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Efficacy of Certain Insecticides and Fungicides Alone and in Combination Against *Spodoptera litura* (Fab.) by Topical Application Method

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ABSTRACT

Studies on the efficacy of certain insecticides *viz.,* emamectin benzoate 5 SG @ 0.5 g/l, chlorfenapyr 10 SC @ 1.5 ml/l, indoxacarb 14.5 SC @ 1.0 ml/l, flubendiamide 480 SC @ 0.3 ml/l, spinosad 45 SC @0.3 ml/l and certain fungicides *viz.,* carbendazim 50 WP @ 1.0 g/l, chlorothalonil 50 WP @ 2.0 g/l, hexaconazole 10 SC @ 2.0 ml/l alone and in combination against *Spodoptera litura* were conducted under laboratory conditions. Emamectin benzoate, chlorfenapyr alone and in combination with all the three fungicides *viz.,* carbendazim, chlorothalonil and hexaconazole was found to be superior which caused cent mortality of third instar larvae of *S. litura* at 72 HAT by topical application method.

Key words : Insecticides, Fungicides, *S. litura.*

Insect pests are causing severe losses to crops and are recognized as one of the major constraint. The most important lepidopteran pests *viz,* American bollworm, *Helicoverpa armigera* (Hubner); Tobacco caterpillar, *Spodoptera litura.* (Fabricius) and Spotted bollworm, *Earias vitella*, (Fabricius) pose a serious threat in cultivation of major crops like cotton, pulses, oil seeds and vegetables *etc.*

A wide range of insecticides have been proved to be an effective weapon in reducing the pest population. However, negligence of the principles in the crop protection, indiscriminate and extensive use of pesticides (organophosphates, carbamates and synthetic pyrethroids) for the pest control has created a number of problems such as insects developing resistance to insecticides,pest resurgence, insecticide residues and also causing adverse effect on the non target organisms (Mohapatra and Gupta, 1998).

The tobacco caterpillar, *S. litura* is one of the most important polyphagous pests, infesting more than 120 host crops of major economic importance. To decrease the environmental impact of crop protection measures, there is an urgent need to find alternatives for the control of *S. litura.* Insecticides with novel mode of action have attracted particular interest. In general farmers apply insecticides and fungicides together for the control of insect pests and diseases to reduce the cost increassed on plant protection and waste of precious time of farmer. If insecticides and fungicides are applied in combination it may be cheaper to the farmer and such combination become useful for the control of both insect pests and diseases without loosing their efficacy individually, but when insecticides and fungicides applied simultaneously the compatibility may pose a problem, hence it requires thorough investigation on insecticide and fungicide combination before application.

MATERIAL AND METHODS

Laboratory studies were undertaken to study the bio – efficacy of insecticides, fungicides alone and in combination against *S. litura*. A pair of *S. litura* moths were collected from the field and released in a oviposition cage for egg laying. Cotton dipped in 2% sucrose mixed with honey was provided as food for moths.

Castor leaves along with the petioles were kept in conical flask containing water for egg laying. Then the egg masses were collected and kept in petridishes, on castor leaf discs for hatching. After hatching the neonate larvae were changed into rearing jars. Castor leaves after thorough cleaning with tap water and shade drying, were provided as diet for the text insect.

The feed was replenished daily and rearing space was increased regularly by using more

Table 1. Bio-efficacy of certain insecticides and fungicides alone to *S. litura* larvae by topical application method.

