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Bio-efficacy evaluation of some insecticides (solo and pre mixed) against major insect pests of rice

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ABSTRACT

Present investigation was carried out to evaluate the efficacy of some insecticides and their can mixtures against major insect pests of rice during Kharif seasons of 2013, 2014 and 2015 at Regional Research and Technology Transfer Station (RRTTS), Coastal Zone, OUAT, Bhubaneswar, Odisha. The experiment constituted eleven treatments such as profenophos 50EC @1000ml ha^{-1}, cypermethrin 10EC @500ml/ha, flubendiamide 39.35EC @125ml ha^{-1}, thiacloprid 240SC @625ml ha^{-1}, imidacloprid 30.5SC @150ml ha^{-1}, profenophos 40% + cypermethrin 4% @440ml ha^{-1}, ethiprole 40% + imidacloprid 40% @ 125g ha^{-1}, flubendiamide 240SC + thiacloprid 240SC @300ml ha^{-1}, fipronil 0.3%G @20 kg ha^{-1}, monocrotophos 36EC @750ml $ha^{-1}$and untreated control for comparison. All the treatments significantly reduced the major insect pests in comparison to the untreated control due to their specific mode of action. The results clearly indicated that flubendiamide 240SC + thiacloprid 240SC @300ml $ha^{-1}$was most effective in management of major insect pests in rice by reduction of 71.24 per cent dead heart (DH) and 66.26 per cent white ear head (WEH) caused by stem borer, 86.39 per cent silver shoot (SS) by gall midge, 48.48 per cent infested leaves by leaffolder (LF), 91.15 per cent in population of brown plant hopper (BPH) over untreated control. Apart from that the said treatment could achieve highest average yield (53.40 q ha^{-1}) and net return of ₹ 20,492 ha^{-1} over control with highest benefit cost ratio (1.43) compared to the individual insecticidal treatments of flubendiamide 39.35EC @125ml $ha^{-1}$with (1.16) and thiacloprid 240SC @625ml ha^{-1} with (1.19) benefit cost ratio. The overall performance of other pre mixed *insecticides were found to be better than the performance of the individual insecticides.*

***Keywords*:** Can mixture of insecticides, dead heart (DH), net return over control , silver shoot (SS), white ear head (WEH)

Rice (*Oryza sativa* L) is the most important cereal crop of the world with 463.3 million tones of annual production (Thawait *et al*., 2014). In India rice alone meets 42 per cent of food grain production and 55 per cent of cereal production and we have to produce 135-140 million tons of rice by 2030. But the productivity faces many biotic and abiotic constraints (Nayak *et al*., 2015). Rice crop is attacked by several insect pests from nursery to harvest, which cause severe yield loss to the country (Asghar *et al*., 2009). Among the large number of insect pests damaging rice the yellow stem borer (*Scirpophaga incertulas* Walker), gall midge (*Orseolia oryza* Wood-Mason), leaffolders (*Cnaphalocrocis medinalis* Guenee) and brown plant hoppers (*Nilaparvata lugens* Stal) causes regular yield loss in *Kharif* rice. Kharbade *et al*., 2016 said that the stem borer and brown plant hopper causes severe damage and yield loss to rice crop in later stage. The pest management strategy in India is mainly relying on chemical pesticides. The quick and effective control of insect pests by insecticides convinces the farmers easily as against the non chemical methods of pest management. The development of resistance and resurgence has limited the application of single insecticides as compared to tank mixtures. The mixtures of insecticides may give best control of a complex of pests with varying susceptibilities to the different components of the mixture. The insecticide mixture can be classified into two major groups, the tank mixtures and pre packed mixtures (ready mix formulations). The tank mixtures are prepared in the field directly by the farmers before spraying which lack the knowledge about the compatibility of the compound and proportion. Mixing of two or more insecticides is very common among the Indian farmers though not recommended. These problems can be overcome by ready mix formulations (Regupathy *et al*., 2004). Combination of two chemicals with different mode of action is the new strategy to reduce development of resistance among insects.

