Studies on compatibility of biorational insecticides with fungicides against tobacco caterpillar, *Spodoptera litura* Fabricius on tobacco

B Sailaja Jayasekharan, U Sreedhar and G Raghupathi Rao

Division of Crop Protection, ICAR-Central Tobacco Research Institute, Rajahmundry- 533 105, Andhra Pradesh, India.
E mail: sailaja8489@gmail.com

Abstract

S*tudies were conducted to assess the physical, chemical and biological compatibility of new insecticides with fungicides against tobacco caterpillar,* Spodoptera litura Fabricius. *Emamectin benzoate 5 SG @ 0.0025 % in combination with copper oxy chloride 50 WP @ 0.2 % and azoxystrobin 23 SC @ 0.1 % recorded 100 and 96.43 % mortality within 48 hours after treatment. Spinosad 48 SC @ 0.012 % and its combination with test fungicides recorded less than 85 % mortality. Insect growth regulators, lufenuron 5.4 EC @ 0.006 % and novaluron 10 EC @ 0.01 % in combination with various fungicides also recorded reduced mortality. Hence, it is better to apply the insecticides and fungicides used in the study separately barring the combinations of emamectin benzoate 5 SG @ 0.0025 % with copper oxy chloride 50 WP @ 0.2 % and azoxystrobin 23 SC @ 0.1 % .*

Keywords: insecticides, emamectin benzoate, insect growth regulators, tobacco caterpillar, compatibility, fungicides

Introduction

Application of insecticide and fungicide mixtures has become a practice among the farmers of late to save time, labour and money. Any delay in the application of pesticides to control pests and diseases that occur simultaneously cause huge losses, especially in the case of commercial crops like tobacco. In recent times, broad spectrum pesticides were discontinued considering their toxicity to non-target organisms. However, pesticides or their combinations possessing both insecticidal and fungicidal properties, would help in reducing the pesticide consumption and pesticide load in the environment.

Compatibility of pesticides is the effectiveness of a combination with reference to its active component, i.e., whether it has maintained, reduced or potentiated its insecticidal activity. If the pesticide mixture is an unstable mixture or a soapy flocculate with layering or balling up or sediment formation, they are said to be physically incompatible. The p^H, chemical composition, length of time and even the temperature of water can affect physical compatibility. Heinrichs *et al*. (1981) stressed the necessity of ensuring the compatibility of insecticides with other pesticides before recommending them as a tank mix. Chemical incompatibility occurs when there is a loss or reduction of effectiveness of one or all components of the pesticide mixture. This may occur due to the deactivation of active ingredients. Phytotoxic or biological incompatibility occurs when two or more pesticides used in combination result in injury to the host plants.

The problem of tank-mixes has rarely been studied and it covers certain risks in the application. Therefore, information on effective and economical combinations need to be generated for preventing wasteful expenditure as well as crop loss. The present study aims at understanding the effect and efficacy of certain biorational insecticides in combination with commonly used fungicides in tobacco against the tobacco caterpillar, *S. litura.*

Materials and methods

The two groups of insecticides used against *S. litura*, microbial derivatives and insect growth regulators (IGRs) were applied at recommended dose *viz*., emamectin benzoate 5 SG @ 0.0025 %, spinosad 48 SC @ 0.012 %, novaluron 10 EC @ 0.01 % and lufenuron 5.4 EC @ 0.006 %. They were also tested in combination with fungicides *viz*., copper oxy chloride 50 WP @ 0.2 %, carbendazim 50 WP @ 0.03 %, pyraclostrobin + metiram 60 WG @ 0.2 %, metalaxyl + mancozeb 68 WP @ 0.2 %, fenamidon + mancozeb 60 WG @ 0.3 % and azoxystrobin 23 SC @ 0.1 %.

