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Effect of chemical defoliation on boll opening percentage, yield and quality parameters of Bt Cotton (*Gossypium hirsutum*)

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ABSTRACT

A field experiment was conducted during *kharif* of 2008 and 2009 to study the effect of chemical defoliation on boll opening percentage (BOP), yield and quality parameters of Bt Cotton (*Gossypium hirsutum* L.). The experiment was laid out in a randomized complete block design with four replications comprising twelve treatments, *viz*. control, thidiazuron 100, 150 and 200 g/ha, ethrel 1.0 and 1.5 l/ha applied at 40 or 60 BOP and gramoxone (paraquat) 1.0 l/ha applied after first picking. Defoliation with ethrel 1.5 l/ha at 60 BOP resulted in higher number of picked bolls/plant and BOP when compared with control. However, maximum seed cotton yield was obtained with ethrel at 1.0 l/ha (2.27 and 1.96 t/ha) and it was followed by thidiazuron 100 g/ha (2.21 and 1.92 t/ha) applied at 60 BOP. Gramoxone (paraquat) application at 1.0 l/ha after first picking failed to exert any significant influence on seed cotton yield and yield contributing characters. The B:C ratio of thidiazuron 100 g/ha at 60 BOP was comparatively higher when compared with rest of the defoliation treatments. Seed index, lint index, ginning-outturn, oil content (%) in seeds and fibre quality parameters, *viz.* 2.5 % span length, fibre bundle strength and fibre fineness were not significantly influenced by any of the defoliation treatment.

Key words : Boll opening percentage, Bt cotton, Defoliants, Fibre quality parameters, Seed cotton yield

Cotton is a major cash crop of *kharif* season in south-western region of Punjab. It occupied an area of 6.04 lakh ha during 2008-09 with total production of 22.34 lakh bales and has an average productivity of 663 kg lint/hectare (PAU, 2010). Punjab, a leader in cotton production till recent times has trailed behind other states in average productivity. One of the constraints that limit realization of potential yield of cotton is poor and uneven opening of mature bolls. Excessive vegetative growth attained by cotton hybrids and thick crop canopy as a result of liberal use of nutrients hinders the opening of mature bolls, delays crop maturity and prolongs picking duration. Dense foliage also hinders the circulation of air and sunlight penetration. Thus not only the photosynthetic and metabolic activities are adversely affected but dehiscence and delayed opening of bolls are also caused in cotton (Jain *et al.,* 1983). Shedding of leaves with defoliants, terminate cotton development in preparation for harvest and expose the bolls to better circulation of air and sunlight which in turn favors quick boll opening and early picking (Christidis and Herrisen, 1955). Defoliants normally produce ethylene, which is a ripening hormone and causes leaf drop and bolls to crack open and fluff out. Secondly, it leads to clean and efficient picking as the pigments in the leaves can stain and reduce the quality of the cotton fibre. Defoliants are therefore used to synchronize and enhance boll opening in cotton, thus allowing the farmer to obtain maximum yield in a single harvest. The present investigation was, therefore, undertaken to study the effect of chemical defoliation on seed cotton yield, boll opening percentage and quality parameters of cotton.

MATERIALS AND METHODS

The experiment was carried out at the Students' Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana, during the two consecutive *kharif* seasons of 2008 and 2009. The soil of the experimental field was loamy sand in texture, normal in reaction (pH 8.1), low in organic carbon (0.31%) and available nitrogen (258.5 kg/ha) and high in available phosphorus (24.4 kg/ha) and potassium (339.4 kg/ha). The experiment was laid out in a randomized complete block design with four replications comprising 12 treatments, *viz.* control, thidiazuron 100, 150 and 200 g/ha and ethrel 1.0 and 1.5 l/ha at 40 or 60 BOP (boll opening percentage), respec-

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tively and gramoxone (paraquat) 1.0 l/ha after first picking. Bt Cotton hybrid RCH 134 was sown on 5 May 2008 and 28 April 2009, on a well prepared seed bed with a uniform seed rate of 1.5 kg/ha at inter-row spacing of 67.5 cm and intra-row spacing of 90 cm. Recommended cultural practices and plant-protection measures were followed throughout the crop growth seasons. Data on yield attributes were recorded from five tagged plants per plot, whereas to get total seed cotton yield per plot, the seed cotton yield of first, second and third picking was weighed separately and added. Observations on boll opening percentage (BOP), setting percentage, ginning outturn (GOT) and lint index were computed using following formula:

$$\text{BOP} = \frac{\text{Number of open bolls/plant}}{\text{Total number of bolls/plant}} \times 100$$

$$\text{Setting percentage} = \frac{\text{Total number of bolls/plant}}{\text{Total number of flowers/plant}} \times 100$$

$$\text{GOT} = \frac{\text{Lint weight (g)}}{\text{Weight of seed cotton (g)}} \times 100$$

$$\text{Lint index} = \{\text{Ginning outturn}/100 - \text{Ginning outturn}\} \times 100$$

Different fibre quality parameters were evaluated by High Volume Instrument (HVI) 9000. Oil content of seeds was determined by using hexane in Socs Plus apparatus (AOAC, 2001). Seed germination of harvested crop was evaluated by sowing 20 seeds from each treatment in polyethylene bags under field conditions.