MATERIALS AND METHODS

The present study was conducted at Regional Research and Technology Transfer Station (RRTTS), Coastal Zone, OUAT, Bhubaneswar, Odisha during *Kharif* seasons of 2013, 2014 and 2015 to find out the most effective molecule among different individual insecticides and pre mixed insecticides against major insect pests of rice variety Pratikshya. The field experiment comprising of eleven treatments and three replications in randomized block design. The treatments imposed are profenophos 50EC @1000ml ha^{-1}, cypermethrin 10EC @500ml ha^{-1}, flubendiamide 39.35EC @125ml ha^{-1}, thiacloprid 240SC @625ml ha^{-1}, imidacloprid 30.5SC @150ml ha^{-1}, profenophos 40% + cypermethrin 4% @440ml ha^{-1}, ethiprole 40% + imidacloprid 40% @125g ha^{-1}, flubendiamide 240SC +

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thiacloprid 240SC @300ml ha^{-1}, fipronil 0.3%G @20kg ha^{-1}, monocrotophos 36EC @750ml ha^{-1} and untreated control for comparison. Standard agronomic practices were followed uniformly in all the treatment plots. Two round applications of scheduled insecticides were applied at active tillering stage and panicle initiation stage in the respective treatments. Two sprays done after insect pests reached ETL.

The percentage dead heart (DH) at early stage and white ear head (WEH) at grain filling stage caused by yellow stem borer from 10 randomly selected hills were counted. The percent incidence dead heart and white ear head was calculated as follows.

Percent incidence (dead heart (DH)/ white ear head (WEH)) = {[Number of dead heart (DH)/ white ear head (WEH)]/ (Total number of tillers panicle^{-1})} X 100

The numbers of silver shoots caused by gall midge were counted from 10 randomly selected hills. The percent incidence was calculated as follows.

Percent incidence (silver shoot) = (Number of silver shoot/ Total number of tillers) X 100

The damaged leaves and total leaves from 10 randomly selected hills were observed in each plot. The percentage of leaf damage by leaffolders was calculated as follows.

Percent incidence of leaf damage by leaffolders (LF) = {(Number of damaged leaves/ Total number of leaves)} X 100

Brown plant hoppers were counted from ten numbers of randomly selected hills and the populations per hill were calculated.

All the observations were taken at 3 days, 5 days and 7 days after each spray and the mean incidence was calculated for each treatment plot. Again the average of three replications was calculated. Pre application observation? Pre application observations recorded insect population above the economic threshold level.

Economic analysis

Cost of cultivation

The total cost of cultivation of paddy crop was calculated by computing cost on material inputs and labour charges for carrying out different agronomic operations which are same for all the treatments. The cost of plant protection measures were calculated separately for all the treatments. The total cost of cultivation was calculated for each treatment by adding the individual plant protection cost with the fixed agronomic cost.

Gross returns were calculated by multiplying the grain yield with price realized.

Net return was obtained by calculating the difference between gross return and total cost of cultivation for each treatment. Net return over control was calculated by substituting the net return of the untreated control from that of the individual treatments.

Benefit Cost Ratio (B: C) or Returns per rupee of investment was calculated by dividing the gross return by total cost of cultivation.

