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RESEARCH PAPER

Measuring Adoption and Effect of Insect Resistance Management (IRM) Practices for Managing Pink Bollworm in Cotton in India

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ABSTRACT

Indian cotton farming has been experiencing the resurgence of pink bollworm (PBW) during the recent year even after adopting *Bt* technology that protects from bollworm infestation. In the recent past, pest infestation particularly by PBW caused large-scale damage in cotton production of India. Here, question comes to the scientific backing of *Bt* trait to control bollworm infestation in *Bt* cotton. Another important concern which needs to be noted is that pink bollworm developed the resistance only in India among the 14 *Bt* cotton-growing countries. It means only the efficacy of *Bt* trait cannot be denounced, but the complex mechanism including both off the field (seed quality including trait purity) and on the field (farm practices) needs to be studied. Farm practice involving the Insect Resistance Management (IRM) Practices offer delaying of resistance development by the target pests. The study attempted to evaluate adoption level of IRM practices by the farmers and its effect in cotton cultivation. The study was carried out in 2018 in the states of Gujarat, Maharashtra and Karnataka.

HIGHLIGHTS

- It is found that farmers are hardly aware of two important measures of IRM- growing refuge crops and use of pheromone traps.
- The average yield is found to be higher for the farmers with high IRM adoption level in all the three states.
- Both, yield and net return from cotton increases in increasing order of IRM adoption level (low, medium and high) by the farmers in all three states.

Keywords: *Bt* Cotton, IRM, Pink bollworm, Adoption, Cost of cultivation

Cotton is grown in more than 100 tropical and sub-tropical countries in the world (FICCI, 2014). Despite lower yields, India is the highest producer (6.2 million ton) of cotton in the world with the largest area (around 12.3 million hectares) under cultivation (Cotton Outlook, 2018). The paradigm technological shift in Indian cotton cultivation came in 2002 with the introduction of *Bt* cotton that releases proteins which confer resistance to lepidopteron pests of cotton. Insecticide consumption is considered to be drastically reduced in *Bt*-cotton as it provides protection from Lepidopteran pest infestation like American bollworm (*Helicoverpa armigera*), Spotted bollworm (*Earias vittella*), Pink bollworm (*Pectinophora gossypiella*) and other minor pests such as the cotton semilooper and hairy caterpillar (Kranthi, 2012; Choudhary and Gaur, 2014). In

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the recent past, cotton cultivation in India gained national and international attention with its highest production on one hand and severe pest attack on the other. The severe pest attack by pink bollworm in the past few years in *Bt* cotton led to reservations on effectiveness of *Bt* traits to control bollworm infestation.

Pest infestation in cotton has been gradually increasing over the year in recent past. High level of pink bollworm infestation resulted in crop damage in cotton growing states of India like Gujarat, Madhya Pradesh, Maharashtra, Karnataka and Andhra Pradesh (Kranthi, 2015; Kairon, 2018). The insecticide application has also increased and consumption level crossed to pre-2002 levels in the year 2013 (Gutierrez, 2018). Though *Bt* cotton provided initial relief, it is believed that pink bollworm has developed resistance to Bollgard II (BG II) in India (Kranthi, 2015), whereas no other 14 *Bt* cotton-growing countries have observed this resistance (Vithal, 2018). Vithal (2018) pointed out that the lack of adopting Integrated Pest Management (IPM) practices by the farmers is one of the important reasons for resistance development in pink bollworm along with other bollworms. Based on IPM principles, insecticide resistance management (IRM) practices have placed greater emphasis in recent years (Kumar *et al.* 2012). Pest management system has been strengthened by IRM practices to delay resistance development among the target pests by identifying appropriate insecticides (Kranthi, 2007). Different public institutions (ICAR-CICR, SAUs) and private institutes introduced several IRM interventions among farmers to control pest infestation. Though very few studies have been conducted to study the adoption level of IRM practices and its effects on cotton output. A study on impact of cotton development programme on adoption of recommended management practices in *Bt*-cotton revealed that the use of recommended *Bt* cotton hybrid as well as recommended use of nitrogenous fertilizer was increased significantly (Singh *et al*. 2022). Deciding which recommended practice to be adopted and which not-to-be-adopted depends on many factors. A study by Gowda *et al.* (2022) shows that farmers resort to induced decision making due to complexity of problems in pests. Keeping in view the research gap, the present study was conducted to assess the adoption level of IRM practices, and to evaluate the effects of IRM adoption on cost and return of cotton cultivation in major cotton growing states in India.

