International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2022; 10(2): 124-129

Received: 19-01-2022
Accepted: 21-02-2022

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Management of rice yellow stem borer, *Scirpophaga incertulas* (Walker) using new and conventional granular insecticides

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Abstract
The field experiment was carried out to assess the relative efficacy of new and conventional granular insecticides which were cost effective and ecologically feasible against rice yellow stem borer *Scirpophaga incertulas* at 'A' block, College of Agriculture, V. C. Farm Mandya during *Kharif* 2018. The experiment had eight treatments replicated thrice in randomized complete Block Design (RCBD). The result clearly indicated that, A significant and lower per cent dead heart (2.79%) was recorded in spinetoram 0.8 GR @ 9.5 Kg ha^{-1} and this was followed by fipronil 3G @ 25 Kg ha^{-1} and benfuracarb 3G @ 33 Kg ha^{-1} which recorded 3.77 and 4.86 per cent dead heart, respectively. A significant higher per cent dead heart was recorded in untreated control (12.45%) at 14 days after second application. The highest per cent reduction was observed in spinetoram 0.8GR @ 9.5 Kg ha^{-1} and this was followed by fipronil 0.3G @ 25 Kg $ha^{-1,}$ benfuracarb 3G @ 33 Kg ha^{-1}, carbofuran 3G @ 33 Kg ha^{-1}, cartap hydrochloride 4G @ 25 Kg ha^{-1}, Chlorantraniliprole 0.4G @ 10 Kg ha^{-1} and flubendiamide 0.8 GR @ 10 Kg ha^{-1} which recorded 69.71, 60.96, 54.45, 53.41, 47.77 and 45.46 per cent, respectively. Regarding yield spinetoram 0.8GR @ 9.5 Kg ha^{-1}recorded the highest yield (57.89 q ha^{-1}) and all other insecticidal treatments showed significantly superior over untreated control (43.85 q ha^{-1}).

Keywords: Insecticide, yellow stem borer, dead hearts, white ears, rice

Introduction
Rice (*Oryza sativa* Linn.) an ancient crop domesticated more than 8000 years ago, evolved along with man adapted to diverse ecological conditions. Rice is the staple food of more than 65 per cent of the world's population especially in Asia and Africa. Nearly 92 per cent of the world's rice is being produced and consumed in Asia. Globally rice occupies 13 per cent of the world's arable area and grown in 114 countries with an area and production of 160.6 m ha and 745.6 m tons, respectively (FAO, 2017) [3]. Hence, the epithet "Rice is life" endorses its overwhelming importance in food and nutritional security, for the whole world (Rai, 2006) [10].
Major insect pests that cause significant economic losses in Asian countries are the yellow stem borer, *Scirpophaga incertulas* (Walker), *Cnaphalocrocis medinalis* (Guenee), brown planthopper, *Nilaparvata lugens* (Stal.), Green leafhopper, *Nephotettix virescens* (Distant) and Asian rice gall midge, *Orseolia oryzae* (Wood-Mason). In South-Asia, yellow stem borer, Asian rice gall midge and brown plant hoppers are the major production constraints (Ramaswamy *et al.*, 1996) [11].
Amongst the insect pests which feed on rice, the yellow stem borer (YSB) *Scirpophaga incertulas* (Walker) is the most destructive pest causes about 25-30% reduction in yield. This results in annual yield loss of 27.34% (Catling *et al.*, 1987 and Prasad *et al.*, 1988) [2, 9] of the production. The adult moths lay eggs in clusters of 50 to 75 on the upper surface of the leaves towards the tip. During the vegetative stage of the crop, newly emerged caterpillar bores into the stem and feeds on the internal content. As a result, the central shoot dries up and produces dead heart. In reproductive stage of the crop grownup larvae bore in to the peduncle leading to white ear heads and offer higher loss to crop. (Karthikeyan and Purushothaman, 2000) [6].
The management of rice stem borer is mainly through the application of different granular and foliar insecticides (Khan *et al.*, 1989) [7]. Many farmers use systemic granular insecticides for its management repeatedly for many years which often result in development of resistance against most commonly used insecticides especially in southern parts of India (Singh *et al.*, 2017) [12]. Keeping in view the importance of rice crop, the field experiment was designed to determine relative efficacy of different new insecticides to find out the effect of these

insecticides on reduction of the infestation of YSB, yield attributes and B:C ratio.

Material and Methods

The field experiment was conducted during late *Kharif* 2018 at "A" block College of Agriculture, V.C. Farm Mandya to evaluate the new and conventional granular insecticides. The trail consists of 8 treatments, including untreated control (table 1) with three replications and the treatments were imposed followed Randomized Complete Block Design. IR-64 rice variety was used for the study and was sown in an area of 45m^2. From this plot 25 days old seedlings were transplanted in replicated blocks of 4 X 4.5m with the spacing of 20 X15 cm between rows and plants, respectively. The crop was raised as per packages of practices except management schedule for YSB.