RESULTS AND DISCUSSION

The results revealed that all the treatments have significant insecticidal activity. Stem borer has affected the crop both at tillering and panicle initiation stage during all the three seasons. At tillering stage the per cent dead heart (%DH) ranged from 2.38 to 7.50 per cent and at maturity stage percent white ear head (%WEH) was noticed to be lowest (6.07%) in flubendiamide 240SC + thiacloprid 240SC @300ml ha^{1} compared to 12.42 to 20.28 per cent dead heart (DH) and 17.99 per cent white ear head (WEH) in untreated control plot (Table 1). Gall midge incidence was found only during the *Kharif*, 2013 and 2014. Upto 15.53 per cent silver shoot (SS) was found in untreated control. Flubendiamide 240SC + thiacloprid 240SC @300ml ha^{-1} could suppress the infestation to 1.61 per cent silver shoot during both the seasons (Table 2) with highest reduction over control (86.39%) (Fig 1). Leaffolder incidence was negligible during 2013 and 2014 *Kharif* seasons and found upto 16.50% leaf damage in *Kharif* 2015. Monocrotophos 36EC @750ml ha^{-1} was found to be most efficient having 57.57 per cent reduction of leaffolder incidence over control followed by flubendiamide 240SC + thiacloprid 240SC @300ml ha^{-1} with 48.48 per cent reduction over control (Fig 1). Brown plant hopper incidence was only marked during *Kharif*, 2013 and 2014 ranged from 6.24 to 9.82 numbers hill^{-1} in untreated control (Table 2). Highest percent reduction of brown plant hopper (BPH) population over control (91.15%) was found in flubendiamide240SC + thiacloprid 240SC @300ml ha^{-1} (Fig 1).

From the results it can be visualised that apart from the successful management of all the major insect pests infested the rice crop during the experimental seasons the yield achivement was also highest (53.40q ha^{-1}) with the pre mixed insecticides flubendiamide 240SC + thiacloprid 240SC @300ml ha^{-1} among all other treatments (Table 1). The yield performance were also promising in other can mixtures *i.e.* profenophos 40% + cypermethrin 4% @440ml ha^{-1} (45.45q ha^{-1}), ethiprole 40% + imidacloprid 40% @125g ha^{-1} (48.58q ha^{-1}). Fig 2 revealed that the yield improvement over control in

Table 1: Insecticidal effect on infestation of dead heart (DH), white ear head (WEH) and yield (q ha^{-1}).

Treatment details	Dose (g or ml ha^{-1})	Percentage of DH				Percentage of WEH				Yield (q ha^{-1})			
		2013	2014	2015	Mean	2013	2014	2015	Mean	2013	2014	2015	Mean
1. Profenophos 50EC	1000ml	9.52 (3.16)	13.21 (3.70)	12.0 (3.53)	11.57	19.17 (4.44)	8.26 (2.96)	11.0 (3.39)	12.81	26.25	45.12	48.46	39.94
2. Cypermethrin 10EC	500ml	10.51 (3.32)	13.28 (3.71)	14.5 (3.87)	12.76	20.06 (4.54)	10.24 (3.28)	13.2 (3.70)	14.5	25.72	42.14	45.00	37.62
3. Flubendiamide 39.35EC	125ml	7.42 (2.81)	13.61 (3.75)	8.00 (2.91)	9.67	16.67 (4.14)	9.28 (3.13)	7.10 (2.76)	11.01	28.24	41.44	53.75	41.14
4. Thiacloprid 240SC	625ml	9.11 (3.01)	12.39 (3.59)	14.8 (3.91)	12.10	17.24 (4.21)	9.18 (3.11)	13.4 (3.73)	13.27	27.91	44.21	44.58	38.90
5. Imidacloprid 30.5SC	150ml	6.56 (2.65)	12.32 (3.57)	15.00 (3.93)	11.29	15.89 (4.05)	8.23 (2.95)	13.50 (3.74)	12.54	29.01	48.58	50.75	42.78
6. Profenophos 40% + Cypermethrin 4%	440ml	5.51 (2.45)	6.86 (2.71)	12.80 (3.65)	8.39	13.88 (3.79)	6.58 (2.66)	11.20 (3.42)	10.55	36.50	52.36	47.50	45.45
7. Ethiprole 40% + Imidacloprid 40%	125g	3.38 (1.97)	6.52 (2.64)	9.50 (3.16)	6.46	12.12 (3.55)	6.13 (2.57)	7.50 (2.83)	8.58	35.50	56.49	53.75	48.58
8. Flubendiamide240SC + Thiacloprid 240SC	300ml	2.38 (1.69)	5.24 (2.39)	7.50 (2.82)	5.04	8.13 (2.93)	3.28 (1.94)	6.80 (2.70)	6.07	44.46	60.34	55.41	53.40
9. Fipronil 0.3%G	20kg	3.36 (1.96)	6.41 (2.63)	5.00 (2.35)	4.92	10.90 (3.37)	4.69 (2.28)	4.80 (2.30)	6.79	39.67	59.77	54.19	50.00
10. Monocrotophos 36EC	750ml	4.15 (2.15)	8.80 (3.05)	7.00 (2.74)	6.65	15.23 (3.97)	7.59 (2.84)	6.00 (2.55)	9.60	30.20	51.26	52.50	44.65
11. Untreated check		12.42 (3.59)	20.28 (4.56)	19.90 (4.51)	17.53	21.85 (4.73)	16.62 (4.14)	15.5 (4.00)	17.99	22.02	37.40	41.43	33.62
LSD (0.05)		**0.14**	**0.29**	**0.21**		**0.22**	**1.23**	**0.11**		**1.79**	**1.67**	**2.13**	

