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Impact of insecticide resistance management strategies on cotton insect pest in districts of Rajasthan

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ABSTRACT : During survey on insect faunal complex of cotton in semi arid Plain of Rajasthan, fourteen insect pests were recorded on cotton in the zone. Among the sucking pests, aphid (*Aphis gossypii* Glover), leafhopper (*Amrasca biguttula biguttula* Ishida), thrips (*Scirtothrips dorsalis* Hood) and whitefly (*Bemisia tabaci* Gennadius) attack at early vegetative stage of the crop, while bollworms *viz.,* spotted bollworm (*Earias vittella* Fabricious) and (*Earias insulana* Boisdual), American bollworm (*Helicoverpa armigera* Hubner) and pink bollworm (*Pectinophora gossypiella* Saunders) are the most damaging at reproductive stages of the crop. To make the cotton production profitable, efforts were made for developing IRM strategies module on cotton. Fields experiments conducted on I.R.M. from the period 2002 to 2011 produced better results for lower pest population, pest incidence, pesticidal exposure and in return higher conservation of bio-agents, seed cotton over chemical spray schedule. The components used under IRM were variety resistant/tolerant to insect-pests and adoption of cultural, mechanical, biological and chemical methods of pest control. In IRM fields, for keeping the population of insect pest under control, multiple suppression techniques were used involving resistant varieties like Bioseed 6588, Bioseed 6488, MRC 6317 etc., sanitation practices and need based application of insecticides developed for control of insect pest to conserve natural enemies of insect pests. In cultural and mechanical control physical barriers, removal and burnt of all crop residues in previously infested fields, eradication of weeds and deberies, remove alternate host of insects. Avoid use of any insecticidal sprays first sixty days after sowing to protect natural enemies and also use 5 per cent NSKE for sucking pests. The overall of ten years (2002 to 2011) number of sprays in IRM farmers field were 5.64, whereas non IRM farmers sprayed 8.52 times. The per cent reduction in number of sprays and cost of sprays was 32.86 and 24.46, respectively. IRM plots produced 16.52 per cent (302 kg/ha) more seed cotton yield than non IRM.

Key words*:* Bollworms, cotton, insecticide resistance management, sucking pest

Cotton is the most important ancient fiber crop, which provides raw material for textile industry. During survey on insect faunal complex of cotton in semi arid plain of Rajasthan, fourteen insect pests were recorded on cotton in the zone (Dhaka, 2013). Among the sucking pests, aphid (*Aphis gossypii* Glover), leafhopper (*Amrasca biguttula biguttula* Ishida), thrips (*Scirtothrips dorsalis* Hood) and whitefly (*Bemisia tabaci* Gennadius) attack at early vegetative stage of the crop, while bollworms *viz.,* spotted bollworm (*Earias vittella* Fabricious) and (*Earias insulana* Boisdual), American bollworm (*Helicoverpa armigera* Hubner) and pink bollworm (*Pectinophora gossypiella* Saunders) are the most damaging at reproductive stages of the crop. In the years of pest favourable climatic conditions, the cotton growers have to go repeated number of chemical sprays resulting in not only increase in the cost of cultivation but also imbalance in the cotton agro eco system. So to make the cotton production profitable, efforts were made for developing IRM strategies module on cotton. Fields experiments conducted on IRM from the period 2002 to 2011 produced better results for lower pest population, pest incidence, pesticidal exposure and in return higher conservation of bio-agents, seed cotton over chemical spray schedule. The components used under IRM were variety resistant/tolerant to insect pests and adoption of cultural, mechanical, biological and chemical methods of pest control. Of the various

insect pests attacking cotton, sucking pests and bollworms cause severe damage to a number of commercial crops including cotton. Excessive and indiscriminate use of insecticides against cotton pests have created several problems such as development of resistance insecticide induced resurgence of non target organisms, accumulation of harmful residues, environmental pollution, increase in cost of cultivation and crop failure leading to various socio-economic problems. Studies conducted by Kranthi *et al.,* (2001 and 2002) revealed that resistance in *H. armigera* to pyrethroids and conventional insecticide in India was increasing. This has prompted the necessity for development of non insecticidal alternatives that could be practical and effective for eco friendly insect pest management. The primary objectives were to disseminate insecticide resistance management strategy in farmer's field and monitoring level of resistance in *H. armigera* and other cotton pests.

