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NOTE

Field Efficacy of some Combination Insecticide Formulations against Paddy Planthoppers

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Comparative field efficacy of certain insecticide combination formulations with their sole insecticidal treatments is reported against rice planthoppers [brown (BPH) and white backed (WBPH)] during *kharif* 2016. The plots treated with fipronil 5 per cent + buprofezin 20 per cent SC @ 62.5+250 g a.i. ha^{-1} recorded the lowest number of BPH population (3.83 and 2.61 per 5 hills) in the first and second insecticidal sprays, respectively, followed by indoxacarb 10 per cent + thiamethoxam 10 per cent WG @ 50 + 50 g a.i. ha^{-1} (4.81 and 3.45 per 5 hills, respectively). The sole treatments of thiamethoxam 25WG @ 25 g a.i. ha^{-1} and buprofezin 25WG @ 50 g a.i. ha^{-1} performed as the third and fourth best treatments, respectively. The WBPH population was low in plots treated with fipronil + buprofezin EC (2.95 and 2.60 per 5 hills) after the first and second insecticidal sprays, respectively, followed by indoxacarb + thiamethoxam WG (3.83 and 3.36 per 5 hills, respectively). The highest population was recorded in untreated control. The highest per cent yield over control was recorded in fipronil + buprofezin EC treated plot (47.84), followed by indoxacarb + thiamethoxam 10 WG (44.88).

Key words: Fipronil, buprofezin, indoxacarb, thiamethoxam, combination formulations, rice, BPH, WBPH, efficacy

Rice (*Oryza sativa* L.) is one of the most important staple food crops in the world providing food for nearly half of the global population (Anonymous, 2004). India is one of the major rice growing countries and it leads the world with an area of 43.38 million hectares and a production of 104.32 million tonnes (Anonymous, 2017). Rice crop requires warm and humid environment which is also conducive for survival and proliferation of many insect pests, the major constraint in enhancing rice productivity, besides the diseases and weeds (Behura *et al.,* 2011). The crop is vulnerable to attack by more than 100 species of insects and among them 15-20 species of insects can cause economic damage (Heong and Hardy, 2009) and caused 21 to 51 per cent yield loss (Arora and Dhaliwal, 1996). The sucking insect pests, brown planthopper (BPH), *Nilaparvata lugens* (Stål) and whitebacked planthopper (WBPH), *Sogatella furcifera* (Horvath) of the order Homoptera and family Delphacidae are the economically most important pests of rice crop (Singh *et al.,* 2002). The yield loss due to planthoppers ranged from 1 to 33 per cent in India (Chaudhary *et al.,* 2014). Planthoppers damage the plants by sucking the plant sap as well as oviposition in plant tissues, thereby resulting in plant wilting or hopper burn (Turner *et al.,* 1999). Planthopper damage also resulted from the transmitted plant viral diseases like grassy stunt and wilted stunt. Severe attack causes, "hopper burn" symptoms in the field (Horgan, 2009). Farmers mostly rely on insecticides for their management. However, indiscriminate use of insecticides has led to many problems like elimination of natural predators, environmental pollution (Balakrishna and Satyanarayana, 2013), resistance and resurgence (Krishnaiah *et al*., 2006). Continuous use of single insecticide resulting in high selection pressure has led to evolution of resistance to insecticides in both BPH and WBPH in Asia (Ling e*t al.,* 2011; Matsumura and Morimura, 2010; Su *et al.,* 2013). However, there is a need to explore the possibility of utilizing effective eco-friendly insecticides, particularly combinations of those with different and novel mode of action which can fit idyllically in IPM programme against hoppers in rice agroecosystem. Keeping in view the economic importance of these planthoppers on rice crop, the present study was undertaken with the objective to assess the efficacy of new insecticide combinations along with sole insecticide treatments against BPH and WBPH under field conditions. The study will enhance the choice for farmers to select insecticides from different groups and different mode of action for an effective management of the pest on rice crop.

