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Evaluation of newer insecticides against rice leaf folder *Cnaphalocrocis medinalis* Guenee (Pyralidae: Lepidoptera)

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ABSTRACT

The field trials were experimented in rice variety Naveen during Kharif season of 2019 and 2020 at the rice research farm of College of Agriculture, Birsa Agricultural University, Kanke, Ranchi to investigate the efficacy of new molecules of insecticides against leaf folder. Nowadays evaluation of newer molecules of insecticides is very much essential for recommendation against insect pests to the farmers because so many widely used insecticides were restricted and prohibited for agricultural use in India. Three new combi products (Flubendamide 240 SC + thiacloprid 240 SC, spinetoram 6 SC + methoxyfenizide 30 SC, indoxacarb 14.5 SC + novaluron 7.7 SC with two different doses and one new molecule (flubendiamide 480 SC) with two different doses, one chemical control (cartap hydrochloride) and untreated control have been selected for this experiment. Novaluron 5.25 % SC + indoxacarb 4.5 SC @ 750 ml ha $^{-1}$ recorded 1.15, 1.33 and 1.24 per cent leaf damage caused by leaf folder which was significantly superior over all treatments in the overall mean of both the years 2019, 2020 and pooled mean respectively, which is on par with novaluron 5.25 % SC +indoxacarb 4.5 SC @ 500 ml ha $^{-1}$ (1.54, 1.66 and 1.60 % LDLF) but it is not performed better than flubendamide 240 SC + thiacloprid 240 SC @ 220 ml ha $^{-1}$ (1.98, 2.30 and 2.14 % LDLF).Highest yield i.e. 50.58 q ha^{-1} recorded in novaluron 5.25 % SC +indoxacarb 4.5 SC @ 750 ml ha^{-1}. Benefit cost analysis of the crop indicated that maximum net profit of Rs. 24,213/- obtained with the application of novaluron 5.25 % SC +indoxacarb 4.5 SC @ 750 ml ha^{-1} with highest benefit cost ratio i.e. 3.21:1.

***Keywords*:** Leaf folder, novaluron 5.25 % SC + indoxacarb 4.5 SC, *oryza sativa,* plethora, rice

Rice (*Oryza sativa* L., 2n = 24) belongs to the genus *Oryza* under tribe *Oryzeae* in grass family Gramineae or Poaceae and is originated in Indo-Burma Region. *Oryza sativa* L. is distributed all over the world with a high concentration in Asia. Rice is the staple food for over half of the world's population. It holds the key to our country's ability to produce enough food for our people. It is primarily high energy or high calorific food. India is the leading country in terms of area of rice production in the world followed by China and Indonesia (Sunda, 2013). Rice is the major staple food crop of Jharkhand. It is grown in the state in around 18 lakh hectares (Prasad *et al.*, 2018).Out of one dozen insect pests species prevailing in rice – agro- ecosystem in the state of Jharkhand, half of a dozen of them are considered as major insect pests which are responsible for causing loss in yield ranging from 20-35 percent in general (Prasad *et al.,* 2006 and Krishnaiah *et al.*, 2008).Insect pest fauna causes yield loss of about 20-30% (Dhaliwal and Arora, 1996). *Cnaphalocrocis medinalis* (Pyralidae: Lepidoptera) is the most widespread and important species of leaf folder (Bhatti 1995). Since the mid-1960s the rice leaf folder has increased in abundance in intensified rice growing areas of Asia and now considered as important pest (Dale 1994). The larvae of insect fold leaves longitudinally and remain inside the folded leaves and scrap the green tissue resulting drying and whitening of the affected leaves. During severe infestation the whole field appear as scorched. Each larva is capable of destroying several leaves. It causes 11.18 per cent of yield losses (Shanmungam *et al*., 2006) but sever infestation may lead 60-70% leaf damage (Kushawaha and Singh, 1984) and 30-80 % reduction in yield under epidemic situation (Kaushik 2010 and Gangwar, 2015). Generally, the yield loss caused by leaf folder was about 5 to 25 per cent (Kulgagod *et al*., 2011). Nowadays evaluation of newer molecules of insecticides is very much essential for recommendation against insect pests to the farmers because many common insecticides were banned and prohibited for use, import, manufacture, sale, transport and distribution. Therefore, three new combi products have been selected for this experiment. Babu *et al.* (2018) were reported that chlorantraniliprole showed significant maximum larval mortality of tobacco caterpillar, *Spodoptera litura* (F.) (lepidopteran pest) in soybean, achieving a cumulative value of 79.29–84.77%. Indoxacarb showed a cumulative efficacy of 70.53-72.22%. Emamectin benzoate and novaluron+ indoxacarb demonstrated more than 50% efficacy and recorded a cumulative efficacy of 56.72–56.58% and 55.92–58.62% in emamectin benzoate and novaluron+ indoxacarb, respectively whereas, novaluron showed the cumulative efficacy of 46.23-49.96%. Floret and