The primarily strategies of IRM/IPRM are to slow down the development of resistance, thereby extending the usefulness of available chemicals.

MATERIALS AND METHODS

In the cropping season of cotton during 2002-2011, for conducting insecticide resistance management (IRM/IPRM) trials, farmers were selected in the villages of Sriganganagar and Hanumangarh districts of Rajasthan. The agronomic practices and plant protection measures were adopted according to package of practices for *kharif* crops of Rajasthan. The pest incidence and crop yield were observed in both IRM and Non IRM fields.

The IRM Project was implemented in the year of 2002 in two Districts of Rajasthan *i.e.* Sriganganagar and Hanumangarh. For evaluating IRM technologies in the selected villages, studies were conducted for two years and selection criteria for village was based on the number of framers adopted the IRM technology. To evaluate the impact of IRM strategies, the observation regarding average number of sprays, spray cost (Rs/ha) and yield (q/ha) of 10consecutive years were taken from IRM and non IRM adopted fields.

IRM strategies adopted were: -

- Sowing of insect pest resistant/tolerant cultivars like RST 9, *Bt* 134, Bio Seed 6588, Bio Seed 6488, MRC 6317, Bihani 161, RS 810 etc
- Seed treatment for hybrids – For pink boll worm 4 to 40 kg seed treated by 3 g Aluminium phosphide / EDB ampul 3 ml. for 24 h as fumigation. Solarisation for minimum 6 h. Seeds should be socked in 1 l water (1 g streptrocyclin or 10 g plantomycin- 100 ppm solution)/beegha seed for 8-10 h. Fuzzless seed should be treated with imidacloprid 70W.S. @ 5g/ kg seed and thiomithoxam 70 WS @ 4 g/ kg seed for sucking pests.
- Sowing 2-3 rows of trap crops on ridge around cotton field like pearl millets, sorghum, cowpea or maize for birds/ predators.
- Farmers were trained for identifying the different stages (egg, nymph, pupa etc.) of insect pests and their natural enemies.
- Avoid use of any insecticide upto first week of July to conserve natural enemies. Zero insecticidal sprays till first 60 days after sowing.
- Farmers were found to be very much convinced for the use of insecticides only after observing ETL of key pests and hence they could minimize the tendency of blanket spray to a greater extent. At ETL, spray Novaluron for bollworm

management and NSKE (*Neem* seed kernel extract) 5 per cent foliar spray for sucking pests or if needed then spray of Imidacloprid/Acetamiprid.

- Farmers were convinced to realize the disadvantages of mixing of insecticides and hence they avoided the practice of mixing and repetition of the same chemical groups in subsequent sprays for management of insecticide resistance.
- Farmers were unanimously found to be highly motivated for the reduction in number of insecticidal sprays and so the cost of cultivation decrease without any compromise with the seed cotton yield.

Level of resistance in *H. armigera* : The level of resistance in *H. armigera* was studied against 5 commonly used insecticides with their discriminating doses *viz.,* cypermethrin (0.1mg/ml), fenvalerate (0.2mg/ml), quinalphos (0.75mg/ml), methomyl (1.2mg/ml) and endosulfan (10mg/ml) and a new insecticide spinosad (1.0mg/ml). Discriminating doses for *H. armigera* was calibrated from an insecticide-susceptible strain which was made available from A.R.S., Sriganganagar Entomology Laboratory. Third instar of *H. armigera* larvae was used for the discriminating dose calibration bioassays with a topical application procedure. Serial dilutions of technical insecticides in acetone were applied as 1.0 ml drops (by Hamilton repeating dispenser) to at least 10 larvae. Larvae were kept individually in 10 well tissue culture plates containing artificial diet, at 25 ± 2°C for 6 days when mortality assessments were made. Larvae were considered dead if they were unable to move in a coordinated manner when prodded. Larval mortality occurred in the strains of two Districts after treatments were observed. The data on larval mortality/survival were pooled.

