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Farmers' Knowledge and Perceptions of Cotton Insect Pests and their Management Practices in Haryana

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Abstract: A survey was carried out in major cotton growing districts namely, Hisar, Sirsa and Bhiwani of Haryana state for acquiring information on farmers' knowledge, perception and practices of insect pest management in *Gossypium hirsutum* during *kharif*, 2019. Majority of respondents (70.0%) belonged to the age group of 40-60 years with an overall literacy rate of 87 per cent and 56 per cent of the respondents had more than 15 years of experience in cotton cultivation. RCH 773 BG II, RCH 776 BG II, US 51 BG II, Ankur 3028 BG II and US 81 BG II were the most commonly grown hybrids by the farmers. Whitefly, *Bemisia tabaci* and leafhopper, *Amrasca biguttula biguttula* were identified as the most important pests among sucking pests in *Bt* cotton. All the farmers targeted whitefly and leafhopper for control whereas none targeted the dusky cotton and red cotton bug for control. The incidence, severity and yield losses caused by whitefly and leafhopper were estimated to be high by 100.0, 86.6 & 82.7; 76.6, 74.0 & 64.6 per cent farmers, respectively. Cent per cent farmers adopted control measures at 61-90 days after sowing as highest pest incidence was estimated by cent per cent farmers in this duration. Majority of the farmers (44.6%) were dependent on agriculture input dealers for information on cotton cultivation followed by CCS HAU, Hisar/ICAR-CICR-RS, Sirsa (34.6%). Higher cost of insecticides, extreme weather conditions, lack of knowledge about bioagent and poor efficacy of insecticides were identified as major constraints faced by farmers for insect pest management in cotton. Insecticides like imidacloprid, thiamethoxam, emamectin benzoate, fipronil, dimethoate and monocrotophos were mainly used by farmers to manage sucking pests. Besides, newer insecticides like flonicamid, dinotefuran, diafenthiuron, spiromesifen and spinetoram were also used by farmers.

Keywords: *Bt* cotton, Farmers, Whitefly, Leafhopper, Information, Constraints

Cotton, *Gossypium* spp. popularly known as “White Gold” is a major fiber crop of the world and is used by about 75 per cent of world's population for textile purposes. It is native to tropical and subtropical regions around the world, including America, India and Africa. In India all four cotton species *viz*., old-world cotton, *G. arboreum* L., *G. herbaceum* L. and new world cotton, *G. barbadense* L. and *G. hirsutum* L. as well as some hybrids are cultivated commercially. The American cotton, *G. hirsutum* accounts for about 90% of the hybrid cotton genotypes grown in India (Hong-Bin et al 2008). Cotton is grown in an area of more than 38 million hectares (m ha) in the world, of which approximately 24 per cent is covered in India. The major producers of cotton are China, India, USA, Pakistan, Uzbekistan, Argentina, Australia, Greece, Brazil, Mexico and Turkey contributing about 85% to global cotton production. India is the second-largest cotton producer globally after China (Anonymous 2021). In India, it is cultivated over an area of 12.35 m ha with production and productivity of 34.06 million bales and 468.87 kg ha^{-1}, respectively (Kiruthika et al 2022). Among Indian states, Haryana is the 6th largest cotton-producing state with an area of 0.74 m ha, production of 1.82 million bales and productivity of 419 kg ha^{-1} (Anonymous 2021). Cotton crop is attacked by several insect pests from germination to harvesting stage. These insect pests may be classified into sap sucking insects (aphids, jassids and whitefly) and chewing insects (bollworms, leaf-eating caterpillars, *etc*.). Before the introduction of *Bacillus thuringiensis* (*Bt*) cotton, insecticides were the only option to manage these insect pests (Razaq et al 2013) and nearly 50 per cent of the pesticides were sprayed on cotton for the control of bollworms, which accounts for major damage (Anonymous, 2014). Although the introduction of *Bt* cotton reduces bollworms problem in cotton but the problem of sucking pests remain as such. Therefore nowadays the insecticides are mainly applied to manage sucking pests. But the information on insecticide use patterns in different cotton-growing areas in the Haryana state is limited. Therefore, the present study is devised to gather information on farmers' knowledge, perception and practices of insect pest management in *Bt* cotton.

