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Evaluation of Botanical - Insecticide modules against stem borer, brown planthopper and natural enemies in rice

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***Abstract*— *Field experiment was conducted at Regional Agricultural Research Station, Maruteru, West Godavari (A.P.) during fourrabi seasons of 2019-20to 2022-23 to evaluate botanical-insecticide modules against stem borer and brown planthopper. Significantly superior results were recorded in insecticides alone module, T4 (Chlorantraniliprole 0.4 G @ 1.0 g m^{-2}, Cartap hydrochloride 50% SC @ 2.0 g l^{-1}, Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT respectively) with 50% ROC, 33% ROC in dead hearts and white ears, respectively in case of stem borer and 94% ROC in brown planthopper population and registered the highest grain yield.Among botanical – insecticide modules, treatment, T_2 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Neem oil @ 10.0 ml l^{-1} and Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT respectively) is the best against stem borer (26% ROC in dead heart damage & 13% ROC in white ear damage) and brown planthopper (91% ROC in brown planthopper population). Further, T_2 is at par with insecticides alone module (T4) in managing stem borer and BPH and recorded the grain yield (6718 kg ha^{-1}) on par with the insecticides alone module (6824 kg ha^{-1}).*

***Keywords*— botanicals, brown planthopper, insecticides, rice, yellow stem borer**

I. INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple food crop for more than half of the world population. It alone provides 20% of the global dietary energy supply. Insect pests and diseases remain as the key biotic stresses limiting the rice production significantly. Rice is infested by more than 100 species of insects and mites and about 20 of them are considered to be major economic significancewhich includes stem borers, gall midges, leaf folders, defoliators, and vectors like leafhoppers and plant hoppers that cause serious damage and spread many diseases. The Yellow stem borer attacks the crop from nursery stage till harvesting of the rice crop. It causes dead hearts during vegetative stage and white ears during reproductive stage. The yield losses to rice due to yellow stem borer are estimated 1-19% in early planted and 38-80% in late planted conditions (Catinding and Heong, 2003). Besides yellow stem borer, brown planthopper (BPH), *Nilaparvata lugens* (Stal) considered as the major yield limiting factor in all rice growing countries both in tropics and temperate regions (Krishnaiah, 2014). Both nymphs and adults of the BPH suckplant sap from phloem cells resulting in "hopper burn" symptoms and causes almost 10 to 90 per cent yield losses in rice (Seni and Naik, 2017).

Farmers rely solely on insecticides for management of insect pests and diseases and almost 50% of the insecticides used in rice are targeted against brown planthopper alone (Venkatreddy*et al*. 2012) but their repeated applications often result in problems such as development of resistance, induction of resurgence and residues on farm produce besides environmental concern.Because of this, interest in botanical pesticides has increased. Botanicals are effective in very small concentrations, only affect the targeted pest and closely related organisms, degrade quickly, and offer residue-free food and safe to environment. When used in integrated pest management programmes, rotational applications, or in combination with other insecticides, botanical pesticides can significantly reduce the use of conventional pesticides. This may result not only inreduction in the total amount of pesticide load used in a crop ecosystembut also preventing or delaying the emergence of pest populations with resistance (Khater, 2012). Keeping this in view, the present study was carried out to evaluate the efficacy of botanical– insecticide modules against stem borer and brown planthopper in rice eco-system.

II. MATERIALS AND METHODS

The experiments were conducted in the experimental farm of Regional Agricultural Research Station (RARS), Maruteru (16.38^{0}N, 81.44^{0}E), Andhra Pradesh, India to evaluate Botanical - Insecticide modules against stem borer and brown planthopper in ricefor four seasons from *rabi* 2019-20to *rabi*2022-23 in a randomized block design (RBD) with five treatments and four replications.Rice variety, MTU 3626wasused for the present investigation during rabi season (*rabi* 2019-20 to *rabi* 2022-23). One to two seedlings per hill were planted with a spacing of 15 cm x 15 cm during *rabi*seasonwith a help of a marked rope. The crop husbandry operations as recommended in the package of practices of Acharya N. G. Ranga Agricultural University, Andhra Pradesh were adopted.The details of treatments along with spray schedule are given in Table1.The treatments were imposed thrice at 25, 45 and 60 days after transplanting (DAT) in all the four *rabi* seasons (*rabi* 2019-20 to *rabi* 2022-23).A spray fluid of 500 l ha^{-1} was used to ensure thorough coverage of the crop canopy with battery operated hand sprayer.

