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COMPARATIVE BASELINE RESISTANCE OF *SPODOPTERA LITURA* AND *HELICOVERPA ARMIGERA* TO INSECTICIDES ON TOBACCO

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In view of a shift in the use of pesticides on tobacco in consonance with growing concern on pesticide residues, baseline resistance data of two lepidopteran pests of tobacco *viz.*, *S. litura* and *H. armigera* have been generated against select insecticides. Bio-assays as per the Insecticide Resistance Action Committee (IRAC) was followed. Among the insecticides tested for toxicity against *S. litura* through stomach action, the lowest LC_{50} value was recorded with emamectin benzoate followed by rynaxypyr and the growth regulator novaluron. Out of the eleven insecticides with stomach action against which base line resistance data of *H. armigera* were generated, the lowest LC_{50} value was recorded with emamectin benzoate followed by indoxacard, spinosad and rynaxypyr establishing their efficacy at very low concentrations. The comparison of baseline resistance of *S. litura* from East Godavari and Guntur districts of Andhra Pradesh revealed that Guntur population recorded 7.09, 1.27, 1.44, 2.57, 1.65 and 2.68 times higher LC_{50} values for novaluron, spinosad, acephate, indoxacarb, emamectin benzoate and endosulfan respectively compared to Rajahmundry population. The Guntur population of *H. armigera* recorded 1.41, 1.33, 1.08, 33.06, 12.08, 1.41, 1.21 and 1.14 times higher LC_{50} values of novaluron, thiodicarb, fipronil, rynaxypyr, acephate, hlorpyriphos, endosulfan and flubendiamide respectively compared to Rajahmundry population when tested for stomach action.

INTRODUCTION

Several molecules belonging to new chemical groups with novel modes of action have been introduced to control lepidopteran pests of tobacco and many of the earlier recommended ones have been withdrawn from use in response to growing concern on insecticide residues on cured tobacco. These molecules are very potent and are required in very low quantities to bring about effective control of the target pests. In light of the shift in pesticide use pattern on tobacco, it has been contemplated to generate baseline resistance data of the two lepidopteran pests of tobacco *viz, S. litura* and *H. armigera* to conventional insecticides and novel insecticides so that the response of these pests to these insecticides could be monitored over time to avoid development of resistance by following suitable Integrated Resistance Management (IRM) strategies.

MATERIALS AND METHODS

The cultures of the two test insects were collected from tobacco nursery/field crop and maintained on leaves/capsules of tobacco for two generations before bio-assays were conducted for generating baseline resistance data for stomach and contact poison separately following methods as suggested by Insecticide resistance action committee (Kranthi, 2005). Early third instar larvae of the test insects were used for the bio-assays. The data were analyzed for arriving at LC_{50} and LC_{90} values using SPSS software. Insecticides belonging to different chemical groups *viz.*, organophosphate, carbamates, cyclodienes, pyrethroids, avermectins, spinosyns, oxidiazines, fiproles, pyrroles, chitin synthesis inhibitors and amides were procured from local market.

RESULTS AND DISCUSSION

The results indicate that in case of *S. litura* population from Rajahmundry the lowest LC_{50} value was recorded with emamectin benzoate followed by rynaxypyr and the growth regulator novaluron when tested for their stomach action. Treatment of rynaxypyr resulted in very quick cessation of feeding followed by heavy mortality of the test insect in bio-assays (Table 1). Though similar trend was recorded with population from Guntur (Table 2), there was marked difference in the LC_{50} values of both the populations. The

Table 1: Baseline resistance data of S. *litura* (Rajahmundry population) to insecticides (stomach action)

S. No	Insecticide	Chi ²	LC_{50} (mg/l)	95% Fiducial limits	LC_{90} (mg/ml)	95% Fiducial limits
1	Novaluron	8.31	0.386	0.19-0.64	1.18	0.85-2.10
2	Spinosad	3.80*	180.2	141.2-250.25	287.67	226.32-432.63
3	Fipronil	2.96	108.50	79.50-150.38	205.22	160.81-302.13
4	Rynoxypyr	6.82*	0.361	0.133-0.642	1.219	0.85-2.411
5	Acephate	5.11*	1652.59	1196.05-2341.55	3119.55	2408.38-4761.50
6	Indoxacarb	9.39*	9.80	7.57-13.49	17.53	13.76-24.97
7	Emamectin benzoate	11.88	0.047	0.026 – 0.097	0.098	0.065-0.234
8	Chlorpyriphos	6.77	213.23	158.94-301.81	399.41	308.5-597.04
9	Endosulfan	2.062*	59.62	47.29-78.56	92.38	74.63-129.86
10	Flubendiamide	3.39	0.901	0.673-1.277	1.61	1.25-2.48

