An IPM system for summer irrigated cotton in South India

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ABSTRACT

*A local IPM module comprised basal neem cake application 150 kg/ha followed by 1% neem oil; drenching, seed treatment with imidacloprid @ 5 g/kg; use of trap crops (castor, sunflower, bhendi, red gram); predator enhancing crops (maize, cowpea) along the borders and bunds; use of yellow sticky traps for white flies and pheromone traps for bollworms (*Helicoverpa armigera *Hüb. and* Pectinophora gossypiella *Saund.); clipping of terminals at 75 days after sowing (DAS); two releases of* Trichogramma *and need based plant protection with chemicals. The IPM module registered a yield of 1,960 kg/ha, an increase of 32.4% over farmer's practice, which used ten applications of plant protection chemicals only. A net profit of Rs.22,100/ha was realized in the IPM module compared to only Rs.15,500/ha in the former practice areas.*

Introduction

The summer cotton (Feb-July) area of 12000 ha around the Cotton Research Station, Srivilliputtur in Virudhunagar district of Tamil Nadu State is distinct from the main winter cotton (Sep-Feb) and is prone to cotton stem weevil *Pempherulus affinis* attack in addition to *Helicoverpa armigera* and *Pectinophora gossypiella* menace. Among the sucking pests, damage by jassids, *Amrasca devastans* (Dist.) starts in the early vegetative phase and continues into the reproductive phase. Inappropriate use of stronger insecticides against jassids in the initial stages and against stem weevil, and bollworms in the later crop stages results in elimination of natural enemies, escalation of plant protection costs and finally ends in very poor yields and returns. Deterioration in the quality aspects of varieties under cultivation are also detrimental to cotton production and the interests of the farming community. With summer irrigated cotton beset with these problems, farmers, though aware of few IPM technologies, have not been willing to undertake them. To overcome these problems and to sustain cotton production, an adoptable IPM module was developed after testing for three years from 1998-2001 in both the Cotton Research Station, Srivilliputtur and farmers holdings under summer irrigated conditions.

Experimental procedure

The IPM module was compared with farmers practice in three locations the Research farm, Srivilliputtur (L1), farmers holdings in Chithalamputtur village (L2) and Mamsapuram villages (L3) for three years (1998-99, 1999-2000 and 2000-2001). The IPM module included components to tackle the pest type and pest load of summer cotton and was compared with Farmers Practice (FP). Trials were taken up in 0.40 ha each for each IPM module and FP for the three seasons. Both the IPM module and FP utilized the SVPR 2 variety, which is moderately resistant to *A. devastans* and *P. affinis*. SVPR 2 variety (Koodalingam *et al.*, 2001) was raised in ridges and furrows (Dharmarajulu *et al.*, 1934; Anonymous, 1995) in the IPM module and in beds and channels in FP. IPM included acid delinting, seed treatment with imidacloprid @ 5g/kg (Mote *et al.*, 1995), basal neem cake application (150 kg/ha) followed by a 1% neem oil drenching at 20 and 30 days after sowing (DAS) (Mohan and Raveendran, 2001; Anonymous, 1997), use of trap crops (castor, sunflower, bhendi, red gram), predator enhancing crops (maize, cowpea) along the borders and bunds (Dhawan, 1998; Regupathy *et al.*, 1997), use of yellow sticky traps @ 12/ha for whiteflies (Berlinger, 1980; Diraviam and Uthamasamy, 1992) and pheromone traps @ 12/ha for bollworms *H. armigera* (Patil and Bheemanna, 1985), and *P. gossypiella*, (Balasubramnian *et al.*, 1979), clipping of terminals at 75 DAS to reduce egg load of *H. armigera*, (Surilivelu *et al.*, 1998), two releases of *Trichogramma* @ c. 42,500/ha (as pupae in *Corcyra cephalonica* eggs) (Dhandapani *et al.*, 1992) and ETL based plant protection with chemicals. ETLs were as suggested in the Tamil Nadu Agricultural University Crop Production Guide (Anonymous, 1995), i.e. jassids 1-2/leaf, thrips 50/50 leaves, bollworms – 10% damaged squares or bolls). For stem weevil damage, plant protection measures were taken up before 45 days after sowing (Parameswaran and Chelliah, 1984). Farmers practice included cow dung slurry seed treatment and ten rounds of plant protection chemicals including synthetic pyrethroids and mixtures of pesticides. Spray usage in farmers practice plots was fixed, based on materials used by >65% of farmers in a survey in the district in 1996 carried out by the senior author. Bhendi infested with spotted bollworms were removed twice a week in IPM.