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Regupathy (2019 a) reported that field efficacy of chlorantraniliprole 9.3 w/w + lambdacyhalothrin 4.6 w/w 150 ZC, chlorantraniliprole 18.5 SC, lambda-cyhalothrin 4.9 CS, novaluron 5.25SC + indoxacarb 4.5% SC in sequential application to tomato crop against leaf eating caterpillar is reported. Two sequential applications of each insecticide at 30 days interval were shown better result in single application. Floret and Regupathy (2019 b) recorded that on the basis of reduction in insect population over control on 7th day after spray, the order of efficacy against *L. trifolii* was chlorantraniliprole 9.3 w/w + lambdacyhalothrin 4.6 w/w 150 ZC > novaluron 5.25 SC + indoxacarb 4.5 SC >chlorantraniliprole 18.5 SC >lambdacyhalothrin 4.9 CS against tomato leaf miner (*Liriomyzatrifolii*) (lepidopteran insect).

MATERIALS AND METHODS

The field trials were experimented in rice var-Naveen during *Kharif* season of 2019 and 2020 at the rice research farm of College of Agriculture, Birsa Agricultural University, Kanke, Ranchi to investigate the efficacy of new molecules of insecticides against rice leaf folder. Field experiment was conducted in randomized block design (RBD) replicating thrice with a plot size of 5m x 4m and spacing of 20cm x15cm.Three new combi products (Flubendamide 240 SC + thiacloprid 240 SC, spinetoram 6 SC + methoxyfenizide 30 SC, indoxacarb 14.5 SC + novaluron 7.7 SC with two different doses and one new molecule (flubendiamide 480 SC) with two different doses, one chemical control (cartap hydrochloride) and untreated control have been selected for this experiment (Table-1). Date of sowing was 4th July and; date of transplanting was on 25th August and the crop was harvested on 28th December;in both the year.

Treatment application

Need based foliar sprays of the test insecticides has been made on the basis of ETL of the pest species at the different stages of the crop. Two foliar sprays were applied on need basis starting 1stspray at 25 DAT (days after transplanting) followed by 2ndspray at 55 DAT.

Observation recorded

Observations of leaf damage due to leaf folder (LDLF) were recorded at 4,7,10 and 14 DAA (days after application) of the 2nd round of foliar spray of the insecticides made at 55 DAT. Maximum infestation of leaf folder started from 50 DAT,; therefore,LDLF was not recorded after 1st spray.Shukla *et al*. (2008) studied for fifteen years on Raipur and found that peak activity of leaf folder infestation was observed during the month of October.

Statistical analysis of the experimented results

The data obtained from the aforesaid experiments in terms of pest incidence were compiled and tabulated in the form of mean values and their suitable transformations were made for appropriate statistical analysis for their proper interpretation and drawing the conclusions. Data recorded from different plots replication/entry wise in terms of Kg were converted into q $ha^{-1}$to calculate their mean values for appropriate statistical analysis for drawing the inferences. Duncan's multiple range test(DMRT) was done at 0.05 per cent probability for appropriate statistical analysis for drawing the inferences. Benefit cost ratio was also computed.

RESULTS AND DISCUSSION

After second round of insecticidal application at 55 DAT

The results recorded after 2nd round of insecticides application made at 55 DAT are shown in table- 2. Observations of leaf damage; due to leaf folder (LDLF) were recorded at4,7,10 and 14 DAA (days after application) of the 2nd round of foliar spray of the insecticides. The lowest level of leaf damage due to leaf folder at 4, 7, 10 and 14 DAA were recorded in the plots treated with novaluron 5.25 % SC +indoxacarb 4.5 SC @ 750 $mlha^{-1}$with 0.64 (0.75 % & 0.53 % LDLF in the year 2019 and 2020, respectively), 0.93 (0.83% & 1.03 % LDLF in the year 2019 and 2020, respectively), 1.17 (1.00% & 1.33 % LDLF in the year 2019 and 2020, respectively), and 2.21 (2.00% & 2.42 % LDLF in the year 2019 and 2020, respectively) per cent LDLF. However, it remained on par with foliar application with novaluron 5.25 % SC +indoxacarb 4.5%SC @ 500 $mlha^{-1}$with 1.00 (1.03% & 0.97 % LDLF in the year 2019 and 2020, respectively), 1.20 (1.13 % & 1.27 % LDLF in the year 2019 and 2020, respectively), 1.43 (1.33 % & 1.53 % LDLF in the year 2019 and 2020, respectively) and 2.77 (2.67 % & 2.87 % LDLF in the year 2019 and 2020, respectively) per cent LDLF but not better than flubendamide 240 SC + thiacloprid 240 SC @ 220 $mlha^{-1}$with 1.67 (1.57 % & 1.77 % LDLF in the year 2019 and 2020, respectively), 1.96 (1.80 % & 2.12 % LDLF in the year 2019 and 2020, respectively), 2.16 (1.98 %& 2.33 % LDLF in the year 2019 and 2020, respectively) and 2.76 (2.55 % & 2.97 % LDLF in the year 2019 and 2020, respectively) per cent LDLF. The highest level of mean leaf damage by leaf folder *i.e*., 8.68 %, 10.20 %, 12.94 % and 13.49 % LDLF at 4, 7, 10 and 14 DAA was found in case of the untreated plots.