Tr.No	Treatments	Concentration (per litre)	Mortality (%)		
			24 HAT	48 HAT	72 HAT
T1	Spinosad 45 SC	0.3ml	13.33 (21.42)^{d}	16.67 (24.10)^{f}	43.33 (41.17)^{d}
T2	Indoxacarb 14.5 SC	1.0 ml	53.33 (46.91)^{c}	56.67 (48.83)^{b}	56.67 (48.83)^{c}
T3	Flubendiamide 480 SC	0.3 ml	50.00 (45.00)^{c}	53.33 (46.91)^{c}	63.33 (52.73)^{b}
T4	Chlorfenpyr 10 SC	1.5 ml	100.00 (90.00)^{a}	100.00 (90.00)^{a}	100.00 (90.00)^{a}
T5	Emamectin benzoate 5 SG	0.5 g	96.67 (79.48)^{b}	100.00 (90.00)^{a}	100.00 (90.00)^{a}
T6	Carbendazim 50 WP	1.0 g	13.33 (21.42)^{d}	26.67 (31.09)^{d}	26.67 (31.09)^{e}
T7	Chlorothalonil 50 WP	2.0 g	3.33 (10.52)^{f}	23.33 (28.88)^{e}	23.33 (28.88)^{f}
T8	Hexaconazole 5 SC	2.0 ml	6.67 (14.96)^{e}	13.33 (21.42)^{g}	20.00 (26.56)^{g}
T9	Untreated control	0.0 ml	0.00	0.00	0.00
	Sem		0.99	0.51	0.63
	CD		2.94	1.52	1.68

* Values in the parentheses are arcsine transformed values
In each column values with the similar alphabet do not vary significantly at P=0.05
HAT – Hours After Treatment

number of jars for avoiding over crowding of the larvae and for promoting uniform growth and development of the larvae. The larvae of third instar (eight day old with an average weight of 30 ± 2.5 mg) were used for the experiment. The full grown larvae was transferred into glass jar containing a 20 cm layer of soil at the bottom for pupation. The adults emerged from them were used for maintenance of larval population of *S. litura*.

TOPICAL APPLICATION METHOD

Manually operated Hamilton microlitre syringe was used to apply two microlitres of insecticide, fungicidal solution alone and in combination to the dorsum of thorax for eight day old larvae (each weighing 30 ± 2.5 mg) @ 20 per treatment in three replications. Larvae in the control was treated with acetone only. The treated larvae were maintained by feeding on castor leaves at a constant temperature 27±2^{0}c and at 78±2% relative humidity. Mortality of treated larvae was recorded at 24, 48 and 72 HAT.

RESULTS AND DISCUSSION

BIO – EFFICACY OF THE INSECTICIDES, FUNGICIDES ALONE AGAINST *S. LITURA*

Emamectin benzoate 5 SG @ 0.5 g/l was found to be superior among the treatments with cent per cent mortality of *S. litura* at 24, 48 and 72 HAT, respectively. Similarly Venkateswari *et al.* (2008) reported the lowest LC_{50} value of emamectin benzoate against third instar larvae (19.1 µg/ml) by topical method (Table 1)

Chlorfenapyr 10 SC @ 1.5 ml/l recorded 96.67 per cent mortality at 24 HAT and cent per cent mortality of *S. litura* larvae at 48 and 72 HAT, respectively. These results are in concurrence with Quan *et al.* (2003) who found higher toxicity of

Table 2. Bio – efficacy of emamectin benzoate alone and in combination with certain fungicides against *S. litura* larvae by topical application method.

Tr.No	Treatments	Concentration (per litre)	Mortality (%)		
			24 HAT	48 HAT	72 HAT
T1	Emamectin benzoate 5 SG	0.5 g	96.67 (79.48)[a]	100.00 (90.00)[a]	100.00 (90.00)[a]
T2	Carbendazim 50 WP	1.0 g	13.33 (21.42)[c]	26.67 (31.10)[b]	33.33 (35.26)[b]
T3	Hexaconazole 5 SC	2.0 ml	10.00 (18.43)[c]	13.33 (21.42)[d]	23.33 (28.88)[c]
T4	Chlorothalonil 50 WP	2.0 g	3.33 (10.52)[d]	23.33 (28.88)[c]	23.33 (28.88)[c]
T5	Emamectin benzoate + Carbendazim	0.5 g + 1.0g	93.33 (75.04)[b]	100.00 (90.00)[a]	100.00 (90.00)[a]
T6	Emamectin benzoate + Hexaconazole	0.5 g + 2.0 ml	93.33 (75.04)[b]	100.00 (90.00)[a]	100.00 (90.00)[a]
T7	Emamectin benzoate + Chlorothalonil	0.5 g + 2.0 g	93.33 (75.04)[b]	100.00 (90.00)[a]	100.00 (90.00)[a]
T8	Untreated control	0.0 ml	0.00	0.00	0.00
	Sem		1.15	0.42	0.36
	CD		3.44	1.25	1.07