MATERIAL AND METHODS

Designing of survey schedule: The farmers' knowledge regarding cotton insect pest management was evaluated through a questionnaire. For this purpose, a preliminary survey was performed to develop a questionnaire. Major

cotton-growing districts namely, Hisar, Sirsa and Bhiwani of Haryana state were selected and in each district five block and two villages per block were selected purposively based on total cotton area coverage and production. Personal interviews were conducted with five selected farmers from each village and thus, the total sample size of the respondents was 150 comprising 50 from each district. The blocks selected were namely, Hisar- I, Adampur, Hisar- II, Agroha and Barwala; Rania, Nathusera Chopta, Baragudha, Ellenabad and Sirsa and; Bhiwani, Loharu, Bawani Khera, Tosham and Kairu from Hisar, Sirsa and Bhiwani districts respectively. The villages selected were Dhansu and Shikarpur; Sadalpur and Kohli; Kaluwas and Kirtan; Shamsukh and Kirara and; Khedar and Iserheri from Hisar- I, Adampur, Hisar- II, Agroha and Barwala blocks respectively. The villages selected were Mangalia and Dhottar; Ding and Gudia Khera; Baragudha and Karamgarh; Beharwala Khurd and Poharka and; Darbi and Shahpur Begu from Rania, Nathusera Chopta, Baragudha, Ellenabad and Sirsa blocks respectively. Similarly, the villages selected were Manheru and Gauripur; Dhigawa Shamyan and Singhani; Milakpur and Barsi; Chhapar Rangran and Chhapar Jogian and; Shimliwas and Bhangarh from Bhiwani, Loharu, Bawani Khera, Tosham and Kairu blocks respectively.

Collection of data: The farmers were interviewed individually in the appropriate local language using a structured questionnaire. Questions were focused first on farmers' age, level of education, farm size and history of cotton cultivation. Subsequently, questions bordered on tests of farmers' knowledge of cotton insect pests, their damage to cotton, control measures adopted, farmers' perception of incidence, severity and yield loss, use of insecticides/ biopesticides, crop stage and frequency of application and constraints faced in insect pest management of cotton. On an average, each questionnaire took 30-40 minutes of the interview with each farmer.

Statistical analysis: Survey data were summarised and Chi-square test with Cramer's *V* for independent attributes was used to indicate the association between farmers in different districts using SPSS software (version 23).

RESULTS AND DISCUSSION

Farmers' profile: Details of farmers profile are given in Table 1. All the farmers (100.0%) were growing *Bt* cotton across the selected districts and none was reported to be growing non-*Bt* cotton. Yadav and Goel (2019) in survey during 2015-16 also observed same trend in Sirsa and Fatehabad districts of Haryana state. The major *Bt* hybrids cultivated by the respondents were BG II cotton hybrids namely, RCH 773, RCH 776, US 51, Ankur 3028 and US 81. The majority of the respondents (34.0%) were growing RCH 773 followed by RCH 776 which is cultivated by 31.3% of the respondents. The proportion of farmers growing cotton hybrids like US 51, Ankur 3028 and US 81 was 13.3, 13.3 and 8.0%, respectively. Rani and Selvaraj (2009), Singh et al (2013) and Hoshmath et al (2012) confirmed that majority of the farmers adopted *Bt*-cotton technology mainly because of more yield, less number of labour, high producer price, lower pest attack and decrease in volume of insecticides sprayed are supporting the present findings. Statistical analysis of data revealed that age of farmer, educational status of farmers, experience in cotton cultivation, type of *G. hirsutum* and hybrid use pattern among farmers is non-significantly associated within the district.