Overall mean of all observations

Novaluron 5.25 % SC +indoxacarb 4.5 SC @ 750 ml/ ha recorded 1.15, 1.33 and 1.24 per cent leaf damage

Table1: Details of the test insecticide used to control leaf folder of rice

Tr. No.	Name of Insecticide		Available Formulation (% a.i.)	Required amount of formulated product (g or ml ha^{-1})	Chemical group	Mode of action
	Trade name	Common name				
T_1	Belt Expert	Flubendiamide 240 SC + thiacloprid 240 SC	480 SC	150 mlha^{-1}	Diamide + neonicotinoids	Ryanodine receptor modulators Nerve and muscle action + Nicotinic acetylcholine receptor (nAChR) competitive modulators Nerve action
T_2	Belt Expert	Flubendiamide 240 SC + thiacloprid 240 SC	480 SC	220 mlha^{-1}		
T_3	Fame	Flubendiamide 480 SC	48 SC	50 mlha^{-1}	Diamide	Ryanodine receptor modulators Nerve and muscle action
T_4	Fame	Flubendiamide 480 SC	48 SC	100 mlha^{-1}		
T_5	Intreprid™ edge	Spinetoram 6 SC + methoxyfenizide 30 SC	36 SC	300 mlha^{-1}	Spinosyns + Diacylhydrazines	Nicotinic acetylcholine receptor (nAChR) allosteric modulators – Site I Nerve action + Ecdysone receptor agonists Growth regulation
T_6	Intreprid™ edge	Spinetoram 6 SC + methoxyfenizide 30 SC	36 SC	400 mlha^{-1}		
T_7	Plethora	Novaluron 5.25 SC +Indoxacarb 4.5 SC	9.75 SC	500 mlha^{-1}	Benzoylureas + Oxadiazines	Inhibitors of chitin biosynthesis affecting CHS1 Growth regulation + Voltage-dependent sodium channel blockers Nerve action
T_8	Plethora	Novaluron 5.25 SC +Indoxacarb 4.5 SC	9.75 SC	750 mlha^{-1}		
T_9	Caldan	Cartap Hydrochloride	50 SP	1000gha^{-1}	Neristoxin analogue	Nicotinic acetylcholine receptor (nAChR) channel blockers Nerve action
T_{10}	Untreated Control		-	-	-	- -

caused by leaf folder which was significantly superior over all treatments in the overall mean of both the years 2019, 2020 and pooled mean respectively, which is on par with novaluron 5.25 % SC +indoxacarb 4.5 SC @ 500 ml/ ha (1.54, 1.66 and 1.60 % LDLF) but it is not performed better than flubendamide 240 SC + thiacloprid 240 SC @ 220 mlha^{-1}(1.98, 2.30 and 2.14 % LDLF). Whereas untreated control recorded highest percent of leaf damage caused by leaf folder (11.10, 11.56 and 11.33 % LDLF) followed by cartap hydrochloride @1000 g ha^{-1}(5.97, 6.28 and 6.12 % LDLF) for the year 2019, 2020 and their pooled mean.

