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Adoption of an Eco-Friendly Technology (AESA based IPM) in Cotton for Sustainable Agriculture by Farmers of Haryana

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A B S T R A C T

AESA based IPM emphasizes on plant compensation ability, abiotic factors and Pest: Defender (P:D) ratio. Through FFS (Farmer Field School) participants observe and monitor all elements of the agro-ecosystem on farm and learn how to make management decisions in order to minimize the effects of adverse climate change. In order to assess this aspect the study was conducted in Haryana state during 2019 to assess the farmers' adoption status of technology through the Agro-Eco System Analysis (AESA) based IPM strategy for sustainable agriculture with special focus on pest-defender dynamics, characteristic abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest buildup in changing climate scenario. Results indicated that farmers' knowledge of AESA based IPM practices for control of insect-pests was moderate to high due to cultural practices followed by chemical control measures. Whereas, they had less knowledge/no knowledge of use of bio agents or botanical measures (*Chrysoperla* grubs, NPV, *Trichogramma* etc.) for control of pests and diseases and their alternate host plants as well as trap crops. While, use of bio control measures, no removal of alternate hosts, management of trap crops, seed treatment with *Trichoderma* as well insecticides for sucking pests, crushing of shoot borer larvae, destruction of disease affected plants and use of pheromone traps as well yellow sticky traps for monitoring of pests were not adopted or very low in adoption. It showed that farmers had no comprehensive knowledge of AESA based IPM practices for its proper sequential adoption in the field. So more farmer field schools should be organized by extension personnel to prove the worth of low cost and eco-friendly sustainable technology in order to minimize the climate changes effects for enhancement of production, productivity and profitability of commercial crop in the region.

Keywords

Agro-eco system analysis, Integrated pest management, Climate change, Adoption

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Introduction

Agro-Eco System Analysis (AESA) based IPM is a globally accepted strategy for promoting sustainable agriculture and minimizing the climate change effects with special focus on pest-defender dynamics, innate abilities of plant to compensate for the damages caused by the pests and the influence of abiotic factors on pest buildup. According to Intergovernmental Panel on Climate Change (IPCC, 2001), it is defined as change in climate over time, either due to natural variability or as a result of human activity. Communities are encouraged to change practices and take a lead role in defining the future: FFS (Farmer Field School) embraces sustainable agriculture anchored in ecology and farmer empowerment. The unwise and indiscriminate use of pesticides had resulted in resistance development in insects and resurgence of new pests besides environmental pollution and public health hazards (Gibbons *et al.,* 2015). Evidences of pesticide threats to human health and economic effects have been documented in several studies (Rola and Pingali, 1993; Antle and Pingali, 1994). It is concerned with everyone since it possesses potential threat to environment, and agricultural productivity and production throughout the world. In India, many integrated pest management (IPM) programs have been implemented to reduce the overreliance on pesticides (mainly insecticides) in cotton and rice. The first IPM program in these crops was conducted under the Operational Research Project (1974–1975) in order to "Grow a healthy crop" allows plants to recover better from environmental or pest injury, avoids nutrient deficiencies related with pest attack (insects and disease), and promotes natural defense to many insects and diseases inherent in plants through the proper crop and plant management methods. The health of a plant is determined by its environment which includes physical factors (i.e. soil, rain, sunshine hours, wind etc.) and biological factors (i.e. pests, diseases and weeds). All these factors can play a role in the balance which exists between herbivore insects and their natural enemies. Even today, cotton is a vital commercial crop of India and is popularly known as 'White gold' and textile industry has grown up as the largest agro based industry in the country with over 2500 textile mill units, about 1.5 million power-looms, 4 million hand-looms and thousands of garment, hosiery and processing units, (Rajendran and Jain, 2004). Climatic conditions are highly influenced for cotton production. But due to unawareness and no adoption of latest cotton production technology its yield per acre is too low. However, rural communities often lack scientific knowledge; they have limited access to opportunities and services to help make production systems more sustainable and profitable.

