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Adoption of integrated pest management practices by mustard farmers of Haryana state

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Abstract
Intensive agricultural practices relying heavily on chemical pesticides are a major cause of wide spread ecological imbalances resulting in serious problems of insecticide resistance, pest resurgence and pesticide residues. To overcome these problems for sustainability of agriculture adoption of latest AESA based IPM strategy is very much apprehensive. The findings revealed that over all knowledge as well as adoption of IPM practices by farmers against pests and diseases of mustard was low to moderate except being high in cultural practices followed by chemical control measures while bio agents and botanical measures were not adopted against pests and diseases of mustard crop since farmers had no proper knowledge of AESA based IPM practices as well as its proper sequential adoption in the field as per emergent ecology. More famer field schools on AESA based IPM strategy should be organized at farmers' field by extension personnel to prove its worth as low cost & eco-friendly sustainable technology.

Keywords: IPM, Knowledge, Adoption and AESA

Introduction
Mustard crop accounts for nearly one-third of the oil produced in India, making it the country's key edible oilseed crop. Due to the gap between domestic availability and actual consumption of edible oils, India has to resort to import of edible oils. Rapeseed-mustard is the major source of income especially even to the marginal and small farmers in rainfed areas since these crops are cultivated mainly in the rain-fed and resource scarce regions of the country, their contribution to livelihood security of the small and marginal farmers in these regions is also very important. By increasing the domestic production substantial import substitution can be achieved.

At national level Indian Mustard (*Brassica juncea*) is grown over an area of 5.76 million hectare with production and productivity of 6.82 million tons and 1184 kg/ha, respectively (Anonymous, 2016) [2]. The major area under this crop exists in Rajasthan state followed by U.P., Haryana, Gujrat, M.P., Punjab, Assam and West Bengal. Haryana is the second most important state in the country with production of 0.94 million tons over an area of 0.51 million hectare with average yield of 1853 kg/ha during the year 2016-17 (Anonymous, 2017) [3] which is highest in the country.

Intensive modern cultivation practices for higher production, productivity and profitability relying heavily on chemical pesticides are a major cause of wide spread ecological imbalances resulting in serious problems of insecticide resistance, pest resurgence and pesticide residues. There is a growing awareness world over on the need for promoting environmentally sustainable agriculture practices. Integrated Pest Management (IPM) is a globally accepted strategy for promoting sustainable agriculture. During last century, IPM relied substantially on economic threshold level use of chemical pesticides. However, since the late 1990s there is an apprehensive shift to more ecologically sustainable Agro-Eco System Analysis (AESA) based IPM strategies. The AESA based IPM focuses on the relationship among various components of an agro-ecosystem 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. In addition, Ecological Engineering for pest management - a new paradigm to enhance the natural enemies of pests in an agro-ecosystem is being considered as an important strategy. The ecological approach stresses the need for relying on bio intensive strategies prior to use of chemical pesticides. Besides other insect pests, nowadays Orobanche and

Sclerotinia stem rot are emerging as greatest threat to sustainability of crop in Haryana state. Keeping the facts in view the study was under taken with following objectives:

1. To assess the farmers' knowledge regarding integrated pest management practices of mustard cultivation technology
2. To find out farmers' adoption level of integrated pest management practices

Material and methods/Methodology

Ex post facto research design was followed to collect the primary data on "Adoption of integrated pest management practices by mustard farmers". The respondents were selected with the multistage sampling. From major mustard growing states of country viz. Rajasthan followed by U.P., Haryana, Gujrat, M.P., Punjab, Assam and West Bengal, Haryana state was selected purposively being second important state with highest productivity. Further three major mustard growing districts namely Hisar, Bhiwani and Mahendergarh were selected. Hisar-1 from Hisar, Tosham from Bhiwani and Satnali block from Mahendergarh district were selected randomly. Then two villages from selected blocks viz. Saharwa, Chirod, Miran, Sidhan, Surehti Pilania and Barda were selected, respectively. Finally, fifteen farmers were randomly selected from each village and a total of 90 farmers were interviewed. The data were collected with the help of well-structured pre-tested interview schedule on AESA based IPM practices. The data were analyzed by applying the statistical techniques like frequency, percentage, and weighted mean to draw meaningful inferences.