* Values in the parentheses are arcsine transformed values
In each column values with the similar alphabet do not vary significantly at P=0.05
HAT – Hours After Treatment

chlorfenapyr over abamectin against fourth instar larvae of *S. litura* by topical method.

Flubendiamide 480 SC @ ml/l was found to be the next best treatment in causing the mortality of third instar larvae of *S. litura* which recorded 50.00, 53.33 & 63.33 per cent mortality at 24, 48 and 72 HAT, respectively. These results are in accordance with Thilagam *et al*. (2010) and Lakshminarayana and Rajasri (2006) who reported the marked reduction in the larval population of *H. armigera* and reduction in cotton square and boll damage due to flubendiamide.

Indoxacarb 14.5 SC @ 1.0 ml/l recorded 53.33, 56.67 and 56.67 per cent larval of *S.litura* mortality at 24, 48 and 72 HAT, respectively. Similarly Gupta *et al.* (2004) also reported 1.62 relative toxicity of indoxacarb at LC_{50} (0.0064 %) value which is next to the emamectin benzoate.

Spinosad 45 SC @ 0.3 ml/l exhibited poor efficacy which recorded the lowest per cent mortality of *S. litura* larvae with 13.33, 16.67 and 43.33 per cent mortality at 24, 48 and 72 HAT, respectively. Poor efficacy of spinosad by potter's tower application method was also reported by Gupta *et al.* (2004) with LC_{50} value of 0.0233% and 0.44 relative toxicity at 48 and 72 HAT, respectively.

Fungicides *viz.,* carbendazim 50 WP @ 1.0 g/l, chlorothalonil 50 WP @ 2.0 g/l, and hexaconazole 5 SC @ 2.0 ml/l caused slight mortality of third instar larvae of *S. litura* to the extent of 26.67, 23.33 and 20.00 per cent mortality at 72 HAT, respectively. Similarly Padmaja and Kameswara Rao (2000) reported 12.22 and 8.33 per cent mortality of *S. litura* at 0.1 and 0.05 per cent concentration of carbendazim.

BIO-EFFICACY OF INSECTICIDES, FUNGICIDES ALONE AND IN COMBINATION AGAINST *S. LITURA*

Emamectin benzoate alone caused 96.67 per cent mortality of *S. litura* larvae followed by

Table 3. Bio – efficacy of chlorfenapyr alone and in combination with certain fungicides against *S. litura* larvae by topical application method.

Tr.No	Treatments	Concentration (per litre)	Mortality (%)		
			24 HAT	48 HAT	72 HAT
T1	Chlorfenapyr 10 SC	1.5 ml	100.00 (90.00)[a]	100.00 (90.00)[a]	100.00 (90.00)[a]
T2	Carbendazim 50 WP	1.0 g	16.67 (24.09)[e]	26.67 (31.10)[b]	30.00 (33.21)[b]
T3	Hexaconazole 5 SC	2.0 ml	6.67 (14.96)[f]	16.67 (24.09)[d]	26.67 (31.10)[c]
T4	Chlorothalonil 50 WP	2.0 g	6.67 (14.96)[f]	23.33 (28.88)[c]	23.33 (28.88)[d]
T5	Chlorfenapyr + Carbendazim	1.5 ml + 1.0 g	93.33 (75.04)[c]	100.00 (90.00)[a]	100.00 (90.00)[a]
T6	Chlorfenapyr + Hexaconazole	1.5 ml + 2.0 ml	70.00 (56.79)[d]	100.00 (90.00)[a]	100.00 (90.00)[a]
T7	Chlorfenapyr + Chlorothalonil	1.5 ml + 2.0 g	96.67 (79.48)[b]	100.00 (90.00)[a]	100.00 (90.00)[a]
T8	Untreated control	0.0 ml	0.00	0.00	0.00
	Sem		1.24	0.42	0.31
	CD		3.71	1.25	0.92