Based on ETL (5% dead heart at tillering stage), the recommended granular insecticides were applied 20-25 days after transplanting and 25 days after first application. A pretreatment observation on the per cent dead heart was recorded a day before application. Post treatment observation on dead heart was recorded at 3, 7, 10 and 14 days after application from 20 randomly selected hills per replication. In each replication, the number of damaged tillers (dead heart) and total number of tillers were recorded. The percent dead heart was worked out as below.

$$\% \text{ dead heart } = \frac{\text{Total no of dead heart per 10 hill}}{\text{Total no of tillers}} \times 100$$

Likewise, in each treatment per cent white ear was recorded 15 days before harvest and per cent was worked out by

$$\% \text{ white ears } = \frac{\text{Total no of white ears per 10 hills}}{\text{Total no of panicles}} \times 100$$

Thus the data obtained was on per cent dead heart and white ear were processed after suitable transformation (Arc sin) and subjected to ANOVA (Gomez and Gomez, 1984; Hosmand, 1988) [4, 5] and means were separated by Tukey's HSD (Tukey, 1953).

The treatments includes, benfuracarb 3G @ 33 Kg ha$^{-1,}$ fipronil 0.3G @ 25 Kg ha^{-1}, Chlorantraniliprole 0.4G @ 10 Kg ha$^{-1,}$ spinetoram 0.8GR @ 9.5 Kg ha^{-1}, cartap hydrochloride 4G @ 25 Kg ha^{-1}, flubendiamide 0.8 GR @ 10 Kg ha^{-1}, carbofuron 3G @ 33 Kg ha^{-1}and untreated control

Grain yield and cost economics

The harvesting was done at physiological maturity, grain and fodder yield were recorded treatment wise from each treatment the additional gain in yield over untreated control was calculated as below

$$\% \text{ Additional gain yield } = \frac{\text{Yield in treatment} - \text{yield in control}}{\text{Yield in control}} \times 100$$

Cost economics of each treatment was worked out as per market price, labour wages and additional costs during the course of study and benefit cost ratio was calculated.

$$\text{Cost benefit ratio } = \frac{\text{Net profit (Rs)}}{\text{Total cost (Rs)}}$$

Results and Discussion

Regarding the efficacy of insecticides against Yellow stem borer, two insecticidal applications were done. The first insecticidal application was done at 25 days after transplanting of the crop and the second application at panicle initiation stage of the crop at recommended field concentrations of individual insecticides were applied. The results regarding YSB infestation and yields are summarized and discussed below. The result revealed that all the insecticide treatments recorded significantly lower per cent of dead heart as compared to the untreated control up to 14 DAA. In first spray, at3 days after application, the dead heart observed in different granular insecticides, the per cent dead hearts ranged from 7.78 to 8.38 per cent as against 9.59 per cent in untreated control. Spinetoram 0.8GR @ 9.5 Kg ha^{-1}was found most effective among different insecticides and followed by fipronil 0.3G@ 25 Kg ha^{-1} which recorded 6.49 percent dead heart. At fourteen days after application a significant and lower per cent dead heart (2.79%) was recorded in spinetoram 0.8GR @ 9.5 Kg ha^{-1} and this was followed by fipronil 3G @ 25 Kg ha^{-1} and benfuracarb 3G @ 33 Kg ha^{-1} which recorded 3.77 and 4.86 per cent dead heart, respectively and were differed significantly with each other. This was followed by carbofuran 3G @ 33 Kg ha$^{-1,}$ cartap hydrochloride 4G @ 25 Kg ha$^{-1,}$ Chlorantraniliprole 0.4G @ 10 Kg ha^{-1} and flubendiamide 0.8GR @ 10 Kg ha^{-1} which recorded 5.67, 5.80,6.59 and 6.79per cent dead heart, respectively. However, a significant higher per cent dead heart was recorded in untreated control (12.45%). (Table 1) (Figure 1).