Results and Discussion

Table 1: Socio-economic attributes profile of mustard farmers (n=90)

S. No	Variable	Category	Frequency	Percentage
1	Age	Young (up to 37 years)	22	24.45
		Middle (38-55 years)	56	62.22
		Old (above 55 years)	12	13.33
2	Experience	Up to 15 years	24	26.67
		16-25 years	20	22.22
		26-48 years	46	51.11
3	Education	Up to primary	14	15.55
		Up to higher secondary	50	55.56
		Graduation	20	22.22
		Post-graduation	06	6.67
4	Family type	Nuclear	68	75.56
		Joint	22	24.44
5	Family size	Small family (Up to 4 members)	16	17.78
		Medium family (5 to 6 members)	50	55.55
		Large family (More than 6 members)	24	26.67
6	Land holding	Marginal farmers (Less than 2.5 acres)	04	4.44
		Small farmers (2.5 to 5 acres)	24	26.67
		Medium farmers (6.00 -10.00 acres)	34	37.78
		Large farmers (> 10.00 acres)	28	31.11
7	Occupation	Agriculture	80	88.89
		Agriculture + allied occupation	06	6.67
		Agriculture + government service	04	4.44
8	Source of irrigation	Tube well	44	48.89
		Both tube well & canal	46	51.11
9	Farm mechanization	No draft animal	44	48.89
		Bullock cart/camel cart	08	8.89
		Tractor, Trolley, Cultivator & Harrow	14	15.56
		Thresher	04	4.44
		Straw reaper	10	11.11
		Combine harvester	02	2.22
		Power sprayer	08	8.89
10	Sources of information	Neighbours, friends, relatives & other farmers	72	80.00
		Scientists	05	5.56
		Extension functionaries	13	14.44

Data pertaining to socio-personal attributes of respondents presented in Table 1depicts that majority of farmers belonged to middle age category and had more than 26 years of farming experience, about 56.00 per cent of them had up to higher secondary education while around 30.00 per cent were having graduation and above educational qualification.

Pertaining to family type and size, vast majority (75.65%) belonged to nucleus family and medium size family of 5-6 members (55.55%). Regarding land holding of farmers, around 65.00 per cent of farmers belonged to small to medium farmers' category. A vast majority (88.89%) had agriculture as their main occupation followed by agriculture plus allied occupation (6.67%) and agriculture with government service 4.44 per cent only. Both tube well and canal was source of irrigation of majority of farmers followed by tube well. About half of the respondents were without farm mechanization i.e. no draft animals while around 42.00 per cent had farm mechanization in form of tractors with other farm implements. The main source of information of vast majority (80.00%) was personal localite channels of communication followed by extension functionaries (14.44%) and scientists 5.56 per cent only. Sincere efforts by field functionaries in form of more FFS on AESA based IPM are required to have proper comprehension as well adoption of practices by mustard farmers.

Table 2: Farmers' Knowledge level of integrated pest management practices against mustard pests & diseases (n=90)

Pre sowing	Frequency	Percentage
Nutrients		
(i) Apply FYM @4.0 t/acre or vermicompost @ 2.0 t/acre	44	48.89
(ii) Seed treatment with Azotobactor culture @ 240 g/acre	27	30.00
Weeds		
(i) Deep ploughing in summer (May & June) and exposure to Sunshine	53	58.89
(ii) Stale seed bed technique to minimize the weeds menace in the field	09	10.00
Defoliators/soil borne pathogens		
(i) Deep ploughing in summer (May & June to exposure the soil borne pathogens and hibernating stage of defoliators	53	58.89
(ii) Prepare the level and well drained field to reduce the incidence of Sclerotinia rot	54	60.00
(iii)Destruction of plant debris	54	60.00
(iv) For club rot management, soil amendment with lime @ 1kg/m^2 to raise soil pH to 7.2 or apply Neem cake @ 0.5 kg/m^2	02	2.22
(v) Seed treatment with Bavistin @ 2g/kg seed for Sclerotinia rot	18	20.00
Sowing/seedling		
Nutrients		
i) Basal application of NPK is done on soil test basis	63	70.00
ii) Generally 32 kg N, 16 kg P and 16 kg K/acre is applied	41	45.55
iii) Half of the N dose should be applied at the time of sowing	54	60.00
iv) Sulphur should be applied through Gypsum	36	40.00
Weeds		
i) Adopt crop rotation	90	100.00
ii) If there is infestation of Orobanche in previous season, pulse crop should be sown	63	70.00
iii) Apply oxadiargyl 6% EC (Raft ^{TM}) @600ml in 200 litre of water/acre 0-3 days after sowing as pre-emergence herbicide	01	1.11
Aphids		
Cultural control		
i) Early sowing	65	72.22
ii) Use yellow sticky traps	12	13.33
Mechanical		
Destroy the affected part along with aphid population in the initial stage	17	18.89
Biological control		
i) 2 per cent Neem oil and 5 per cent Neem Seed Kernel Extract (NSKE)	02	2.22
ii) Ladybird beetles are most efficient predators, and also Syrphid/Hoverfly, lacewing are predators	08	8.89
Chemical control	62	68.89
Painted bug		
Cultural control		
Deep ploughing the soil to destroy eggs of painted bug	53	58.89
Avoid very early sowing	72	80.00
Irrigate the crop in IV week after sowing to reduce pest attack	72	80.00
Mechanical control:		
Burn the remains of mustard crop so that the stages of insect do not reach the next year crop	36	40.00
The bugs usually congregate on the leaves and stem which can be jerked to dislodge them and killed in kerosin water	18	20.00
Biological control: Conserve bio-control agents such as *Alophora* spp. (Tachinid fly) parasitizing eggs of painted bugs.	-	-
Chemical control	48	53.33
White rust/Downy mildew		
Cultural control:		
Use certified seeds of resistant/tolerant variety	81	90.00
Follow timely sowing of crop.	90	100.00
Follow proper crop rotation.	90	100.00
Destruct crop debris particularly stag heads of previous year crop.	35	38.89
Avoid over irrigation or water stagnation.	63	70.00
Apply potash in recommended dose	11	12.22
Botanical control: Treat the seeds with freshly prepared garlic bulb extract @ 2% (w/v).	-	0.00
Chemical control:	62	68.89
Vegetative		
Nutrients		
Top dressing of N @ 16 Kg per acre at 45 days after sowing.	90	100.00
Foliar application of thiourea (0.1%) at 50% flowering to enhance mustard productivity.	02	2.22
Weeds		
Application of two drops of soyabean oil per young shoot of *Orobanche* reduced infestation.	01	1.11
Hand tool weeding at 25 and 45 days after sowing	81	90.00
Two sprays of Glyphosat 41% SL (Round up) @ 25 ml/acre at 25 days after sowing and 50 ml/acre after 55days of sowing with 150 litre of water and irrigation is prerequisite either 2 days before spray or after spray with flat fan	18	20.00