Observations on dead heart by stem borer were recorded on 20 plants selected at random at 15 days after each application along with total tillers. Also record the data on white ears prior to harvest along with total productive tillers.Data on nymphs and adults of BPH were taken directly from twenty randomly selected hills per plot at one day before spray (Pre-treatment count) and ten days after third spray (Post-treatment count).

Grain yield was recorded per plot leaving two border rows on all sides and expressed in terms of kg ha^{-1}.

Data on per cent dead hearts and white ears caused by stem borer and BPH population were first converted in toangular transformations and square root transformations, respectively and subjected to analysis of variance technique (ANOVA) (Gomez and Gomez, 1984). The treatment means were compared by least significant difference (LSD) method.

III. RESULTS AND DISCUSSION

3.1 Efficacy of botanical –insecticide modules against yellow stem borer (*Scirpophagaincertulas* Walker)

The pooled data on per cent dead hearts and white ears caused by stem borer and population of brown planthopper per hill of four *rabi* seasons (*rabi* 2019-20 to *rabi* 2022-23) was analysed statistically and presented in Tables 2.

From the data presented in Table 2, the treatment, T_4comprising all insecticides (Chlorantraniliprole 0.4 G @ 1.0 g m^{-2}, Cartap hydrochloride 50% SC @ 2.0 g l^{-1}, Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT, respectively) recorded significantly the lowest per cent dead hearts with 1.60%DH followed by T_2 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Neem oil @ 10.0 ml l^{-1} and Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT, respectively) with 2.37% DH, which were at par with each other and superior over untreated control (3.21%DH). Rest of the treatments,T_1(Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Eucalyptus oil @ 2.0 ml l^{-1} and Cartap hydrochloride 50% SC @ 2.0 g l^{-1} applied at 25, 45 and 60 DAT respectively)and T_3(Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Eucalyptus oil @ 2.0 ml l^{-1} and Neem oil @ 10.0 ml l^{-1} applied at 25, 45 and 60 DAT respectively) registered 2.53% DH and 2.64%DH, respectively.

In terms of per cent reduction over control, T_4, T_2 T_1 and T_3 registered 50%, 26%, 21% and 18% reduction in dead hearts, respectively.

With regard to white ear damage, T_4 (Chlorantraniliprole 0.4 G @ 1.0 g m^{-2}, Cartap hydrochloride 50% SC @ 2.0 g l^{-1}, Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT, respectively) recorded significantly the lowest per cent white ears (7.26% WE) and superior over other treatments including untreated control (10.89% WE) with 33% reduction in white ears over untreated control.

Among the botanical – insecticide modules, T_1 (Azadirachtin 10000 ppm @ 2 ml l^{-1}, Eucalyptus oil @ 2 ml l^{-1} and Cartap hydrochloride 50% SC @ 2 g l^{-1}applied at 25, 45 and 60 DAT respectively), T_2 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Neem oil @ 10.0 ml l^{-1} and Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT, respectively) and T_3 (Azadirachtin 10000 ppm @ 2 ml l^{-1}, Eucalyptus oil @ 2 ml l^{-1} and Neem oil @

10 ml l^{-1} applied at 25, 45 and 60 DAT respectively) registered 9.40% WE, 9.47%WE and 9.80% WE, respectively and on par with untreated control (10.89%WE) (Table 2).

The present findings are in agreement with observations made by earlier workers. Neem Oil @ 1% offers protection against yellow stem borer (YSB) and gall midge (GM) by affecting the oviposition of YSB and GM (Krishnaiah and Kalode, 1991).Dhaliwal *et al.* (2002) evaluated four Azadirachtin-based neem formulations (Rakshak 1%, NeemAzal 1% and 5% and Nimbecidine 0.03%) against rice leaffolder and yellow stem borer and reported that the incidence of YSB was minimum in Monocrotophos and was at par with NeemAzal 5% @ 0.50 ml 1^{-1}. Among botanicals tested Eucalyptus oil @ 1000 ml/ha was found effective against stem borer and planthoppers in rice (Seni, 2019). Azadirachtin1%EC @ 750 ml/ha was significantly superior to other biopesticides tested (*B. bassiana* and Bt) against leaf folder and stem borer (Kaur*et al*. 2021).