METHODOLOGY

The study is based on primary data collected from cotton farmers about farm operations, IRM practices and costs and returns in the year 2018. Gujarat, Maharashtra and Karnataka were selected purposively as these three states hold more than 60% of total cotton crop area and produce about 58% of total cotton production in India according to triennium ending (TE) average of 2017/18 i.e. 3-year average (2015/16 to 2017/18). Based on the large area under cotton cultivation, four districts from Gujarat and two each from Karnataka and Maharashtra were selected with random sample of total 611 cotton growing farmers. The sample distribution and survey area is depicted in Table 1.

Table 1: Survey area and sample distribution

State	District	Sample Size
Gujarat	Amreli	88
	Bhavnagar	94
	Junagadh	92
	Surendranagar	30
Maharashtra	Jalna	91
	Yavatmal	38
Karnataka	Gadag	88
	Raichur	90

After consulting available literatures, considering advisory of ICAR-Central Institute of Cotton Research (CICR), Nagpur and other agencies, the following 11 activities were identified under IRM practices:

1. Deep summer ploughing
2. Selection of varieties with early maturity
3. Using branded or certified seeds
4. Cultivation of non-*Bt* cotton as refugee crop
5. Insecticide sprays based on economic threshold level (ETL)
6. Use of Pheromone traps
7. Synchronized harvesting by all cotton farmers in the village
8. Destruction of green bolls at the end of the cropping season

9. Destruction of cotton stubbles
10. Keeping the field weed-free during off-season
11. Crop rotation (cycle)/ breaks

Farmers adopting four or less number of practices, five to eight practices and above eight practices were categorized as 'Low adopters', 'Medium adopters' and 'High adopters', respectively. Though the influence of individual component on pink bollworm (PBW) infestation are different, equal weightage has been considered for each component after consultation with different stakeholders (researchers, seed companies, cotton growers).

One way analysis of variance (ANOVA) was used to find the effect of different IRM adoption levels on the cotton yield in the three states. Tukey HSD post hoc test was used to confirm where the differences occurred between the groups and has been used only in those cases where there is statistically significant difference in group means of the one way ANOVA result.

The cost of cultivation has been estimated in terms of cost A1 (MOSPI, 2008), where, Cost A1= Sum of value of hired human labour, hired bullock labour, owned bullock labour, owned machine labour, hired machinery charges, seed (both farm produced and purchased), insecticides and pesticides, manure (owned and purchase), fertilizers, irrigation charges, depreciation on implements and farm building, land revenue, cesses and other taxes, and interest on working capital.

In order to simplify the objectives, few components like transportation charges, interest on working capital and miscellaneous expenses were not considered in the study.

Net Return is calculated using the following formula:

$$\text{Net Return} = \text{Gross Return} - \text{Total Cost of Cultivation}$$

RESULTS AND DISCUSSION

Socio-economic characteristics of sample farmers

The profile of the sample farmers is depicted in Table 2. The average age of farmers in all the three states was found to be varying between 45 and 50 years. More than half of the farmers in the study area had school education, whereas one-fifth were illiterate. Less than 10% had university degree in all the three selected states. Family size was found to be relatively large in the study villages, as more than 60% of households had 5 to 9 members. However, the proportion of nuclear family with number of members up to four were also in sizeable proportion. Open well was major source of irrigation in Gujarat and Maharashtra, whereas, canal in Karnataka. But open well was found to have very less water, and in many cases, wells went dry during crop season. Therefore, farmers had to depend on monsoon for irrigation in selected districts of Gujarat and Maharashtra. Hence, monsoon plays a major role in cotton production.