nozzle.		
***Sclerotinia* stem rot**.		
Cultural control		
Implement deep ploughing during summer	53	58.89
Use certified seeds of resistant/tolerant varieties	73	81.11
Follow timely sowing of crop.	81	90.00
Use proper field sanitation practices	54	60.00
Chemical control: Bavistin @ 200 g/200litre of water per acre at 45 days and 65 days	18	20.00

Perusal of data pertaining to knowledge of IPM practices against pest and diseases at pre sowing stage presented in Table 2 clearly indicate that about 60.00 per cent farmers had knowledge of destruction of plant debris, land leveling to have well drained field, and deep ploughing in summer and exposure to Sunshine for reduction of soil borne pathogens as well as weeds infestation followed by FYM & vermicompost application (48.89%), seed treatment with Azotobactor culture (30.00%), seed treatment with Bavistin for control of Sclerotinia rot (20.00%) and soil amendment for club rot management 2.22 per cent only.

Regarding knowledge of sowing/seedling stage IPM measures, all respondents had knowledge that crop rotation controls weeds infestation, pulse crop rotation for Orobanche in previous season followed by NPK application on soil test basis for proper nutrient management (70.00%) and half of nitrogen application at sowing (60.00%), recommended dose of NPK (45.55%), sulphur application through gypsum (40.00%) while they had little/no knowledge of pre emergence herbicides use for weed control i.e. 1.11 per cent only.

Knowledge pertaining to IPM practices for Aphid control indicted that majority of farmers (72.22%) were aware of early sowing to avoid infestation, chemical control measures at infestation (68.89%), destroying the infested twigs at boundaries at initial stage (18.89 %), yellow sticky traps (13.35%) and lady bird beetle as predators (8.89%) while they had less knowledge pertaining to bio-chemicals practices like neem oil and NSKE (2.22%) only.

IPM practices for Painted bug control indicted that avoid very early sowing (80.00%), irrigate the crop in 4th week at pest attack (80.00%), deep ploughing in summer to destroy eggs (58.89%), burning of mustard remains to reach the insect stages to next season crop (40.00%) while, 20.00 percent know that bugs usually congregate on the leaves and stem which can be jerked to dislodge them and killed in kerosin water and no one had knowledge of biocontrol agents such as Tachinid fly.

Farmers knowledge regarding IPM practices against White rust/Downy mildew indicated that vast majority of farmers had knowledge of cultural practices like certified seeds of resistant/tolerant variety, timely sowing, crop rotation, avoidance of over irrigation/water stagnation and chemical control at disease infestation while they had less knowledge about destruction of stag heads & potash application and no knowledge about botanical control with garlic bulb extract.