Table 1. Physical properties of insecticides and fungicides

Treatments	Colour	Solubility	pH (30 min)	pH (2 hr)	Other parameters
Emamectin benzoate 5 SG @ 0.0025 %	White	Readily Soluble	7.15	7.36	No clumps
Spinosad 48 SC @ 0.012 %	White	Readily Soluble	7.40	7.63	No clumps
Novaluron 10 EC @ 0.01 %	Colourless	Readily Soluble	7.08	7.29	No clumps
Lufenuron 5.4 EC @ 0.006 %	Colourless	Readily Soluble	6.90	7.22	No clumps
Copper Oxy Chloride 50 WP @ 0.2 %	Green	Suspends after vigorous stirring	7.21	7.31	Slight precipitate
Carbendazim 50 WP @ 0.03 %	White	Suspends after vigorous stirring	7.15	7.25	Slight precipitate
Pyraclostrobin + Metiram 60 WG @ 0.2 %	Brown	Readily soluble	7.20	7.26	No clumps
Metalaxyl + Mancozeb 68 WP @ 0.2 %	Yellow	Readily soluble	7.30	7.36	No clumps
Fenamidon + Mancozeb 60 WG @ 0.3 %	Yellow	Readily soluble	7.29	7.33	No clumps
Azoxystrobin 23 SC @ 0.1 %	White	Readily soluble	7.16	7.30	No clumps
Emamectin Benzoate 5 SG @ 0.0025 % + Copper Oxy Chloride 50 WP @ 0.2 %	Green	Readily soluble	7.31	7.43	No clumps
Emamectin Benzoate 5 SG @ 0.0025 % + Carbendazim 50 WP @ 0.03 5	White	Readily soluble	7.18	7.34	No clumps
Emamectin Benzoate 5 SG @ 0.0025 % + Pyraclostrobin + Metiram 60 WG @ 0.2 %	Brown	Readily soluble	7.28	7.47	No clumps
Emamectin Benzoate 5 SG @ 0.0025 % + Metalaxyl+Mancozeb 68 WP @ 0.2 %	Yellow	Readily soluble	7.27	7.39	No clumps
Emamectin Benzoate 5 SG @ 0.0025 % + Fenamidon + Mancozeb 60 WG @ 0.3 %	Yellow	Readily soluble	7.3	7.42	No clumps
Emamectin Benzoate 5 SG @ 0.0025 % + Azoxystrobin 23 SC @ 0.1 %	White	Readily soluble	7.28	7.52	No clumps
Spinosad 48 SC @ 0.012 % + Copper Oxy Chloride 50 WP @ 0.2 %	Green	Readily soluble	7.05	7.2	No clumps
Spinosad 48 SC @ 0.012 % + Carbendazim 50 WP @ 0.03 %	White	Readily soluble	7.08	7.18	No clumps
Spinosad 48 SC @ 0.012 % + Pyraclostrobin + Metiram 60 WG @ 0.2 %	Brown	Readily soluble	7.24	7.39	No clumps
Spinosad 48 SC @ 0.012 % + Metalaxyl + Mancozeb 68 WP @ 0.2 %	Yellow	Readily soluble	7.33	7.48	No clumps
Spinosad 48 SC @ 0.012 % + Fenamidon + Mancozeb 60 WG @ 0.3 %	Yellow	Readily soluble	7.32	7.5	No clumps
Spinosad 48 SC @ 0.012 % + Azoxystrobin 23 SC @ 0.1 %	White	Readily soluble	7.27	7.4	No clumps
Novaluron 10 EC @ 0.01 % + Copper oxy chloride 50 WP @ 0.2 %	Green	Readily soluble	6.91	7.12	No clumps
Novaluron 10 EC @ 0.01 % + Carbendazim 50 WP @ 0.03 %	White	Readily soluble	6.89	7.1	No clumps
Novaluron 10 EC @ 0.01 % + Pyraclostrobin + Metiram 60 WG @ 0.2 %	Brown	Readily soluble	6.91	7.09	No clumps
Novaluron 10 EC @ 0.01 % + Metalaxyl + Mancozeb 68 WP @ 0.2 %	Yellow	Readily soluble	6.99	7.13	No clumps
Novaluron 10 EC @ 0.01 % + Fenamidon + Mancozeb 60 WG @ 0.2 %	Yellow	Readily soluble	7.1	7.15	No clumps
Novaluron 10 EC @ 0.01 % + Azoxystrobin 23 SC @ 0.1 %	White	Readily soluble	7.09	7.11	No clumps
Lufenuron 5.4 EC @ 0.006 % + Copper oxy chloride 50 WP @ 0.2 %	Green	Readily soluble	7.57	7.69	No clumps
Lufenuron 5.4 EC @ 0.006 % + Carbendazim 50 WP @ 0.03 %	White	Readily soluble	7.72	7.89	No clumps
Lufenuron 5.4 EC @ 0.006 % + Pyraclostrobin + Metiram 60 WG @ 0.2 %	Brown	Readily soluble	7.90	8.38	No clumps
Lufenuron 5.4 EC @ 0.006 % + Metalaxyl + Mancozeb 68 WP @ 0.2 %	Yellow	Readily soluble	8.37	8.53	No clumps
Lufenuron 5.4 EC @ 0.006 % + Fenamidon + Mancozeb 60 WG @ 0.3 %	Yellow	Readily soluble	8.07	8.25	No clumps
Lufenuron 5.4 EC @ 0.006 % + Azoxystrobin 23 SC @ 0.1 %	White	Readily soluble	7.04	7.28	No clumps