RESULTS AND DISCUSSION:

The status of sucking pests and bollworms was observed lower, while natural enemies population was more in the IRM adopted farmers cotton fields as compared to non IRM. Studies conducted on different entomological aspects under IRM as well as non IRM fields of two Districts viz. Sriganganagar and Hanumangarh of western Rajasthan revealed quite good results in Hanumangarh as compared to Sriganganagar, however, the studies was almost similar in both the districts with respect to observed parameters (Table 4 ; Fig. 1). During survey it was noted that soil condition and irrigation facilities are better in Hanumangarh district as compared to Sriganganagar which also facilitate timely sowing of the crop as crop was sown timely in Hanumangarh, whereas, crop sowing in Sriganganagar depends on availability of water in canal by government agency. There observation interface that adoption of IRM program is better in timely sown crop.

The average population of the leafhopper occurred 2.34/3 leaves and that of whitefly 18.07/3 leaves (Table 2 c). Bhosle *et al.,* (2007) reported that mean population of leafhopper (0.4/plant) and whitefly (0.39/plant) in IRM plots was lower than that of non IRM plots. In IRM plots, average spotted bollworm incidence was 13.18 per cent

Table 1. Total number of villages, farmers of IRM v/s non IRM fields and cotton cropped area

Particulars		Year										
		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	**Total**
Number of villages adopted		20	20	30	55	32	32	32	32	30	28	**311**
Farmers participation	IRM	214	243	630	1738	4560	3222	3704	2979	3563	3402	**24255**
	Non IRM	20	26	87	1015	1279	820	1080	875	1100	1025	**7327**
Cotton area (ha)		2428	2631	2842	3551	6860	4273	4505	3326	10058	9537	**50011**

Table 2 (a). Status of insect pests and their natural enemies in IRM v/s non IRM fields of Sriganganagar (2002-2011)

Insect-pests and natural enemies	Sriganganagar																					
	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		**Average**	
	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	**IRM**	**Non IRM**
Sucking pest population																						
Leafhopper /3 leaves	0.45	0.81	1.32	1.57	1.59	1.88	0.67	0.93	0.68	1.03	3.98	4.20	3.90	4.55	3.51	4.05	4.23	5.36	3.91	4.95	**2.42**	**2.93**
Whitefly /3 leaves	17.53	26.16	11.95	14.51	12.44	13.01	10.66	13.88	10.84	17.67	27.20	28.75	20.15	23.45	30.28	36.15	15.00	16.33	18.44	20.11	**17.44**	**21.02**
Fruiting bodies damage																						
Spotted bollworm incidence (%)	8.21	10.87	10.28	12.20	9.51	14.12	10.86	13.47	8.56	16.21	9.87	15.51	26.71	30.50	15.11	18.42	19.22	22.65	15.55	19.23	**13.38**	**17.31**
American bollworm incidence (%)	0.51	0.76	7.13	9.97	6.59	10.22	2.44	3.37	3.23	5.18	1.91	3.05	-	-	-	-	-	-	-	-	**3.63**	**5.42**
Natural enemies population / plant																						
Spider	0.53	0.26	0.61	0.27	0.87	0.39	0.62	0.21	0.79	0.37	1.95	1.20	1.77	1.10	1.14	1.02	2.75	2.24	3.08	2.21	**1.41**	**0.92**
Chrysopa (adult and grub)	0.83	0.39	1.29	0.42	1.41	0.41	1.50	1.00	1.62	1.14	1.66	1.31	1.95	1.05	0.84	0.72	1.76	0.80	1.93	0.70	**1.47**	**0.79**
Coccinellids	0.11	0.04	0.10	0.05	0.19	0.04	0.28	0.09	0.53	0.36	0.77	0.54	0.78	0.55	0.41	0.30	0.12	0.09	0.14	0.09	**0.34**	**0.21**