Table 2: Socioeconomic profile of the sample farmers (percent of total sample size in the respective state)

Particulars	Gujarat	Maharashtra	Karnataka	Total
Sample size	304	129	178	611
Average Age (years)	48	48	46	47
Educational level				
Illiterate	19.47	25.78	23.03	21.84
Primary	29.70	18.75	21.35	24.96
Secondary	34.98	2.81	17.98	29.56
Higher secondary	11.22	15.61	29.21	17.4
Graduate and above	4.62	7.03	8.43	6.24
Family size				
Up to 4	22.77	30.47	36.52	28.4
5-9	66.67	58.59	56.74	62.1
10 and above	10.56	10.94	6.74	9.52
Source of irrigation				
Canal	8.91	3.13	46.63	18.7
Open well	75.91	74.22	0.56	53.5
Bore well	24.09	11.72	12.92	18.2
River	2.64	0.78	2.81	2.3
Tank	0	1.56	0.56	0.49

IRM adoption level

Resistance developed among the target pests to the *Bt* toxin poses one of the biggest threat to the sustainability of *Bt* cotton yield. Therefore, IRM strategies become more important to preserve the usefulness of *Bt* traits by delaying the development

of insect resistance (Dhruva and Gujar, 2011). The United State Environmental Protection Agency (EPA) mandates to grow non-*Bt* refuge with *Bt* crop (Singla *et al.* 2013). In refuge, a certain fraction of the insect population is not allowed to get exposed to *Bt* proteins. These insect mate with any *Bt*-susceptible insects so as to pass on the susceptibility to their offspring (Li *et al*. 2017; Tabashnik *et al.* 2013, Kranthi, 2012). To induce such susceptibility, research institutions and seed industry recommended different farm practices, which are commonly known as Insect Resistance Management (IRM) practices.

The identified 11 IRM practices have been subjected to inquiry from the cotton farmers in the study area to assess their adoption level. During the field survey, it was found that none of the farmers across the selected states adopted all the identified IRM practices. There is also a big concern that many farmers were not aware of certain important IRM practices (Table 3). For instance, large proportion of farmers were unaware of cultivation of refuge crop. Karnataka has more 'High' IRM adopters (47%) than Gujarat (38%) and Maharashtra (20%). Maharashtra has the highest proportion of 'Low' IRM adopters (21%), while Karnataka has a high proportion of 'Medium' adopter (48%). ('Low' are following 4 or less, 'Medium' are following 5-8 and 'High' are following more than 8 IRM practices). It was also observed that more than 75% of sample farmers in Maharashtra and about 57% in Gujarat were not aware of pheromone trap. Agriculture Universities and other organizations distributed pheromone traps at some point of time in the past, which few farmers implemented but discontinued later. The proportions of 'disadopted' farmers in Karnataka were 47 % and 46 % for 'non-*Bt* crop cultivation' and 'use of pheromone traps', respectively. Similarly, about 46%, 43% and 31% of farmers in Gujarat, Maharashtra and Karnataka, respectively were not aware of cultivation of non-*Bt* cotton as refuge crop. Realizing this concerns, seed companies as well as the governments have introduced mixing of *Bt* cotton seed with non*Bt* cotton seed in the same packet called as 'Refuge-in-Bag' (RIB) (NSA

Table 3: Farmers' awareness and adoption of various IRM practices (percent of total)

	Gujarat				Karnataka				Maharashtra			
IRM Practice	Disadopted	Adopted	Aware but not adopted	Not Aware	Disadopted	Adopted	Aware but not adopted	Not Aware	Disadopted	Adopted	Aware but not adopted	Not Aware
Deep summer ploughing	1	96	1	3	1	97	1	2	0	88	1	11
Selection of varieties with early maturity	0	98	1	1	0	42	19	39	2	38	16	44
Using branded or certified seeds	0	98	1	1	0	96	2	3	1	91	3	5
No spray before 20-25 days after sowing		97	1	2		85	4	11		78	3	19
Use of pheromone traps	3	20	20	57	0	11	13	76	5	2	17	75
Harvesting along with other farmers	0	93	1	7	0	79	10	11	1	57	2	41
Grazing/destruction of left over green bolls	1	83	2	14	0	77	6	17	2	57	4	37
Destruction of cotton stubbles	0	92	1	6	0	90	2	8	1	79	3	17
Maintaining weed free land during off-season		90	1	8		81	15	4		70	2	28
Crop rotation (cycle)/ breaks	1	58	20	21	0	87	11	2	5	64	11	20
Cultivate non-*Bt* cotton as refugee crop	3	26	25	46	0	56	13	31	1	36	20	43