Observations on sucking pests such as *A. devastans*, thrips (*Thrips tabaci*) and aphids (*Aphis gossypii*) etc. were recorded from three leaves top, middle and bottom in 25 randomly selected plants at 25, 45, 55, 67, 77, 90, 115, 130 and 147 DAS. *P. affinis* infestation was monitored from its appearance up to harvest. The extent of damage by *Earias vittella*, *H. armigera* and *P. gossypiella* were assessed in 25 plants selected at random. The number of good opened bolls (GOB), bad opened bolls (BOB), and percent locule damage was also recorded on these plants. The population of natural enemies was also recorded (as percentage plants) from the same 25 plants selected at random as the pest counts. Data recorded on the pest and natural enemy populations was subjected to analysis of variance. Paired data on pests was compared between the IPM module and farmers practice with paired T-tests (Gomez and Gomez, 1984). Yield

was recorded and cost economics were worked out. Based on the quantitative and qualitative parameters, the effectiveness and efficiency of the IPM module was calculated.

Results and Discussion

Quantitative and qualitative aspects of the IPM module

Data on the spray schedule along with cost of insecticides and other IPM inputs, comparative pest and natural enemy population, border and bund crop utility, are presented in Tables 1 to 5. The number of sucking pests and damage by bollworms and stem weevil are presented in Figure 1.

Pest load and natural enemies recorded at various growth stages in the IPM module and FP were found to be significantly different. Incidence was higher in the FP module during the early as well as reproductive phase.

Sucking pests

Seed treatment with imidacloprid @ 5 g/kg was effective up to six weeks (early square formation stage) in warding off sucking pests in the IPM module. The IPM module recorded a lower sucking pest population compared to farmers practice as is evident from the 80% decrease of *T. tabaci*, 71% decrease in *A. gossypii* and 75% decrease in *A. devastans* populations over farmers practice in the early phase (Table 2). Sucking pests in the FP, which decreased with the first spray, then increased in the later stages. Higher populations of sucking pests in farmers practice, which might be due to use of stronger pesticides exerting adverse effect on natural enemy population.

P. affinis Farmers practice recorded 50% stem weevil infestation while the IPM module registered only 18.4% at harvest (Table 2). This could be due to prophylactic basal application of neem cake @ 150 kg/ha coupled with drenching 1% neem oil suspension at 20 and 30 DAS in IPM module. Drenching with 1% neem oil helped in control of stem weevil through reduced oviposition in the initial stages.

Bollworm Incidence of *P. gossypiella* was higher than that of *H. armigera* in both modules. The incidence of *Earias vittella*, *H. armigera* and *P. gossypiella* was lowered by 47, 66 and 58% respectively in the IPM module (Table 2). Locule damage by pink bollworm was less by 67% in IPM. The low damage by pink bollworm in IPM module was obtained through the setting up of delta sticky traps and spraying of insecticides at 110 and 140 DAS.

Natural enemies The population of coccinellids was higher in the IPM module due to usage of eco-friendly botanical pesticides like neem oil 1% and neem formulations. The heavy use of insecticides in the farmers practice often almost eliminated spider and coccinellids populations beyond 75 DAS. In the IPM areas, coccinellids numbers of 6/plant were observed at 105 DAS (Table 3).

Use of traps and pest management Delta traps and yellow sticky traps played an effective role in the management of pink bollworm (46/day) and whitefly (129/trap/day) respectively (Table 4). *Helicoverpa* pheromone traps recorded a high catch of 25/week (Table 4).

Intercrops *vis-à-vis* pest management Maize, cowpea served as predator enhancing crops (Table 5). These crops harbored pests such as, *Perigrinus maidis* and *Aphis craccivora*, which serve as prey for coccinellids and *Chrysopa*. Trap crops *viz.*, castor, sunflower, redgram, served as indicators of pest damage and also trapped sucking pests and *Helicoverpa* to an appreciable degree.