This experimental finding is partially supported by finding of the bio-efficacy of thenovaluron 5.25 % SC +indoxacarb 4.5% SC against other insects in rice as well as different crops (because information regarding this insecticide against rice leaf folder is scarcely available in the literatures)like, Kumar *et al.* (2020) reported that the minimum infestation of the rice gall midge 5.52 per cent was recorded in the plot treated with novaluran + indoxacarb 5.25% SC+ 4.5% SC. Sasmal *et al.* (2018) revealed 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, 48.48 per cent infested leaves by leaffolder (LF) over untreated control. Vesalu *et al.* (2020) found that Indoxacarb 4.5

Table 2: Effect of new molecular insecticides (after 2nd spray at 55 DAT) on the incidence of leaf folder (*Cnaphalocrocis medinalis* Guenee) in terms of LDLF (%) infesting rice (Var. Naveen)

Treatment	LDLF % after 2nd spray														
	4 DAA			7DAA			10 DAA			14 DAA			Overall mean		
	2019	2020	Pooled Mean	2019	2020	Pooled Mean	2019	2020	Pooled Mean	2019	2020	Pooled Mean	2019	2020	Pooled Mean
T_1	2.20 (8.47)cd	2.53 (9.13)bc	2.37 (8.80)c	2.43 (8.93)cd	2.88 (9.76)cd	2.66 (9.34)c	2.50 (9.05)cd	2.97 (9.90)c	2.73 (9.48)bc	3.87 (11.32)c	4.00 (11.51)bc	3.93 (11.41) c	2.75 (9.51) cd	3.10 (10.12)cd	2.92 (9.81)c
T_2	1.57 (7.14)bc	1.77 (7.55)b	1.67 (7.34)b	1.80 (7.67)bc	2.12 (8.30)bc	1.96 (7.98)b	1.98 (8.05)bc	2.33 (8.74)bc	2.16 (8.39) b	2.55 (9.15) ab	2.97 (9.89)abc	2.76 (9.52) ab	1.98 (8.04)bc	2.30 (8.66)bc	2.14 (8.35)b
T_3	4.33 (12.00)fg	3.87 (11.29)de	4.10 (11.65)ef	4.87 (12.73)e	5.00 (12.88)f	4.93 (12.80)de	5.27 (13.25)ef	5.60 (13.65)d	5.43 (13.45) d	6.08 (14.25)d	6.22 (14.41) d	6.15 (14.33)de	5.14 (13.08)ef	5.17 (13.11)ef	5.15 (13.10)de
T_4	3.33 (10.49)ef	3.23 (10.34)cd	3.28 (10.42)de	4.43 (12.13)e	4.57 (12.29)ef	4.50 (12.21)d	4.50 (12.22)e	5.20 (13.13)d	4.85 (12.67)d	5.77 (13.87)d	6.00 (14.16)d	5.88 (14.02) d	4.51 (12.23) e	4.75 (12.56)e	4.63 (12.39)d
T_5	2.87 (9.71)de	2.97 (9.88)cd	2.92 (9.80)cd	3.00 (9.94)d	3.37 (10.52)de	3.18 (10.23)c	3.23 (10.32)d	3.33 (10.46)c	3.28 (10.39)c	4.25 (11.86)c	4.30 (11.91)c	4.28 (11.89) c	3.34 (10.49) d	3.49 (10.72)d	3.41 (10.60)c
T_6	2.53 (9.12)de	2.33 (8.76)bc	2.43 (8.94)c	2.77 (9.52)cd	2.87 (9.74)cd	2.82 (9.63)c	2.97 (9.88)cd	3.00 (9.96)c	2.98 (9.92)c	3.33 (10.49)bc	3.71 (11.09)bc	3.52 (10.79)bc	2.90 (9.77)cd	2.98 (9.92)cd	2.94 (9.84)c
T_7	1.03 (5.81)ab	0.97 (5.58)a	1.00 (5.69)a	1.13 (6.07)ab	1.27 (6.32)ab	1.20 (6.19)a	1.33 (6.58)ab	1.53 (6.95)ab	1.43 (6.76)a	2.67 (9.36)ab	2.87 (9.67)ab	2.77 (9.51)ab	1.54 (7.09)ab	1.66 (7.32)ab	1.60 (7.21)ab
T_8	0.75 (4.86)a	0.53 (4.07)a	0.64 (4.47)a	0.83 (5.10)a	1.03 (5.74)a	0.93 (5.42)a	1.00 (5.54)a	1.33 (6.61)a	1.17 (6.08)a	2.00 (8.05)a	2.42 (8.87)a	2.21 (8.46)a	1.15 (6.06)a	1.33 (6.57)a	1.24 (6.31)a
T_9	4.87 (12.73)g	5.03 (12.95)e	4.95 (12.84)f	5.57 (13.63)e	5.97 (14.13)f	5.77 (13.88)e	6.47 (14.72)f	6.77 (15.06)d	6.62 (14.89)e	6.97 (15.29)d	7.33 (15.69)d	7.15 (15.49)e	5.97 (14.12)f	6.28 (14.49)f	6.12 (14.31)e
T_{10}	8.33 (16.78)h	9.03 (17.49)f	8.68 (17.13)g	9.87 (18.29)f	10.53 (18.92)g	10.20 (18.61)f	12.87 (21.02)g	13.02 (21.14)e	12.94 (21.08)f	13.32 (21.40)e	13.67 (21.69)e	13.49 (21.54)f	11.10 (19.46)g	11.56 (19.87)g	11.33 (19.67)f
SEm (±)	**(0.57)**	**(0.59)**	**(0.38)**	**(0.62)**	**(0.71)**	**(0.42)**	**(0.67)**	**(0.64)**	**(0.42)**	**(0.63)**	**(0.68)**	**(0.42)**	**(0.58)**	**(0.60)**	**(0.38)**
LSD (0.05)	**(1.68)**	**(1.76)**	**(1.10)**	**(1.85)**	**(2.09)**	**(1.21)**	**(1.99)**	**(1.91)**	**(1.20)**	**(1.86)**	**(2.01)**	**(1.18)**	**(1.73)**	**(1.79)**	**(1.08)**
CV (%)	**(10.09)**	**(10.57)**	**(10.33)**	**(10.37)**	**(11.25)**	**(10.84)**	**(10.47)**	**(9.62)**	**(10.04)**	**(8.66)**	**(9.08)**	**(8.88)**	**(9.18)**	**(9.23)**	**(9.20)**