Solution preparation and application

Insecticide and fungicide solutions were prepared at recommended dose and mixed just before treatment in equal proportions. The combined solutions were prepared following the order suggested by Sreedhar and Krishnamurthy (2007) i.e., wettable powder (WP) and dry flowable (DF) or water-dispersible granules (WDG) followed by emulsifiable concentrates (EC) and solution (S) or soluble powder (SP) products. Dry formulations were pre-slurried by mixing with little water before adding them to the spray fluid. Emulsifiers were not used in the study.

Jar compatibility test

This physical compatibility test was conducted prior to bioassays to observe changes in colour, wettability etc., as suggested by Marer (1988). The hydrogen potential (p^H) of the combination products was recorded with digital p^H meter after 0.5 and 2 hrs of solution preparation.

Phytotoxicity experiments

Replicated experiment was conducted with the combined solutions on tobacco plants. Observations were taken 1, 3, 7, 9, 11 and 14 days after the spray for symptoms or grades like leaf tip and surface injury, wilting, vein clearing, necrosis, epinasty and hyponasty. Per cent leaf injury due to a treatment was calculated by using the formula given after Suneel Kumar *et al.* (2016).

$$\text{Per cent leaf injury} = \frac{\text{Total Grade points}}{\text{Maximum grade} \times \text{No of leaves}} \times 100$$

Based on per cent leaf injury, phytotoxicity rating is given.

Phytotoxicity Rating	0	1	2	3	4	5	6	7	8	9	10
Per cent leaf injury	Nil	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100

Bioassay

The efficacy of the combined products and individual insecticides against tobacco caterpillar was quantified by leaf dip bioassay. Ten early third instar larvae of *S. litura* were released on the treated virginia tobacco leaves and maintained at room temperature. The mortality was recorded at 24 and 48 hours after the treatment (HAT) and also at 72 HAT in the case of insect growth regulators. Mortality data were converted to per cent values and corrected for control mortality as per Abbott (1925).