Farmers must adapt and fine-tune practices for growing and marketing their produce sustainably, but "ecological intensification" requires adaptive management reflecting the local context: ecological literacy and farmer collaboration are keys. There is a growing awareness world over on the need for promoting environmentally sustainable agriculture practices. This low cost and ecological /eco-friendly approach stresses the need for relying on bio intensive strategies prior to use of chemical pesticides wherein whole agro-ecosystem, plant health at different stages, built-in-compensation abilities of the plant, pest and defender population dynamics, soil conditions, climatic factors and farmers' past experience are considered. This technology has not only shown decreased applications of pesticides and low environmental risks but has also raised crop yields and net returns. Farmers' adoption of AESA based integrated pest management practices depends on many factors, such as their technical skill and socio-economic conditions as well as psychological and cultural factors, farming situations etc.

Since farmers are the final decision-makers for adoption of any technology, it is important for the technology developers/providers to identify how farmers' react to the provided techniques and what about the adoption process of certain innovations. Against this backdrop, the case study was conducted for the country as a whole and Haryana (India) in particular with the objective to find out the farmers' knowledge of AESA based IPM practices, their adoption and constraints faced by them. Since cotton consume a sizeable share of total pesticide application in the country. Moreover, farmers' perception regarding pest control practices and impact of IPM practices will augment farm efficiency in changing climate scenario.

Materials and Methods

The survey was done following ex post facto research design to collect the primary data on "Adoption of AESA based integrated pest management practices for curtailing climate change effects by cotton farmers of Haryana state". Being the pioneering state in the country, the IPM concept has been well understood by the farmers especially through the Farmers Field School implemented in cotton. AESA entails both living and non-living things found in an agro ecosystem and the environment and improves decision-making skills, through a field situation analysis by observing, all the biotic and abiotic drawing and discussion. The state was selected purposively being one of the important contributing states to textile industry as well high cotton productivity. The study was conducted in two major cotton-growing districts of the state of Haryana (India): Bhiwani and Jind. These districts were selected purposively as they were being covered under the AESA based IPM program, and account for more than 60 % of the total area under cotton cultivation in Haryana. From these districts two blocks were selected randomly viz. Bawani Khera from Bhiwani, Uchana from Jind district. Then two villages from each selected block viz. Milkpur, Jeeta Kheri, Durjanpur and Udaipur were selected randomly. Finally, thirty cotton farmers were randomly selected from each village and thus a total of 120 cotton growing farmers were interviewed during the survey. The data were collected with the help of well-structured pre-tested interview schedule designed for different crop stages & agro-ecological system following the recommendations by Ministry of Agriculture, Department of Agriculture and Cooperation, Directorate of Plant Protection, Quarantine & Storage, Government of India, IPM practices for cotton. The data were analyzed by Statistical Package for the Social Sciences. Farmers' response was obtained in yes or no in case of knowledge while adoption was measured on three point continuum scale (full adoption, partial adoption and no adoption) for which scores of 2, 1 and 0 were given respectively. After that frequency was multiplied with the scores of (2, 1 or 0) to get total weighted score. The total weighted score was divided by total no. of respondents for obtaining weighted mean score (WMS).The study hypothesized that the level of education will have a positive effect and age a negative effect on adoption behaviour towards IPM technology. In addition, farmers' economic characteristics (farm-size and gross value of crop) and institutional variables, IPM training, frequency of meeting with extension personnel, years of experience in practicing (IPM) will also have positive effects on IPM adoption. Farmers' perception about yield loss due to pests if no pesticide used, was hypothesized to have a negative influence on IPM adoption. Constraints were measured on technical aspects such as cultural, mechanical, biological practices and chemical control measures with response of yes or no in frequency and percentage.

Results and Discussion

Farmers' knowledge of AESA based IPM practices against cotton pests and disease

The farmers knowledge pertaining to IPM practices against pest and diseases starting from pre sowing operation clearly indicated that they were fully aware to adopt season wise crop rotation in order to avoid cotton after cotton and deep ploughing in summer to expose soil inhabiting/resting larvae stages of insects, pathogen and nematodes (73.33%) while they had no knowledge about alternate hosts which should be removed from the field (Table 1). Weather conditions, soil nitrogen levels, and degree of host plant resistance will determine if pest will subside or become more serious.