Farmers' knowledge and perception: Among the sucking pests, all the respondents were having knowledge of whitefly and leafhopper and targeted for control whereas in case of dusky cotton and red cotton bugs, all the respondents were having knowledge about these pests but no one was targeting for their control (Table 2). It may be because of less economic damage caused by these pests. Similarly, among other insect pests, despite knowing about tobacco caterpillar by 82.7% farmers, only 32.0% apply insecticides for control as it is sporadic pest and it is only considered as the important pest on cotton at some locations. The farmers were also having knowledge of bollworms but no one was found to target for control. Previous studies have also reported that the introduction of *Bt* cotton resulted in the reduction in the population of bollworms, damage of cotton squares and bolls (Rani and Selvaraj 2009). There is a significant association between farmers' knowledge of thrips and targeting for control (V=0.22 and 0.26) among different districts. Similarly, in the case of pink bollworm among bollworms and tobacco caterpillar among defoliators, there is a significant association between farmers in having knowledge among different districts.

Insect pests' incidence, severity, and yield losses: There is less variation in insect pests' incidence, severity and yield losses among three districts of Haryana (Table 3). On the mean basis, the incidence, severity and yield losses were categorized as high for whitefly and leafhopper by farmers (100.0, 86.6, 82.7%; 76.6, 74.0, 64.6%, respectively) among sucking pests. These findings are in agreement with the those of Sharma and Pampapathy (2006) wherein *Bt* cotton-growers reported a high incidence of sucking pests including whitefly and jassid, as *Bt* cotton hybrids are not possessing resistance for sucking insect pests. The incidence, severity and yield losses by other sucking pests like thrips, mealybug, aphid, dusky cotton bug and red cotton bugs were categorized into low to medium.

Table 1. Profile of cotton growing farmers in selected districts of Haryana (n=150)

Parameters	Name of district				Tests
	Hisar	Sirsa	Bhiwani	Mean	
Age of farmer					
<40 years	13.00 (26.00)	12.00 (24.00)	10.00 (20.00)	11.67 (23.30)	NS
40-60 years	35.00 (70.00)	34.00 (68.00)	36.00 (72.00)	35.00 (70.00)	
>60 years	2.00 (4.00)	4.00 (8.00)	4.00 (8.00)	3.33 (6.70)	
Educational status					
Illiterate	7.00 (14.00)	7.00 (14.00)	6.00 (12.00)	6.67 (13.30)	NS
Primary	11.00 (22.00)	9.00 (18.00)	7.00 (14.00)	9.00 (18.00)	
Middle	14.00 (28.00)	13.00 (26.00)	15.00 (30.00)	14.00 (28.00)	
Matric	13.00 (26.00)	15.00 (30.00)	14.00 (28.00)	14.00 (28.00)	
Graduation & above	5.00 (10.00)	6.00 (12.00)	8.00 (16.00)	6.33 (12.70)	
Literacy rate	(86.00)	(86.00)	(88.00)	(87.00)	
Experience in cotton cultivation					
<5 years	5.00 (10.00)	4.00 (8.00)	10.00 (20.00)	6.33 (12.70)	NS
5-15 years	18.00 (36.00)	13.00 (26.00)	16.00 (32.00)	15.67 (31.30)	
> 15 years	17.00 (54.00)	33.00 (66.00)	24.00 (48.00)	24.67 (56.00)	
Type of *Gossypium hirsutum*					
Bt cotton	50.00 (100)	50.00 (100)	50.00 (100)	50.00 (100)	NS
Non- *Bt* cotton	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	
Major *Bt* hybrids					
RCH 773 BG II	19.00 (38.00)	15.00 (30.00)	17.00 (34.00)	17.00 (34.00)	NS
RCH 776 BG II	18.00 (36.00)	14.00 (28.00)	15.00 (30.00)	15.67 (31.30)	
US 51 BG II	7.00(14.00)	7.00 (14.00)	6.00 (12.00)	6.67 (13.30)	
Ankur 3028 BG II	4.00 (8.00)	8.00 (16.00)	8.00 (16.00)	6.67 (13.30)	
US 81 BGII	2.00 (4.00)	6.00(12.00)	4.00 (8.00)	4.00 (8.00)	