* Significant at 5%

Table 2: Baseline resistance data of S. *litura* (Guntur population) to insecticides (stomach action)

S. No	Insecticide	Chi^2	LC_{50} (mg/l)	95% Fiducial limits	LC_{90} (mg/ml)	95% Fiducial limits
1	Novaluron	20.45	2.74	1.43 – 5.23	5.64	3.78 – 10.43
2	Spinosad	49.55*	230.45	80.44 – 560.56	546.76	324.67 – 1786.54
3	Thiodicarb	17.34*	1265.42	1020.56 – 1723.45	2560.75	2325.35 – 3275.23
4	Fipronil	20.34	52.65	28.95 – 78.65	142.25	110.25 – 230.35
5	Rynoxypyr	52.25*	0.275	0.075 – 0.723	0.720	0.430 – 2.352
6	Acephate	32.12*	2395.76	1587.56 – 4025.35	5634.25	4021.12 – 8955.25
7	Indoxacarb	30.25*	25.25	13.45 – 50.12	45.35	30.25 – 115.55
8	Emamectin benzoate	30.12	0.078	0.048 – 0.132	0.175	0.125– 0.421
9	Chlorpyriphos	16.64	219.88	139.74-347.33	483.43	353.47-856.17
10	Endosulfan	20.36*	159.85	99.94-261.44	336.09	242.70-626.08

* Significant at 5%

Guntur population recorded 7.09, 1.27, 1.44, 2.57, 1.65 and 2.68 times higher LC_{50} values of novaluron, spinosad, acephate, indoxacarb, emamectin benzoate and endosulfan respectively compared to Rajahmundry population.

Baseline resistance data for *S. litura* populations from Rajahmundry and Guntur were generated for contact insecticides. It was observed that the lowest LC50 value was recorded with emamectin benzoate followed by chlorpyiphos, profenophos and quinolphos in both the populations (Table 3 & 4). The Guntur population recorded 1.46, 1.31,1.19, 4.76, 1.27, 3.46 and 1.25 times higher LC_{50} values of cypermethrin, methomyl, thiodicarb, profenophos, quinolphos, chlorpyriphos and triazophos respectively compared to Rajahmundry population. On the other hand the *S. litura* population from Rajahmundry recorded 1.55 and 1.14 times higher LC_{50} values of acephate and emamectin benzoate respectively compared to Guntur population.

Of the eleven insecticides with stomach action for which baseline resistance data of *H. armigera* (Guntur) were generated, the lowest LC_{50} value

Table 3: Baseline resistance data of *S. litura* (Guntur population) to insecticides (contact action)

S. No	Insecticide	Chi²	LC_{50} (mg/l)	95% Fiducial limits	LC_{90} (mg/ml)	95% Fiducial limits
1.	Cypermethrin	9.12	3223.45	2815.16-3656.35	4995.95	4220.25-5673.25
2	Methomyl	11.24*	4523.14	4125.23-4863.72	6247.34	5645.125-7275.45
3	Thiodicarb	2.35	7442.25	6654.22-7865.45	10231.45	9725.25-11638.45
4	Emamectin benzoate	30.35	1.523	0.85-2.76	3.89	2.96- 6.98
5	Acephate	20.11	1814.03	946.00-3359.63	3564.46	2485.39-8422.05
6	Profenophos	34.06	1257.23	884.20 – 1759.95	2585.51	2013.46 – 3739.57
7	Quinolphos	2.03	1509.01	1395.22 – 1626.64	2324.69	2163.25 – 2531.25
8	Chlorpyriphos	30.45*	347.37	252.99 – 523.81	623.99	468.86 – 1013.04
9	Triazophos	9.22 *	4494.43	3597.34 – 5819.16	8063.28	6546.63 – 10882.3

* Significant at 5%

Table 4: Baseline resistance data of *S. litura* (Rajahmundry population) to insecticides (contact action)

S. No	Insecticide	Chi²	LC_{50} (mg/l)	95% Fiducial limits	LC_{90} (mg/ml)	95% Fiducial limits
1.	Cypermethrin	1.23	2199.56	1895.03-2527.90	3195.58	2807.51-3936.09
2	Methomyl	7.58	3459.59	2211.55-5158.99	7686.99	5776.09-12440.92
3	Thiodicarb	2.14	6201.93	5170.47-7417.15	9328.17	7978.29-11998.12
4	Acephate	3.58	2807.62	1780.25-4276.94	6380.91	4741.15-10673.69
5	Profenophos	5.35	263.85	189.97-382.42	512.65	390.98-811.42
6	Quinolphos	4.02	1189.8	1014.52-1388.12	1892.00	1641.74-2338.45
7	Chlorpyriphos	2.189	100.43	78.20-141.78	157.54	123.22-241.64
8	Triazophos	1.51	3600	3119.32– 4086.52	5015.45	4450.10-6164.78
9	Emamectin benzoate	6.45	1.74	0.65-3.87	4.23	2.34-7.85