Among the treatments at fourteen days after second application per cent reduction in dead heart over untreated control was varied between 77.59 to 45.46 per cent. The highest per cent reduction was observed in spinetoram 0.8GR @ 9.5 Kg ha^{-1} and this was followed by fipronil 0.3G @ 25 Kg ha^{-1}, benfuracarb 3G @ 33 Kg ha^{-1}, carbofuran 3G @ 33 Kg ha^{-1}, cartap hydrochloride 4G @ 25 Kg ha^{-1}, Chlorantraniliprole 0.4G @ 10 Kg ha^{-1} and flubendiamide 0.8 GR @ 10 Kg ha^{-1} which recorded 69.71, 60.96, 54.45, 53.41, 47.77 and 45.46 per cent, respectively (Table 2) (Figure 2). At ninety days after application per cent white ear was recorded. A significant and lower per cent white ear was observed in spinetoram 0.8GR @ 9.5 Kg ha^{-1} which was recorded 4.31 per cent white ear this was followed by fipronil 0.3G @ 25 Kg ha^{-1} and benfuracarb 3G @ 33 Kg ha^{-1} which recorded 4.69 and 4.95 per cent white ear and were on par with each other. The next best treatment was carbofuron 3G @ 33 Kg ha^{-1} which recorded 5.27 per cent white ear and was on par with cartap hydrochloride 4G @ 25 Kg ha^{-1} (5.30%). Likewise, the per cent white ear in Chlorantraniliprole 0.4G @ 10 Kg ha^{-1} was recorded 6.74 per cent and in flubendiamide 0.8 GR @ 10 Kg ha^{-1} (8.57%) which were differed significantly each other. However, a significant and higher per cent white ear was observed in untreated control which recorded 15.71 per cent white ear (Table 2) (Figure 2). At ninety days after application, among the treatments, the per cent reduction in white ear over untreated control was varied between 72.56 per cent and 57.10 per cent. The highest per cent reduction was observed in spinetoram 0.8GR @ 9.5 Kg ha^{-1} which was recorded 72.56 per cent. This was followed by fipronil 0.3G @ 25 Kg ha^{-1}, benfuracarb 3G @ 33 Kg ha^{-1}, carbofuron 3G @ 33 Kg ha^{-1}, cartap hydrochloride 4G @ 25 Kg ha^{-1}, Chlorantraniliprole 0.4G @ 10 Kg ha^{-1} and flubendiamide 0.8 GR @ 10 Kg ha^{-1} and was recorded 70.15, 68.49, 66.45, 66.26, 57.10 and 44.45, respectively (Table 2) (Figure 3).

The present results are in conformity with the results of Kumar *et al*. (2017) [1, 8] where they observed that spinetoram

12 SC was significantly effective at controlling the leaf damage due to *Spodoptera litura* on onion. Ragaei and Sabry (2011) reported that the mixture of spinosad and buprofezin was more active than spinosad or buprofezin alone in all concentrations used for the control of cotton leafworm, *Spodoptera littoralis.* Further, Ambrish *et al*. (2017) reported that application of Spinetoram 10% w/w + Sulfoxaflor 30% W/W WG @ 140 g ai/ha had resulted in less number of whiteflies per leaf (0.41) and leaf hopper (0.48) and also the lowest incidence of bollworm was recorded in spinetoram. Similar results were observed by Wagh *et al*. (2017) [13] recorded spinosad 45 SC @ 125 g a.i/ha was most effective in reducing aphid, whiteflies and thrips population.

Grain yield

The grain yield from the bio efficacy of granular insecticide against yellow stem borer was varied significantly between 57.89 and 43.85 q ha^{-1}. The significant higher yield of 57.89 q ha^{-1} was recorded in spinetoram 0.8GR @ 9.5 Kg ha^{-1} with 32.02 per cent increase over control and this was on par with fipronil 0.3G @ 25 Kg ha^{-1} with 57.2 q ha^{-1} which recorded 30.49 per cent increase over control. This was followed by benfuracarb 3G @ Kg ha^{-1} (55.93 q ha^{-1}), carbofuron 3G @ 33 Kg ha^{-1} (52.54 q ha^{-1}), cartap hydrochloride 4G@ 25 Kg ha^{-1}(51.24 q ha^{-1}), Chlorantraniliprole 0.4G @ 10 Kg ha^{-1}(50.56 q ha^{-1}) with 27.54,19.81, 16.85 and 15.30 per cent increase over control, respectively. The treatment *viz.,* flubendiamide 0.8GR @ 10 Kg ha^{-1} recorded 48.70 q ha^{-1} with lower per cent increase in yield over control (11.06%). However, lower yield (43.85 q ha^{-1}) was recorded in untreated control (Table 3) (Figure 4).The present results are in corroborate with the findings of Kumar *et al*. (2017) [1, 8] where they observed that the highest bulb yield of onion was recorded in spinetoram 12 SC 45 g a.i./ha (18.1 t/ha) followed by spinetoram 12 SC 36 g a.i./ha (17.5 t/ha), Spinetoram 12 SC 30 g a.i./ha, spinosad 45 SC at 78 g a.i./ha, fipronil 80 WG at 40 g a.i./ha and emamectin benzoate 5 SG 11 g a.i./ha. Further, Sarkar *et al.* (2015) reported that the highest fruit yield of okra (53.67 q/ha) was recorded in spinosad treated plots followed by *B.t.* (42.26 q/ha), *B. bassiana* (39.28 q/ha) and azadirachtin (37.92 q/ha), respectively.

Plant biomass yield

Significantly higher biomass yield was observed in fipronil 0.3G @ 25 Kg ha^{-1} (63.37 q ha^{-1}) with 20.20 per cent increase in yield over untreated control. This was followed by spinetoram 0.8 GR @ 9.5 Kg ha^{-1}, benfuracarb 3G @ 33 Kg ha^{-1},carbofuron 3G @ 33 Kg ha$^{-1,}$ chlorantraniliprole 0.4 GR @ 10 Kg ha^{-1} and cartap hydrochloride 4G @ 25 Kg ha^{-1}which recorded 47.43, 56.33, 51.37, 50.56 and 50.13 q ha^{-1}, respectively, with 36.54, 33.92, 22.13, 20.20 and 19.18per cent increase in biomass yield over control. This was followed by flubendiamid0.8 GR @ 10 Kg ha^{-1} which recorded 48.06 q ha^{-1} with lowest per cent increase over control. However, significantly lower biomass yield with 42.06 q ha^{-1} was recorded in untreated control (Table 3) (Figure 4).