* Values in the parentheses are arcsine transformed values

In each column values with the similar alphabet do not vary significantly at P=0.05

HAT – Hours After Treatment

emamectin benzoate in combination with all the three fungicides *viz.,* carbendazim, hexaconazole and chlorothalonil and found to be on par with each other with 93.33 per cent mortality at 24 HAT, respectively. Carbendazim resulted 13.33 per cent mortality and found to be on par with hexaconazole with 10.00 per cent mortality of *S. litura* at 24 HAT. Emamectin benzoate alone and in combination with all the three fungicides *viz.,* carbendazim, chlorothalonil and hexaconazole caused cent per cent mortality of *S. litura* larvae at 48 and 72 HAT, respectively (Table 2).

Chlorfenapyr alone caused the cent per cent mortality followed by chlorfenapyr in combination with chlorothalonil, carbendazim and hexaconazole which recorded 96.67, 93.33 and 70.00 per cent mortality at 24 HAT, respectively. Carbendazim recorded 16.67 per cent mortality and hexaconazole was found to be on par with chlorothalonil with 6.67 per cent mortality at 24 HAT. Chlorfenapyr alone and in combination with all three fungicides *viz.,* carbendazim, chlorothalonil and hexaconazole caused cent per cent mortality at 48 and 72 HAT, respectively (Table 3).

Indoxacarb alone was proved to be best at 24 HAT with 53.33 per cent mortality followed by indoxacarb in combination with chlorothalonil which caused 46.67 per cent mortality and on par with indoxacarb in combination with carbendazim and hexaconazole with 43.33 per cent mortality at 24 HAT. The mortality of the larvae was slightly increased to 56.67 per cent with indoxacarb alone at 48 HAT, indoxacarb in combination with carbendazim was on par with indoxacarb in combination with hexaconazole which caused 46.67 per cent mortality followed by indoxacarb in combination with chlorothalonil with 43.33 per cent mortality of *S. litura* larvae. Indoxacarb alone and in combination with carbendazim were superior and caused 56.67 per cent mortality followed by indoxacarb in combination with hexaconazole and found to be on par with indoxacarb in combination

Table 4. Bio – efficacy of indoxacarb alone and in combination with certain fungicides against *S. litura* larvae by topical application method

Tr.No	Treatments	Concentration (per litre)	Mortality (%)		
			24 HAT	48 HAT	72 HAT
T1	Indoxacarb 14.5 SC	1.0 ml	53.33 (70.99)[a]	56.67 (48.83)[a]	56.67 (48.83)[a]
T2	Carbendazim 50 WP	1.0 g	16.67 (38.9)[c]	30.00 (33.21)[d]	33.33 (35.26)[c]
T3	Hexaconazole 5 SC	2.0 ml	10.00 (30.03)[d]	16.67 (24.09)[f]	23.33 (28.88)[e]
T4	Chlorothalonil 50 WP	2.0 g	10.00 (30.03)[d]	26.67 (31.09)[e]	26.67 (31.09)[d]
T5	Indoxacarb + Carbendazim	1.0 ml + 1.0 g	43.33 (63.63)[b]	46.67 (43.08)[b]	56.67 (48.83)[a]
T6	Indoxacarb + Hexaconazole	1.0 ml + 2.0 ml	43.33 (63.63)[b]	43.33 (41.17)[c]	53.33 (46.91)[b]
T7	Indoxacarb + Chlorothalonil	1.0 ml + 2.0 g	46.67 (66.16)[b]	46.67 (43.08)[b]	53.33 (46.91)[b]
T8	Untreated control	0.0 ml	0.00	0.00	0.00
	Sem		1.28	0.59	0.46
	CD		3.83	1.77	1.39