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MATERIALS AND METHODS

Test insecticides

Fipronil (5-amino-1-[2,6-dichloro-4-(trifluoromethyl)phenyl]-4- (trifluoromethylsulfinyl)-1H-pyrazole-3-carbonitrile) 5 per cent + buprofezin (2-*tert*-butylimino-3-isopropyl-5-phenyl-1,3,5-thiadiazinan-4-one) 20 per cent SC, indoxacarb (methyl (*S*)-*N*-[7-chloro-2,3,4a,5-tetrahydro-4a-(methoxy-carbonyl) indeno[1,2-e][1,3,4]oxadiazin-2-ylcarbonyl]-4'-(trifluoromethoxy)carbanilate) 10 per cent + thiamethoxam (3-(2-chloro-1,3-thiazol-5-ylmethyl)-5-methyl-1,3,5-oxadiazinan-4-ylidene(nitro)amine) 10 per cent WG, cypermethrin (α-cyano-3-phenoxybenzyl (1*RS*,3*RS*; 1*RS*,3*SR*)-3-(2,2-dichlorovinyl)-2,2-dimethyl-cyclopropanecarboxylate) 10 per cent + indoxacarb 10 per cent SC, buprofezin 25 SC (Machan), indoxacarb 14.5SC (King DOXA), thiamethoxam 25WG (Cover), chlorpyriphos (*O*,*O*-diethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate) 20EC (Chlorguard) and quinalphos (*O*,*O*-diethyl *O*-quinoxalin-2-yl phosphorothioate) 25EC (Gilquin). All the insecticide formulations were procured from Gharda Chemicals Limited, Maharashtra and among all insecticide formulations, combination insecticide formulations have not been commercialized till date.

Field experiment

The field experiment was conducted during *kharif* 2016 at Agricultural Research Farm, Banaras Hindu University, Varanasi, India. Varanasi lies between 24° 56' N to 25° 35' N Latitude and 82° 14' E to 83° 24' E Longitude and the elevation is 82 m above the mean sea level.

Pure seeds of the test variety (cv. Rajendra Kasturi) were procured from the Agricultural Research Farm of the University and sown in nursery beds on 29th June 2016 at the rate of 1.5 kg per 50 m^2 nursery area for transplanting in 500 m^2 main field (30 kg ha^{-1}). The experimental plot was laid out under Randomized Block Design (RBD) having three replications. Twenty one days old seedlings were transplanted at a rate of 2-3 seedlings per hill on 20th July 2016. The row-to-row spacing was 20 cm and plant to plant 15 cm. The total field area 429 m^2 (including bunds and irrigation channels) and 81 m^2 replicated plot (excluding bunds and irrigation channels) and 9 m^2 each plot. All the recommended agronomic practices like weed control, fertilizer application and irrigations were followed (Anonymous, 2011). The infestation of planthoppers can be observed at vegetative stage because of conducive temperature and R.H. (av. temp. 21-29°C, av. R.H. 62-93%, rainfall 849.5 mm). The insecticidal treatment details are as follows:

Fipronil 5 per cent + buprofezin 20 per cent SC @ 62.5 + 250 g a.i. ha^{-1}

Indoxacarb 10 per cent + thiamethoxam 10 per cent WG @ 50 + 50 g a.i. ha^{-1}

Cypermethrin 10 per cent + indoxacarb 10 per cent SC @ 37.5 + 37.5 g a.i. ha^{-1}

Buprofezin 25SC @ 50 g a.i. ha^{-1}

Indoxacarb 14.5SC @ 125 g a.i. ha^{-1}

Thiamethoxam 25WG @ 25 g a.i. ha^{-1}

Chlorpyriphos 50EC @ 375 g a.i. ha^{-1}

Quinalphos 25EC @ 500 g a.i. ha^{-1}

The insecticidal spray solution of desired concentration as per each treatment was freshly prepared every time at the experimental site just before the start of spraying operation. All the sprays were given during the evening hours. A hand compression knapsack sprayer was used for imposing the treatments @ 500 L ha^{-1}. Two sprays were imposed during entire crop season when pest population reached its economic threshold level (ETL) *i.e.* 5-10 plant hoppers per hill. First spray was done on 9th September, 2016 at vegetative stage and second after 24 d of first spray *i.e.* 03rd October 2016 at panicle initiation stage, when re-building of pest population towards ETL was observed.

Observations

The number of motile (adult and nymphs) stages of BPH and WBPH on 5 hills selected at random from each treatment replication prior and 3, 7, 10 and 14 d after each spray was recorded. For counting the number of individuals of BPH and WBPH, each hill was tilted and tapped 2 or 3 times at the base and the planthoppers fallen on water were counted (Heinrichs *et al.,* 1984). WBPH adults are smaller than BPH and have white band on the junction of wings.