The practices pertaining to sowing time IPM measures for soil and seed borne diseases indicate that all respondents had knowledge to use of certified seeds of tolerant and resistant varieties followed by seed dipping in antibiotic (Streptocycline) + fungicides (10.00 percent). While 93.33 per cent were aware about early sowing for control of sucking pests especially white fly followed by recommended spacing as well fertilizers application *i.e.*73.33 per cent. Only 10.00 percent had knowledge about seed treatment with insecticides for control of sucking pests.The farmers reported timely sowing benefits were visible in terms of higher crop yield in comparison to late sown due to less damage of insect pests. This shows that local or indigenous knowledge of the environment; varieties, pests, etc. play a major role in decision making.

But knowledge of weed control by application of pre emergence and post emergence herbicides measures was possessed by 70.00 percent respondents (Table 1). Further, knowledge pertaining to IPM practices for weed control at vegetative growth stage indicted that all respondents had knowledge of intercultural and hand weeding followed by gap filling and thinning (80.00 percent).

For sucking pest control measures they did not have proper knowledge of cultural practice like trap crops management as well biological measures while, 43.33 percent had knowledge about spray of neem products. Similarly none of the respondents knew mechanical control measures for control of Shoot borer (*Earias sp.*) Only 10.00 percent of respondents had proper knowledge of using Pheromone traps for monitoring of bollworms as well use of yellow sticky traps for monitoring the white fly population in fields. The knowledge pertaining to early fruiting stage for control of sucking pests and bollworms, most of the farmers did not have any knowledge for cultural and biological practices like management of trap crops, release of *Chrysoperla* grubs and setting up bird perches. Only 26.67 per cent farmers knew that yellow sticky traps can be used for monitoring of boll worms. Weather conditions, soil nitrogen levels, and degree of host plant resistance will determine if pest will subside or become more serious. However, 20.00 percent farmers had knowledge on proper and timely chemical measures for control of bollworms (Table 1).

For white fly control by IPM practices indicted that spray of recommended insecticides (100.00 percent) followed by spray neem products (43.33 percent) and use of yellow sticky traps for monitoring (16.67 percent). All the respondents had knowledge for spray of recommended chemicals for control of CLCV Disease, but no knowledge of destruction of affected plants. The adoption regarding IPM practices against control ofwhite fly at Peak flowering and fruiting stage indicated that all respondent farmers had knowledge of chemical measures followed by biological control through spray of neem products (43.33%) and yellow sticky traps for monitoring (16.67%). Similarly,for control of bollworms through IPM measures indicated that only 43.33 per cent farmers recognized chemicals to be sprayed and biological measures like neem products

(16.67%0 whereas they did not have any knowledge regarding use of NPV. The findings are in consonance with findings of Ghanghas *et al.,* (2018) who reported that farmers had high knowledge of cultural practices followed by chemical control measures whereas they had less knowledge/no knowledge of bio agents or botanical measures for control of pests and diseases of mustard crop. Thus, the application of pesticides to combat pest-damage increases the direct risk of environmental pollution, increases selection pressure for insecticide resistance both in target and non-target pests and often reduces the abundance of beneficial, thereby contributing secondary pest outbreaks.

Adoption of IPM practices against Spodoptera observed that all respondent farmers have knowledge of chemical control measures followed by mechanical measure such as monitoring through pheromone traps while none of them knew about hand collection and destruction of egg masses and early instar larvae. Cent percent respondents had knowledge pertaining to spray of recommended chemicals for control of CLCV Disease while they had no knowledge pertaining to destruction of affected plants. This finding is in conformity with the findings of Dubey and Shrivastava (2007) and David Rajni (2005).