Figures without parentheses are numbers of farmers and figures in parentheses are data in percentage; Chi-square test with Cramer's *V* to indicate the strength of association; NS = non-significant

Table 2. Percentage of farmers having knowledge of cotton pests and targeting for control (n=150)

Scientific name	Local Name	Name of district								Tests	
		Hisar		Sirsa		Bhiwani		Mean			
		Pest	Target	Pest	Target	Pest	Target	Pest	Target	Pest	Target
Sucking pests											
Thrips tabaci	Churda	88.00	68.00	90.00	76.00	72.00	46.00	83.30	63.33	0.22*	0.26**
Bemisia tabaci	Safedmakkhi	100	100	100	100	100	100	100	100	NS	NS
Amrasca biguttula biguttula	Tela	100	100	100	100	100	100	100	100	NS	NS
Phenacoccus solenopsis	Milibug	78.00	0.00	88.00	0.00	84.00	0.00	83.30	0.00	NS	NS
Aphis gossypii	Chepa	84.00	4.00	86.00	6.00	74.00	2.00	81.30	4.00	NS	NS
Oxycarenus hyalinipennis		100	0.00	100	0.00	100	0.00	100	0.00	NS	NS
Dysdercus cingulatus	Laldi	100	0.00	100	0.00	100	0.00	100	0.00	NS	NS
Bollworms											
Helicoverpa armigera	Hari sundi	42.00	0.00	56.00	0.00	38.00	0.00	45.30	0.00	NS	NS
Pectinophora gossypiella	Gualbi sundi	12.00	0.00	28.00	0.00	8.00	0.00	16.00	0.00	0.24*	NS
Earias vittella & *E. insulana*	Kanto wali sundi	60.00	0.00	64.00	0.00	42.00	0.00	55.30	0.00	NS	NS
Spodoptera litura	Tambacu keeda	88.00	12.00	92.00	16.00	68.00	8.00	82.70	32.00	0.28**	NS

Chi-square test with Cramer's V to indicate the strength of association. NS = non-significant,* significant at 5% level, ** significant at 1% level

Based on mean value, the incidence, severity and yield losses were negligible due to bollworms. Among defoliators, the incidence, severity and yield losses due to tobacco caterpillar were rated from low to medium by the majority of farmers. There is a significant association between farmers estimating incidence and severity of leafhopper but yield losses are non-significantly associated with districts. In case of bollworms, the incidence, severity and yield losses, all are

Table 3. Percentage of farmers estimating incidence, severity and yield loss of major cotton insect pests in selected districts (n=150)