2016, NSA 2017, Komarlingam 2018). Seed mixtures of *Bt* and non-*Bt* seeds have advantages in terms of convenience for farmers and elimination of possibility of non-compliance. Some of the practices like deep summer ploughing, using branded seeds were followed by most of the farmers irrespective of states. Summer deep ploughing was particularly practiced to make the field ready for the next crop by destroying the insects by exposing its eggs or larvae in the sun. Selection of early maturity variety was adopted poorly in Maharashtra and Karnataka.

Harvesting till fourth and fifth picking up to March-April is a regular practice, mostly in Maharashtra, as there is less opportunity to cultivate for the next season. Primarily, long duration character of *Bt* hybrids induces the growth of resistance to pink bollworm in India (Vithal 2018, Parmer and Patel 2016). Insects like pink bollworm, a monophagus insect gets easy hibernation into plant parts to continue its life cycle when cotton stubbles are left in the field. It was observed that some of the farmers used to leave the crop standing in the field till the next monsoon or till the month of May to obtain additional pickings.

Effects of IRM Adoption on Cotton Yield

Adoption of IRM practices is considered to give immediate gains to the farmers in terms of higher cotton yield across the states. To test this hypothesis, cotton yield has been estimated for 'low', 'medium' and 'high' adoption level categories of farmers in all the 3 selected states. The picking-wise average cotton yield has been estimated and presented in Table 4.

The results clearly exhibited the yield advantage for high IRM adopters as compared to those who adopted less IRM practices. The 'High' IRM level farmers are able to get a higher yield in all the selected states. The second pick invariably gave higher yield than other picks. The cotton yield in Gujarat is always higher than other states across adoption level as well as across different pickings. While the same is the lowest for Maharashtra. The lower yield in Maharashtra may be due to the reason that most of the farmers in the state cultivate cotton as intercrop with pigeon pea or soybean or other crops. Another reason could be due to the fact that crop is grown mostly under rainfed condition, coupled with high climatic variability.

The average yield for high IRM level farmers is estimated to be 24.74, 16.39 and 23.33 q/ha as compared to 16.26, 11.32 and 21.25 q/ha for low IRM adopters in the states of Gujarat, Maharashtra and Karnataka, respectively. Farmers in Gujarat are found to harvest cotton up to third pick, whereas it is up to fourth and fifth pick in Karnataka and Maharashtra, respectively. Kumar *et al*. (2012), revealed the similar outcome of average cotton yield variation as 23.79 q/ha and 21.61 q/ha for IRM and non-IRM adopter, respectively.

A one-way between-groups analysis of variance (ANOVA) was conducted for each of the selected states to explore the effect of IRM level on yield of cotton. In case of Gujarat, there was a statistically significant difference at the $p < 0.05$ level in cotton yield for the three IRM levels. Cotton yield for 'Low' adopters is significantly less than that of 'High' adopters. Though, 'Medium' adopters did not differ significantly from either 'Low' or 'High' adopters. In case of Maharashtra and Karnataka, the effect of IRM level on yield of cotton was found to be insignificant (Tables 5a-c). Post-hoc comparisons using the Tukey HSD test indicated that the cotton yield for 'Low' adopters (*Mean* = 16.25, *S.D.* = 7.58) was significantly less than that of 'High' adopters

Table 4: Picking wise cotton yield (q/ha) across different IRM adoption level

	Adoption Level								
	Gujarat			Maharashtra			Karnataka		
Picking	Low	Medium	High	Low	Medium	High	Low	Medium	High
1st	5.9	8.5	8.5	3.5	3	3.9	7.4	5.5	6
2nd	6	7.9	10	3.7	4.7	5.2	7.8	8.8	9.5
3rd	4.3	4	6.3	3.1	4.8	5.3	6.1	8.2	7.8
4th	0	0	0	0.9	1	1.4	0	0.2	0.2
5th	0	0	0	0.1	0.3	0.7	0	0	0

Table 5a: One way ANOVA for testing the difference in cotton yield with different IRM adoption level in Gujarat