Figures in parenthes are X+0.5 square root transformed values.

Table 2: Insecticidal effect on infestation of leaffolder (LF), silver shoot (SS) and population of brown plant hopper (BPH).

	Treatment details	Dose	Percentage of LF	Percentage of SS			Population (No. hill^{-1}) of BPH		
		(g or ml ha^{-1})	2015	2013	2014	Mean	2013	2014	Mean
1.	Profenophos 50EC	1000ml	11.4 (3.45)	7.52 (2.83)	3.00 (1.87)	5.26	3.10 (1.89)	2.03 (1.59)	2.57
2.	Cypermethrin 10EC	500ml	10.50 (3.31)	8.90 (3.07)	4.45 (2.23)	6.67	3.35 (1.96)	3.07 (1.89)	3.21
3.	Flubendiamide 39.35EC	125ml	11.50 (3.46)	6.12 (2.57)	3.43 (1.98)	4.78	3.33 (1.96)	3.18 (1.92)	3.26
4.	Thiacloprid 240SC	625ml	12.00 (3.54)	6.34 (2.61)	4.11 (2.15)	5.23	3.15 (1.91)	3.53 (2.01)	3.34
5.	Imidacloprid 30.5SC	150ml	12.50 (3.61)	5.88 (2.52)	3.54 (2.01)	4.71	2.71 (1.79)	2.74 (1.80)	2.73
6.	Profenophos 40% + Cypermethrin 4%	440ml	11.20 (3.42)	5.41 (2.43)	2.57 (1.75)	3.99	4.23 (2.18)	2.96 (1.86)	3.60
7.	Ethiprole 40% + Imidacloprid 40%	125g	12.40 (3.59)	4.45 (2.22)	2.15 (1.63)	3.30	1.86 (1.53)	2.56 (1.75)	2.21
8.	Flubendiamide240SC + Thiacloprid 240SC	300ml	8.50 (3.00)	3.22 (1.93)	0.00 (0.71)	1.61	0.72 (1.07)	0.70 (1.06)	0.71
9.	Fipronil 0.3%G	20kg	10.20 (3.27)	3.54 (2.01)	2.80 (1.82)	3.17	1.10 (1.26)	0.72 (1.07)	0.91
10.	Monocrotophos 36EC	750ml	7.00 (2.74)	5.76 (2.50)	3.23 (1.93)	4.50	1.67 (1.46)	1.93 (1.56)	1.80
11.	Untreated check		16.50 (4.12)	15.53 (4.01)	8.13 (2.94)	11.83	9.82 (3.21)	6.24 (1.72)	8.03
	LSD (0.05)		**0.23**	**0.17**	**0.06**		**0.27**	**0.81**	

Figures in parenthes are X+0.5 square root transformed values.