* Significant at 5%

was recorded with emamectin benzoate followed by indoxacarb, spinosad and rynaxypyr (Table 5). In a similar study involving *H. armigera* population from Rajahmundry, the lowest LC_{50} value was recorded with rynaxypyr followed by emamectin benzoate, spinosad and fipronil (Table 6). The Guntur population of *H. armigera* recorded 1.41, 1.33, 1.08, 33.06, 12.08, 1.41, 1.21 and 1.14 times higher LC_{50} values for novaluron, thiodicarb, fipronil, rynaxypyr, acephate, chlorpyriphos, endosulfan and flubendiamide respectively compared to Rajahmundry population. On the other hand, Rajahmundry population of *H. armigera* recorded 1.31 ,6.74 and 12.5 times higher LC_{50} values of spinosad, indoxacarb and emamectin benzoate respectively compared to Guntur population.

The baseline resistance data of *H. armigera* populations from Guntur and Rajahmundry were generated for eleven insecticides with contact action. In case of Guntur population, the lowest LC_{50} value was recorded with rynaxypyr followed by thiodicarb, spinosad and profenophos (Table 7). The lowest LC_{50} value was recorded with rynaxypyr followed by spinosad, profenophos and thiodicarb

Table 5: Baseline resistance data of *H. armigera* (Guntur population) to insecticides (stomach action)

S. No	Insecticide	Chi²	LC_{50} (mg/l)	95% Fiducial limits	LC_{90} (mg/ml)	95% Fiducial limits
1	Novaluron	15.46	2.76	1.42 – 4.76	6.18	4.35 – 12.45
2	Spinosad	34.45	1.24	0.65– 2.87	2.34	1.55 – 7.36
3	Thiodicarb	43.78*	36.89	21.35 – 78.45	79.8	57.34 – 220.39
4	Fipronil	4.52	3.21	2.75 – 3.84	5.85	4.14 – 7.78
5	Rynoxypyr	44.92	2.05	0.65 – 4.65	4.98	2.87 – 14.75
6	Acephate	18.89*	440.34	225.65 – 815.25	901.25	670.75 – 1680.75
7	Indoxacarb	36.45*	0.543	0.455 – 1.74	2.728	1.55 – 10.55
8	Emamectin benzoate	4.87	0.0052	0.0038 – 0.006	0.015	0.007 – 0.034
9	Chlorpyriphos	30.43	17.25	7.56 – 37.32	41.25	24.65 – 132.14
10	Endosulfan	7.45	22.34	16.35 – 24.68	44.56	34.33 – 72.38
11	Flubendiamide	32.67	12.35	0.98 - 22.64	30.69	24.75 – 95.45

* Significant at 5%

Table 6: Baseline resistance data of *H. armigera* (Rajahmundry population) to insecticides (stomach action)

S. No	Insecticide	Chi²	LC_{50} (mg/l)	95% Fiducial limits	LC_{90} (mg/ml)	95% Fiducial limits
1	Novaluron	9.36	1.95	0.76 – 3.45	5.54	3.35 – 09.73
2	Spinosad*	9.63	1.63	0.6414-4.63	5.31	3.24-23.87
3	Thiodicarb	34.56	27.59	18.43-58.41	60.12	42.13-164.12
4	Fipronil	8.54	2.95	1.78-4.21	4.35	3.48-9.14
5	Rynoxypyr	4.71	0.062	0.037-0.1017	0.1572	0.113-0.287
6	Acephate	3.164	36.438	27.28-53.23	63.19	48.37-103.35
7	Indoxacarb*	6.42	3.64	2.38-5.86	9.18	6.68-15.75
8	Emamectin benzoate	5.32	0.065	0.047-0.0955	0.1282	0.0977-0.2031
9	Chlorpyriphos*	24.56	12.14	6.13-27.18	28.48	18.13-95.42
10	Endosulfan	10.25	18.45	12.15-24.54	34.12	29.54-64.15
11	Flubendiamide	7.57	14.15	3.54-21.76	36.42	19.57-105.15

* Significant at 5%

in case of *H. armigera* population from Rajahmundry (Table 8). The Guntur population of *H. armigera* showed 5.56, 1.40, 1.96, 2.38, 1.13, 1.39, 1.25 and 1.81 times higher LC_{50} values for spinosad, rynaxypyr, acephate, chlorpyriphos, endosulfan, cypermethin, triazophos and profenophos respectively compared to Rajahmundry population. The Rajahmundry population of *H. armigera* recorded 26.75, 1.94 and 1.27 higher LC_{50} values for thiodicarb, methomyl and quinolphos respectively compared to Guntur population.