Cotton yield descriptive (q/ha)								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Low	3	16.25	7.58	4.38	-2.58	35.08	7.50	20.75
Medium	187	20.39	9.60	.70	19.00	21.77	1.30	45.00
High	114	24.74	11.98	1.12	22.51	26.96	8.00	67.50
Total	304	21.98	10.74	.62	20.77	23.19	1.30	67.50

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1437.40	2	718.70	6.461	.002
Within Groups	33483.84	301	111.24		
Total	34921.24	303			

Multiple Comparisons

Dependent Variable: Yield

Tukey HSD

(I) IRM level	(J) IRM level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low	Medium	-4.14	6.14	.779	-18.60	10.32
	High	-8.49*	6.17	.002	-23.02	6.04
Medium	Low	4.14	6.14	.779	-10.32	18.60
	High	-4.35	1.25	.355	-7.30	-1.39
High	Low	8.49*	6.17	.002	-6.04	23.02
	Medium	4.35	1.25	.355	1.39	7.30

*. The mean difference is significant at the 0.05 level.

Table 5b: One way ANOVA for testing the difference in cotton yield with different IRM adoption level in Maharashtra

Cotton yield descriptive (q/ha)								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Low	27	11.32	6.77	1.30	8.65	14.00	2.50	30.00
Medium	76	13.70	7.27	.83	12.03	15.36	3.50	40.00
High	26	16.38	9.34	1.83	12.61	20.16	6.38	48.75
Total	129	13.74	7.74	.68	12.39	15.09	2.50	48.75

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	339.83	2	169.91	2.921	.058
Within Groups	7328.97	126	58.17		
Total	7668.80	128			

Table 5c: One way ANOVA for testing the difference in cotton yield with different IRM adoption level in Karnataka

Cotton yield descriptive (q/ha)								
					95% Confidence Interval for Mean			
	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Low	9	21.25	5.00	1.67	17.41	25.09	15.00	30.00
Medium	86	22.83	8.75	.94	20.95	24.71	7.50	57.50
High	83	23.33	11.19	1.23	20.88	25.77	3.75	60.00
Total	178	22.98	9.80	.73	21.53	24.43	3.75	60.00

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	38.94	2	19.47	.201	.818
Within Groups	16972.14	175	96.98		
Total	17011.09	177			

Table 6: Detailed cost of cultivation of cotton in the study area (₹/hectare)

Particulars	Gujarat			Maharashtra			Karnataka		
IRM level adoption	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Seed Cost	2696	2633	2448	3691	3352	2957	3501	4042	3598
Land Preparation charges	2042	2526	2602	2903	2829	2699	2153	2452	2323
Fertilizers	4064	4855	4487	6089	6230	5981	6050	5044	5990
Fertilizer Labour Cost	1250	1365	1454	2536	3314	3409	3208	2078	2814
FYM cost + application	0	1250	990	176	105	0	0	832	745
Plant Protection Chemicals	3979	4792	5541	5268	4741	5182	5332	3239	3735
Plant Protection Labour Cost	1383	1483	1394	1782	1870	2260	1880	1681	1973
Pheromone Trap	200	52	303	0	0	0	0	6	10
Manual weeding	1250	1203	811	1185	1448	1058	1111	1539	1639
Herbicide Application	1000	637	830	644	574	813	667	658	439
Cost of crop cultivation (Pre-harvest)	17865	20796	20859	24273	24463	24357	23902	21572	23265
Harvest cost- 1st picking	6667	7725	7304	2284	2227	3091	5583	3990	4618
Harvest cost- 2nd picking	6917	7101	8964	2400	3557	4068	6056	6558	7516
Harvest cost- 3rd picking	3750	3527	5616	2082	4302	4669	4917	6290	6572
Harvest cost- 4th picking	—	27	—	1913	1918	2490	—	3350	2750
Harvest cost- 5th picking	—	—	—	692	960	1633	—	3750	1563
Total cost of cultivation	35198	39176	42744	33644	37427	40308	40457	45511	46284
Net returns over 1st harvest	19026	30544	30126	11714	9593	13050	18832	18109	19337
Net returns over 2nd harvest	19128	28342	35658	12364	15455	17081	20873	28964	31035
Net returns over 3rd harvest	15068	14130	22809	10659	15822	18009	15391	27094	27121
Net returns over 4th harvest	0	94	0	3112	3522	4094	0	588	580
Net returns of 5th harvest	0	0	0	423	1092	2500	0	87	92
Average yield (q/ha)	16.3	20.4	24.7	11.3	13.7	16.4	21.3	22.8	23.5
Average Price (₹/q)	4318	4486	4473	3988	4011	4026	3384	4022	3985
Gross revenue	70168	91520	110598	45162	54957	65921	71905	91793	93542
Net Return	34970	52344	67854	11518	17529	25612	31448	46283	47258