Note:T_1: Flubendiamide 19.92 + thiacloprid 19.92 SC @ 150 ml ha^{-1};T_2: Flubendiamide 19.92 + thiacloprid 19.92 SC @ 220 ml ha^{-1}; T_3: Flubendiamide 480 SC @ 50 ml ha^{-1}; T_4: Flubendiamide 480 SC @ 100 ml ha^{-1}; T_5: Spinetoram 5.66 + methoxyfenozide 30 SC@ 300 ml ha^{-1}; T_6: Spinetoram 5.66 + methoxyfenozide 28.30 SC@ 400 ml ha^{-1}; T_7: Novaluron 5.25 +Indoxacarb 4.5 SC@ 500 ml ha^{-1}; T_8: Novaluron 5.25 +Indoxacarb 4.5 SC@ 750 ml ha^{-1};T_9: Cartap Hydrochloride @ 1000g ha^{-1} and T_{10}: Untreated control; Figures under parentheses correspond to angular transformed values, DAA- days after application, LDLF-Leaf Damage due to leaf folder, Means followed by same letters did not differ significantly by DMRT (P=0.05)

Table 3: Effect of new moleculer insecticides on grain yield of rice (Var. Naveen)

Treatment	Yield (q/ha)			Additional yield over control (q/ ha)			Additional yield over control (%)			Additional loss in yield (%)		
	2019	2020	Pooled Mean	2019	2020	Pooled Mean	2019	2020	Pooled Mean	2019	2020	Pooled Mean
T_1	46.00 ^{ab}	45.33 ^{ab}	45.67^{abc}	11.17	12.33	11.75	32.06	37.37	34.64	24.28	27.21	25.73
T_2	47.83 ^{ab}	47.33 ^{ab}	47.58^{abc}	13.00	14.33	13.67	37.32	43.43	40.29	27.18	30.28	28.72
T_3	41.00 ^{b}	40.50^{bc}	40.75 ^{c}	6.17	7.50	6.83	17.70	22.73	20.15	15.04	18.52	16.77
T_4	45.33 ^{ab}	43.00 ^{ab}	44.17^{abc}	10.50	10.00	10.25	30.14	30.30	30.22	23.16	23.26	23.21
T_5	48.17 ^{a}	44.13 ^{ab}	46.15^{abc}	13.33	11.13	12.23	38.28	33.74	36.07	27.68	25.23	26.51
T_6	49.83 ^{a}	49.00 ^{ab}	49.42 ^{ab}	15.00	16.00	15.50	43.06	48.48	45.70	30.10	32.65	31.37
T_7	45.67 ^{ab}	44.67 ^{ab}	45.17^{abc}	10.83	11.67	11.25	31.10	35.35	33.17	23.72	26.12	24.91
T_8	51.00 ^{a}	50.17 ^{a}	50.58 ^{a}	16.83	17.17	17.00	48.33	52.02	50.12	32.58	34.22	33.39
T_9	44.07 ^{ab}	42.17 ^{ab}	43.12^{bc}	9.23	9.17	9.20	26.51	27.78	27.13	20.95	21.74	21.34
T_{10}	34.83 ^{c}	33.00 ^{c}	33.92 ^{d}	-	-	-	-	-	-	-	-	-
SEm (±)	**2.18**	**2.80**	**1.60**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CD (0.05)	**6.46**	**8.31**	**4.57**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CV (%)	**8.30**	**11.03**	**9.72**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Note:T_1: Flubendiamide 19.92 + thiacloprid 19.92 SC @ 150 ml ha^{-1};T_2: Flubendiamide 19.92 + thiacloprid 19.92 SC @ 220 ml ha$^{-1;}$ T_3: Flubendiamide 480 SC @ 50 ml ha$^{-1;}$ T_4: Flubendiamide 480 SC @ 100 ml ha$^{-1;}$ T_5: Spinetoram 5.66 + methoxyfenozide 28.30 SC@ 300 ml ha^{-1}; T_6: Spinetoram 5.6 + methoxyfenozide 28.30 SC@ 400 ml ha^{-1}; T_7: Novaluron 5.25 +Indoxacarb 4.5 SC@ 500 ml ha^{-1}; T_8: Novaluron 5.25 +Indoxacarb 4.5 SC@ 750 ml ha^{-1};T_9: Cartap Hydrochloride @ 1000g ha^{-1} and T_{10}: Untreated control