Insect	Categor	Incidence					Severity					Yield loss				
		Hisar	Sirsa	Bhiwani	Mean	Tests	Hisar	Sirsa	Bhiwani	Mean	Tests	Hisar	Sirsa	Bhiwani	Mean	Tests
Sucking pests																
Thrips tabaci	Low	64.00	52.00	70.00	62.00	NS	68.00	60.00	74.00	67.33	NS	94.00	86.00	90.00	90.00	NS
	Medium	36.00	48.00	30.00	38.00		32.00	40.00	26.00	32.67		6.00	14.00	10.00	10.00	
	High	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
Bemisia tabaci	Low	0.00	0.00	0.00	0.00	NS	0.00	0.00	0.00	0.00	NS	0.00	0.00	0.00	0.00	NS
	Medium	0.00	0.00	0.00	0.00		14.00	16.00	10.00	13.33		18.00	10.00	24.00	17.30	
	High	100	100	100	100		86.00	84.00	90.00	86.67		82.00	90.00	76.00	82.70	
Amrasca biguttula biguttula	Low	0.00	0.00	0.00	0.00	0.25**	0.00	0.00	0.00	0.00	0.24**	0.00	0.00	0.00	0.00	NS
	Medium	24.00	10.00	36.00	23.33		28.00	12.00	38.00	26.00		38.00	26.00	42.00	35.33	
	High	76.00	90.00	64.00	76.67		72.00	88.00	62.00	74.00		62.00	74.00	58.00	64.67	
Phenacoccus solenopsis	Low	94.00	90.00	92.00	92.00	NS	98.00	94.00	96.00	96.00	NS	98.0	96.00	98.00	97.30	NS
	Medium	6.00	10.00	8.00	8.00		2.00	6.00	4.00	4.00		2.00	4.00	2.00	2.70	
	High	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
Aphis gossypii	Low	94.00	96.00	92.00	94.00	NS	96.00	98.00	94.00	96.00	NS	98.00	100	96.00	98.00	NS
	Medium	6.00	4.00	8.00	6.00		4.00	2.00	6.00	4.00		2.00	0.00	4.00	2.00	
	High	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
Oxycarenus hyalinipennis	Low	14.00	16.00	20.00	16.70	NS	30.00	32.00	34.00	32.00	NS	92.00	96.00	90.00	92.70	NS
	Medium	86.00	84.00	80.00	83.30		70.00	68.00	66.00	68.00		8.00	4.00	10.00	7.30	
	High	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
Dysdercus cingulatus	Low	88.00	82.00	90.00	86.70	NS	90.00	86.00	92.00	90.00	NS	92.00	94.00	94.00	93.30	NS
	Medium	12.00	18.00	10.00	13.30		10.00	14.00	8.00	10.00		8.00	6.00	6.00	6.70	
	High	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
Bollworms																
Old world bollworm (*Helicoverpa armigera*)	Nil	94.00	96.00	94.00	94.70	NS	94.00	96.00	94.00	94.70	NS	90.00	94.00	92.00	92.00	NS
	Low	6.00	4.00	6.00	5.30		6.00	4.00	6.00	5.30		10.00	6.00	8.00	8.00	
	Medium	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
Pink bollworm (*Pectinophora gossypiella*	Nil	98.00	96.00	94.00	96.00	NS	98.00	96.00	94.00	96.00	NS	94.00	96.00	98.00	96.00	NS
	Low	2.00	4.00	6.00	4.00		2.00	4.00	6.00	4.00		6.00	4.00	2.00	4.00	
	Medium	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
Spotted and spiny bollworm (*Earias vittella* & *E. insulana*)	Nil	92.00	90.00	86.00	89.30	NS	92.00	90.00	86.00	89.30	NS	84.00	76.00	88.00	82.70	NS
	Low	8.00	10.00	14.00	10.70		8.00	10.00	14.00	10.70		16.00	24.00	12.00	17.30	
	Medium	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	
Defoliator																
Tobacco caterpillar (*Spodoptera litura*)	Low	72.00	52.00	70.00	64.70	0.19*	80.00	58.00	74.00	70.67	0.20*	64.00	54.00	78.00	65.30	0.20*
	Medium	28.00	48.00	30.00	35.30		20.00	42.00	26.00	29.33		36.00	46.00	22.00	34.70	
	High	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	

Chi-square test with Cramer's *V* to indicate the strength of association. NS = non-significant,* significant at 5% level, ** significant at 1% level

non-significantly associated with districts. The incidence, severity and yield losses due to tobacco caterpillar among defoliators were dependent of districts with association values of V= 0.19, 0.20 and 0.20, respectively.