Table 1: Bio-efficacy of new granular insecticides against rice yellow stem borer *S. incertulas, Kharif* 2018

Sl. No.	Treatments	Dose (g a.i./ha)	Dose (Kg /ha)	% Dead hearts in first application					Reduction over control (%)
				1DBA	3DAA	7DAA	10DAA	14DAA	
1	Benfuracarb 3G	1000	33	8.53 (16.99)	8.30 (16.75)^{bc}	7.95 (16.39)^{bc}	7.45 (15.85)^{bc}	6.21 (14.44)^{bc}	42.76
2	Fipronil 0.3G	75	25	8.54 (17.00)	8.27 (16.72)^{bc}	7.70 (16.12)^{b}	6.95 (15.29)^{b}	5.12 (13.08)^{ab}	52.81
3	Chlorantraniliprole 0.4G	40	10	8.58 (17.04)	8.38 (16.83)^{c}	8.21 (16.65)^{c}	7.68 (16.10)^{c}	6.84 (15.17)^{c}	36.96
4	Spinetoram 0.8 GR	75	9.5	8.54 (17.00)	7.78 (16.20)^{a}	6.94 (15.28)^{a}	5.37 (13.41)^{a}	4.64 (12.44)^{a}	57.24
5	Cartap hydrochloride 4G	1000	25	8.52 (16.98)	8.22 (16.67)^{abc}	8.07 (16.51)^{bc}	7.94 (16.37)^{c}	6.68 (14.99)^{c}	38.43
6	Flubendiamide 0.8 GR	80	10	8.54 (17.00)	7.87 (16.29)^{ab}	7.69 (16.11)^{b}	7.47 (15.87)^{bc}	7.23 (15.61)^{c}	33.36
7	Carbofuron 3G (SC)	1000	33	8.54 (16.99)	8.35 (16.81)^{c}	8.09 (16.53)^{bc}	7.86 (16.29)^{c}	6.59 (14.89)^{c}	39.26
8	Untreated control	--	--	8.52 (16.98)	9.59 (18.05)^{d}	10.18 (18.62)^{d}	12.34 (20.57)^{d}	10.85 (19.24)^{d}	--
SE m ± CD @ p=0.05				NS	0.10 0.32	0.11 0.33	0.12 0.37	0.35 1.07	--

DBA-Day before application; DAA- Days after application; SC – Standard check; figures in the parenthesis indicate arc sin transformed values; Values in the column followed by common letters are non-significant at p=0.05 as per DMRT

Table 2: Bio-efficacy of new granular insecticides against rice yellow stem borer *S. incertulas, Kharif* 2018