Table 4: Economics of new molecular insecticidal treatments used against leaf folder of rice (Var. Naveen)

Treatment	Additional yield over control (qha^{-1})			Money value of additional yield over control (Rs.)			Treatment cost	Net profit (Rs. ha^{-1})			Benefit Cost Ratio		
	2019	2020	Pooled Mean	2019	2020	Pooled Mean		2019	2020	Pooled Mean	2019	2020	Pooled Mean
T_1	11.17	12.33	11.75	23039	20859	21949	5788	15071	17251	16161	2.60	2.98	2.79
T_2	13.00	14.33	13.67	26775	24284	25529	6684	17600	20091	18845	2.63	3.01	2.82
T_3	6.17	7.50	6.83	14010	11519	12765	5323	6196	8687	7442	1.16	1.63	1.40
T_4	10.50	10.00	10.25	18680	19614	19147	6778	12836	11902	12369	1.89	1.76	1.82
T_5	13.33	11.13	12.23	20797	24907	22852	8368	16539	12429	14484	1.98	1.49	1.73
T_6	15.00	16.00	15.50	29888	28020	28954	9868	18152	20020	19086	1.84	2.03	1.93
T_7	10.83	11.67	11.25	21793	20237	21015	6318	13919	15475	14697	2.20	2.45	2.33
T_8	16.83	17.17	17.00	32067	31445	31756	7543	23902	24524	24213	3.17	3.25	3.21
T_9	9.23	9.17	9.20	17123	17248	17186	7008	10240	10115	10178	1.46	1.44	1.45
T_{10}	-	-	-	-	-	-	-	-	-	-	-	-	-

Note:*T_1: Flubendiamide 19.92 + thiacloprid 19.92 SC @ 150 ml ha^{-1};T_2: Flubendiamide 19.92 + thiacloprid 19.92 SC @ 220 ml ha^{-1}; T_3: Flubendiamide 480 SC @ 50 ml ha^{-1}; T_4: Flubendiamide 480 SC @ 100 ml ha^{-1}; T_5: Spinetoram 5.66 + methoxyfenozide 28.30 SC@ 300 ml ha^{-1}; T_6: Spinetoram 5.66 + methoxyfenozide 28.30 SC@ 400 ml ha^{-1}; T_7: Novaluron 5.25 +Indoxacarb 4.5 SC@ 500 ml ha^{-1}; T_8: Novaluron 5.25 +Indoxacarb 4.5 SC@ 750 ml ha^{-1};T_9: Cartap Hydrochloride @ 1000g ha^{-1} and T_{10}: Untreated control; 6 labour /spray / ha @ Rs. 314.00, Procurement price of rice @ Rs. 1868 / q, Price of insecticide (mentioned in Table-1), Sprayer hiring charge –Rs. 50,Misc. –Rs.50.*

+ Novaluron 5.25 SC were effective against *Marucavitrata* (lepidopteran pest) in pigeon pea.

Effect of newer molecules of insecticides on grain yield (q ha^{-1})