Table 2 (b). Status of insect pests and their natural enemies in IRM v/s non IRM fields of Hanumangarh (2002-2011)

Insect-pests and natural enemies	Hanumangarh																					
	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		**Average**	
	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	**IRM**	**Non IRM**
Sucking pest population																						
Leafhopper /3 leaves	0.69	1.03	1.90	2.01	1.21	2.10	0.88	1.35	0.72	1.22	2.98	3.60	3.11	3.80	2.91	3.60	4.16	4.76	4.19	5.56	**2.27**	**2.90**
Whitefly /3 leaves	21.87	30.94	16.61	19.57	16.10	17.27	11.23	15.76	10.56	18.45	25.09	26.45	24.19	27.20	32.55	37.65	14.90	18.25	14.08	15.63	**18.71**	**22.71**
Fruiting bodies damage																						
Spotted bollworm incidence (%)	8.65	12.84	11.92	14.53	13.03	16.59	10.57	14.53	9.01	16.35	10.97	18.69	18.62	21.40	13.19	17.71	16.82	19.33	17.13	21.64	**12.99**	**17.31**
American bollworm incidence (%)	0.58	0.98	9.47	13.89	8.81	12.82	3.14	6.31	2.41	4.89	2.49	3.75	-	-	-	-	-	-	-	-	**4.48**	**7.10**
Natural enemies population / plant																						
Spider	0.45	0.34	0.69	0.33	0.81	0.29	0.76	0.27	0.62	0.23	1.77	0.44	1.83	0.94	1.36	1.00	2.55	2.00	2.86	1.68	**1.37**	**0.75**
Chrysopa (adult and grub)	0.97	0.45	1.51	0.48	1.59	0.47	1.75	1.05	1.50	1.06	1.49	1.05	1.82	1.05	0.78	0.45	1.57	0.70	1.84	0.85	**1.48**	**0.76**
Coccinellids	0.15	0.06	0.14	0.09	0.25	0.08	0.48	0.12	0.32	0.17	0.38	0.26	0.80	0.65	0.42	0.28	0.33	0.08	0.12	0.08	**0.33**	**0.18**

Table 2 (c). Average status of insect pests and their natural enemies in IRM v/s non IRM fields of Sriganganagar and Hanumangarh (2002-2011)

Insect-pests and natural enemies	Sriganganagar and Hanumangarh																					
	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		**Average**	
	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	IRM	Non IRM	**IRM**	**Non IRM**
Sucking pest population																						
Leafhopper /3 leaves	0.57	0.92	1.61	1.79	1.40	1.99	0.77	1.14	0.70	1.12	3.48	3.90	3.50	4.17	3.21	3.82	4.19	5.06	4.05	5.25	**2.34**	**2.91**
Whitefly /3 leaves	19.70	28.55	14.28	17.04	14.27	15.14	10.94	14.82	10.70	18.06	26.14	27.60	22.17	25.32	31.41	36.90	14.9	12.29	16.26	17.87	**18.07**	**21.36**
Fruiting bodies damage																						
Spotted bollworm incidence (%)	8.43	11.85	11.10	13.36	11.27	15.35	10.71	14.00	8.78	16.28	10.42	17.10	22.66	25.95	14.15	18.06	18.02	20.99	16.34	20.19	**13.18**	**17.31**
American* bollworm incidence (%)	0.54	0.87	8.30	11.93	7.70	11.52	2.79	4.84	2.82	5.03	2.20	3.40	-	-	-	-	-	-	-	-	**4.05**	**6.26**
Natural enemies population / plant																						
Spider	0.49	0.30	0.65	0.30	0.84	0.34	0.69	0.24	0.70	0.30	1.86	0.82	1.80	1.02	1.25	1.01	2.65	2.12	2.97	1.94	**1.39**	**0.83**
Chrysopa (adult and grub)	0.90	0.42	1.40	0.45	1.50	0.44	1.62	1.02	1.56	1.10	1.57	1.18	1.88	1.05	0.83	0.58	1.66	0.75	1.88	0.77	**1.48**	**0.77**
Coccinellids	0.13	0.05	0.12	0.07	0.22	0.06	0.38	0.10	0.42	0.26	0.57	0.40	0.78	0.60	0.41	0.29	0.22	0.08	0.26	0.17	**0.35**	**0.20**

* From 2008 the population of *Helicoverpa armigera* was negligible during the crop season because up to 2008 the almost area of this region was covered by *Bt* I American cotton verities and population of sucking pest was continuously increased.