Table 3: Economic analysis of some insecticides and their can mixtures against major insect pests of rice

Treatment details	Dose(g or ml ha^{-1})	Cost of pesticideha^{-1} (Rs)	Gross cost ha^{-1} (Rs)	Gross return ha^{-}(@ Rs1400/q)	Net return ha^{-}(Rs)	Net profit over control ha^{-1}(Rs.)	B : C ratio
1. Profenophos 50EC	1000ml	1,400	46,400	55,916	9,516	7,448	1.20
2. Cypermethrin 10EC	500ml	600	45,600	52,668	7,068	5,000	1.16
3. Flubendiamide 39.35EC	125ml	4,750	49,750	57,596	11,996	5,778	1.16
4. Thiacloprid 240SC	625ml	876	45,876	54,460	8,584	6,516	1.19
5. Imidacloprid 30.5SC	150ml	1,380	46,380	59,892	13,512	11,444	1.29
6. Profenophos 40% + Cypermethrin 4%	440ml	2,376	47,376	63,630	16,254	14,186	1.34
7. Ethiprole 40% + Imidacloprid 40%	125g	2,800	47,800	67,200	19,400	17,332	1.40
8. Flubendiamide240SC + Thiacloprid 240SC	300ml	7,200	52,200	74,760	22,560	20,492	1.43
9. Fipronil 0.3%G	20kg	4,000	49,000	70,000	21,000	18,932	1.42
10. Monocrotophos 36EC	750ml	900	45,900	62,510	16,610	14,542	1.36
11. Untreated check		Nil	45,000	47,068	2,068		1.05

the can mixture of insecticides were better than the individual insecticides. Data presented in table 3 showed that the most cost efficient insecticidal treatment found in the experiment was flubendiamide 240SC + thiacloprid 240SC @300ml ha^{-1} which achieved net return over control of Rs20,492 ha^{-1} with 1.43 benefit cost ratio compared to Rs5,778 ha^{-1} in flubendiamide 39.35EC @125ml ha^{-1} and Rs6,516 ha^{-1} in thiacloprid 240SC @625ml ha^{-1}. The second best economical treatment was found to be ethiprole 40% + imidacloprid 40% @ 125g ha^{-1} had net return of Rs17,332 ha^{-1} and 1.40 benefit cost ratio.

From the present experiment this has been observed that flubendiamide 240SC + thiacloprid 240SC @300 ml ha^{-1} performed best among all other insecticides in management of major insect pests of rice. This can mixture constitutes of two insecticides such as flubendiamide 240SC and thiacloprid 240SC which have different mode of action. Flubendiamide, a phthalic acid diamide protects the plants against a broad range of economically important lepidopterus pests. This acts as a Ryanodine Receptor disruptor of cellular calcium movement, important for muscle contractions. It causes lethargy, paralysis, rapid feeding cessation and death. Kuladod *et al*. (2011) opined that flubendiamide proved to be highly effective against leaf folder and was at par with spinosad, indoxacarb and fipronil. Devi *et al.* (2016) reported that 'Flubendiamide 39.35SC afforded more effective control of YSB'. Thiacloprid a second generation neonicotinoid is effective against the sucking insects (Sharma *et al*., 2013). This belongs to chloronicotinyl group and it acts as an antagonist on the post synaptic nicotinic acetylcholine receptors of motor neurons in insects, causes an over stimulation of the nervous system and ultimately kill the insect. Combination of two mode of chemistry gives dual action against insect pests causes muscular dysfunction and nervous system dysfunction.