The yield per plot in each treatment was extrapolated to quintals per hectare. The yield data in each treatment was recorded separately and subjected to statistical analysis to test the significance of mean yield variation in different treatments.

Statistical analysis

The data pertaining to population of planthoppers were statistically analyzed with analysis of variance (ANOVA). The significance of differences were tested by F-test, while the significance of differences between treatment means were compared using least significant difference (LSD) at 5 per cent probability level (Gomez and Gomez, 1984). All the data were checked for normality before subjecting to analysis. Data on insect population lacking normality were transformed using square root transformations. The yield data was not transformed.

RESULTS AND DISCUSSION

Brown planthopper

First spray. The BPH population ranged from 10.24 to 13.18 nos. per 5 hills prior to treatments. The mean BPH population was the lowest in fipronil 5 per cent + buprofezin 20 per cent SC treated plots recording 4.14 nos. per 5 hills on 3rd d after the first spray and the same efficacy was observed at 7 DAS also, the average number of BPH population being 2.29 nos. per 5 hills, followed by indoxacarb 10 per cent + thiamethoxam 10 per cent WG and thiamethoxam 25 WG alone with an average number of insects of 3.23 and 3.70 nos. per 5 hills, respectively which were at par with each other. Among insecticidal treatments, the highest population of BPH was recorded in chlorpyriphos treated plots at 6.96 per 5 hills and in untreated control 13.82 nos. per 5 hills. The BPH population counted on 10th and 14th d after spray (DAS) was also significantly lower in fipronil 5 per cent + buprofezin 20 per cent SC treated plots (3.66 and 5.23 nos. per 5 hills, respectively) and differed significantly from the rest of the treatments. Indoxacarb 10 per cent + thiamethoxam 10 per cent WG was again statistically at par with the sole treatment of thiamethoxam 25WG, while the population in control reached 15.33 nos. per 5 hills (Table 1).

Second spray. The BPH population ranged from 5.86 to 16.67 per 5 hills prior to treatments (Table 1). The data on overall mean revealed the order of same efficacy amongst treatments as the first spray. The lowest mean BPH population was recorded in fipronil 5 per cent + buprofezin 20 per cent SC (2.61 per 5 hills), followed by indoxacarb 10 per cent + thiamethoxam 10 per cent WG and thiamethoxam 25 WG (3.45 and 4.10 per 5 hills, respectively). Indoxacarb and chlorpyriphos treated plots recorded 7.07 and 7.77 nos. per 5 hills, respectively while the highest population was recorded in untreated control (16.52 per 5 hills).

The results of present investigation revealed that the combination insecticide formulations fipronil 5 per cent + buprofezin 20 per cent SC (phenyl pyrazole and chitin synthesis inhibitor) and indoxacarb 10 per cent + thiamethoxam 10 per cent WG (contact and systemic mode of action) were consistently most effective treatments, respectively. The present finding is in accordance with Roshan *et al.* (2016) who confirmed that a combination insecticide acetamiprid + fipronil was most effective against BPH. Tudu *et al.* (2010) observed that combination of insecticides with different modes of action reduced the population of BPH. However, in sole insecticide, the neonicotinoid thiamethoxam 25 WG and chitin synthesis inhibitor buprofezin 25 SC reduced the BPH popuations effectively in both sprays and these results are close resemblance with Bhavani (2006) and Krishnaiah *et al.* (2003, 2004), who reported thiamethoxam as the most effective against BPH. Earlier, Prashant *et al.* (2015), Shera and Sarao (2016) and Soni and Tiwari (2014) reported that buprofezin 25SC was most effective in reducing BPH population.

White-backed planthopper

First spray. Prior to imposition of treatments, the population of BPH varied from 7.68 to 10.30 nos. per 5 hills and did not vary significantly among the treatments. However, on the 3rd d after imposing the treatments, fipronil 5 per cent + buprofezin 20 per cent SC recorded the lowest number of WBPH (3.16 per 5 hills), followed by indoxacarb 10 per cent + thiamethoxam 10 per cent WG (4.19 per 5 hills), thiamethoxam 25 WG (5.06 per 5 hills) and buprofezin 25 SC (5.75 per 5 hills). Higher number of insect counts were observed in chlorpyriphos 20EC (8.88 per 5 hills) and untreated control (11.60 per 5 hills). The same trend followed after 7th, 10th and 14th DAS. The data of overall mean revealed that fipronil 5 per cent + buprofezin 20 per cent SC treated plots recorded the lowest population (1.95 per 5 hill), followed by indoxacarb 10 per cent + thiamethoxam 10 per cent WG (3.83 per 5 hills), thiamethoxam 25 WG (4.72 per 5 hills) and buprofezin 25 SC (5.45 per 5 hills) and were significantly different from one another. However, the highest population was recorded in chlorpyriphos treated plots (8.66 per hills) while in untreated control it was 14.66 per 5 hills (Table 2).