The yield of rice obtained from different treatments ranged from 50.58 q ha^{-1} to 32.92 q ha^{-1}(Table-3). Highest yield i.e. 50.58 q ha^{-1}(51.00qha^{-1}& 50.17 q ha^{-1}in the year 2019 and 2020, respectively) recorded in novaluron 5.25SC +indoxacarb 4.5 SC @ 750 ml ha^{-1}but found to be *at par* with yield of spinetoram 6 SC + methoxyfenizide 30 SC @ 400 ml ha^{-1}*i.e*. 49.42 q ha^{-1} (49.83q ha^{-1} & 49.00 q ha^{-1} in the year 2019 and 2020, respectively), flubendamide 240 SC + thiacloprid 240 SC @ 220 ml ha^{-1}*i.e*. 47.58 q ha^{-1}(47.83 q ha^{-1}& 47.33 q ha^{-1}in the year 2019 and 2020, respectively), spinetoram 6 % + methoxyfenizide 30 % @ 300 ml ha^{-1}with 46.15 q ha^{-1}(48.17 q ha^{-1}&44.13q ha^{-1}in the year 2019 and 2020, respectively), flubendamide 240 SC + thiacloprid 240 SC @ 150 ml ha^{-1}with 45.67 q ha^{-1} (46.00q ha^{-1}& 45.33q ha^{-1}in the year 2019 and 2020, respectively), novaluron5.25 SC +indoxacarb 4.5 SC @ 500 ml ha^{-1}*i.e*. 45.17 q ha^{-1} (45.67 q ha^{-1}& 44.67q ha^{-1}in the year 2019 and 2020, respectively) andflubendiamide 480 SC @ 100 ml ha^{-1}44.17 q ha^{-1} (45.33 q ha^{-1}& 43.00q ha^{-1}in the year 2019 and 2020, respectively),which in its turn at par with cartap hydrochloride @1000 g ha^{-1}with 43.12q ha^{-1} (44.07q ha^{-1}&42.17q ha^{-1}in the year 2019 and 2020, respectively) and flubendiamide 480 SC @50 mlha^{-1}with 40.75 q ha^{-1} (41.00q ha^{-1}&40.50 q ha^{-1}in the year 2019 and 2020, respectively). However, untreated control had the lowest i.e. 33.92 q ha^{-1} (34.83q ha^{-1}& 33.00 q ha^{-1}in the year 2019 and 2020, respectively) grain yield.

Benefit-Cost Ratio

The table on the cost of production, net return and benefit cost ratio with respect to the treatments have been presented in Table-4.

Additional yield over control varied from 6.83q ha^{-1}(6.17q ha^{-1}&7.50q ha^{-1}in the year 2019 and 2020, respectively) to 17.00q ha^{-1}(16.83q ha^{-1}&17.17q ha^{-1}in the year 2019 and 2020, respectively) in different treatments. The highestadditional yield over control (17.00q ha^{-1}) recorded in novaluron 5.25 SC +indoxacarb 4.5 SC @ 750 mlha^{-1}followed by spinetoram 6 SC + methoxyfenizide 30 SC @ 400 mlha^{-1}(15 .00q ha^{-1}, 16.00q ha^{-1}&15.50q ha^{-1}in 2019,2020 & pooled mean) and lowest (6.83q ha^{-1}) was recorded in flubendiamide 480 SC @50 mlha^{-1}. The total cost of protection involved in different treatments varied from Rs. 5323‘- to Rs.9868/-.

Benefit cost analysis of the crop indicated that maximum net profit of Rs. 24,213/- was obtained with the application of novaluron 5.25 % SC +indoxacarb 4.5 SC @ 750 ml ha^{-1}with highest benefit cost ratio *i.e*.3.21:1, followed by spinetoram 6 SC + methoxyfenizide 30 SC @ 400 ml ha^{-1}having maximum net profit of Rs. 19086 /- but B:C ratio was1.93:1. On the basis of merit, the next better treatment flubendamide 240 SC + thiacloprid 240 SC @ 150 ml ha^{-1} recorded maximum net profit of Rs.18845/- and second highest B:C ratio (2.82:1).

This finding remained almost similar to the findings of Sasmal *et al.* (2018) revealed that flubendiamide 240SC + thiacloprid 240SC @300ml ha^{-1}was most effective in management of major insect pests in rice. Highest average yield (53.40 q ha^{-1}) and net returnof 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.

Novaluron 5.25 SC +indoxacarb 4.5 SC @ 750 ml ha^{-1}recorded 1.15, 1.33 and 1.24per cent leaf damage caused by leaf folder which was significantly superior over all treatments in the overall mean of both the years 2019, 2020 and pooled mean respectively, which is on par with novaluron 5.25SC +indoxacarb 4.5 SC @ 500 ml ha^{-1}(1.54%, 1.66 % and 1.60 % LDLF). Highest yield *i.e*. 50.58 q ha^{-1}(51.00 q ha^{-1}& 50.17 q ha^{-1}in the year 2019 and 2020, respectively) recorded in novaluron 5.25 % SC +indoxacarb 4.5 SC @ 750 ml ha^{-1}.Benefit cost analysis of the crop indicated that maximum net profit of Rs. 24,213/- was obtained with the application of novaluron 5.25 % SC +indoxacarb 4.5 SC @ 750 ml ha^{-1}with highest benefit cost ratio *i.e*.3.21:1.