Similarly knowledge for vegetative stage IPM measures indicated that all farmers know top dressing of nitrogen at 45 days and two hand tool weeding at 25 and 45 days (90.00%) while they had less knowledge about weedicide use (20.00%) and soyabean oil treatment of young shoot of *Orobanche* hardly 1.00 percent.

Farmers' knowledge regarding control of *Sclerotinia* stem rot indicated that 90.00 percent of farmers were aware of timely sowing, certified seeds of resistant/tolerant varieties (81.11%), proper field sanitation (60.00%) and deep ploughing in summer & sunshine exposure (58.89%) while 20.00 percent had knowledge of two Bavistin spray at 45 and 65 days.

Table 3: Farmers' adoption level of integrated pest management practices against mustard pests & diseases (n=90)

Pre sowing	Full adoption (2)	Partial adoption (1)	No adoption (0)	Weighted mean score
Nutrients				
(i) FYM @4.0 t/acre or vermicompost @ 2.0 t/acre	16	12	62	0.48
(ii) Seed treatment with Azotobactor culture @ 240 g/acre	10	-	80	0.22
Weeds				
(i) Deep ploughing in summer (May & June) and exposure to Sunshine	15	-	75	0.33
(ii) Stale seed bed technique to minimize the weeds menace in the field	-	-	90	0.00
Defoliators/soil borne pathogens				
(i) Deep ploughing in summer (May & June to exposure the soil borne pathogens and hibernating stage of defoliators	15	-	75	0.33
(ii) Land levelling and well drained field to reduce the incidence of Sclerotinia rot	45	-	45	1.00
(iii) Destruction of plant debris	27	-	63	0.60
(iv) Soil amendment with lime @ 1kg/m^2 or apply Neem cake @ 0.5 kg/m^2 for club rot management	-	-	90	0.00
(v) Seed treatment with Bavistin @ 2g/kg seed for Sclerotinia rot	18	-	72	0.40
Sowing/seedling				
Nutrients				
i) Basal application of NPK on soil test basis	09	-	81	0.20
ii) Generally 32 kg N, 16 kg P and 16 kg K/acre is applied	9	81		1.10
iii) Half of the N dose should be applied at the time of sowing	35	-	55	0.77
iv) Sulphur should be applied through Gypsum	18		72	0.40
Weeds				
i) Adopt crop rotation	77	09	04	1.81
ii) Pulse crop sown in case of infestation of Orobanche in previous season	13	-	77	0.28

iii) Apply oxadiargyl 6% EC (Raft ™) @600ml in 200 litre of water/acre 0-3 days after sowing as pre-emergence herbicide	-	-	90	0.00
Aphids				
Cultural control				
i) Early sowing	54	-	36	1.20
ii) Yellow sticky traps	05	-	85	0.11
Mechanical				
Destroy the affected part along with aphid population in the initial stage	08	-	82	0.17
Biological control				
i) 2 per cent Neem oil and 5 per cent Neem Seed Kernel Extract (NSKE)	-	-	90	0.00
ii) Ladybird beetles as predators, and also Syrphid/Hoverfly, lacewing as predators	-	-	90	0.00
Chemical control	32	-	58	0.71
Painted bug				
Cultural control				
Deep ploughing the soil to destroy eggs of painted bug	15	-	75	0.33
Avoid very early sowing.	53	-	37	1.17
Irrigate the crop in IV week after sowing to reduce pest attack	20	-	70	0.44
Mechanical control				
Burn the remains of mustard crop so that the stages of insect do not reach the next year crop	-	-	90	0.00
Dislodge bugs congregated on the leaves and stem by jerk into kerosin water to kill.	03	-	87	0.06
Biological control: Conserve bio-control agents such as *Alophora* spp. (tachinid fly) parasitizing eggs of painted bugs.	-	-	90	0.00
Chemical control	32	-	58	0.71
White rust/Downy mildew				
Cultural control				
Certified seeds of resistant/tolerant variety	90	-	-	2.00
Timely sowing of crop.	81		09	1.80
Proper crop rotation.	77	09	04	1.81
Destruct crop debris particularly stag heads of previous year crop.	09	-	81	0.20
No over irrigation or water stagnation.	52	-	38	1.15
Potash in recommended dose			90	0.00
Botanical control Treat the seeds with freshly prepared garlic bulb extract @ 2% (w/v).	-	-	90	0.00
Chemical control	32	-	58	0.71
Vegetative				
Nutrients				
Top dressing of N @ 16 Kg per acre at 45 days after sowing	90	-	-	2.00
Foliar application of thiourea (0.1%) at 50% flowering to enhance mustard productivity.	-	-	90	0.00
Weeds				
Applications of two drops of soyabean oil per young shoot of *Orobanche* reduced infestation.	-	-	90	0.00
Hand tool weeding at 25 and 45 days after sowing	18	45	27	0.90
Two sprays of Glyphosat 41% SL (Round up) @ 25 ml/acre at 25 days after sowing and 50 ml/acre after 55days of sowing with 150 litre of water and irrigation is prerequisite either 2 days before spray or after spray with flat fan nozzle.	02	-	88	0.04
***Sclerotinia* stem rot**.				
Cultural control				
Deep ploughing during summer	15	-	75	0.33
Certified seeds of resistant/tolerant varieties	90	-	-	2.00
Timely sowing of crop.	81	-	09	1.80
Proper field sanitation practices	01	17	72	0.21
Chemical control				
Spray of Bavistin @ 200 g/200 litre of water per acre at 45 days and 65 days	10	44	36	0.71