Table 1. Effect of insecticidal treatments on brown plant hopper population

Treatment	Dose (g a.i. ha^{-1})	Average number of adults & nymphs per 5 hills at different DAS											
		First spray						Second spray					
		1 DBS	3 DAS	7 DAS	10 DAS	14 DAS	Overall mean	1 DBS	3 DAS	7 DAS	10 DAS	14 DAS	Overall mean
Fipronil 5% + buprofezin 20% SC	62.5+ 250	10.73* (3.43)**	4.14 (2.27)	2.29 (1.82)	3.66 (2.16)	5.23 (2.51)	3.83 (2.19)	5.86 (2.62)	2.86 (1.96)	1.70 (1.64)	2.57 (1.88)	3.33 (2.07)	2.61 (1.88)
Indoxacarb 10% + thiomethoxam 10WG	50+50	10.55 (3.40)	5.12 (2.47)	3.23 (2.05)	4.57 (2.36)	6.33 (2.71)	4.81 (2.39)	7.30 (2.88)	3.58 (2.14)	2.46 (1.80)	3.45 (2.10)	4.31 (2.30)	3.45 (2.08)
Cypermethrin 10% +indoxacarb 10% SC	37.5+ 37.5	13.18 (3.77)	6.65 (2.76)	5.33 (2.52)	7.37 (2.89)	8.33 (3.05)	6.92 (2.80)	8.53 (3.08)	5.56 (2.56)	4.31 (2.30)	5.46 (2.54	6.64 (2.76)	5.49 (2.54)
Buprofezin 25 SC	50	10.24 (3.35)	6.96 (2.85)	4.70 (2.39)	6.33 (2.71)	7.16 (2.86)	6.28 (2.70)	8.16 (3.02)	4.81 (2.41)	3.69 (2.16)	4.68 (2.38)	5.87 (2.61)	4.76 (2.39)
Indoxacarb 14.5 SC	125	12.30 (3.65)	7.83 (2.97)	6.42 (2.72)	8.26 (3.04)	8.55 (3.09)	7.76 (2.95)	10.13 (3.33)	6.75 (2.78)	5.63 (2.58)	7.07 (2.84)	8.63 (3.10)	7.02 (2.82)
Thiamethoxam 25 WG	25	12.59 (3.69)	5.56 (2.56)	3.70 (2.17)	5.13 (2.48)	6.67 (2.77)	5.26 (2.49	7.80 (2.96)	4.15 (2.27)	3.03 (2.00)	4.10 (2.25)	5.13 (2.47)	4.10 (2.24)
Chlorpyriphos 20 EC	375	11.81 (3.58)	9.27 (3.21)	6.96 (2.85)	8.28 (3.05)	9.18 (3.19)	8.42 (3.07)	10.66 (3.41)	7.30 (2.88)	6.35 (2.72)	7.90 (2.98)	9.54 (3.25)	7.77 (2.95)
Quinalphos 25EC	500	11.67 (3.56)	7.16 (2.86)	5.33 (2.52)	7.76 (2.96)	8.20 (3.03)	7.11 (2.84)	9.33 (3.21)	6.14 (2.67)	5.00 (2.44)	6.27 (2.69)	7.66 (2.94)	6.26 (2.68)
Control	-	11.71 (3.56)	13.17 (3.76)	13.82 (3.85)	14.82 (3.98)	15.33 (4.04)	14.28 (3.90)	16.67 (4.20)	17.44 (4.29)	15.33 (4.04)	16.61 (4.17)	16.70 (4.20)	16.52 (4.17)
SE(m)±	-	-	0.07	0.06	0.05	0.07	-	-	0.03	0.04	0.04	0.05	-
C.D. at 5%	-		0.21	0.18	0.16	0.20	0.20	-	0.10	0.14	0.13	0.15	-

*Mean of three replications; **Figures in the parentheses are square root transformed values; DBS = Day before spray; DAS = Days after spray.