* Values in the parentheses are arcsine transformed values
In each column values with the similar alphabet do not vary significantly at P=0.05
HAT – Hours After Treatment

with chlorothalonil with 53.33 per cent mortality at 72 HAT (Table 4).

Flubendiamide in combination with hexaconazole was superior among the treatments which caused 56.67 per cent mortality and found to be on par with flubendiamide in combination with chlorothalonil with 53.33 per cent mortality which is also on par with flubendiamide alone with 50.00 per cent mortality and it was on par with flubendiamide in combination with carbendazim which caused 43.33 per cent mortality of *S. litura* larvae at 24 HAT. Flubendiamide in combination with hexaconazole caused 66.67 per cent mortality of *S. litura* larvae followed by flubendiamide in combination with chlorothalonil, carbendazim and flubendiamide alone which caused 56.67, 53.33 and 53.33 per cent mortality and found to be on par with each other at 48 HAT. The combination of flubendiamide with hexaconazole showed higher efficacy with 83.33 per cent mortality followed by flubendiamide in combination with carbendazim, chlorothalonil and flubendiamide alone which caused 76.67, 66.67 and 63.33 per cent mortality of *S. litura* larvae at 72 HAT, respectively (Table 5).

Spinosad combination with fungicides showed poor efficacy in causing the mortality of the *S. litura* larvae at 24 HAT. Spinosad in combination with hexaconazole caused 16.67 per cent mortality followed by spinosad alone found to be on par with carbendazim with 13.33 per cent mortality. Spinosad in combination with carbendazim , chlorothalonil and hexaconazole were on par with each other which caused 6.67,16.67 and 6.67 per cent mortality at 24 HAT. The mortality of larvae was slightly increased at 48 HAT due to spinosad in combination with hexaconazole, chlorothalonil and carbendazim, carbendazim and chlorothalonil which were found to be on par with each other with 23.33 per cent mortality followed by spinosad alone which caused 16.67 per cent

Table 5. Bio – efficacy of flubendiamide alone and in combination with certain fungicides against *S. litura* larvae by topical application method

Tr.No	Treatments	Concentration (per litre)	Mortality (%)		
			24 HAT	48 HAT	72 HAT
T1	Flubendiamide 480 SC	0.3 ml	50.00 (45.00)^{ab}	53.33 (46.91)^{b}	63.33 (52.73)^{d}
T2	Carbendazim 50 WP	1.0 g	16.67 (24.09)^{c}	23.33 (28.88)^{c}	30.00 (33.21)^{e}
T3	Hexaconazole 5 SC	2.0 ml	13.33 (21.42)^{cd}	20.00 (26.56)^{d}	23.33 (28.88)^{f}
T4	Chlorothalonil 50 WP	2.0 g	10.00 (18.43)^{d}	20.00 (26.56)^{d}	23.33 (28.88)^{f}
T5	Flubendiamide + Carbendazim	0.3 ml + 1.0g	43.33 (41.17)^{b}	53.33 (46.91)^{b}	76.67 (61.12)^{b}
T6	Flubendiamide + Hexaconazole	0.3 ml + 2.0 ml	56.67 (48.83)^{a}	66.67 (54.73)^{a}	83.33 (65.91)^{a}
T7	Flubendiamide + Chlorothalonil	0.3 ml + 2.0g	53.33 (46.91)^{a}	56.67 (48.83)^{b}	66.67 (54.73)^{c}
T8	Untreated control	0.0 ml	0.00	0.00	0.00
	Sem		1.34	0.71	0.54
	CD		4.02	2.14	1.61