Some research experiments also results that flubendiamide 240SC + thiacloprid 240SC perform better in other crops like cotton, tomato and chilli. Kumar *et al*. (2010) tested different concentrations of flubendiamide + thiacloprid 480SC for the management of bollworms and sucking pests of cotton under field condition during 2006-08 among which flubendiamide + thiacloprid 480SC @120g a.i ha^{-1} showed significantly lower bollworm damage and population of bollworms, aphids, whitefly and leaf hopper compared to standard checks spinosad 45SC + imidacloprid 200SL @90+30 g a.i. ha^{-1} and indoxacarb 14.5SC + imidacloprid 200SL @75+30 g a.i. ha^{-1}. From Horticulture Research Station, Devihospur, Havari, Karnataka, Tatagar *et al.* (2014) reported that the bioefficacy of flubendiamide 24% + thiacloprid 24%-48%SC @48 + 48g a.i ha^{-1} recorded

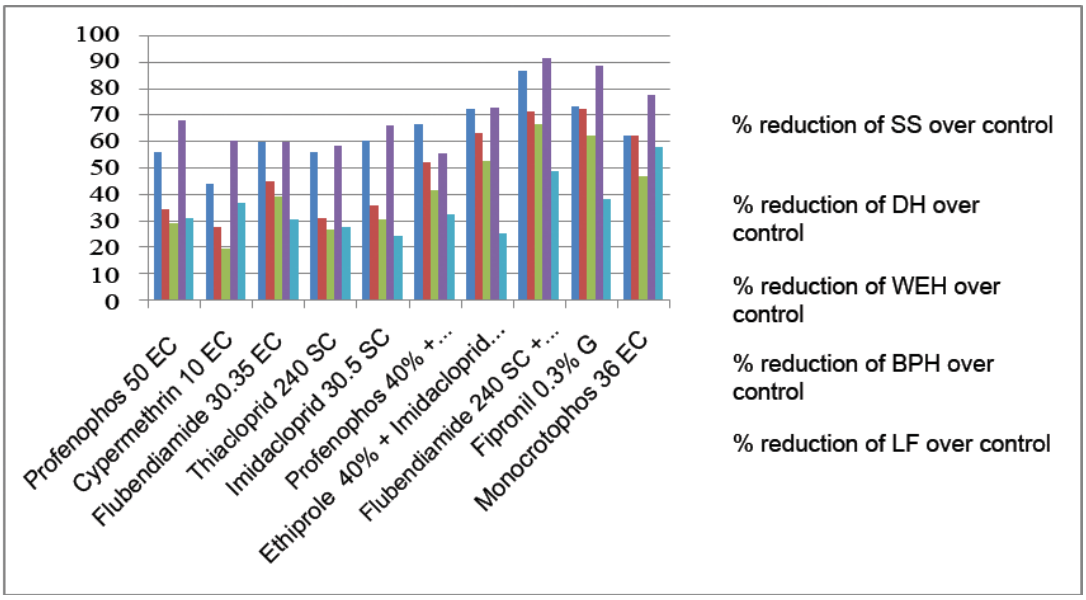

Fig. 1: **Graphical representation of percent reduction over control by different insecticidal treatments**

