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Flubendiamide, a novel insecticide for management of lepidopteron defoliators in soybean

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ABSTRACT

Flubendiamide 20 WG, a benzenedicarboxamide compound with novel mode of action was evaluated against the major lepidopteron defoliators of soybean namely, *Chrysodeixis acuta* (Walker), *Diachrysia orichalcea* (Fabricius), *Gesonia gemma* Swinhoe, and *Spodoptera litura* (Fabricius) during 2010 and 2012 rainy seasons under the field conditions at Indore. Three application rates; 50, 60 and 120 g a.i. ha^{-1} of Flubendiamide 20 WG were tested in comparison to the conventional insecticides *viz.*, Endosulfan 35 EC @ 250g a.i. ha^{-1} (2010) and Triazophos 40 EC @ 320 g a.i. ha^{-1} (2012). The application rate of 60 g a.i. ha^{-1} of Flubendiamide 20 WG was found most effective with better incremental cost benefit ratio as compared to the check insecticides. It has provided significantly better protection to soybean crop from the lepidopteron defoliators up to 15 days after spraying.

Key words: Flubendiamide, Insects, Insecticides, Soybean.

In soybean [*Glycine max* (L.) Merril] crop production insect pests have been the major impediments in realizing the yield potential of the cultivars and are reported to cause yield losses up to the extent of 27 per cent (Sharma and Shukla, 1997). Lepidopteron defoliators namely, *Chrysodeixis acuta* (Walker), *Diachrysia orichalcea* (Fabricius), *Gesonia gemma* Swinhoe, and *Spodoptera litura* (Fabricius) are key pests in soybean across the major growing regions of the country. Due to the absence of resistant cultivars and other effective control tactics, chemical insecticides are heavily relied upon for the management of these herbivores. However, in the wake of widespread resistance and cross resistance to chemical insecticides (Kranthi *et al.*, 2002) the need for newer insecticides with novel chemistries and modes of action is increasingly felt. In this context, Flubendiamide, a new insecticide compound discovered by Nihon Nohyaku Company Limited in 1998 was evaluated against the major soybean defoliators in a field experiment and the results were presented in this communication. Flubendiamide, a benzenedicarboxamide insecticide a first in this class of chemistry acts by activating ryanodine-sensitive intracellular calcium release channels resulting in an uncontrolled release of calcium stores. In treated insects Flubendiamide causes symptoms similar to those by ryanodine such as gradual contraction of the insect body, and thickening and shortening without convulsions (Toshini *et al*., 2010). It is reported to be selective to lepidopteron caterpillars. The objectives of this experiment were to evaluate Flubendiamide 20 WG (Takumi®, Rallis India Limited, Bengaluru, India) against soybean lepidopteron defoliators, to arrive at its effective application rate, and to know the period of protection as compared to the conventional insecticides under field conditions.

Field trials were conducted at research farm of the Directorate of Soybean Research, Indore (Madhya Pradesh) during rainy seasons of the years 2010 and 2012 in a completely randomized block design with widely adopted soybean cultivar, JS 335. Soybean crop was raised with recommended full package of practices except the application of insecticides. There were five treatments consisting of Flubendiamide 20 WG at three application rates (50, 60, and 120 g a.i. ha^{-1}), and one check organochlorine insecticide, Endosulfan 35 EC @ 250 g a.i. ha^{-1} in the year 2010 and organophosphorous insecticide, Triazophos 40 EC @ 320 g a.i. ha^{-1} in the year 2012 and one untreated check. All the treatments were replicated thrice. Insecticides were applied as foliar spray using pneumatic knapsack sprayer delivering 500 l of spray solution per hectare when test insects populations reached economic threshold level.

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Number of green semiloopers (*C. acuta*, *D. orichalcea*, and *G. gemma*) and tobacco caterpillars (*S. litura*) per meter row length (mrl) of crop were recorded at three random points per replication at one DBT (day before treatment) and seven and fifteen DAT (days after treatment). Phytotoxicity to soybean plants due to the application of insecticides also was recorded on a scale of 0-9 in terms of leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty. Harvesting was done separately for each plot and the yield was recorded. Absolute and per cent counts were subjected to square root and arc sine transformations respectively. Data were subjected to two way ANOVA and treatment means were separated by Tukey's studentized range test (P=0.05) (SAS Institute, 2008).