3.2 Efficacy of botanical -insecticide modules against brown planthopper (*Nilaparvata lugens* Stal)

From the data evident from Table 2, the insecticide alone module, T_4 (Chlorantraniliprole0.4 G @ 1.0 g m^{-2}, Cartap hydrochloride50% SC @ 2.0 g l^{-1}, Triflumezopyrim10% SC @ 0.48 ml l^{-1}applied at 25, 45 and 60 DAT respectively) recorded significantly the lowest population of BPH (4.00 hoppers/hill) followed by T_2 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Neemoil @ 10.0 ml l^{-1} and Triflumezopyrim 10% SC@ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT respectively) with 5.87 hoppers/hill, which were at par with each other and superior over other treatments including untreated control (64.77hoppers/hill). Other treatments, T_1 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Eucalyptus oil @ 2.0 ml l^{-1} and Cartap hydrochloride 50% SC @ 2.0 g l^{-1} applied at 25, 45 and 60 DAT respectively) and T_3 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Eucalyptus oil @ 2.0 ml l^{-1} and Neemoil @ 10.0 ml l^{-1} applied at 25, 45 and 60 DAT respectively) registered 45.42 hoppers/hill and 55.56 hoppers/hill, respectively. In terms of per cent reduction over control, $T_{4,}$ T_2 and T_1modulesregistered 94%, 91% and 30% reduction in BPH population, respectively.

The observations noticed in the present study are supported by the findings made by earlier workers who reported that NSKE at 7.5% recorded higher efficacy against planthoppers in rice (Venkatreddy et al. 2012) and biopesticides that were tested (azadirachtin 1%EC, *Bacillus thuringiensis*, *Beauveriabassiana*) were found significantly effective against planthoppers in rice (Kaur et al., 2022). Pymetrozine and Triflumezopyrim as sole treatments were highly effective against brown planthopper (BPH) by registering over 90% reduction in BPH population(Anand Kumar et al., 2022).

3.3 Effectof botanical – insecticide modules on natural enemies

The pooled data on population of spiders and green mirid bug per hill of four *rabi* seasons (*rabi* 2019-20 to *rabi* 2022-23) was analysed statistically and presented in Tables 3 and 4.

3.3.1Spiders

The results on the population of spiders in different botanical - insecticide modules revealed that there was no significant difference in the population of spiders among the treatments including untreated control during all the four seasons of testing indicating their safety to natural enemies (Table 3).

3.3.2 Green Mirid Bug

At 70 days after transplanting, mirid bug population was significantly more in untreated control (T_5) followed by T_1 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Eucalyptus oil @ 2.0 ml l^{-1} and Cartap hydrochloride 50% SC @ 2.0 g l^{-1} applied at 25, 45 and 60 DAT respectively) and T_3 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Eucalyptus oil @ 2.0 ml l^{-1} and Neem oil @ 10.0 ml l^{-1} applied at 25, 45 and 60 DAT respectively) and on par with each other. Insecticide alone module, T_4 (Chlorantraniliprole 0.4 G @ 1.0 g m^{-2}, Cartap hydrochloride 50% SC @ 2.0 g l^{-1}, Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT respectively) recorded significantly the lowest population of mirid bug followed by T_2 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Neem oil @ 10.0 ml l^{-1} and Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT respectively), which were at par with each other and superior over untreated control during four consecutive *rabi* seasons from 2019-20 to 2022-23. This indicates the density dependence nature of the mirid bug, specific predator of the planthopper (the population of the natural enemy are in direct proportion to the numbers of its prey). Thus, T_2 and T_4 modules did not showany adverse effect on mirid bug population (Table 4).

3.4 Effect of botanical – insecticide modules on grain yield

The results (Table 5) indicated that there was significant yield difference among the treatments after imposition of treatments. Insecticides alone module,T_4 (Chlorantraniliprole 0.4 G @ 1.0 g m^{-2}, Cartap hydrochloride 50% SC @ 2.0 g l^{-1}, Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT respectively) recorded the highest grain yield of 6824 kg ha^{-1} with 26.00% increase over control followed by T_2

(Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Neem oil @ 10.0 ml l^{-1} and Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT respectively) with grain yield of 6718 kg ha^{-1} with 24.00% increase over control which were at par with each other and superior over untreated control (5421kg ha^{-1}).