Cotton yield and cost effectiveness However the IPM module registered the higher yield of 1,960 kg/ha, this was an increase of 32.4% over farmers practice. The cost of plant protection input was Rs. 5,570/ha in the IPM module and Rs. 4,285 in FP. A net profit of Rs. 22,100/ha was realized in the IPM module compared to Rs. 15,500/ha (Table 6). The lower profit margin realized in farmers practice was worsened exacerbated by excessive pesticide application, erratic dosage, timing and cocktails with synthetic pyrethroids.

Conclusion

A balance sheet of the IPM module and farmers practice is presented in Table 7. Location specific IPM modules have gained significance due to the changing pest scenario in different seasons and agro eco systems. Several workers attempted to develop working IPM modules for cotton (Patil *et al*., 1992; Sidhu *et al.*, 1992; Sundaramurthy and Chitra, 1992). Components evolved in the current IPM module for bollworms are akin to the best-bet method designed for insecticide resistance management of *H. armigera* by Regupathy *et al.* (1997) and the system approach developed for sustainable insect pest management in cotton by Surilivelu *et al.* (1998) and field demonstrations of cotton IPM conducted by Basu (1998). The current IPM module is different from the above-discussed approaches by the incorporation of management practices for stem weevil.

Four chemical applications used for the control of sucking pests and bollworm as used in the IPM module in the present study may not be a favorable environment for entomophagous arthropod activity. Using bio-control agents in intensive production systems is hampered by the availability of bio control agents, which must be in good condition at the right time, lack of trained staff to supervise releases. Lack of knowledge

(on the part of farmers) on biological processes involved, lack of quality assurance, lack of monitoring set up to supervise the 'in house quality' of production systems, the need for good genetic base of breeding stock in the production systems and non acceptance of bio control agents by the farmers are all problems faced by bio-intensive systems.

However, the current IPM system, evolved for summer irrigated cotton, shows the advantages which can be gained by rationalizing the spray application, timing the spray application based on ETL by monitoring for sucking pests in the initial stages and bollworms in the later stages, the use of low cost monitoring tools *viz.*, yellow sticky traps for whiteflies and pheromone traps for bollworms especially for American bollworm and pink bollworm, and the raising of border and bund crops. Large-scale field demonstrations of the IPM module are now required.

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Table 1. *Spray schedule and cost of IPM inputs.*

Sl. No	DAS	IPM	Cost Rs/ha)	FP	Cost (Rs/ha)
1	Basal	Seed treatment with imidacloprid @ 5 g/kg	210	Cow dung slurry	70
		Neem cake application @ 150kg/ha	900		
2	20, 30	Neem oil	900	Dimethoate	200
		1 % drenching		625 ml/ha	
3	40	Vijayneem 1500ppm	600	Monocrotophos	270
		500 ml/ha		750 ml/ha	
4	50	-		Endosulfan	360
				1500 ml/ha	
5	60	Endosulfan	590	-	
		2500 ml/ha			
6	75	Clipping of terminals and release of	225	Chlorpyriphos 1000 ml +	475
		Trichogramma		Fenvalerate 750 ml/ha	
7	85	Release of *Trichogramma*	75	Quinalphos	300
				1250 ml /ha	
8	90	-		Dimethoate	330
				1000 ml/ha	
9	110	Profenophos 1500 ml/ac	750	Quinalphos 1250 ml/ha +	450
				Deltamethrin 500 ml/ha	
10	120	-		Monocrotophos	720
				2000ml/ha	
11	140	Quinalphos 2.0 lit/ac	480	Cypermethrin 1250ml/ha +	750
				Dimethoate 1000 ml/ha	
12	>140	-		Cypermethrin	360
				1000 ml/ha	
Other IPM inputs					
13	25-60	Yellow sticky traps	30	-	
		@ 12/ha			
14	60-100	Helicoverpa pheromone	330	-	
		(12 traps and 24 septa)			
15	100-140	PBW pheromone	430	-	
		(12 traps and 24 septa)			
16	Basal	Border and bund crops	60	-	
		(6 @ 500 g each)			
TOTAL			5,600		4,285