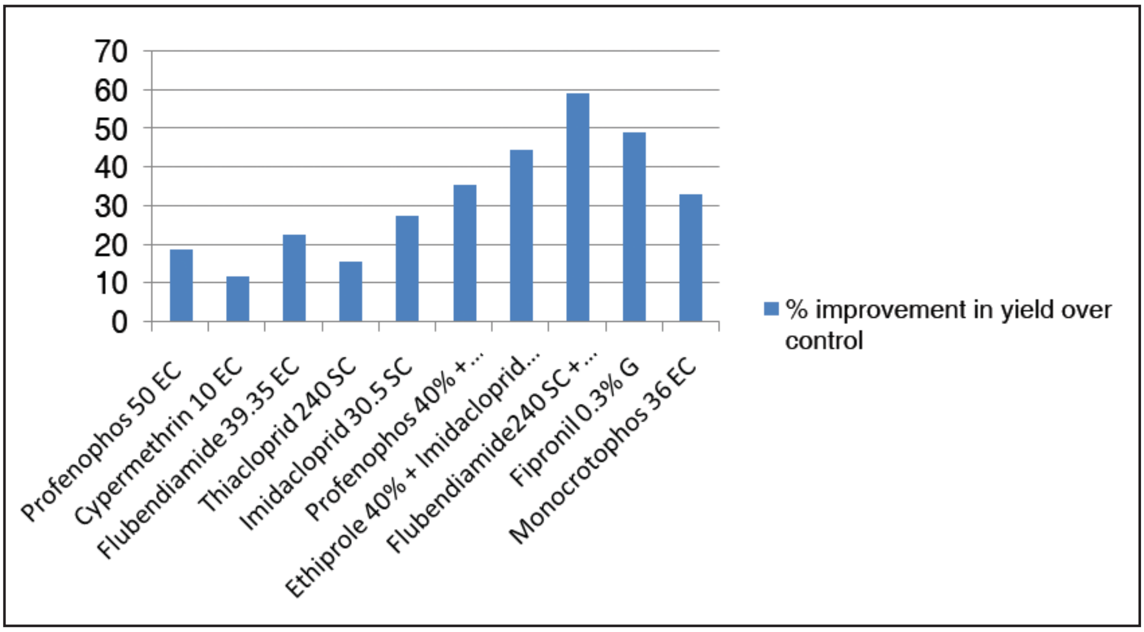

Fig. 2: **Graphical representation of percent improvement in yield over control by different insecticidal treatments**.

least number of thrips and leaf curl damage in chilli among different dosages tested. In tomato crop flubendiamide + thiacloprid 480SC @96g a.i.ha^{-1} showed significantly lower fruit damage and population of fruit borer larva, aphids, white fly and leaf hopper compared to standard checks spinosad 45SC + imidacloprid 200SL @90+30g a.i ha^{-1} and indoxacarb 14.5SC + imidacloprid 200SL @75+30g a.i.ha^{-1} (Vinothkumar *et al*., 2010). The combination effect is better than the individual effect of insecticides or biopesticides has been proved by the other scientists in rice. Shakir *et al*. (2015) conducted his experiment on effectiveness of *Beauveria bassiana*, imidacloprid and potassium silicate both individually and in combination against rice leaf folder and concluded that the combination of *Beauveria bassiana* + imidacloprid +

potassium silicate had achieved maximum mortality (61.91%).

Residual effect of this can mixture had been studied in detail. The foliar application of the combination product flubendiamide 24% + thiacloprid 24%- 480SC @ 48+48 g a.i. ha^{-1} at 10 days interval did not pose any residue problem in tomato when harvested at 3 days after the last spray (Shah *et al*., 2011). Cotton plants sprayed with flubendiamide + thiacloprid 480SC each at 120, 240 and 480 g a.i.ha^{-1} doses did not show any phytotoxic symptoms like epinasty, hyponasty, leaf injury, wilting, vein clearing and necrosis (Kumar *et al*., 2010). Flubendiamide and thiacloprid residues were observed to dissipate below their determination limit of 0.01 mg kg^{-1} after 3 and 5 days, respectively, when applied @ 48 g a.i. ha^{-1} and soil samples collected after 15 days did not show the presence of flubendiamide, desiodo flubendiamide, and thiacloprid at their determination limit of 0.01 mg kg^{-1} and a waiting period of 5 days is recommended for safe consumption of tomato fruit after application of combination formulation of flubendiamide 24% + thiacloprid 24% (480SC) @200g ha^{-1} (www.researchgate.net). Flubendiamide residues behaved in almost identical manner when applied alone or in combination with thiacloprid (Sharma *et al*., 2011).

From this experiment it can be concluded that the pre mixed of insecticides flubendiamide 240SC + thiacloprid 240SC has been proved to have adequate capacity for management of insect pests with different mode of action, comparatively ecnomic and posses least adverse effect on environment. So this pre mixed of insecticides flubendiamide 240SC + thiacloprid 240SC @300ml ha^{-1} can be included in sustainable rice insect pest management strategy.

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