Data pertaining to adoption of IPM practices by farmers at pre sowing stage presented in Table 3 clearly indicate that land leveling to have well drained fields was most adopted by farmers with the mean score of 1.00 followed by destruction of plant debris (mean score 0.60) and FYM application (mean score 0.48), deep ploughing in summer for weeds & soil borne pathogens (mean score 0.33), seed treatment with Azotobactor culture (mean score 0.22) and no soil amendment for club rot management by farmers.

Similarly adoption of IPM practices at sowing/seedling stage by farmers indicate that crop rotation was most adopted with mean sore of 1.81 followed by recommended dose of NPK (mean sore 1.10), half N application at sowing (mean sore 0.77), sulphur through gypsum (mean sore 0.40), pulse crop sown in case of infestation of Orobanche in previous season (mean score 0.28) and NPK application on soil test basis (mean score 0.20) while no adoption of pre-emergence herbicide by farmers.

Adoption of IPM practices by farmers for Aphid control indicated that early sowing was most adopted practice with mean score of 1.20 followed by chemical measures (mean score 0.71), destroy of border twigs with initial infestation (mean sore 0.17) and yellow sticky traps (mean sore 0.11) while no biological measure was adopted by farmers.

Adoption of IPM practices by farmers for Painted bug control indicated that avoidance of early sowing was most adopted practice with mean score of 1.17 followed by chemical measures (mean score 0.71), irrigation in 4th week (mean score 0.44) and deep ploughing in summer (mean score 0.33) while mechanical method of dislodging the congregated bug in kerosin water to kill was least adopted with mean score of 0.06 and non-adoption of bio agents for its control.

Adoption of IPM practices by farmers against White rust/Downy mildew clearly indicated that cultural practices like certified seeds of resistant/tolerant variety was most adopted followed by proper crop rotation, timely sowing, no over irrigation and chemical control with mean scores of 2.00, 1.81 1.80 1.15 and 0.71 respectively while no adoption of potash in recommended dose and botanical treatment by farmers.

Similarly adoption of IPM measures by farmers at vegetative stage indicated that top dressing of N was most adopted with mean score of 2.00 followed by hand tool weeding (0.90) and Orobanche control by weedicide use was least adopted (mean score 0.04) by farmers.

Adoption of IPM practice for control of *Sclerotinia* stem rot by farmers depicted that certified seeds of resistant/tolerant varieties at the top with mean score of 2.00 followed by timely sowing (1.80), chemicals use (0.71) while least adopted were deep summer ploughing, the reason expressed by farmers high power tractor requirement and proper field sanitation (mean sore 0.21).

The findings are in agreement with findings of Alka *et al.* (2008) [1] 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 practising 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.

Similar findings were reported by Paikra (2008) [4] in which it was found that cultural practices and chemical control methods were mostly adopted by the paddy growers. While other important practices like use of plant extracts, biological control were least adopted.

Conclusion

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 and even Orobanche control by soyabeen oil drops was not known to farmers. At the same time over all adoption was low to moderate except being high in cultural practices like certified seeds of resistant/tolerant varieties(mean score 2.00), top dressing of N fertilizer (mean score 2.00), crop rotation (mean score 1.81) and timely sowing (mean score 1.80) while it was very low in case of adoption of bio fertilizers(mean score 0.22), sowing of pulse crop in case of Orobanche in previous season (mean score 0.28), deep summer ploughing (mean score 0.33) and bio agents and botanical measures were not adopted against pests and diseases of mustard crop. In nut shell farmers had no proper knowledge of AESA based IPM practices as well as its proper sequential adoption in the field.

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