3.5 Economics of the treatments

Cost Benefit ratios were calculated for all the treatments (Table 5). Incremental Cost Benefit Ratio (ICBR) was the highest (1:2.72) in insecticides alone module (T4). It was followed by Botanical - Insecticide module (T_2) with cost benefit ratio of 1: 2.23.

Table1. Details of the treatments and spray schedule

Treatment	Treatment number	Particulars	Time of application	Dose (ml/l or g/m^2)
Botanicals - Insecticide	T_1	Azadirachtin 10000 ppm	25 DAT	2.0 ml/l
		Eucalyptus oil	45 DAT	2.0 ml/l
		Cartap hydrochloride 50% SC	60 DAT	2.0 g/l
Botanicals - Insecticide	T_2	Azadirachtin 10000 ppm	25 DAT	2.0 ml/l
		Neemoil	45 DAT	10.0 ml/l
		Triflumezopyrim 10% SC	60 DAT	0.48 ml/l
All botanicals	T_3	Azadirachtin 10000 ppm	25 DAT	2.0 ml/l
		Eucalyptus oil	45 DAT	2.0 ml/l
		Neem oil	60 DAT	10.0 ml/l
All insecticides	T_4	Chlorantraniliprole 0.4G	25 DAT	1.0 g/m2
		Cartap hydrochloride 50% SC	45 DAT	2.0 g/l
		Triflumezopyrim 10% SC	60 DAT	0.48 ml/l
Untreated control	T_5	Untreated control (Water Spray)	-	-

Table 2. Effect of botanical- insecticide modules on stem borer and BPH during rabi season (Pooled analysis of four seasons, Rabi 2019-20, 2020-21, 2021-22 & 2022-23)

Treatment		Stem borer				BPH	
		DH% (60 DAT)	ROC (%)	WE%	ROC (%)	(No./ hill) (70 DAT)	ROC (%)
T_1	Azadirachtin 10000 ppm (25 DAT)	2.53 (9.14)^{bc}	21	9.40 (17.83)^{b}	14	45.42 (6.69)^{b}	30
	Eucalyptus oil (45 DAT)						
	Cartap hydrochloride 50% SC (60 DAT)						
T_2	Azadirachtin 10000 ppm (25 DAT)	2.37 (8.84)^{b}	26	9.47 (17.91)^{b}	13	5.87 (2.39)^{a}	91
	Neem oil (45 DAT)						
	Triflumezopyrim 10% SC (60 DAT)						
T_3	Azadirachtin 10000 ppm (25 DAT)	2.64 (9.31)^{bc}	18	9.80 (18.20)^{b}	10	55.56 (7.44)^{bc}	14
	Eucalyptus oil (45 DAT)						
	Neem oil (60 DAT)						
T_4	Chlorantraniliprole 0.4G (25 DAT)	1.60 (7.19)^{a}	50	7.26 (15.60)^{a}	33	4.00 (2.00)^{a}	94
	Cartap hydrochloride 50% SC (45 DAT)						

	Triflumezopyrim 10% SC (60 DAT)						
T_5	Untreated control (Water Spray)	3.21 (10.29)^{c}		10.89 (19.19)^{b}		64.77 (7.44)^{c}	
CV (%)		**10.38**		**7.75**		**11.80**	
CD (0.05)		**1.43**		**2.12**		**0.94**	
F test		**Sig.**		**Sig.**		**Sig.**	

DAT- Days after transplanting; DH% - Per cent dead hearts; WE% - Per cent white ears

ROC (%) – Per cent reduction over control; Means followed by common letters are not significantly different by LSD (0.05%)

Table 3. Effect of botanical- insecticide modules on spiders during rabi season

(Pooled analysis of 4 seasons, 2019-20 to 2022-23)