Overall knowledge of AESA based IPM practices against insect pests for protecting environment

Data presented in Table 2 indicate that cotton farmers' overall knowledge of integrated pest management practices against insect-pests was moderate since 60.00 per cent of farmers belonged to this categories followed by 33.33 per cent to high knowledge category. Only 6.67 percent had low knowledge of the integrated pest management practices against insect-pests of cotton. It can be concluded that farmers, overall knowledge of IPM practices was moderate to high since vast majority (93.33%) of farmers belonged to these categories. The results are in consonance with Shambharkar *et al.,* 2018 for Maharashtra and Peshin, R. 2013 for Punjab. This indicated that IPM has helped farmers in the village to augment their income, improve their livelihood as well as health and enhancing environmental literacy is one of the goals of IPM-FFS (Integrated Pest Management-Farmer Field School)

Adoption of AESA based IPM practices against cotton pests and diseases by farmers

Data pertaining to adoption of IPM practices by farmers presented in Table 3 clearly indicate that at pre sowing stage, crop rotation was most adopted by farmers with the mean score of 1.20 (especially mustard cropping system) followed by deep ploughing in summer for to expose soil inhabiting/resting stages of insects, pathogen and nematodes (mean score 1.00) though not to desired level due to demand of high power tractors as well deep/RB ploughs availability to complete the operation and non adoption of removal of alternate hosts as well use of neem cake for control of termites and nematode by farmers. Similarly, adoption of IPM practices at sowing stage by farmers indicated that for soil and seed born diseases control, cultural practices like use of certified seeds of tolerant and resistant cultivars were most adopted with mean sore of 2.00 followed by seed deeping in antibiotics plus fungicides (mean sore 0.20).

Adoption of IPM practices by farmers for sucking pests indicated that early sowing was most adopted practice with mean score of 1.60 to escape the menace of white fly in the region followed by recommended spacing and fertilizers application (mean score 1.43) since sowing with cotton seed drill, seed treatment with insecticides (mean score 0.20). Chemical practices for control of weeds by application of recommended pre-emergence/post emergence herbicides were adopted by farmers (mean score of 0.93). Pest management is a complex technology for farmers to master (Litsinger *et al.,* 2009).

Adoption of IPM practices by farmers at vegetative growth stage for control of weeds indicated that intercultural and hand weeding was most adopted practice with mean score of 1.36 followed by gap filling and thinning with mean score of 0.73 mostly in cases of ridge sowing. For control of sucking pests chemical measures were most adopted (mean score 1.86), followed by spray of neem products (mean score 0.46) while no adoption of practices such trap crop management and release of Chrysoperla grubs was observed. None of the respondent farmers adopted the practices viz. shoot borer control by crushing of larvae in the shoots, pheromone traps for monitoring bollworms population, yellow sticky traps for monitoring white fly population as well removal and destruction of root rot affected plants. Further, IPM practices adopted by farmers at early fruiting stage against weeds clearly indicated that intercultural and hand weeding was most adopted practice with mean score of 1.33 followed by chemical control for bollworms (mean scores 0.63) and no cultural and biological control measure for sucking pests by farmers while control measures against white fly show that spray of recommended insecticides was most adopted practice with mean score of 1.86 followed by spray of neem products (mean score of 0.36). Similarly CLCV was controlled by spray of recommended chemicals (mean score 1.86) but no one destroyed the disease affected plants. Similar results were also reported by Shambharkar *et al.,* 2018 in Amravati district of Maharashtra State.

The adoption of IPM measures by farmers at peak flowering & fruiting stage for control of white fly included spray of recommended insecticides as most adopted practice with mean score of 2.00 followed by biological measure (mean score 0.26) IPM practices adopted for control of boll worms was chemicals spray (mean score 0.36) by farmers.

Farmers did not adopt any cultural, mechanical and biological measures for their control. Adoption of IPM practice for control of *spodoptra* indicated that chemical practice was the only practice adopted with mean score of 1.73 and similarly they sprayed the recommended chemicals for control of vector of CLCV disease (mean sore 2.00) and not at all destroyed the affected plants. The findings are in agreement with findings of Alka *et al.,* (2008) who reported that various cultural practices have widespread adoption as against very low adoption of biological practices.