Pests incidence during different cotton crop growth stages: There is less variation in farmers estimating pest incidence during different crop durations in all three districts (Table 4). The highest pest incidence was at 61-90 days after sowing (DAS) by cent per cent farmers followed by 70.0, 18.0 and 9.3% farmers at 91-120, >120 and 31-60 DAS, respectively and minimum pest incidence (6.0%) was estimated by farmers at <30 DAS. This may be due to the prevailing high temperature, high humidity and lush growth of plants in July-August (61-90 DAS) providing conducive environment for higher pest incidence. Statistical analysis of data revealed that estimation of pest incidence at different crop growth stages is independent of the district.

Use of insecticides at different crop durations: On the mean basis, the cent per cent farmers targeted the pests for their control at 61-90 DAS as maximum pest incidence was estimated at this crop duration followed by 61.3, 13.3 and 8.0% farmers at 91-120, >120 and 31-60 DAS, respectively (Table 5). None of the farmers in three districts used insecticides when the crop is <30 days old as very low pest incidence was recorded at this stage. The data revealed that use of insecticides by farmers against target pests at different crop duration is non-significantly associated with districts.

Components of insect pest management: The knowledge of the sampled respondents about the various components of pest management ranged from 8.6 to 52.6% (Table 6). Among the various components of plant protection, about 52.6% of respondents read the label and leaflets before applying the insecticides. Majority of the farmers (32.6%) used the seed supplied by agricultural input dealers which is claimed to be already treated with insecticides. Only 23.3% of the farmers knew about the economic thresholds of insects. The knowledge of yellow sticky trap, use of stickers and bioagents of cotton insect pests were found to be 28.0, 18.0 and 8.67%. Relatively a few farmers (8.6%) were familiar with bioagents in *Bt* cotton. Yang et al (2005) reported that farmers have moderate level of awareness about natural enemies in their *Bt* cotton field farmers. Statistical analysis of data revealed that farmers' knowledge about various components of pest management is independent of the district.

Information source for inputs in cotton cultivation: Most of the farmers (44.6%) were dependent on agricultural input dealers for information on inputs in cotton cultivation followed by the recommendations from CCS HAU/CICR-RS, and relatives/neighbours *i.e.*, 34.6 and 32.0% farmers, respectively. It is followed by farmers using information disseminated through TV/ social media, farmers' group, newspaper and radio, respectively. A few farmers were also depending on self-observations (4.6%) and farmers' field group (3.3%) as an information source for input in cotton cultivation. However, statistical analysis revealed that it was non-significantly associated with districts (Table 7). The

Table 4. Percentage of farmers estimating pests incidence during different crop duration in selected districts (n=150)

Crop duration	Name of district				Tests
	Hisar	Sirsa	Bhiwani	Mean	
< 30 DAS	8.00	6.00	4.00	6.00	NS
31-60 DAS	10.00	10.00	8.00	9.33	NS
61-90 DAS	100	100	100	100	NS
91-120 DAS	70.00	68.00	72.00	70.00	NS
>120 DAS	18.00	20.00	16.00	18.00	NS

Chi-square test with Cramer's *V* to indicate the strength of association. NS = non-significant

Table 5. Percentage of farmers using insecticides against target pests at different crop durations in selected districts (n=150)

Crop duration	Name of district				Tests
	Hisar	Sirsa	Bhiwani	Mean	
< 30 DAS	0.00	0.00	0.00	0.00	NS
31-60 DAS	8.00	10.00	6.00	8.00	NS
61-90 DAS	100	100	100	100	NS
91-120 DAS	60.00	68.00	56.00	61.33	NS
>120 DAS	14.00	14.00	12.00	13.33	NS

Chi-square test with Cramer's *V* to indicate the strength of association. NS = non-significant

insecticide usage seems to be highly influenced by agriculture input dealers. The main reason for this dependence appeared to be that most of farmers depend on the dealers for credit. Rani and Selvaraj (2009) also reported that primary source of information for input in cotton cultivation is the local input dealer.