Treatment		**Spiders (No./hill) (At 70 DAT)**				
		Rabi 2019-20	**Rabi 2020-21**	**Rabi 2021-22**	**Rabi 2022-23**	**Pooled**
T1	Azadirachtin 10000 ppm (25 DAT) Eucalyptus oil (45 DAT) Cartap hydrochloride 50% SC (60 DAT)	0.93 (0.94)	1.60 (1.26)	1.86 (1.36)	1.46 (1.21)	1.46 (1.21)
T2	Azadirachtin 10000 ppm (25 DAT) Neem oil (45 DAT) Triflumezopyrim 10% SC (60 DAT)	1.08 (1.03)	1.18 (1.08)	1.68 (1.29)	1.43 (1.19)	1.34 (1.16)
T3	Azadirachtin 10000 ppm (25 DAT) Eucalyptus oil (45 DAT) Neem oil (60 DAT)	1.15 (1.07)	1.71 (1.29)	2.15 (1.47)	1.65 (1.28)	1.54 (1.24)
T4	Chlorantraniliprole 0.4G (25 DAT) Cartap hydrochloride 50% SC (45 DAT) Triflumezopyrim 10% SC (60 DAT)	0.98 (0.98)	1.24 (1.11)	1.66 (1.29)	1.76 (1.31)	1.41 (1.19)
T5	Untreated control (Water Spray)	1.30 (1.11)	1.71 (1.31)	1.88 (1.36)	1.48 (1.21)	1.55 (1.25)
CV (%)		17.14	11.67	6.33	11.57	4.82
CD (0.05)		-	-	-	-	-
F test		NS	NS	NS	NS	NS

DAT- Days after transplanting; The figures in parenthesis are square root transformed values

Table 4.Effect of botanical- insecticide modules on green mirid bug during rabi season (Pooled analysis of 4 seasons, 2019-20 to 2022-23)

Treatment		Green Mirid bug (No./hill) (At 70 DAT)				
		Rabi 2019-20	**Rabi 2020-21**	**Rabi 2021-22**	**Rabi 2022-23**	**Pooled**
T1	Azadirachtin 10000 ppm (25 DAT) Eucalyptus oil (45 DAT) Cartap hydrochloride 50% SC (60 DAT)	5.55 (2.35)[b]	6.09 (2.46)[b]	8.88 (2.97)[b]	2.18 (1.47)[b]	5.71 (2.39)[b]
T2	Azadirachtin 10000 ppm (25 DAT) Neem oil (45 DAT) Triflumezopyrim 10% SC (60 DAT)	1.58 (1.25)[a]	0.74 (0.80)[a]	1.64 (1.28)[a]	0.64 (0.80)[a]	1.15 (1.07)[a]
T3	Azadirachtin 10000 ppm (25 DAT) Eucalyptus oil (45 DAT) Neem oil (60 DAT)	5.40 (2.31)[b]	5.95 (2.43)[b]	10.68 (3.27)[c]	2.08 (1.43)[b]	6.17 (2.48)[bc]
T4	Chlorantraniliprole 0.4G (25 DAT) Cartap hydrochloride 50% SC (45 DAT) Triflumezopyrim 10% SC (60 DAT)	1.58 (1.25)[a]	0.94 (0.97)[a]	1.49 (1.22)[a]	0.56 (0.75)[a]	1.14 (1.07)[a]
T5	Untreated control (Water Spray)	6.20 (2.48)[b]	6.81 (2.61)[b]	11.26 (3.36)[c]	2.34 (1.52)[b]	6.47 (2.54)[c]
	CV (%)	11.27	11.45	4.96	12.50	4.52
	CD (0.05)	0.33	0.33	0.18	0.23	0.13
	F test	Sig.	Sig.	Sig.	Sig.	Sig.