Table 3. Reduction in number of insecticidal sprays, spray cost and increase in seed cotton yield in IRM vs Non-IRM Fields of Sriganganagar (2002-2011).

Details		Av. No. of sprays	Spray cost (Rs/ha) (Aprox.)	Details	Yield (q/ha)	Av. No. of sprays	Spray cost (Rs/ha) (Aprox.)	Details	Yield (q/ha)	Av. No. of Sprays	Spray cost (Rs/ha) (Aprox.)	Details	Yield (q/ha)
Kharif,2002	IRM	5.37	3251.56	IRM	11.27	5.45	3299.45	IRM	12.81	5.41	3275.5	IRM	12.04
	Non IRM	9.00	4711.47	Non IRM	9.10	9.30	4868.53	Non IRM	10.1	9.15	4790.00	Non IRM	9.60
	Reduction (%)	40.33	30.98	Increase (%)	23.85	41.4	32.22	Increase (%)	26.83	40.87	31.61	Increase (%)	25.42
Kharif,2003	IRM	4.73	2861.17	IRM	16.89	5.68	3493.83	IRM	19.35	5.20	3150.5	IRM	18.12
	Non IRM	8.38	4310.13	Non IRM	15.21	10.33	5316.86	Non IRM	16.90	9.35	4813.49	Non IRM	16.05
	Reduction (%)	43.56	33.61	Increase (%)	11.05	45.01	35.30	Increase (%)	14.50	44.36	34.54	Increase (%)	12.86
Kharif,2004	IRM	6.60	3349.39	IRM	21.01	7.3	3704.6	IRM	23.84	6.95	3526.99	IRM	22.43
	Non IRM	10.4	4694.04	Non IRM	17.19	12.00	5415.96	Non IRM	18.99	11.2	5055	Non IRM	18.09
	Reduction (%)	36.54	28.64	Increase (%)	22.22	39.17	31.59	Increase (%)	25.54	37.95	30.22	Increase (%)	23.96
Kharif,2005	IRM	5.86	3504.00	IRM	21.81	6.92	3669.00	IRM	22.08	6.39	3586.50	IRM	21.95
	Non IRM	8.45	4583.00	Non IRM	20.55	11.87	5218.00	Non IRM	20.27	10.16	4900.50	Non IRM	20.41
	Reduction (%)	30.65	23.54	Increase (%)	6.13	41.70	29.68	Increase (%)	8.93	37.11	26.81	Increase (%)	7.52
Kharif,2006	IRM	5.05	3479.26	IRM	24.68	4.59	3405.15	IRM	26.63	4.82	3442.20	IRM	25.66
	Non IRM	8.37	4868.00	Non IRM	21.06	8.11	5463.00	Non IRM	22.44	8.24	5165.50	Non IRM	21.75
	Reduction (%)	39.67	28.52	Increase (%)	17.19	43.4	37.66	Increase (%)	18.67	41.5	33.36	Increase (%)	17.95