Constraints faced by cotton growers in insect pest management: The major constraints faced by farmers in insect pest management were the high cost of insecticides, weather problems and lack of knowledge about bioagent which are represented by 85.3, 83.3 and 80.0% farmers, respectively (Table 8). Yadav and Goel (2019) reported that the major problem in implementing the plant protection measures was the high cost of pesticides (99.0%), adulteration (82.0%), lack of knowledge about correct dose (54.5%) and non-availability of pesticides (38.0%).The next major constraint was the insubstantial control or poor efficacy of insecticides, which was reported by 73.3% farmers. It

Table 6. Percentage of farmers having knowledge about various components of pest management (n=150)

Particulars	Name of district				Tests
	Hisar	Sirsa	Bhiwani	Mean	
Economic threshold level	24.00	30.00	16.00	23.33	NS
Labels on pesticide containers	52.00	62.00	44.00	52.67	NS
Use of stickers	16.00	26.00	12.00	18.00	NS
Bioagents	8.00	12.00	6.00	8.67	NS
Seed treatment	32.00	38.00	28.00	32.67	NS
Yellow sticky trap	30.00	36.00	18.00	28.00	NS

Chi-square test with Cramer's *V* to indicate the strength of association. NS = non-significant

Table 7. Percentage of farmers getting the information for inputs in cotton cultivation (n=150)

Source of information	Name of district				Tests
	Hisar	Sirsa	Bhiwani	Mean	
Radio	10.00	8.00	8.00	8.66	NS
TV/Social media	12.00	12.00	10.00	11.33	NS
Newspaper	8.00	10.00	8.00	8.66	NS
CCS HAU/CICR-RS	38.00	34.00	32.00	34.66	NS
Relative or neighbor	32.00	30.00	34.00	32.00	NS
Agriculture input dealer	44.00	50.00	40.00	44.67	NS
Farmers' group	12.00	10.00	10.00	10.67	NS
Farmers' field school	4.00	4.00	2.00	3.33	NS
Self-observation	4.00	4.00	6.00	4.67	NS

Chi-square test with Cramer's *V* to indicate the strength of association. NS = non-significant

Table 8. Percentage of farmers indicating different constraints faced by cotton growers in insect pest management (n=150)

Constraints	Name of district				Tests
	Hisar	Sirsa	Bhiwani	Mean	
High cost of pesticides	92.00	88.00	76.00	85.33	NS
Non-availability of good seeds	52.00	42.00	64.00	52.67	NS
Weather problems	100.00	82.00	68.00	83.33	0.35**
Non-availability of labour	66.00	72.00	52.00	63.33	NS
Insubstantial control	74.00	78.00	68.00	73.33	NS
Lack of knowledge about traps	48.00	32.00	72.00	50.70	0.33**
Non-availability of chemicals	52.00	40.00	66.00	52.67	0.21*
Lack of knowledge about bioagents	88.00	62.00	90.00	80.00	0.32**
Non-availability of sprayer	0.00	0.00	32.00	10.07	0.49**

Chi-square test with Cramer's *V* to indicate the strength of association. NS = non-significant,* significant at 5% level, ** significant at 1% level

could be due to various reasons like use of spurious insecticides or inappropriate selection of insecticides against target pests, improper application methodology, poor conditions of spraying equipments, unfavourable weather condition, *etc*. Kumar (2014) revealed that the most important constraints faced by the farmers in *Bt* cotton production were non-availability of labour, unfavourable weather conditions, inadequate insect pest control, high cost of pesticides and fertilizers, and non-availability of inputs *etc.*, which also corroborate the present findings. The other constraints faced by cotton growers were the non-availability of labour (63.3%), non-availability of good seed (52.6%) and the non-availability of insecticides on time (52.6%) and lack of knowledge about traps (50.7%). Mohanasunderm (2015) also reported that among the various problems faced by *Bt* cotton farmers in cotton cultivation, the shortage of labour at the time of cultivation and harvesting is the major constraint in cotton production. On mean basis, about 10.0% of farmers responded to non-availability of sprayers among selected districts. Statistical analysis of data revealed that the constraints faced by cotton growers in insect pest management namely, non-availability of sprayers, weather problems, lack of knowledge about traps, lack of knowledge about bioagents and non-availability of insecticides are significantly associated with districts.