Table 2. Bioefficacy of insecticides and fungicides applied alone against *S. litura*

Treatment	Mortality %	
	24 HAT	48 HAT
Emamectin benzoate 5 SG @ 0.0025 %	100.00 (89.09)a	100.00 (89.09)a
Spinosad 48 SC @ 0.012 %	82.76 (66.15)b	85.18 (74.69)b
Novaluron 10 EC @ 0.01 %	50.00 (45.00)d	62.06 (52.77)d
Lufenuron 5.4 EC @ 0.006 %	66.67 (54.78)c	75.86 (61.22)c
Copper Oxy Chloride 50 WP @ 0.2 %	33.33 (35.22)a	46.66 (43.07)b
Carbendazim 50 WP @ 0.03 %	10.00 (15.30)bc	66.66 (55.07)b
Pyraclostrobin+Metiram 60 WG @ 0.2 %	0.00 (0.90)d	93.33 (80.54)a
Metalaxyl+Mancozeb 68 WP @ 0.2 %	6.66 (12.59)cd	16.66 (23.36)c
Fenamidon+Mancozeb 60 WG @ 0.3 %	3.33(6.75)cd	20.00 (26.07)c
Azoxystrobin 23 SC @ 0.1 %	20.00 (26.56)	46.66 (43.07)
Untreated control	0.00 (0.90)e	0.0 (0.90)e
SE±	1.77	2.74
CD (p<0.05)	5.39	8.04

Figures in parenthesis are arcsine transformed values; HAT- Hours after Treatment In each column means with the similar letter do not vary significantly at P=0.05

Table 3. Bioefficacy of Novaluron 10 EC in combination with fungicides against *S.litura*

	Mortality %		
Treatment	24 HAT	48 HAT	72 HAT
Novaluron 10 EC @ 0.01 %	50.00 (45.00)a	62.07 (52.77)a	79.31(63.93)a
Novaluron 10 EC @ 0.01 % + Copper oxy chloride 50 WP @ 0.2 %	23.33 (28.78)c	37.93(39.14)b	68.96 (57.79)a
Novaluron 10 EC @ 0.01 % + Carbendazim 50 WP @ 0.03 %	0.00 (18.44)e	13.79 (23.36)c	34.48(37.23)b
Novaluron 10 EC @ 0.01 % + Pyraclostrobin+Metiram 60 WG @ 0.2 %	36.70 (37.23)b	48.27(45.00)ab	68.41(59.00)a
Novaluron 10 EC @ 0.01 % + Metalaxyl + Mancozeb 68 WP @ 0.2 %	13.33 (21.15)de	55.17 (48.93)ab	79.31(63.93)a
Novaluron 10 EC @ 0.01 % + Fenamidon + Mancozeb 60 WG @ 0.3 %	13.33 (21.15)de	55.17 (48.85)ab	58.62 (50.85)ab
Novaluron 10 EC @ 0.01 % +Azoxystrobin 23 SC @ 0.1 %	20.00 (26.07)cd	55.17(48.92)ab	65.51 (55.08)a
Untreated control	0.00 (0.90)f	0.00 (6.75)d	0.00 (6.75)c
SE±	2.39	3.55	4.67
CD (p<0.05)	7.26	10.79	14.19

Figures in parenthesis are arcsine transformed values; HAT- Hours after Treatment. In each column means with the similar letter do not vary significantly at P=0.05

Table 4. Bioefficacy of Lufenuron 5.4 EC in combination with fungicides against *S.litura*