Second spray. Before the 2nd spaying, WBPH population ranged from 5.87 to 15.33 per 5 hills (Table 2). In all insecticide treatments, significant reduction in the average number of insects was observed. The overall mean data revealed that the lowest WBPH population was recorded in fipronil 5 per cent + buprofezin 20 per cent SC treated plots (2.60 per 5 hills) followed by indoxacarb 10 per cent + thiamethoxam 10 per cent WG (3.66 per 5 hills), thiamethoxam 25 WG (4.08 per 5 hills), buprofezin 25 SC (4.79 per 5 hills) and cypermethrin 10 per cent + indoxacarb 10 per cent SC (5.54). The highest population was recorded in indoxacarb 14.5SC (7.00 per 5 hills) and chlorpyriphos 20EC (7.76 per 5 hills) while the population in untreated control was 13.88 per 5 hills (Table 2). Among different insecticides evaluated against WBPH, again fipronil + buprofezin SC combination insecticide was most effective, followed by indoxacarb + thiamethoxam WG. The finding is in accordance with Chander *et al.* (2012) who reported that a combination product (buprofezin + acephate) was effective against planthoppers. Fipronil as a component of a combination insecticide (fipronil + fenobucarb) was reported effective in controlling WBPH (Panda and Rath, 2003). Thiamethoxam 25 WG and buprofezin 25 SC was also effective against WBPH population and these findings corroborate with those of Hegde and Nidagundi (2009) and Shera and Sarao (2016) who reported that buprofezin 25 EC exhibited a better persistent toxicity against WBPH. However, Bhavani (2006) reported that thiamethoxam 25 WG, followed by buprofezin 25 SC were most effective in suppressing WBPH population.

Effect on paddy yield

The insecticidal treatments employed to reduce the BPH and WBPH population helped to increase the yield of the crop. The paddy yield in all the insecticidal treatments was significantly higher than the untreated control. On the basis of per cent increase over control, increase in yield in various insecticide treatments are in the following order: Fipronil 5

Table 2. Effect of insecticidal treatments on white backed plant hopper population

Treatment	Dose (g a.i. ha^{-1})	Average number of adults & nymphs per 5 hills at different DAS											
		First spray						Second spray					
		1 DBS	3 DAS	7 DAS	10 DAS	14 DAS	Overall mean	1 DBS	3 DAS	7 DAS	10 DAS	14 DAS	Overall mean
Fipronil 5% + buprofezin 20% SC	62.5+ 250	8.25* (3.04)**	3.16 (2.04)	1.95 (1.72)	3.00 (2.00)	3.70 (2.17)	2.95 (1.98)	5.87 (2.62)	2.79 (1.95)	1.64 (1.62)	2.65 (1.91)	3.33 (2.08)	2.60 (1.89)
Indoxacarb 10% + thiomethoxam 10WG	50+ 50	8.22 (3.03)	4.19 (2.28)	2.79 (1.95)	3.91 (2.22)	4.45 (2.34)	3.83 (2.19)	7.30 (2.88)	3.52 (2.13)	2.24 (1.80)	3.51 (2.12)	4.18 (2.28)	3.36 (2.08)
Cypermethrin 10% + indoxacarb 10% SC	37.5+ 37.5	10.2 (3.34)	6.55 (2.75)	5.303 (2.51)	6.35 (2.71)	6.87 (2.81)	6.26 (2.69)	8.53 (3.09)	5.56 (2.56)	4.39 (2.32)	5.56 (2.56)	6.67 (2.77)	5.54 (2.55)
Buprofezin 25 SC	50	7.68 (2.95)	5.75 (2.60)	4.50 (2.35)	5.48 (2.55)	6.09 (2.66)	5.45 (2.54)	8.17 (3.03)	4.81 (2.41)	3.65 (2.16)	4.85 (2.42)	5.87 (2.61)	4.79 (2.40)
Indoxacarb 14.5 SC	125	9.49 (3.24)	8.04 (3.01)	6.723 (2.78)	8.00 (3.00)	8.55 (3.09)	7.82 (2.97)	10.10 (3.34)	6.75 (2.78)	5.56 (2.56)	7.07 (2.84)	8.63 (3.10)	7.00 (2.82)
Thiamethoxam 25 WG	25	9.74 (3.28)	5.06 (2.46)	3.79 (2.19)	4.67 (2.38)	5.39 (2.53)	4.72 (2.39)	7.80 (2.97)	4.16 (2.27)	2.94 (1.99)	4.24 (2.29)	5.00 (2.45)	4.08 (2.25)
Chlorpyriphos 20 EC	375	10.30 (3.36)	8.88 (3.14)	7.563 (2.93)	8.93 (3.15)	9.29 (3.21)	8.66 (3.10)	10.70 (3.42)	7.31 (2.88)	6.22 (2.68)	7.90 (2.98)	9.64 (3.27)	7.76 (2.68)
Quinalphos 25EC	500	9.13 (3.18)	7.22 (2.87)	6.15 (2.67)	7.23 (2.87)	7.62 (2.94)	7.05 (2.83)	9.33 (3.21)	6.15 (2.67)	4.94 (2.44)	6.27 (2.69)	7.67 (2.94)	6.25 (2.68)
Control	-	9.42 (3.23)	11.60 (3.55)	14.82 (3.98)	15.33 (4.04)	16.67 (4.20)	14.60 (3.94)	15.33 (3.33)	14.21 (3.90)	13.14 (3.75)	13.75 (3.84)	14.42 (3.92)	13.88 (3.85)
SE(m)±	-	-	0.04	0.05	0.04	0.03	-	-	0.04	0.05	0.03	0.05	-
C.D. at 5%	-	-	0.13	0.16	0.12	0.10	-	-	0.13	0.14	0.11	0.16	-