Table 2. *Pest load and yield comparison in IPM and FP.*

Component	IPM module	FP	T test (t values)	% Increase or decrease over FP
Pests				
1. Thrips no/plant 25 DAS	2.8	15.2	11.8**	-80.5
2. Aphids no/plant 25 DAS	2.5	8.7	8.7**	-71.3
3. Leafhopper no/plant 45 DAS	1.2	4.8	4.3**	-75.0
Damage				
% Square (SBW) 45 DAS	5.8	10.9	3.3**	-46.8
% Bollworm (ABW) 90 DAS	3.8	11.2	5.1**	-66.1
% Bollworm (PBW) 130 DAS	5.6	16.8	4.3**	- 66.7
% Locule damage (PBW) 130 DAS	8.8	18.9	3.9**	-53.4
% Stem weevil (harvest)	18.4	49.5	6.4**	-62.8
GOB/plant	18.2	12.2	3.4**	+33.0
BOB/plant	6.9	13.4	4.1**	-48.5
Yield				
Seed cotton yield kg/ha	1960	1325	-	+32.4

** Significant at 1 % level.

Table 3. *Natural enemy comparison in IPM module.*

		Coccinellids/plant		Spiders/plant	
S.No	DAS	IPM	FP	IPM	FP
1	30	3.1 (± 1.3)	0.9 (± 0.7)	1.3 (± 0.6)	N
2	45	6.6 (± 2.1)	0.7 (± 0.4)	2.5 (± 1.4)	0.03
3	75	5.2 (± 1.8)	0.5 (± 0.3)	3.1 (± 1.2)	0.02
4	105	6.2 (± 2.6)	N	2.7 (± 1.1)	N
5	130	5.8 (± 2.1)	N	2.1 (± 0.9)	N

N- negligible

Table 4. *Traps catch for pest management.*

S No	Traps	Target pest	Mean catch (number/trap)
1.	Yellow sticky trap	Whitefly	128.6/day (±72.9)
2.	Delta trap	Pink bollworm	46.4/day (± 12.2)
3.	Pheromone trap	Helicoverpa	25.0/week (± 6.2)

Table 5. *Intercrops* vis-à-vis *sucking pest population in IPM modules.*

S.No	Crop	Category	Target pest
1.	Bhendi	Trap crop	Jassids, spotted bollworm
2.	Castor	Trap crop	Whitefly & minor pests
3.	Sunflower, Red gram	Trap crop	*H. armigera*
4.	Maize, Cowpea	Predator enhancing crop	Aphids and jassids

Table 6. *Economics of IPM module.*

Sl No	Factors	IPM	FP	% Increase over FP
1	Cotton yield (kg/ha)	1960	1325	32.4
2.	Gross Income	39,200	26,500	32.4
3.	Total Cost	14,100	13,000	7.8
4.	Net Profit	25,100	13,500	46.2
5.	Cost benefit ratio	1.8	1.1	-

Table 7. *Balance sheet of IPM and FP.*

Sl. No	Component/factor	IPM	F.P
I	**INPUT**		
1.	Seed treatment imidacloprid	Yes	Yes
2.	Neem cake 150 kg/ha	Yes	No
3.	Neem oil 1% drenching 20, 30 DAS	Yes	No
4.	(i) Botanical pesticides	1	Nil
	(ii) Chemical pesticides	4 (3+1 seed treatment)	10 (inc. 3 combinations with SP)
4.	Array of inter/border/catch/trap crops	Yes	No
5.	Use of traps	Yes	No
6.	Release of *Trichogramma*	Yes (2 releases)	No
II	**OUTPUT**		
1.	Leafhopper		
	45 DAS	1.2	4.8
	90 DAS	2.4	8.6
2.	Stem weevil infestation % (harvest)	18.4	49.5
3.	SBW damage 45 DAS	5.8	10.9
4.	ABW damage 90 DAS	3.8	11.2
5.	PBW damage 130 DAS	5.6	13.2
3.	Natural enemy presence	Significant	Negligible
4.	Seed cotton yield kg/ha	1960	1325
5.	Profit / ha	Rs.22,100	Rs.15,500
6.	Conclusion	Effective & Economic	Not effective - Not Economic