	Mortality %		
Treatment	24 HAT	48 HAT	72 HAT
Lufenuron 5.4 EC @ 0.006 %	66.67 (54.78)a	75.86 (61.22)a	85.71 (68.85)a
Lufenuron 5.4 EC @ 0.006 % + Copper oxy chloride 50 WP @ 0.2 %	46.67 (43.07)b	55.17 (48.85)bc	75.00 (61.22)ab
Lufenuron 5.4 EC @ 0.006 % + Carbendazim 50 WP @ 0.03 %	43.33 (41.15)bc	65.52 (55.08)abc	78.57 (63.93)ab
Lufenuron 5.4 EC @ 0.006 % + Pyraclostrobin+Metiram 60 WG @ 0.2 %	30.00 (32.71)c	48.28 (45.00)c	67.85 (56.99)b
Lufenuron 5.4 EC @ 0.006 % + Metalaxyl+Mancozeb 68 WP @ 0.2 %	40.00 (39.14)bc	65.52 (54.78)abc	78.57 (63.93)ab
Lufenuron 5.4 EC @ 0.006 % + Fenamidon+Mancozeb 60 WG @ 0.3 %	43.33 (41.15)bc	48.27 (45.00)c	78.57 (63.93)ab
Lufenuron 5.4 EC @ 0.006 % +Azoxystrobin 23 SC @ 0.1 %	66.67 (54.78)a	68.96 (56.99)ab	75.00 (61.22)ab
Untreated control	0.00 (0.90)d	0.00 (6.75)d	0.00 (12.59)c
SE±	3.22	3.99	3.56
CD (p<0.05)	9.78	11.90	10.60

Results and discussion

Jar compatibility and phytotoxicity test

Jar compatibility test revealed that the combined solutions were not affected in terms of p^H even after two hours of preparation and hence are physically compatible (Table 1). The stability of wettable powder fungicide formulations was not affected when mixed with the insecticide solutions. Govindan *et al*. (2013) also observed that the combination of emamectin benzoate and carbendazim (WP formulation) was physically compatible. None of the combined products in the experimental study produced any phytotoxic symptoms indicating that they are biologically compatible.

Effect of insecticides and fungicides applied individually

The bioassays indicate that among the test insecticides, emamectin benzoate demonstrated 100 per cent mortality within 24 hours (Table 2). Its effectiveness against *S. litura* was reported previously in chillies and tobacco (Khalid Ahmed and Prasad, 2009; Sreedhar, 2010). Spinosad recorded 82.75 % mortality at 24 HAT and 85.18 % mortality at 48 HAT. Similarly, Sailaja Rani *et al.* (2005) reported that spinosad spray @ 0.015 % recorded 78 % efficacy over untreated check against *S. litura*. Insect growth regulator insecticides *viz*., novaluron and lufenuron did not achieve 100 per cent mortality even after three

Table 5. Bioefficacy of Emamectin benzoate in combination with fungicides against *S.litura*

Treatment	Mortality %	
	24 HAT	48 HAT
Emamectin benzoate 5 SG @ 0.0025 %	100.00 (89.09)a	100.00 (89.09)a
Emamectin Benzoate 5 SG @ 0.0025 % + Copper Oxy Chloride 50 WP @ 0.2 %	47.00 (43.07)de	100.00 (89.09)a
Emamectin Benzoate 5 SG @ 0.0025 % +Carbendazim 50 WP @ 0.03 %	73.00 (59.00)b	85.71(68.85)c
Emamectin Benzoate 5 SG @ 0.0025 % + Pyraclostrobin + Metiram 60WG @ 0.2 %	37.00 (36.93)e	32.14 (36.93)d
Emamectin Benzoate 5 SG @ 0.0025 % + Metalaxyl + Mancozeb 68 WP @ 0.2 %	67.00 (54.78)bc	82.14(69.77)bc
Emamectin Benzoate 5 SG @ 0.0025 % + Fenamidon + Mancozeb 60 WG @ 0.3 %	63.00 (52.85)bcd	75.00 (61.22)c
Emamectin Benzoate 5 SG @ 0.0025 % + Azoxystrobin 23 SC @ 0.1 %	53.00 (46.93)cde	96.43 (83.25)ab
Untreated control	0.00 (0.90)f	0.00 (12.59)e
SE±	3.85	4.91
CD (p<0.05)	11.68	14.39

days (Tables 3 and 4), but they reduced feeding by 24 HAT and impaired feeding totally by 48 HAT. Among them, lufenuron was found to be superior by registering 76 % mortality as against 62 % with novaluron at 48 HAT. Lufenuron was reported to be effective against *S. litura* in tobacco (Sreedhar and Sitaramaiah, 2011). Their application causes malformation of the endocuticle, partial or complete inhibition of moulting and larvae fail to feed (Retnakaran and Wright 1987). Among the fungicides tested against *S. litura*, carbendazim, copper oxy chloride and azoxystrobin registered 66.66, 46.66 and 46.66 % mortality, respectively, by 48 HAT. There was no mortality with pyraclostrobin+ metiram at 24 HAT, but 93 % mortality was noticed at 48 HAT.