Excessive use of insecticides, especially synthetic pyrethroids, led to problems of insecticide resistance in *H. armigera* and *S. litura*, which further necessitated the repeated application of insecticides. The first few reports related to high levels of resistance of *H. armigera* to pyrethroids and DDT from different cotton and

Table 7: Baseline resistance data of *H. armigera* (Guntur population) to insecticides (contact action)

S. No	Insecticide	Chi²	LC_{50} (mg/l)	95% Fiducial limits	LC_{90} (mg/ml)	95% Fiducial limits
1	Spinosad	64.24*	164.35	82.25– 378.65	365.49	245.34 – 1105.47
2	Thiodicarb	32.34*	18.45	10.56 – 29.28	50.25	34.52 – 92.43
3	Rynoxypyr	64.59	0.76	0.152 – 2.547	2.57	1.22 – 9.88
4	Acephate	45.32*	1998.56	950.53 – 4676.33	4235.78	2776.45 – 11825.4
5	Chlorpyriphos	12.32	1011.25	896.65 – 1194.86	1634.27	1385.4 – 1856.22
6	Endosulfan	134.56*	1124.25	563.8 – 5432. 44	2105.45	1332.45 – 12472.7
7	Cypermethrin	9.235	3425.86	3186.65 – 3895.86	5278.89	4775.44 – 6859.85
8	Triazophos	11.23*	2568.94	2224.09 – 2995.63	4207.65	3676.46 – 5741.85
9	Methomyl	3.28	1005.32	866.29 – 1175.52	1805.27	1346.6 – 2158.58
10	Quinolphos	18.45	922.45	668.75 – 1474.87	1711.25	1294.5 – 2485.58
11	Profenophos	5.657*	487.65	395.68 – 663.56	854.32	692.58 – 998.48

* Significant at 5%

Table 8: Baseline resistance data of *H. armigera* (Rajahmundry population) to insecticides (contact action)

S. No	Insecticide	Chi²	LC_{50} (mg/l)	95% Fiducial limits	LC_{90} (mg/ml)	95% Fiducial limits
1	Spinosad	5.22	29.55	21.62-42.73	57.37	43.81-88.91
2	Thiodicarb	16.74	493.62	354.51-716.59	962.05	733.11-1523.50
3	Rynoxypyr	34.12*	0.54	0.092 – 1.956	1.76	1.01 – 6.82
4	Acephate	23.45*	1018.23	748.15-1445.33	1898.63	1464.78-2921.70
5	Chlorpyriphos	10.52	424.68	317.5-585.21	791.03	620.05-1146.73
6	Endosulfan	32.54*	994.45	435.8 – 4032. 54	1806.08	1105.45 – 8672.6
7	Cypermethrin	18.46	2463.89	1865.43– 3495.76	4268.78	3645.54 – 6743.62
8	Triazophos	2.586	2050.99	1638.16-2513.1	3363.16	2831.54-4372.78
9	Methomyl	4.14	1953.77	1495.29-2800.49	3289.06	2542.1-5163.9
10	Quinolphos	3.46	1170.77	945.44-1447.69	1827.89	1529.73-2440.19
11	Profenophos	7.13	269.15	201.06-379.92	499.95	386.85-753.74

* Significant at 5%

pulse growing regions of the country (Mehrotra and Phokela,1992; Armes *et al.*,1992, 1996; Sekhar *et al.*,1996). Subsequent studies (Armes *et al.*, 1992, 1996; Kranthi *et al.*, 2001a, 2001b, 2002a and 2002b) showed that resistance to pyrethroids was ubiquitous and resistance in *H. armigera* to conventional insecticides such as methomyl, endosulfan and quinalphos was increasing in India. Due to unsatisfactory insect control on account of insecticide resistance, farmers were forced to spray repeatedly, most often with mixtures. Many countries have devised IRM strategies that combine the best of all pragmatic resistant management theories amalgamated with conventional IPM tactics to forge a sustainable method of pest management (Russell, 2004). The basic step in any IRM strategy is to have baseline resistance data of the insect pests to the newly introduced molecules so that changes if any in the reaction of the insect to the insecticide under study can be monitored over time. The baseline resistance data generated in the present study for *H. armigera* and *S. litura* to some of the newly introduced insecticides on tobacco can be of practical use in this context. The geographical variability in the resistance levels of these insects reflects the inherent genetic variability between populations and also the variable selection pressure that they were subject to in those locations.

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