* Values in the parentheses are arcsine transformed values
In each column values with the similar alphabet do not vary significantly at P=0.05
HAT – Hours After Treatment

mortality of *S. litura* larvae at 48 HAT. Spinosad in combination with carbendazim was superior and caused 50.00 per cent mortality followed by spinosad in combination with chlorothalonil which caused 46.67 per cent mortality. Spinosad alone was on par with spinosad in combination with hexaconazole with 43.33 per cent mortality at 72 HAT (Table 6).

The results obtained in the present investigation clearly reveals that emamectin benzoate 5 SG @ 0.5 g/l, chlorfenapyr 10 SC @ 1.5 ml/l were superior in causing cent per cent mortality of eight day old *S. litura* larvae either alone or in combination with carbendazim, hexaconazole and chlorothalonil at 72 HAT by topical application method.

Similarly compatibility of insecticides and fungicides was reported by Padmaja and Kameswara rao (2000) with monocrotophos 0.05% + carbendazim 0.05%; monocrotophos 0.05% + mancozeb 0.1%; carbaryl 0.1% + mancozeb 0.1%; fenvalerate 0.01% + carbendazim 0.05% and fenvalerate 0.01% + mancozeb 0.1% recorded 88.89, 75.56, 87.22, 79.44, 95.00 and 96.11 per cent mortality of *S. litura* by topical application method. Similarly Rajagoud *et al*. (2010) found that indoxacarb at its LC_{50} value 110.34 ppm when combined with chlorothalonil at 1000, 1500, 2000, 2500 and 3000 ppm concentrations resulted the synergistic effect in causing the 53.33, 59.99, 71.11, 77.77 and 83.33 per cent mortality of *H. armigera* larvae respectively. Similarly spinosad at its LC_{50} value 99.83 when combined with chlorothalonil at 1000, 1500, 2000, 2500 and 3000 ppm concentrations recorded 52.22, 59.99, 71.11, 76.66 and 83.33 per cent mortality of *H. armigera* larvae.

Table 6. Bio – efficacy of spinosad alone and in combination with certain fungicides against *S. litura* larvae by topical application method.

Tr.No	Treatments	Concentration (per litre)	Mortality (%)		
			24 HAT	48 HAT	72 HAT
T1	Spinosad 45 SC	0.3ml	13.33 (21.42)[a]	16.67 (24.09)[b]	43.33 (41.17)[c]
T2	Carbendazim 50 WP	1.0 g	13.33 (21.42)[a]	23.33 (28.88)[a]	30.00 (33.21)[d]
T3	Hexaconazole 5 SC	2.0 ml	6.67 (14.96)[b]	13.33 (21.42)[c]	13.33 (21.42)[f]
T4	Chlorothalonil 50 WP	2.0 g	3.33 (10.52)[c]	23.33 (28.88)[a]	23.33 (28.88)[e]
T5	Spinosad + Carbendazim	0.3 ml + 1.0 g	6.67 (14.96)[b]	23.33 (28.88)[a]	50.00 (45.00)[a]
T6	Spinosad + Hexaconazole	0.3 ml + 2.0ml	16.67 (24.09)[a]	23.33 (28.88)[a]	43.33 (41.17)[c]
T7	Spinosad + Chlorothalonil	0.3 ml + 2.0 g	6.67 (14.96)[b]	23.33 (28.88)[a]	46.67 (43.09)[b]
T8	Untreated control	0.0 ml	0.00	0.00	0.00
	Sem		1.44	0.63	0.63
	CD		4.31	1.88	1.88

* Values in the parentheses are arcsine transformed values
In each column values with the similar alphabet do not vary significantly at P=0.05
HAT – Hours After Treatment

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