Effect of insecticides and fungicides applied together

Emamectin benzoate in combination with copper oxy chloride, showed 100 per cent mortality at 48 HAT (Table 5). In combination with azoxystrobin, carbendazim and metalaxyl + mancozeb, it has demonstrated 96.43, 85.71 and 82.14 % mortality, respectively. Venkata Rao (2010) also reported that emamectin benzoate 0.003 % + mancozeb 0.25 % combination was effective with 88.77 % mortality of *S. litura* in groundnut. The combinations of emamectin benzoate with pyraclostrobin + metiram and fenamidon + mancozeb have shown to reduce the efficacy of emamectin benzoate (sole application) by 68 and 25 % respectively. Spinosad in combination with copper oxy chloride and mancozeb based fungicides has registered about 80 % mortality at 48 HAT. Combinations of carbendazim and pyraclostrobin + metiram with spinosad have recorded 59.25 and 62.96 % efficacy that could have been 85.18 % by 48 HAT when spinosad was used alone (Table 6).

It is evident that except with metalaxyl+mancozeb (79.31 %), combination treatments of novaluron have recorded mortality below 75 % by 72 HAT (pyraclostrobin+metiram 68.41 %, copper oxy chloride 68.96 %, azoxystrobin 65.51 %, fenamidon+mancozeb 58.62 % and carbendazim 34.48 %). Shaila *et al.* (2013) recorded 54 and 62 % mortality of *S. litura* in the combinations of novaluron with mancozeb and carbendazim respectively. Lufenuron has recorded about 80 % mortality with three fungicides *viz*., carbendazim, metalaxyl+mancozeb and fenamidon+mancozeb. With copper oxy chloride and azoxystrobin, lufenuron has recorded mortality of 75 %. Even though metalaxyl+mancozeb, fenamidon+mancozeb and azoxystrobin when used alone, resulted in 16.66, 20 and 46.66 % mortality, enhanced mortality was observed in their combination with insecticides. Though the combinations of insect growth regulators with fungicides did not show 100 per cent mortality, they reduced the feeding potential of the tobacco caterpillars and hence damage was prevented.

From the current study, emamectin benzoate was found to be highly effective in controlling *S. litura* even when used in combination with copper oxy chloride and azoxystrobin. Among the insect growth regulators, lufenuron was observed to be superior to novaluron either when used alone or in combination with fungicides. However, both the IGRs recorded reduced mortality when combined with the fungicides. Observations also suggest that the best performing insecticides also tend to show slightly reduced toxicity when applied in combination with fungicides. Hence, except the combination of emamectin benzoate

Table 6. Bioefficacy of Spinosad 48 SC in combination with fungicides against *S.litura*