(*Mean* = 24.74, *S.D.* = 11.98). 'Medium' adopters (*Mean* = 20.39, *S.D.* = 9.60) did not differ significantly from either 'Low' or 'High' adopters.

Cost of cultivation and net return across IRM adoption level

The cost is worked out for the three IRM adoption levels in cotton cultivation in 3 states (Table 6). Return over each pick has also been estimated to find the picking number at which the farmers may reach the break-even, where total cost becomes equal to total return. In all the states, 'High' IRM farmers are incurring higher total cost than the other category farmers. The gross return also increases due to increase in the yield for high IRM level farmers.

In Gujarat, the total cost of cotton cultivation is estimated to be ₹ 35,198, ₹ 39,176 and ₹ 42,744 per hectare for 'Low', 'Medium' and 'High' IRM level of adoption, respectively. Irrespective of IRM level, farmers were able to recover the cost after first picking itself in Gujarat. The net return from cotton cultivation were ₹ 34,970, ₹ 52,344 and ₹ 67,854 per hectare for 'Low', 'Medium' and 'High' IRM adoption level, respectively. In case of Maharashtra, the 'Low' IRM level farmers were able to recover the cost after third picking whereas other two category farmers recover after second picking. Here, the total cost of cotton cultivation was ₹ 33,644, ₹ 37,427 and ₹ 40,308 per hectare while net returns were ₹ 11,518, ₹ 17,529 and ₹ 25,612 per hectare for 'Low', 'Medium' and 'High' IRM level farmers respectively. In Karnataka, all IRM level farmers reached break-even after second picking. The total cost of cotton cultivation in the state was estimated to be ₹ 40,457, ₹ 45,511 and ₹ 46,284 per hectare while net return were ₹ 31,448, ₹ 46,283 and ₹ 47,258 per hectare for 'Low', 'Medium' and 'High' IRM level farmers respectively. Similar cost and return of cotton cultivation results were reported by few other researchers as well (Sankar and Naidu 2017, Shelke *et al.* 2016, Kumar *et al.* 2012).

CONCLUSION

Based on the above discussion, it can be concluded that among 11 practices recommended under IRM practices, use of pheromone traps, growing early maturity variety and cultivation of refuge crop are not adopted by majority of the farmers in the study states. Lack of awareness among the farmers is a major concern to adopt the IRM practices.

In order to address the above concerns, implementation of Refuge-in-Bag system should be ensured immediately. However, to ensure quality of non-*Bt* seed, random check of the seed packet from the open market, may be done to check for trait purity. Additionally, free distribution of pheromone trap through seed and fertilizer dealers in the cotton growing area can be adopted. Also, the farmers should be convinced for not growing long duration crop or stop picking after January-end, so that the field can be kept clear from cotton stubbles for at least 90 days.

During the field survey, it was observed that hardly any farmer in the studied villages attended any training programme or have participated in demonstration for PBW control measures. Developing short video clips in vernacular languages and distributing to the farmers through the seed dealers can help to a greater extent.

Labour cost for picking constituted more than 50 percent of total cost of cotton cultivation. The cost of harvesting also increases steeply if there were more infestations in the boll. The study reveals that Gujarat farmers could meet their incurred costs from 1st picking itself, whereas in Karnataka and Maharashtra, farmers could meet their incurred expenses after 2nd pickings. Thus, it can be concluded that higher the adoption of IRM practices, more the yield farmer gets in all three states. Therefore, it opens new door of possibilities of conducting awareness programme among cotton growers to manage PBW infestation.

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