Insecticide use pattern in cotton: The neonicotinoid compounds were the most commonly used insecticides by the majority of cotton growers for control of sucking pests (Table 9). Among neonicotinoids, the leading insecticides were thiamethoxam and imidacloprid which were used against sucking pests of cotton by 81.3 and 78.0% farmers, respectively. The next leading insecticide was emamectin benzoate by 40.0% farmers mainly for thrips management in cotton followed by fipronil, dimethoate and monocrotophos. Cypermethrin, acepahte, and ethion were used by 8.0, 7.3 and 6.0% farmers, respectively. Neem based insecticides and buprofezin were found to be used by 8.0 and 6.0% farmers, respectively. Some novel insecticides were also reported to be used by farmers which include flonicamid, diafenthiuron, spiromesifen and dinotefuran. Spinetoram was found to be used by 2.7% farmers in Hisar and Sirsa districts only, while none of the farmer reported its use in Bhiwani district. The use of majority of insecticides in cotton against target pest is independent upon district except monocrotophos, emamectin benzoate, fipronil and flonicamid which are significantly associated with the district.

Table 9. Percentage of farmers using different insecticides in cotton in selected districts (n=150)

Insecticide	Name of district				Tests
	Hisar	Sirsa	Bhiwani	Mean	
Organophosphates					
1. Monocrotophos	14.00	12.00	30.00	18.67	0.21*
2. Dimethoate	16.00	18.00	24.00	19.33	NS
3. Acephate	6.00	10.00	6.00	7.33	NS
Synthetic pyrethroids					
1. Cypermethrin	8.00	12.00	4.00	8.00	NS
2. Ethion	4.00	12.00	2.00	6.00	NS
Neonicotinoids					
1. Imidacloprid	76.00	82.00	76.00	78.00	NS
2. Thiamethoxam	80.00	86.00	78.00	81.33	NS
3. Dinotefuron	6.00	8.00	2.00	5.33	NS
Other groups					
1.Emamectin benzoate	40.00	60.00	20.00	40.00	0.33**
2. Fipronil	20.00	46.00	6.00	24.00	0.39**
3. Flonicamid	8.00	20.00	4.00	10.67	0.22*
4. Azadirachtin	10.00	10.00	4.00	8.00	NS
5. Diafenthiuron	6.00	10.00	4.00	6.67	NS
6. Buprofezin	6.00	8.00	4.00	6.00	NS
7. Spiromesifen	6.00	8.00	2.00	5.33	NS
8. Spinetoram	4.00	4.00	0.00	2.70	NS

Chi-square test with Cramer's *V* to indicate the strength of association. NS = non-significant,* significant at 5% level, ** significant at 1% level

In present investigation, the use of insecticides was high, probably because farmers assume that the only solution to pest problems is to use insecticides. Similar findings have been reported in many developing countries where growing dependence on synthetic insecticides/non-IPM for the control of crop pests is alarming (Kumela et al 2018, Zhang et al 2018, Ochilo et al 2018, January et al 2018). Present results of group-wise stratification of insecticides usage in Haryana are in line with the findings of Dhawan et al (2011).

CONCLUSION

It can be inferred that among sucking pests, whitefly, *B. tabaci*, leafhopper, *A. biguttula biguttula* and up to some extent thrips, *Thrips tabaci* are considered important pests by the farmers in *Bt* cotton hybrids grown in Haryana in kharif 2019 and farmers are using conventional as well as newer molecules for the management of these insect pests. The insecticide usage pattern varied greatly between three selected districts indicating no definite insecticide usage pattern among the major cotton-growing districts of Haryana. Efforts are needed to educate the farmers about the identification of pests and natural enemies, as well as the establishment of economic thresholds for pests and adopting suitable control measures of pest management.

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