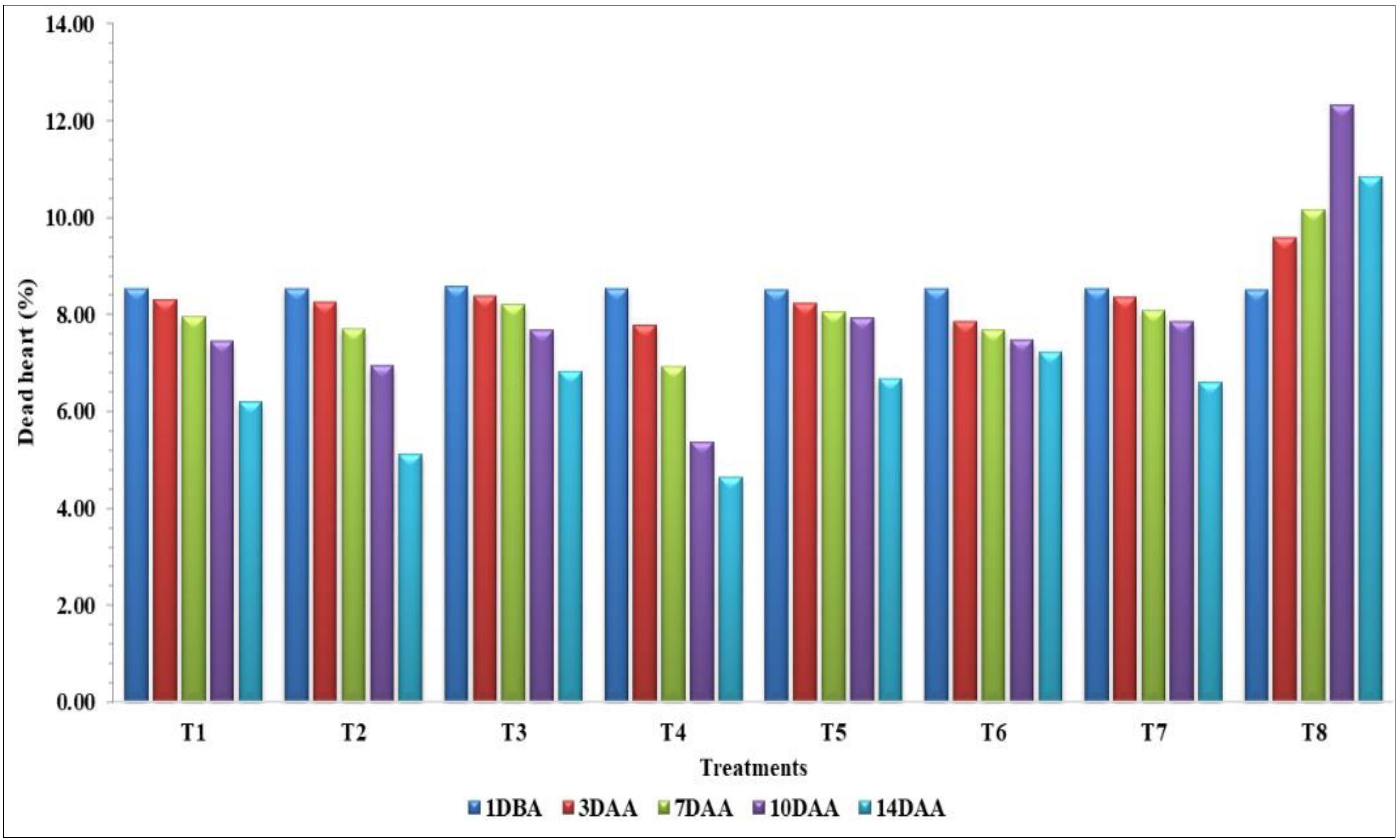
Sl. No.	Treatments	Dose (g a.i./ha)	Dose (Kg /ha)	% Dead hearts in Second application					Reduction over control (%)	White ear at 90 DAT (%)	Reduction over control (%)
				1 DBA	3 DAA	7 DAA	10 DAA	14 DAA			
1	Benfuracarb 3G	1000	33	7.56 (15.97)^{c}	7.24 (15.61)^{c}	6.57 (14.86)^{c}	6.21 (14.44)^{c}	4.86 (12.75)^{c}	60.96	4.95 (12.86)^{ab}	68.49
2	Fipronil 0.3G	75	25	7.17 (15.54)^{b}	6.49 (14.77)^{b}	5.89 (14.05)^{b}	4.35 12.05)^{b}	3.77 (11.20)^{b}	69.71	4.69 (12.51)^{ab}	70.15
3	Chlorantraniliprole 0.4G	40	10	7.81 (16.24)^{cd}	7.32 (15.71)^{c}	6.87 (15.20)^{cd}	6.73 15.04)^{d}	6.51 (14.79)^{e}	47.77	6.74 (15.05)^{c}	57.10
4	Spinetoram 0.8 GR	75	9.5	5.90 (14.07)^{a}	5.56 (13.64)^{a}	4.50 (12.26)^{a}	3.52 10.81)^{a}	2.79 (9.61)^{a}	77.59	4.31 (11.99)^{a}	72.56
5	Cartap hydrochloride 4G	1000	25	8.03 (16.47)^{d}	7.95 (16.38)^{d}	7.55 (15.96)^{e}	7.27 15.65)^{e}	5.80 (13.94)^{d}	53.41	5.30 (13.32)^{b}	66.26
6	Flubendiamide 0.8 GR	80	10	7.91 (16.34)^{cd}	7.24 (15.62)^{c}	7.28 (15.66)^{de}	7.16 (15.53)^{de}	6.79 (15.12)^{e}	45.46	8.57 (17.03)^{d}	45.45
7	Carbofuron 3G (SC)	1000	33	7.87 (16.30)^{cd}	7.40 (15.80)^{c}	7.07 (15.42)^{cde}	6.82 (15.14)^{de}	5.67 (13.79)^{d}	54.45	5.27 (13.27)^{b}	66.45
8	Untreated control	--	--	10.86 (19.25)^{e}	11.18 (19.54)^{e}	11.59 (19.92)^{f}	12.27 (20.52)^{f}	12.45 (20.67)^{f}	--	15.71 (23.37)^{e}	--
SE m ± CD @ p=0.05				0.09 0.29	0.10 0.33	0.13 0.41	0.12 0.41	0.16 0.52	--	0.26 0.80	--

DBA - Day before application; DAA- Days after application; SC - Standard check; figures in the parenthesis indicate arc sin transformed values; Values in the column followed by common letters are non-significant at p=0.05 as per DMRT

Table 3: Bio-efficacy of granular insecticides on grain and biomass yield, *Kharif* 2018