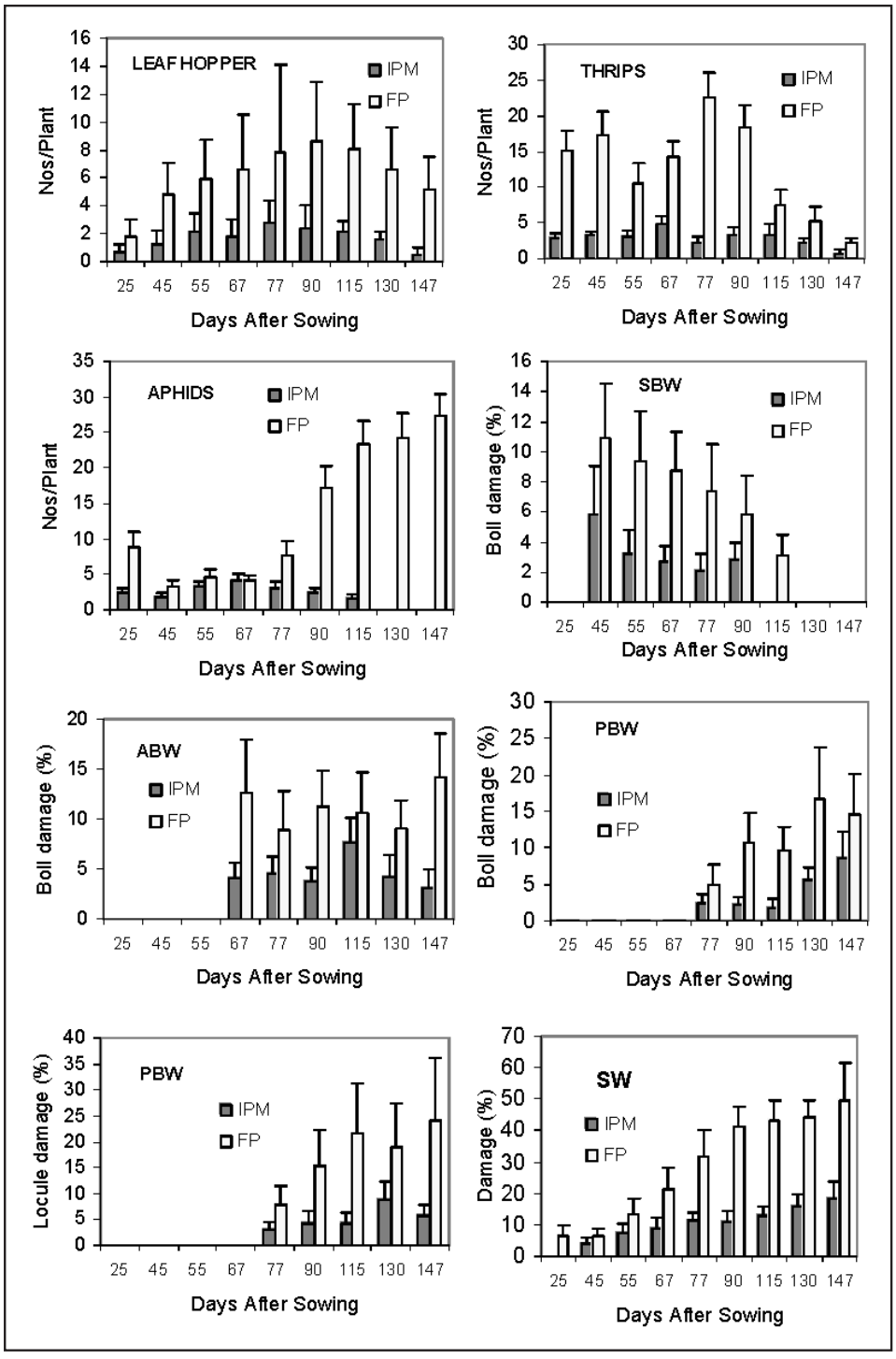

Figure 1. *Pest load in Integrated Pest Management (IPM) and Farmers Practice (FP) modules at various growth stages of cotton.*