Kharif,2007	IRM	5.97	3960.86	IRM	20.63	5.59	3708.75	IRM	21.89	5.78	3834.80	IRM	21.26
	Non IRM	8.00	4409.19	Non IRM	19.2	7.80	4298.81	Non IRM	20.25	7.9	4354.00	Non IRM	19.72
	Reduction (%)	25.38	10.16	Increase (%)	7.45	28.33	13.72	Increase (%)	8.10	26.84	11.92	Increase (%)	7.78
Kharif,2008	IRM	6.26	3474.00	IRM	22.24	5.44	3486.00	IRM	24.49	5.85	3480.00	IRM	23.37
	Non IRM	7.80	3895.00	Non IRM	19.02	7.00	3950.00	Non IRM	20.65	7.40	3922.50	Non IRM	19.83
	Reduction (%)	19.74	10.8	Increase (%)	16.93	22.29	11.74	Increase (%)	18.60	20.95	11.28	Increase (%)	17.80
Kharif,2009	IRM	6.02	3557.00	IRM	23.32	5.36	3428.00	IRM	26.35	5.69	3492.50	IRM	24.84
	Non IRM	7.85	3920.00	Non IRM	20.6	7.05	3960.00	Non IRM	22.55	7.45	3940.00	Non IRM	21.57
	Reduction (%)	23.31	9.26	Increase (%)	13.2	23.97	13.43	Increase (%)	16.85	23.62	11.35	Increase (%)	15.11
Kharif,2010	IRM	5.79	3252.73	IRM	23.39	5.04	3096.86	IRM	24.67	5.41	3174.79	IRM	24.03
	Non IRM	7.80	4355.00	Non IRM	20.25	7.00	4200.00	Non IRM	21.15	7.40	4277.50	Non IRM	20.70
	Reduction (%)	25.77	25.31	Increase (%)	15.51	28.00	26.26	Increase (%)	16.64	26.82	25.77	Increase (%)	16.09
Kharif,2011	IRM	5.39	3259.25	IRM	23.58	4.52	2737.75	IRM	24.84	4.95	2998.50	IRM	24.21
	Non IRM	7.53	4504.97	Non IRM	19.75	6.35	3799.02	Non IRM	20.35	6.94	4151.99	Non IRM	20.05
	Reduction (%)	28.42	27.65	Increase (%)	19.39	28.82	27.93	Increase (%)	22.06	28.60	27.78	Increase (%)	20.75
Average	**IRM**	**5.70**	**3395.00**	**IRM**	**20.88**	**5.58**	**33.98**	**IRM**	**22.70**	**5.64**	**3396.00**	**IRM**	**21.79**
	Non IRM	**8.35**	**4425.00**	**Non IRM**	**18.19**	**8.68**	**46.49**	**Non IRM**	**19.37**	**8.52**	**4537.00**	**Non IRM**	**18.77**
	Reduction (%)	**31.34**	**22.85**	**Increase (%)**	**15.29**	**34.21**	**25.96**	**Increase (%)**	**17.67**	**32.86**	**24.46**	**Increase (%)**	**16.52**