DAT- Days after transplanting; The figures in parenthesis are square root transformed values

Means followed by common letters are not significantly different by LSD (0.05%)

Table 5. Effect of botanical – insecticide modules on grain yield and economics of treatments during rabi season (Pooled analysis of Rabi 2019-20, 2020-21, 2021-22 & 2022-23)

Treatment		Grain yield (kg/ha)	Increase over control (%)	Excess yield (kg)	Excess yield (qtl)	Additional income (Rs.)	Cost of inputs (Rs.)	ICBR
T_1	Azadirachtin 10000 ppm (25 DAT) Eucalyptus oil (45 DAT) Cartap hydrochloride 50% SC (60 DAT)	5473[b]	1.00	52	0.52	988	8700	0.11
T_2	Azadirachtin 10000 ppm(25 DAT) Neem oil (45 DAT) Triflumezopyrim 10% SC (60 DAT)	6718[a]	24.00	1298	12.98	24662	11075	**2.23**
T_3	Azadirachtin 10000 ppm(25 DAT)	5768[b]	6.00	347	3.47	6593	10375	0.64

	Eucalyptus oil (45 DAT)							
	Neem oil (60 DAT)							
T4	Chlorantraniliprole 0.4G (25 DAT)	6824[a]	26.00	1404	14.04	26676	9825	2.72
	Cartap hydrochloride 50% SC (45 DAT)							
	Triflumezopyrim 10% SC (60 DAT)							
T5	Untreated control (Water Spray)	5421[b]	-	-	-	-	-	-
	CV (%)	**7.04**						
	CD (0.05)	**655.0**						
	F test	**Sig.**	Paddy price per qtl:1900/-					

ICBR – Incremental cost benefit ratio; Means followed by common letters are not significantly different by LSD (0.05%)

Table 6. Information on cost of inputs and spraying cost and total cost incurred during rabi season

Treatments	Name of the Botanical/insecticide	Quantity required (kg/l)	Unit Cost	Cost /ha (Rs.)	Cost of spraying operation (Rs.)	Total cost incurred (Rs.)
T1(Botanicals – Insecticide)	Azadirachtin 10000 ppm	1.0 litre	Rs. 1700/litre	1700	875	2575
	Eucalyptus oil	1.0 litre	Rs. 2800/litre	2800	875	3675
	Cartaphydrochloride 50% SC	1.0 kg	Rs. 1575/kg	1575	875	2450
				6075	**2625**	**8700**
T2 (Botanicals – Insecticide)	Azadirachtin 10000 ppm	1.0 litre	Rs. 1700/litre	1700	875	2575
	Neemoil	5.0 litre	Rs. 650/litre	3250	875	4125
	Triflumezopyrim 10% SC	235 ml	1400/94 ml	3500	875	4375
				8450	**2625**	**11075**
T3 (All botanicals)	Azadirachtin 10000 ppm	1.0 litre	Rs.1700/litre	1700	875	2575
	Eucalyptus oil	1.0 litre	Rs.2800/litre	2800	875	3675
	Neem oil	5.0 litre	Rs. 650/litre	3250	875	4125
				7750	**2625**	**10375**
T4 (All insecticides)	Chlorantraniliprole 0.4G	10.0 kg	Rs. 850/4 kg	2125	875	3000
	Cartaphydrochloride 50% SC	1.0 kg	Rs. 1575/kg	1575	875	2450
	Triflumezopyrim 10% SC	235 ml	Rs. 1400/94 ml	3500	875	4375
				7200	**2625**	**9825**

IV. CONCLUSION

Among the different botanical insecticide modules tested against stem borer and BPH,insecticides alone module, T_4 (Chlorantraniliprole 0.4 G @ 1.0 g m^{-2}, Cartap hydrochloride 50% SC @ 2.0 g l^{-1}, Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT respectively) is the best module with 50% reduction over control (ROC), 33% ROC in dead hearts and white ears, respectively with regard to stem borer and 94% ROC in brown planthopper population and registered the highest grain yield (6824 kg ha^{-1}).

Among botanical – insecticide modules, treatment, T_2 (Azadirachtin 10000 ppm @ 2.0 ml l^{-1}, Neem oil @ 10.0 ml l^{-1} and Triflumezopyrim 10% SC @ 0.48 ml l^{-1} applied at 25, 45 and 60 DAT respectively) is the best against stem borer (26% ROC in dead heart damage & 13% ROC in white ear damage) and brown planthopper(91% ROC in brown planthopper population). Further, $T_2$is at par with insecticides alone module (T4) in managing stem borer and BPH and recorded the grain yield (6718 kg ha^{-1}) on par with the insecticides alone module. Hence, botanicals can be used in Integrated Pest Management programmes and in rotations with insecticides against insect pests of rice so as to reduce the pesticide load in the rice crop which in turn lessen the environmental concern.

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