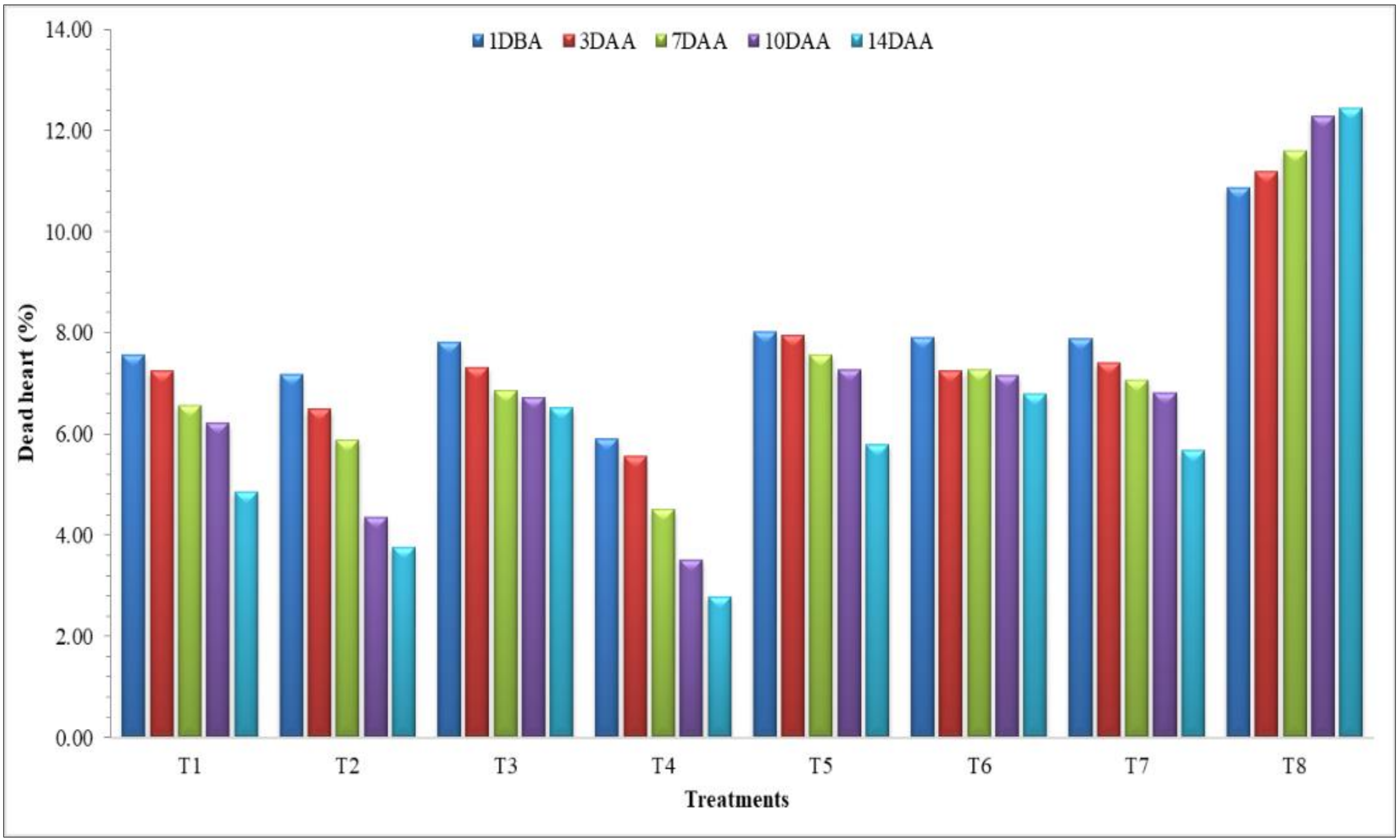
Sl. No.	Treatments	Dosage (g a.i/ha)	Dose (Kg/ha)	Grain yield		% Increase over control	Biomass yield		%Increase over control
				Plot basis (Kg)	Hectare basis (q/ha)		Plot basis (Kg)	Hectare basis (q/ha)	
1	Benfuracarb 3G	1000	33	10.07	55.93^{ab}	27.54	10.14	56.33^{b}	33.92
2	Fipronil 0.3G	75	25	10.30	57.22^{a}	30.49	11.41	63.37^{a}	50.67
3	Chlorantraniliprole 0.4G	40	10	9.10	50.56^{bc}	15.30	9.10	50.56^{c}	20.20
4	Spinetoram 0.8 GR	75	9.5	10.42	57.89^{a}	32.02	10.34	57.43^{b}	36.54
5	Cartap hydrochloride 4G	1000	25	9.22	51.24^{bc}	16.85	9.02	50.13^{c}	19.18
6	Flubendiamide 0.8 GR	80	10	8.77	48.70^{cd}	11.06	8.65	48.06^{d}	14.26
7	Carbofuron 3G (SC)	1000	33	9.46	52.54^{abc}	19.81	9.25	51.37^{c}	22.13
8	Untreated control	--	--	7.89	43.85^{d}	-	7.57	42.06^{e}	-
SE m± CD @ p=0.05				1.24 3.85			0.41 1.27		

Figures in the parenthesis indicate arc sin transformed values; SC - Standard check; Values in the column followed by common letters are non-significant at p=0.05 as per DMRT