Treatment	Mortality %	
	24 HAT	48 HAT
Spinosad 48 SC @ 0.012%	82.75 (61.21)a	85.18 (68.85)a
Spinosad 48 SC @ 0.012 % + Copper Oxy Chloride 50 WP @ 0.2 %	17.24 (26.56)c	77.77 (63.92)ab
Spinosad 48 SC @ 0.012 % + Carbendazim 50 WP @ 0.03 %	17.24 (26.56)c	59.25 (50.85)b
Spinosad 48 SC @ 0.012 % + Pyraclostrobin+Metiram 60 WG @ 0.2 %	13.79 (23.36)c	62.96 (57.79)ab
Spinosad 48 SC @ 0.012 % + Metalaxyl+Mancozeb 68 WP @ 0.2 %	55.17 (47.01)b	77.77 (68.48)a
Spinosad 48 SC @ 0.012 % + Fenamidon+Mancozeb 60 WG @ 0.3 %	62.06 (50.85)ab	81.48 (66.15)ab
Spinosad 48 SC @ 0.012 % +Azoxystrobin 23 SC @ 0.1 %	41.37 (41.15)b	70.37 (59.00)ab
Untreated control	0.00 (6.75)d	0.00 (6.75)c
SE±	4.03	5.62
CD (p<0.05)	12.23	16.73

with copper oxy chloride and azoxystrobin, it is not recommendable to mix the test insecticides with fungicides used in the study against *S. litura* on tobacco.

References

Abbott W S 1925. A method of computing the effectiveness of an insecticide. *Journal of Economic Entomolology* **18 :** 265-267.

Govindan K, Gunasekaran K, Veeramani K and Kuttalam S 2013. Field and laboratory evaluation of biological compatibility of emamectin benzoate 5 SG with agrochemicals against okra fruit borer (*Helicoverpa armigera* Hubner). *International Journal of Plant and Animal Sciences* **1 :** 77-87.

Heinrichs E A, Chellaiah S, Valencia S L, Arceo M B, Fabellar L T, Aquino G B and Pickin S 1981. Manual for testing insecticides on Rice. International Rice Research Institute. Philippines. Pp 81-84.

Khalid Ahmed and Prasad N V V S D 2009. Efficacy of emamectin benzoate 5% G against thrips *Scirtothrips dorsalis* HOOD and pod borer, *Spodoptera litura* (Fab.) on chillies. *Pestology* **33 :** 22-25.

Marer P J 1988. The Safe and Effective Use of Pesticides. University of California Statewide Integrated Pest Management Project. Division of Agriculture and Natural Resources. Publication 3324.

Retnakaran A and Wright J E 1987. Control of insect pests with benzoylphenyl ureas. In: Wright J E and Retnakaran A (Eds Chitin and Benzoylphenyl Ureas, Dr W Junk Publications, Dordrecht, The Netherlands. Pp 205-282.

Sailaja Rani Z, Subba Rao D V, Arjuna Rao P, Madhumathi T and Srinivasa Rao V 2005. Management of tobacco caterpillar *Spodoptera litura* (Fab.) and Ragi cutworm *Spodoptera exigua* (Hub.) on onion. *The Andhra Agriculture Journal* **52 :** 464-468.

Shaila O, Rao S R K and Ramesh Babu T 2013. Chemical Compatibility of Avermectins and Chitin Synthesis Inhibitors with Common Fungicides against *Spodoptera litura*. *European Journal of Zoological Research.* **2 :** 116-123.

Sreedhar U and Krishnamurthy V 2007. Safe Use of Crop Protection Agents in Tobacco. ICAR- Central Tobacco Research Institute, Rajahmundry.

Sreedhar U 2010. Evaluation of emamectin benzoate against *Spodoptera litura* in tobacco nurseries. *Tobacco Research*. **36 :** 42-46.

Sreedhar U and Sitaramaiah S 2011. Effect of lufenuron against *Spodoptera litura* in tobacco nurseries. *Annals of Plant Protection Sciences*. 19 **:** 460-462.

Suneel Kumar G V, Satish Y and Sarada O 2016. Evaluation of new insecticides and fungicides for compatibility and management of defoliators and late leaf spot in groundnut. *International Journal of Plant, Animal and Environmental Sciences.* **6 :** 58-65.

Venkata Rao P 2010. Studies on compatibility of new insecticides with certain fungicides in the control of defoliators and important diseases in groundnut crop. MSc (Ag) thesis submitted to Acharya N G Ranga Agricultural University, Hyderabad.

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