and American bollworm incidence observed was 4.05 per cent. Bhosle *et al.*, (2007) also observed similar trends of bollworm attack on cotton. The average population of natural enemies, spider, chrysopa (adult and grub) and coccinellids was 1.39, 1.48 and 0.35/ plant, respectively in plots receiving IRM strategies adopted fields. IRM plots conserved the natural enemies due to less application of insecticides.

The results pertaing to resistance depicted that maximum resistance (94.29%) was observed against cypermethrin followed by fenvalerate (90.65%) and quinalphos (51.44%). However, the minimum level of resistance (0.95%) was observed in the larva treated with spinosad followed by endosulfan (35.23%) and

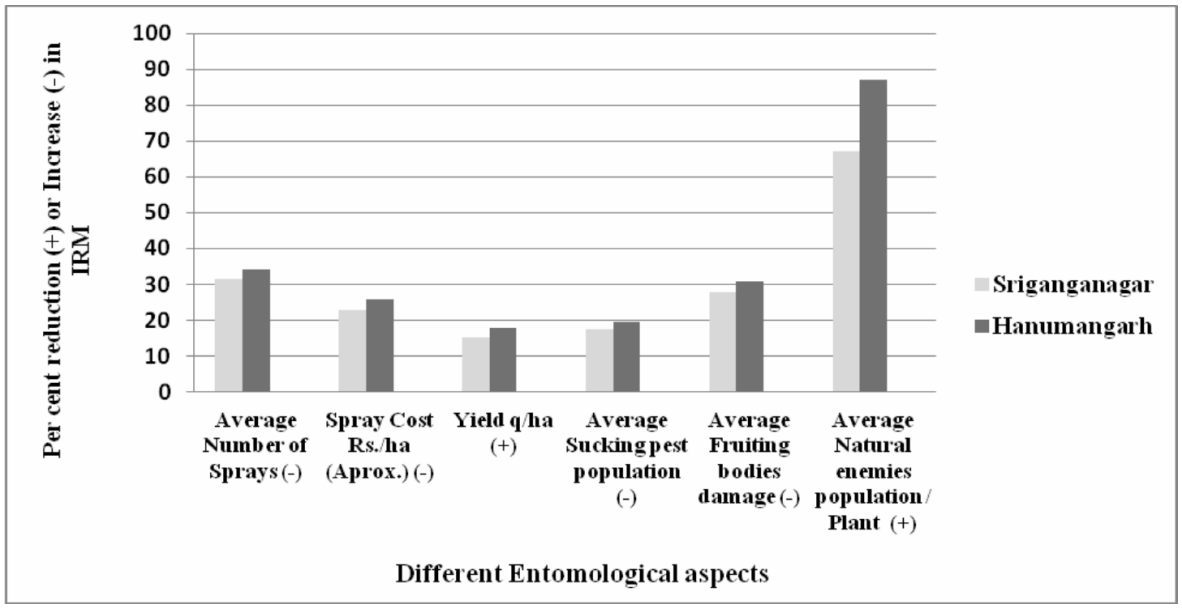

Fig. 1. District wise comparison of IRM vs non IRM Fields with respect to different Entomological aspects

Table 4. District wise comparison of IRM v/s non IRM Fields with respect to different Entomological aspects

Aspects	Sriganganagar			Hanumangarh		
	IRM	N IRM	Decrease or increase IRM (%)	IRM	N IRM	Decrease or Increase IRM (%)
Average number of sprays	5.70	8.35	(-) 31.34	5.58	8.68	(-) 34.21
Spray cost (Rs/ha) (Aprox.)	3395	4425	(-) 22.85	33.98	46.49	(-) 25.96
Yield (q/ha)	20.88	18.19	(+) 15.29	22.70	19.37	(+) 17.67
Sucking pest population						
Leafhopper /3 leaves	2.42	2.93	(-) 17.40	2.27	2.90	(-) 21.72
Whitefly /3 leaves	18.71	22.71	(-) 17.61	17.44	21.02	(-) 17.03
Fruiting bodies damage						
Spotted bollworm incidence (%)	13.38	17.31	(-) 22.70	12.99	17.31	(-) 24.95
American bollworm incidence (%)	3.63	5.42	(-) 33.02	4.48	7.10	(-) 36.90
Natural enemies population / plant						
Spider	1.41	0.92	(+) 53.26	1.37	0.75	(+) 82.66
Chrysopa (adult and grub)	1.47	0.79	(+) 86.07	1.48	0.76	(+) 94.73
Coccinellids	0.34	0.21	(+) 61.90	0.33	0.18	(+) 83.33

methomyl (43.85%). In other words, *H. armigera* has developed highest degree of resistance for cypermethrin and fenvalerate while spinosad gave almost same results in both districts.

Total number of villages, farmers participated under IRM and total cotton crop area were 311, 24255 and 50011 ha, respectively during 2002-2011 (Table 1). Average of 10 years revealed that the average number of sprays were more in non IRM plots *i.e.* 8.52 than in IRM plots where these were observed 5.64. The per cent reduction in number and cost of sprays was 32.86 and 24.46 respectively. Per cent increase in seed cotton yield was observed 16.52 in IRM fields, compared to non IRM (Table 3).

An increase in net return achieved to be Rs. 14250/ha over non IRM plots, with an additional profit of Rs. 4054/ha. Birari *et al.,* (2007) and Mallah and Korejo (2005) reported similar results.

To conclude the IRM is a cost reducing strategy and has an economic potential by reduction in insecticides use on cotton and fit well as an important component of Integrated Pest Management programme.

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