In cultural practices, more than two thirds paddy and cotton farmers were found practicing deep summer ploughing, trimming of bunds, destruction of crop residues, etc. Among the mechanical practices, pheromone traps were being used by only four per cent of farmers in paddy, mainly because of farmers' poor knowledge about its use and non-availability of pest-specific lures. However, a sizeable number of farmers used these traps in cotton. Use of biological control methods for pest control was observed at very low level in both the crops (Table 3).

Similar findings were reported by Paikra (2008) and Ghanghas *et al.,* (2018) who observed that cultural practices and chemical control methods were mostly adopted by the paddy and mustard growers while, other important practices like use of plant extracts, biological control were least adopted.

Table.1 Farmers' Knowledge of AESA based IPM practices against cotton pests & diseases

(n=120)

Pre sowing	Frequency	Percentage
1. Deep ploughing in summer to expose soil inhabiting/resting stages of insects, pathogen and nematodes.	88	73.33
2. Removal of alternate hosts viz. *Sida* sp., Abutilon sp., *Logascaemollis* and other *malvaceous* plants.	-	-
3. Avoid cotton after cotton	120	100.00
4. Adopt crop rotation	120	100.00
5. Use neem cake @ 5 quintal /ha in termite/nematode infested fields.	-	0.00
Sowing		
A. Soil & seed borne diseases		
1. Cultural practice: i) Tolerant/resistant cultivars	120	100.00
ii) Certified seeds	120	100.00
2. Chemical practices: i) Seed treatment with *Trichoderma* spp.	8	6.67
ii). Seed dipping in antibiotic (*Streptocycline*) + fungicides.	12	10.00
B. Sucking pests		
1. Cultural practice: i) Early sowing	112	93.33
ii) Follow recommended spacing & fertilizers application	88	73.33
2. Chemical practice: Seed treatment with Imidachloprid 70 WS * @ 10 g/kg seed or Thiomethoxam 5 g/kg seed or Carbosulfan 25 DS @ 50 g/kg or Acetamiprid 20 SP 20 g/kg of seed	12	10.00
C. Weeds		
Chemical practice: Use recommended pre-emergence/post emergence herbicides.	84	70.00
Vegetative growth stage		
A. Weeds		
1. Cultural Practice: i) Gap filling and thinning	96	80.00
ii) Inter culture and hand weeding. A hoeing at interval of 18 – 20 days after emergence of cotton seedlings to control weeds	120	100.00
B. Sucking pest		
1. Cultural practice: Check population on trap crops like okra, *canabinus*, castor, marigold, jowar, maize crops etc.	-	-
2. Biological control: i) Release of *Chrysoperla grubs* @ 10,000/ha.	-	-
ii). Spray *neem* products (1500 ppm) 2.5 lit/ha for whitefly.	52	43.33
3. Chemical control: spray recommended insecticides.	120	100.00
C. Shoot borer (*Earias sp*.): Crushing of larvae in the shoots	-	0.00
D. Bollworms: Pheromone traps for monitoring	12	10.00
E. Whitefly: Fix yellow sticky traps for monitoring	12	10.00
F. Diseases control: Remove & destroy root rot affected plants	-	0.00
Early fruiting stage		
A. Weeds: Inter culturing & hand weeding. A hoeing in between crop rows is to be given 18 – 20 days after emergence of cotton	120	100.00