*Mean of three replications; **Figures in the parentheses are square root transformed values; DBS = Day before spray; DAS = Days after spray.

per cent + buprofezin 20 per cent SC (47.84%) > indoxacarb 10 per cent + thiamethoxam 10 per cent WG (44.88%) > thiamethoxam 25WG (43.60%) > indoxacarb 14.5SC (42.43%) > cypermethrin 10 per cent + indoxacarb 10 per cent SC (40.49%) > buprofezin 25 SC (38.21%) > quinalphos 25EC (35.18%) > chlorpyriphos 20EC (32.40%) (Fig. 1).

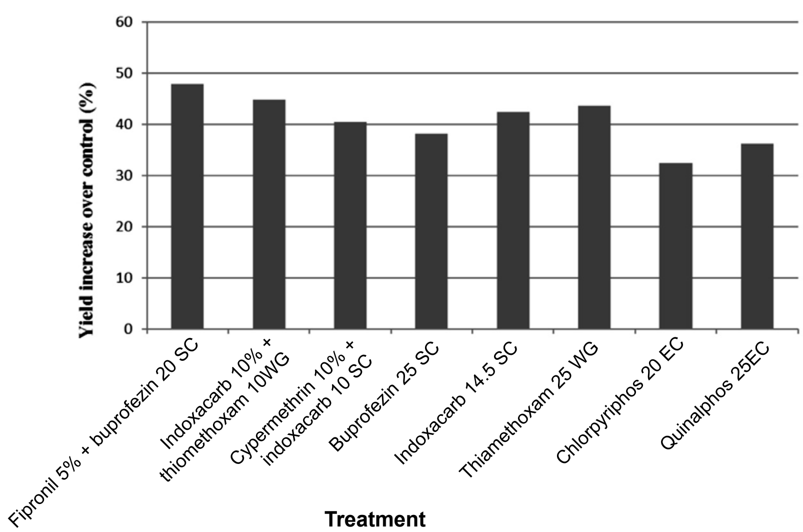

Figure 1. Impact of insecticidal treatments on paddy grain yield

CONCLUSION

From the present results it may be concluded that two sprays are required to maintain the planthoppers population below the ETL level throughout the entire crop season, the first at vegetative stage when the planthoppers population reached its ETL and the second at 24th d after the first treatment at panicle initiation stage when again the planthoppers population attained ETL. Fipronil 5 per cent + buprofezin 20 per cent SC (phenyl pyrazole and chitin synthesis inhibitor) and indoxacarb 10 per cent + thiamethoxam 10 per cent WG (contact and systemic mode of action) combination formulations rendered effective control of BPH and WBPH on rice crop. This combination will enhance the choice of farmers in selecting the insecticides from different groups with different modes of action. This can play an important role as an alternative to neonicotinoids and organophosphates already recommended for the control of planthoppers and play a vital role in insecticide resistance management

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