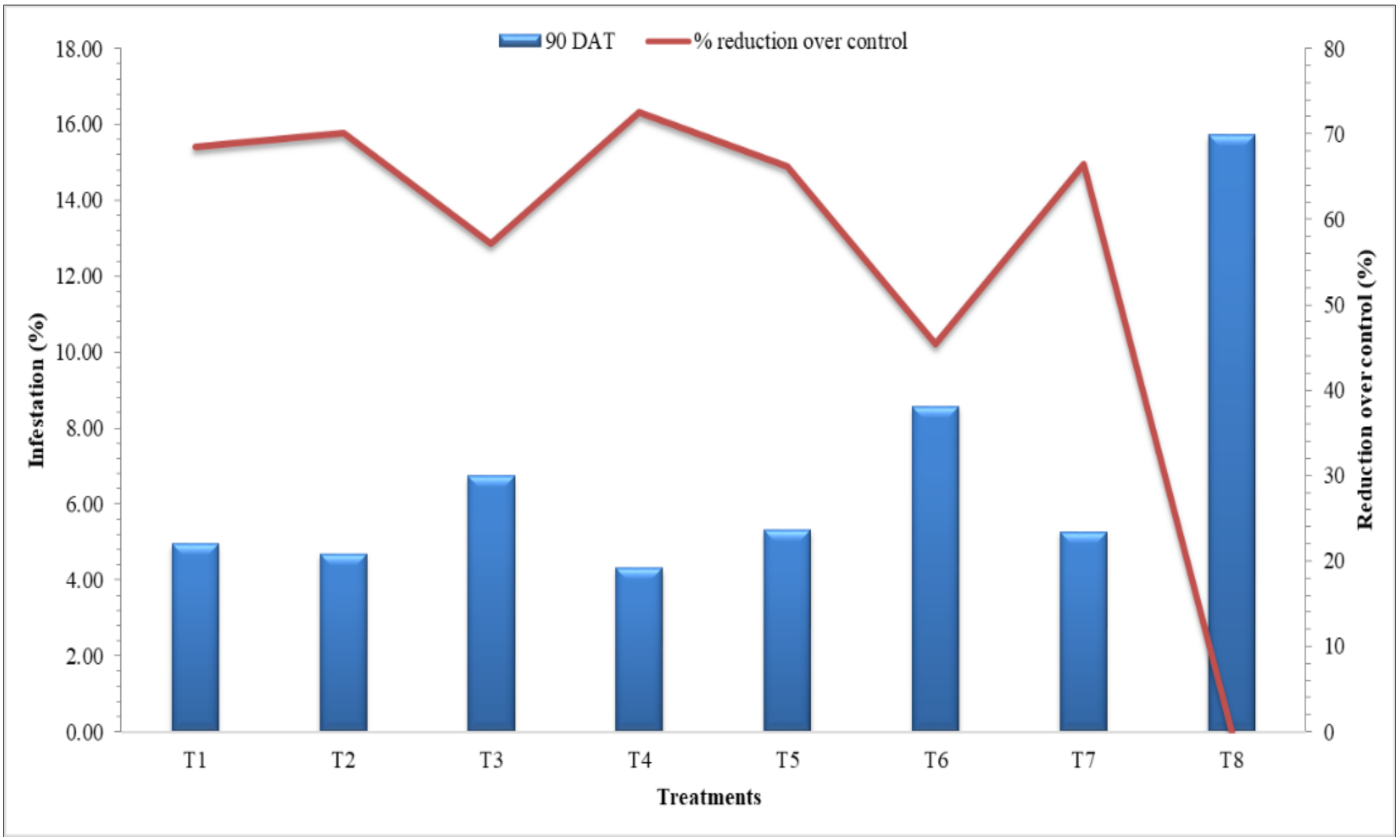
T1. Benfuracarb 3G @ 33 Kg ha^{-1}
T2. Fipronil 0.3 G @ 25 Kg ha^{-1}
T3. Chlorantraniliprole 0.4 G @ 10 Kg ha^{-1}
T4. Spinetoram 0.8 GR @ 9.5 Kg ha^{-1}
T5. Cartap hydrochloride 4G @ 25 Kg ha^{-1}
T6. Flubendiamide 0.8 GR @ 10 Kg ha^{-1}
T7. Carbofuron 3G @ 33 Kg ha^{-1}
T8. Untreated control

Fig 1: Infestation of YSB in different treatments, *Kharif* 2018 (First application)