seedlings to control primary perennial weeds		
B. Sucking pest:		
1. Cultural practice: Management of trap crops crops like okra, canabinus, castor, marigold, jowar, maize crops etc.	-	0.00
2. Biological practice: Release *Chrysoperla grubs*@ 10,000 /ha	-	0.00
C. Bollworms		0.00
1. **Cultural: i) Use pheromone traps for monitoring and change lures**	-	0.00
ii) Management of population in trap crops	-	0.00
2. Biological control: Release of *Trichogramma* @ 1.5 lac/ha.	-	0.00
3. Mechanical: Set up 8 – 10 bird perches per ha.	-	0.00
4. Chemical control: Spray of recommended insecticides.	36	30.00
D. Whitefly		
1. **Cultural: Use yellow sticky traps for monitoring**	20	16.67
2. **Biological: Spray neem products.**	52	43.33
3. **Chemical: Spray insecticides viz. Triazophos/Acephate/Acetamprid**	120	100.00
E. CLCV Disease		
i) Destroy affected plants	-	0.00
ii) Spray recommended chemical for vector control	120	100.00
Peak flowering & fruiting stage		
A. Whitefly		
i) **Use yellow sticky traps for monitoring**	20	16.67
ii) **Biological control: Spray neem products**	52	43.33
iii) **Chemical: Spray insecticides viz. Triazophos/Acephate/Acetamprid**	120	100.00
B. Bollworms:		
1. **Monitoring: Use pheromone traps**	32	26.67
2. **Mechanical: i) Collection & destruction grown up larvae and damaged floral bodies.**	-	0.00
3. **Biological control: i) Use *Ha. NPV* @ 250 – 500 LE/ha.**	-	0.00
ii) Use neem products	20	16.67
4. **Cultural practice: removal of terminals (topping) is to be done.**	-	-
5. **Chemical: spray of recommended of chemicals**	52	43.33
D. Spodoptera		
1. **Monitoring: Use pheromone traps**	20	16.67
2. **Mechanical: Hand collection & destruction of egg masses & early instar larvae**	-	0.00
3. **Biological control: Spray Spodoptera NPV in evening hours**	-	-
4. **Chemical practice: Spray recommended insecticides**	120	100.00
D. CLCV Disease		
i) Destroy affected plants.	-	0.00
ii) Spray recommended chemical for vector control	120	100.00

Table.2 Overall knowledge of cotton farmers on IPM practices against insect pests (n=120)

S. No.	Category	Score	Frequency	Percentage
1	Low	Up to 18	08	6.67
2	Medium	19-22	72	60.00
3	High	23-30	40	33.33

Mean score=21.89 Standard deviation=3.42

Table.3 Adoption of AESA based IPM practices against cotton pests and diseases by farmers

(n=120)

Pre sowing	Full adoption (2)	Partial adoption (1)	No adoption (0)	Weighted mean score
1. Deep ploughing in summer to expose soil inhabiting / resting stages of insects, pathogen and nematode population.	52	16	52	1.00
2. Removal of alternate hosts viz. *Sida sp., Abutilon sp., Logascaemollis* and other *malvaceous* plants in the cultivated area	-	-	120	0.00
3. Adopt crop rotation	56	32	32	1.20
4. Use neem cake with oil content @ 5 quintal /ha in termite / nematode infested fields.	-	-	120	0.00
Sowing				
A. Soil & seed borne diseases				
1. Cultural practice: i) Used tolerant / resistant cultivars	120	-	-	2.00
ii) Use certified seeds	120	-	-	2.00
2. Chemical practices: i) Seed treatment with *Trichoderma spp*. @ 4 g/kg seed	-	-	120	0.00
ii Seed dipping in antibiotic (Streptocycline) + fungicide	12	-	108	0.20
B. Sucking pests				
1. **Cultural practice: i) Early sowing**	72	48	-	1.60
ii) Recommended spacing & fertilizers application	52	68	-	1.43
2. **Chemical practice: Seed treatment with imidachloprid 70 WS 10 g / kg or Thiomethoxam 5 g / kg seed or Carbosulfan 25 DS @ 50 gms / kg or Acetamiprid 20 SP 20 g / kg of seeds**	12	-	108	0.20
C. Weeds				
Chemical practice: Recommended pre-emergence/post emergence herbicides	28	56	36	0.93
Vegetative growth stage				

