:1.14	1:1.30
6.	Dinotefuran 20 SG	200	4.31^{a}	5.77^{a}	1:1.48	1:1.99
7.	Rynaxypyr 20 SC	150	4.16^{a}	5.43^{b}	1:1.42	1:1.98
8.	Untreated check	-	2.85^{f}	3.40^{f}	1:1.06	1:1.27
	CD (P=0.05)	-	0.222**	0.279**	-	-

** - Significant at P=0.01

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