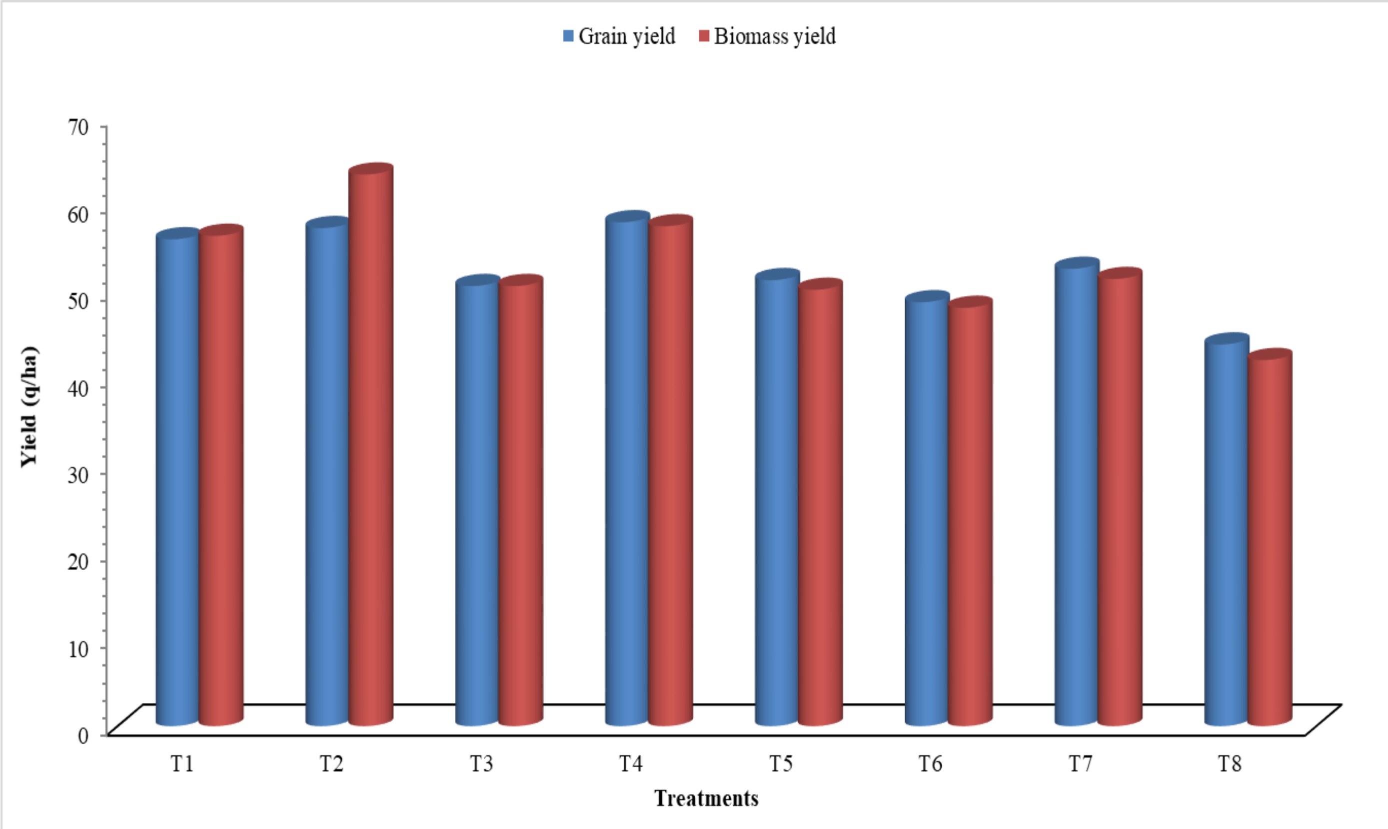
T1. Benfuracarb 3G @ 33 Kg ha^{-1}
T2. Fipronil 0.3 G @ 25 Kg ha^{-1}
T3. Chlorantraniliprole 0.4 G @ 10 Kg ha^{-1}
T4. Spinetoram 0.8 GR @ 9.5 Kg ha^{-1}
T5. Cartap hydrochloride 4G @ 25 Kg ha^{-1}
T6. Flubendiamide 0.8 GR @ 10 Kg ha^{-1}
T7. Carbofuron 3G @ 33 Kg ha^{-1}
T8. Untreated control

Fig 2: Infestation of YSB in different treatments, *Kharif* 2018 (Second application)



T1. Benfuracarb 3G @ 33 Kg ha^{-1}
T2. Fipronil 0.3 G @ 25 Kg ha^{-1}
T3. Chlorantraniliprole 0.4 G @ 10 Kg ha^{-1}
T4. Spinetoram 0.8 GR @ 9.5 Kg ha^{-1}
T5. Cartap hydrochloride 4G @ 25 Kg ha^{-1}
T6. Flubendiamide 0.8 GR @ 10 Kg ha^{-1}
T7. Carbofuron 3G @ 33 Kg ha^{-1}
T8. Untreated control

Fig 3: Per cent reduction over control at 90 DAT



T1. Benfuracarb 3G @ 33 Kg ha^{-1}
T2. Fipronil 0.3 G @ 25 Kg ha^{-1}
T3. Chlorantraniliprole 0.4 G @ 10 Kg ha^{-1}
T4. Spinetoram 0.8 GR @ 9.5 Kg ha^{-1}
T5. Cartap hydrochloride 4G @ 25 Kg ha-1
T6. Flubendiamide 0.8 GR @ 10 Kg ha^{-1}
T7. Carbofuron 3G @ 33 Kg ha^{-1}
T8. Untreated control

Fig 4: Yield of grain and biomass in different treatments.

Acknowledgement
The authors are thankful to University of Agricultural Sciences, GKVK, Bangalore and B.Sc (Agri.) students of Agricultural College, V. C. Farm, Mandya for their help.

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