A. Weeds				
1. Cultural Practice: i) Gap filling and thinning	44	-	76	0.73
ii) Inter culture and hand weeding. A hoeing at interval of 18 – 20 days after emergence of cotton seedlings to control weeds	60	44	16	1.36
B. Sucking pest				
1. Cultural practice: Check population on trap crops like okra, *Canabinus*, castor, marigold, jowar, maize crops etc.	-	-	120	0.00
2. Biological control:i) Release of *Chrysoperla grubs* @ 10,000/ha.	-	-	120	0.00
ii) . Spray *neem* products (1500 ppm) 2.5 lit/ha for whitefly.	16	24	80	0.46
3. Chemical control: spray recommended insecticides	108	8	4	1.86
C. Shoot borer (Earias sp.): Crushing of larvae in shoots	-	-	120	0.00
D. Bollworms: Pheromone traps for monitoring	-	-	120	0.00
E. Whitefly: Fix yellow sticky traps for monitoring	-	-	120	0.00
F. Diseases control: Remove & destroy root rot affected plants	-	-	120	0.00
Early fruiting stage				
A. Weeds: Inter culturing & hand weeding. A hoeing at interval of 18–20 days after emergence of cotton seedlings to control weeds	80	40	-	1.66
B. Sucking pest:				
1. **Cultural practice:Management of trap crops like okra, canabinus, castor, marigold, jowar, maize crops etc.**	-	-	120	0.00
2. **Biological practice: Release *Chrysoperla* @ 10,000 /ha**	-	-	120	0.00
C. Bollworms				
1. **Cultural: i) Use pheromone traps for monitoring**	-	-	120	0.00
ii) Management of population in trap crops	-	-	120	0.00
2. Biological control: Release of *Trichogramma* @ 1.5 lac/ha.				
2. **Mechanical: Set up 8 – 10 bird perches per ha.**	-	-	120	0.00
3. **Chemical control: spray of recommended insecticides**	28	20	72	0.63
D. Whitefly				
1. **Cultural: Use yellow sticky traps for**	-	-	120	0.00

monitoring				
2. **Biological: Spray neem products.**	4	36	80	0.36
3. **Chemical:Spray recommended insecticides viz. Triazophos/Acephate/Acetamprid**	112	-	08	1.86
E. CLCV Disease				
i) Destroy affected plants	-	-	120	0.00
ii) Spray recommended chemical for vector control	112	-	08	1.86
Peak flowering & fruiting stage				
A. Whitefly				
i) Use yellow sticky traps for monitoring	-	-	120	0.00
ii) Biological control: Spray neem products	16	-	104	0.26
iii) Chemical control: Spray triazophos/acephate/acetamprid.	120	-	-	2.00
B. Bollworms:				
1. **Monitoring: Use pheromone traps**	-	-	120	0.00
2. **Mechanical: i) Collection & destruction of grown up larvae and damaged floral bodies.**	-	-	120	0.00
3. **Biologigcal control: i) Use *Ha. NPV* @ 250 – 500 LE/ha..**	-	-	120	0.00
ii) Used neem products	-	-	120	0.00
4. **Cultural practice: removal of terminals (topping) is to be done.**	-	-	120	0.00
5. **Chemical: Recommended chemicals spray**	16	12	92	0.36
C. Spodoptera				
1. **Monitoring: Use pheromone traps**	-	-	120	0.00
2. **Mechanical: Hand collection & destruction of egg masses & early instar larvae**	-	-	120	0.00
3. **Biological control: Spray *Spodoptera NPV* in evening**	-	-	120	0.00
4. **Chemical practice: Spray recommended insecticides**	100	8	12	1.73
D. CLCV Disease				
i) Destroy affected plants.	-	-	120	0.00
ii) Spray recommended chemical for vector control	120	-	-	2.00

Mean score=21.89 Standard deviation=3.42

Table.4 Overall adoption of IPM practice against insect pests by cotton farmers (n=120)

S. No.	Category	Score	Frequency	Percentage
1	Low	Up to 30	32	26.67
2	Medium	31-35	28	23.33
3	High	36-42	60	50.00

Table.5 Constraints faced by cotton farmers in adoption of integrated pest management practices **(n=120)**