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REFERENCES

Babu, S. R., Dudwal, R. and Mahla, M. K. 2018. Field efficacy of newer insecticides against tobacco caterpillar, *Spodoptera litura* (F.) on soybean.*Indian J. Entomol.*,**80**(3): 912-917.

Bhatti, M.N. 1995. Rice leaf folder (*Cnaphalo crosismedinalis*). *Pak. Entomol.*, **17**: 126– 131.

Dale, D. 1994. Insect pests of rice plants, their biology and ecology. In*: Biology and Management of rice insects (Ed. Heinrichs E.A.). IRRI Wiley Eastern Ltd*. Pp. 363-485.

Dhaliwal, G.S. and Arora, R., 1996. An estimation of yield losses due to insect pests in Indian agriculture. *Indian J. Ecol.*, **23**(1):70-73.

Floret, V. M. and Regupathy, A. 2019 a. Bio-efficacy of Ampligo 150 ZC (chlorantraniliprole9.3%+ lambdacyhalothrin 4.6%) against leaf eating caterpillar in tomato (Lepidoptera: Noctuidae). *J. Entomol. Zool. Stud.*, **7**(1): 953-955.

Floret, V. M. and Regupathy, A. 2019 b. Bio-efficacy of Ampligo 150 ZC (chlorantraniliprole9.3%+ lambdacyhalothrin 4.6%) against leaf miner (*Liriomyzatrifolii*) in tomato (*Lycopersicum esculentum* mill.). *Plant Arch.*, **19**(1) :1038-1040.

Gangwar, RK. 2015. Life Cycle and Abundance of Rice Leaf Folder, *Cnaphalocrocismedinalis* (Guenee) - A Review. *J. Nat. Sci. Res.,* **5**(15): 20-25.

Kaushik, C. 2010. Extent of damage by leaf folder, *Cnaphalocrocismedinalis* (Guenee) in paddy cultivars at Raiganj, Uttar Dinajpur, West Bengal. *Curr. Biotica*, **4**: 365-367.

Krishnaiah, N.V., Lakshmi, V.J., Pasalu, I.C., Katti, G.R. and Padmavathi, C. 2008. *Insecticides in Rice IPM, past, present and future*, DRR, (ICAR) Rajendranagar, Hyderabad, Pp.146.

Kulgagod, S.D., Hegade, M., Nayak, G.V., Vastrad, A.S., Hugar, P.S. and Basavanagoud, K. 2011. Evaluation of insecticides and bio-rationales against yellow stem borer and leaf folder in rice crop. *Karnataka J. Agric. Sci.*, **24**(2): 244-246.

Kumar, V., Painkra, K. L., Painkra, G. P. and Bhagat, P. K. 2020. Efficacy of newer insecticides for management of rice gall midge (*Orseoliaoryzae* Wood-Mason) in rice crop. *J. Entomol. Zool. Stud.,***8**(5): 521-524.

Kushawaha, K.S., Singh, R. 1984. Leaf folder outbreak in Haryana. *Int. Rice Res. Newsletter*, **9**(6): 20.

Prasad, R. and Prasad, D. 2006. Account of insect pest problem in rice ecosystem in Ranchi. *Indian J. Entomol.*, **68** (3): 240-246.

Prasad, R., Soren, A., Hembrom, L. and Prasad, D. 2018. Status of prevailing insect pest fauna associated with transplanted rice in Jharkhand. *J. EcofriendlyAgri.*,**13**(1): 60-64.

Sasmal, A., Patro, B. and Sarangi, P. K. (2018). Bio-efficacy evaluation of some insecticides (solo and pre mixed) against major insect pests of rice.*J. Crop Weed*,**14**(1):238-244.

Shanmungam, T.R., Sendhil, R. and Thirumalvalavan, V.V. 2006. Quantification and prioritization of constrainst causing yield loss in rice (*Oryza sativa*) in India. *Agric. Trop. Subtrop.,***39**: 194-201.

Shukla, B.C., Phoply, D.J., Chandrakar, H.K., Gupta, R., Dubey, V.K., Yadu, Y.K., Rana, D.K., Sharma, S., Rana, N. and Gupta, A. (2008). ***In****: Souvenir of National Conference on Pest Management Strategies for Food Security*, IGKV, Raipur. Pp2-3.

Sunda, N. R. 2013. *A competitive Book of Agriculture*. Surahee Publications, Bobas, Jaipur-303338 (Rajasthan), pp 92.

Vesalu, K., Pankaj, N. and Hannah, K.A.2020. Efficacy of insecticides againstmajorinsect pests of pigeon pea in Nagaland. *J. Entomol. Zool. Stud.*, **8**(4): 91-96.