In the year 2010 at 7 DAT Flubendiamide, irrespective of application rates was found significantly superior in suppressing the semiloopers population as compared to the untreated check (7.09 larvae/mrl) but not to Endosulfan (1.34 larvae/mrl) (Table 1). Though the lowest semiloopers population was observed in the treatment Flubendiamide @ 120 g a.i. ha^{-1} (0.08 larvae/mrl), the effect of different application rates of Flubendiamide was not significant. A similar trend was observed at 15 DAT also, except that effectiveness of all the three application rates of Flubendiamide (2.17, 1.08, and 1.09 larvae/mrl respectively) was significantly superior as compared to the untreated check (9.92 larvae/mrl) and Endosulfan (7.42 larvae/mrl), indicating a prolonged protection by Flubendiamide. In the year 2012 at both 7 and 15 DAT, irrespective of the application rates, Flubendiamide treatment resulted in significantly lower semiloopers population as compared to the untreated check as well as the check insecticide Triazophos (Table 2). At both 7 and 15 DAT the lowest semiloopers population was recorded in Flubendiamide @ 120 g a.i. ha^{-1} (1.17 and 0.00 larvae/mrl). But it was significantly not different from Flubendiamide @ 60 g a.i. ha^{-1} (2.58 and 0.17 larvae/mrl respectively).

With respect to tobacco caterpillar, in the year 2010 at both 7 DAT and 15 DAT, Flubendiamide @ 60g a.i. ha^{-1} resulted in the lowest population (0.08 and 1.50 larvae/mrl respectively) (Table 1). At 7 DAT Flubendiamide @ 60g a.i. ha^{-1} was significantly superior as compared only to the untreated check (1.42 larvae/mrl). However, at 15 DAT it was found significantly superior to Endosulfan also (0.42 larvae/mrl), once again indicating a prolonged period of protection. In the year 2012 application of Flubendiamide @ 120 g a.i. ha^{-1} resulted in the lowest tobacco caterpillar population both at 7 and 15 DAT (0.17 and 0.25 larvae per mrl respectively) (Table 2). At 7 DAT it was significantly superior to both the checks, Triazophos (2.83 larvae/mrl) and the untreated check (3.92 larvae/mrl) and at 15 DAT, to the untreated check (4.58 larvae/mrl) alone. The application of Flubendiamide 20 WG at any of the three tested application rates (50, 60, and 120 g a.i. ha^{-1}) did not cause any phytotoxicity symptoms in the soybean plants.

Soybean crop in the year 2010 was severely infected by a disease complex in Indore region resulting in poor grain yields (294 to 382 kg ha^{-1}) and the treatment effects were insignificant. Hence, grain yield data of the year 2010 was not considered to analyze the effect of insecticide application on soybean yield. In the year 2012, grain yield was significantly higher in all the treatments excepting the treatment Flubendiamide @ 50 g a.i. ha^{-1} (1987 kg ha^{-1}) as compared to the untreated check (1789 kg ha^{-1}) (Table 3). The maximum yield was recorded in Flubendiamide @ 120 g a.i. ha^{-1} (2077 kg ha^{-1}). With respect to percentage yield increase the highest increase was in Flubendiamide @120 g

TABLE 1. Efficacy of Flubendiamide 20 WG (Takumi®) against semiloopers and tobacco caterpillar in soybean in year 2010

Treatment	No. of semiloopers larvae per m row of crop			No. of tobacco caterpillar larvae per m crop row		
	1 DBT	7 DAT	15 DAT	1 DBT	7 DAT	15 DAT
Flubendiamide 20 WG	7.08 [a]	1.08 [b]	2.17 [b]	1.33 [a]	1.17 [ab]	3.08 [ab]
@50 g a.i. ha^{-1}	(2.75)	(1.26)	(1.62)	(1.35)	(1.28)	(1.89)
Flubendiamide 20 WG	6.92 [a]	0.25 [b]	1.08 [b]	1.25 [a]	0.08 [c]	1.50 [b]
@60 g a.i. ha^{-1}	(2.72)	(0.86)	(1.21)	(1.32)	(0.76)	(1.38)
Flubendiamide 20 WG	7.00 [a]	0.08 [b]	1.09 [b]	1.42 [a]	0.33 [bc]	1.84 [b]
@120 g a.i. ha^{-1}	(2.73)	(0.76)	(1.24)	(1.38)	(0.90)	(1.47)
Endosulfan 35 EC	7.00 [a]	1.34 [ab]	7.42 [a]	1.58 [a]	0.42 [bc]	4.00 [a]
@ 250 g a.i. ha^{-1}	(2.74)	(1.35)	(2.79)	(1.44)	(0.93)	(2.10)
Control	7.00 [a]	7.09 [a]	9.92 [a]	1.42 [a]	1.42 [a]	5.42 [a]
	(2.74)	(2.73)	(3.22)	(1.38)	(1.38)	(2.42)
F (*df* = 4, 15)P>F	0.02	9.24	33.93	0.45	9.15	6.50
(ANOVA)	0.9991	0.0006	<0.0001	0.7677	0.0006	0.0031

Figures in the parentheses are square root transformed values. Means within a column followed by the same alphabet are significantly not different (Tukey's studentized range test, P>0.05).