S. No.	Constraints	Frequency	Percentage
1.	**Cultural practices**		
	Lack of knowledge of trap crops	120	100.00
	Lack of knowledge of alternate hosts for insect pests	120	100.00
	Improper crop rotation due to intensive cotton wheat cropping system	73	60.83
2.	**Mechanical practices**		
	Inadequate labour availability coupled with high wage rates for undertaking manual works like destruction of larvae in shoot, collection of damaged floral parts, destruction of disease affected plants	120	100.00
	Lack of knowledge about use of pheromone traps	88	73.33
3.	**Biological control**		
	Lack of knowledge of biological control measures especially release of Chrysoperla grubs, NPV etc. for control of sucking pests as well boll worms and spodoptra	120	100.00
	Non availability of bio-agents of seed treatment, Chrysoperla grubs, NPV etc.	97	80.33
4.	**Chemical control**		
	Exorbitant prices of effective pesticides	120	100.00
	Ineffectiveness of spurious chemicals against pests	30	25.00

Overall adoption of IPM practice against insect pests by cotton farmers

The overall adoption of integrated pest management practices against insect-pests of cotton was high since 50.00 per cent of farmers belonged to this category followed by 23.33 per cent to moderate adoption category. Whereas, only 26.67 percent belonged to low adoption of the integrated pest management practices against insect-pests of cotton mainly the biological and mechanical practices were least adopted by the farmers (Table 4). This shows that many insect-pests have high infestation and short generation times, and their phenology, fecundity, survival, selection and habitat use can respond rapidly to the climate change so that adoption is low.

Constraints faced by cotton farmers in adoption of integrated pest management practices

The vast majority of cotton growers faced problems such as lack of knowledge of trap crops, alternate hosts for pests, inadequate labour availability coupled with high wage rates for undertaking mechanical or manual works like destruction of larvae in shoot, collection of damaged floral parts, destruction of disease affected plants, lack of knowledge of biological control measures especially release of *Chrysoperla* grubs, NPV etc. (Table 5). for control of sucking pests as well boll worms and spodoptra, exorbitant prices of effective pesticides followed by non availability of viable bio-agents of seed treatment, *Chrysoperl*a grubs, NPV etc. (80.33%), lack of knowledge about use of pheromone traps (70.33%), improper crop rotation due to intensive cotton-wheat cropping system (60.83%) and ineffectiveness of spurious chemicals against pests were the major constraints in adoption of IPM practices by farmers. Similar findings were also reported by Patel *et.al* (2017) majority of cotton growers faced problems that inadequacy of labours and high wage rate for undertaking the manual work like adoption of mechanical control, lack of knowledge about yellow sticky traps for control of white fly, lack of knowledge about use of pheromone trap, lack of knowledge about intercropping of cotton with cowpea/maize/lady finger as trap crop, lack of knowledge about use of bio-agent were the major constraints in adoption of IPM programme. Findings are also supported by study of Rao *et. al*. (2007) who reported lack of conviction about IPM and knowledge-and labour-intensive nature of IPM were other potent constraints to IPM adoption on a wider scale (Table 5). This showed that AESA is mirror of the IPM technology and Ecology is a balanced system. He was well aware of the degradation of environment. It has become relevant due to a number of advantages like safety to environment, pesticide-free food commodities, low input based crop production system *etc*.

In conclusion, the study has shown that the cultural practices had high adoption followed by chemical control measures while low adoption/no adoption of bio agents or botanical measures except to some extent use of neem products, even no removal of alternate host plants and use of trap crops for control of insect-pests by cotton farmers due to lack proper AESA based IPM knowledge as well labour orientation. The farmer-to-farmer extension delivery approaches and awareness through formal crop-specific IPM training provided by farmers' field schools is extremely important for proper sequential as well wider adoption of IPM in the study area. Hence, investment in IPM education through these programmes will have long-term beneficial impact on adoption of eco-friendly pest control technologies like AESA based IPM in the case of commercial crop like cotton, which use relatively higher level of pesticides. These programmes are likely to develop farmers' capacity on decision-making and finding appropriate solutions for minimizing the climate change.

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