TABLE 2: Efficacy of Flubendiamide 20 WG (Takumi®) against semiloopers and tobacco caterpillar In soybean in year 2012

Treatment	No. of semiloopers larvae per m row of crop			No. of tobacco caterpillar larvae per m crop row		
	1 DBT	7 DAT	15 DAT	1 DBT	7 DAT	15 DAT
Flubendiamide 20 WG	22.17 [a]	4.17 [c]	1.75 [b]	2.83 [a]	1.08 [bc]	0.58 [b]
@50 g a.i. ha^{-1}	(4.75)	(2.14)	(1.47)	(1.80)	(1.19)	(1.01)
Flubendiamide 20 WG	22.08 [a]	2.58 [cd]	0.17 [c]	2.92 [a]	0.75 [bc]	0.42 [b]
@60 g a.i. ha^{-1}	(4.74)	(1.75)	(0.80)	(1.85)	(1.07)	(0.94)
Flubendiamide 20 WG	21.75 [a]	1.17 [d]	0.00 [c]	2.83 [a]	0.17 [c]	0.25 [b]
@120 g a.i. ha^{-1}	(4.71)	(1.26)	(0.71)	(1.82)	(0.80)	(0.85)
Triazophos 40% EC	21.58 [a]	9.17 [b]	2.42 [b]	3.08 [a]	2.83 [ab]	0.58 [b]
@320 g a.i. ha^{-1}	(4.70)	(3.10)	(1.68)	(1.89)	(1.81)	(1.03)
Control	21.83 [a]	36.92 [a]	39.17 [a]	3.00 [a]	3.92 [a]	4.58 [a]
	(4.72)	(6.10)	(6.29)	(1.87)	(2.08)	(2.23)
F (*df* = 4, 15)P>F	0.02	110.33	258.99	0.16	9.95	22.51
(ANOVA)	0.9993	<0.001	<0.0001	0.9555	0.0004	<0.0001

Figures in the parentheses are square root transformed values. Means within a column followed by the same alphabet are significantly not different (Tukey's studentized range test, P>0.05).

TABLE 3: **I**mpact of Flubendiamide 20 WG (Takumi®) on soybean yield and incremental cost benefit ratio in year 2012

Treatment	YieldKg ha^{-1}	Per cent Yield increase*	Incremental cost benefit ratio**
Flubendiamide 20 WG @50 g a.i. ha^{-1}	1987 [ab]	11.50 [a] (6.62)	3.11
Flubendiamide 20 WG @60 g a.i. ha^{-1}	2030 [a]	13.89 [a] (8.00)	3.15
Flubendiamide 20 WG @120 g a.i. ha^{-1}	2077 [a]	16.62 [a] (9.60)	1.88
Triazophos 40% EC @320 g a.i. ha^{-1}	2051 [a]	14.96 [a] (8.63)	19.44
Control	1789 [b]	0.00 [a](0.00)	-
F (*df* = 4, 15)	5.99	2.82	
P>F (ANOVA)	0.0044	0.0631	

Figures in the parentheses are angular transformed values. Means within a column followed by the same alphabet are significantly not different (Tukey's studentized range test, P>0.05). *over control **selling cost of soybean grain: Rs. 3000 per 100 kg, purchase cost of Flubendiamide 20 WG (Rallies India Ltd., Bengaluru) and Triazophos 40 EC(Excel crop care Ltd., Mumbai): Rs. 765 per 100g and Rs. 505 per 1000ml respectively.

a.i. ha^{-1} (16.62), but the treatment effects were not significant. However, incremental cost benefit ratio (ICBR) was highest in Triazophos (19.44) followed by the treatments Flubendiamide @ 60 g a.i. ha^{-1} (3.15), Flubendiamide @ 50 g a.i. ha^{-1} (3.11), and Flubendiamide @ 120 g a.i. ha^{-1} (1.88). High ICBR for Triazophos may be ascribed to its low cost price (Rs. 505 per l) as compared to that of Flubendiamide (Rs. 765 per 100 g).

These findings are in agreement with Tatagar *et al*. (2009) who reported that Flubendiamide 20 WG @ 60 g a.i. /ha was most effective in chilli against *S. litura* and *Helicoverpa armigera* resulting in highest yield with lowest fruit damage. Superior field efficacy of Flubendiamide was also reported against *H. armigera* in chickpea (Deshmukh *et al*., 2010), in tobacco (Shivanna *et al*., 2012), and in tomato (Ametha and Bunker, 2007); *H. armigera* and *Etiella zinkinella* in black gram (Ashok Kumar and Shivaraju, 2009); brinjal fruit and shoot borer (Jagginavar *et al*., 2009; Chakraborti and Sarkar, 2011); *Aproaerema modicella* in groundnut (Praveena *et al*., 2011); yellow stem borer and leaf folder (Kulagod *et al*., 2011); and whorl maggot (Sharma and Srivastava, 2009) in rice.

In conclusion, Flubendiamide 20 WG @ 60 g a.i. ha^{-1} was found most effective against the soybean semiloopers and tobacco caterpillar with better ICBR as compared to the conventional insecticides. Therefore, owing to its novel chemistry and mode of action and superior field performance Flubendiamide 20 WG could become an important insecticidal option in the integrated management of soybean semiloopers.

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