RESULTS AND DISCUSSION

Yield contributing characters

The number of picked bolls per plant and boll opening percentage increased significantly with application of defoliants (Table 1). Maximum number of picked bolls per plant (44.0 and 42.0) was recorded with ethrel 1.5 l/ha applied at 60 BOP which was 14.3 and 16.6 % higher than control (38.5 and 36.0) during 2008 and 2009, respectively. While, thidiazuron 200 g/ha at 60 BOP recorded 11.2 and 12.8% higher number of picked bolls per plant than control in both the years, respectively and was statistically at par with ethrel 1.5 l/ha applied at 60 BOP. All levels of thidiazuron and ethrel resulted in significantly more number of picked bolls/plant when compared with control but were statistically at par with each other. Increase in number of picked bolls per plant with application of defoliants might be due to increased production of ethylene inside the bolls, leading to weakening and dissolving of cell walls and build up of internal pressure causing carpels to split apart and allowing the bolls to open naturally. Gramoxone (paraquat) application at 1.0 l/ha after first picking failed to exert any significant influence on number of picked bolls/plant. The present study endorses the findings of Thakral *et al.* (1991) and Singh *et al.* (2003) on effect of defoliants on number of bolls picked per plant. Maximum BOP of 98.76 and 98.82 was recorded with ethrel 1.5 l/ha applied at 60 BOP which was significantly higher than control (87.42 and 85.75) and gramoxone (91.79 and 90.19), but was statistically at par with rest of the defoliation treatments. Increase in boll opening percentage with increased levels of defoliants was clearly evident from increased number of picked bolls per plant. Application of different defoliants had a non-significant effect on boll weight. Thidiazuron 100 g/ha applied at 60 BOP produced the maximum boll weight of 3.21 and 2.91 g against 2.71 and 2.58 g of control in both the years, respectively.

Seed cotton yield

Application of various defoliants at 40 or 60 BOP had a significant influence on total seed cotton yield in both the crop growth seasons (Table 1). Maximum total seed cotton yield of 2.27 and 1.95 t/ha was obtained with ethrel application 1.0 l/ha at 60 BOP which was 33.2 and 28.9 % higher than the untreated control (1.70 and 1.52 t/ha) in 2008 and 2009, respectively but was statistically at par with rest of the defoliation treatments except gramoxone (paraquat). Thidiazuron 100 g/ha applied at 60 BOP recorded seed cotton yield of 2.21 and 1.92 t/ha which was 29.5 and 26.8 % higher than control and was statistically at par with ethrel 1.0 l/ha applied at 60 BOP. Various levels of ethrel and thidiazuron at 40 or 60 BOP resulted in 15.8 to 19.7 and 15.3 to 17.5 % higher total seed cotton yield than control during 2008 and 2009, respectively. Application of defoliants at 60 BOP although produced numerically higher total seed cotton yield than 40 BOP but was statistically at par with each other. Thus defoliants can successfully be applied either at 40 or 60 BOP for realizing higher seed cotton yield. These findings corroborate with Malik *et al.* (1991), Mehetre *et al.* (1993), Babu *et al.* (1995), and Singh *et al.* (2003). Increase in yield with application of ethrel and thidiazuron was attributed to their favorable effect on yield determining parameters like number of picked (opened) bolls/plant and boll opening percentage (Table 1). Gramoxone (paraquat) application of 1.0 l/ha after first picking, although resulted in numerically higher seed cotton yield (1.82 and 1.63 t/ha) than control (1.70 and 1.52 t/ha) but the differences were non-significant in both the years of study.

Quality parameters

Various defoliation treatments had non-significant influence on seed index, lint index, Ginning-outturn (GOT)

Table 1. Effect of various defoliation treatments on yield contributing characters, seed cotton yield and economics of hybrid Bt-cotton.

Treatment	Picked bolls/ plant		Boll opening percentage (%)		Weight/boll (g)		Seed cotton yield (t/ha)		Cost of cultivation (₹/ha)		Net returns (₹/ha)		B:C ratio	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Control	38.5	36.0	9.4 (87.4)*	9.3 (85.7)*	2.71	2.58	1.70	1.52	17,552	18,604	31,949	25,464	1.82	1.37
Thidiazuron 100g/ha at 40 BOP	41.7	39.5	9.6 (93.5)	9.6 (92.7)	3.05	2.85	2.08	1.84	17,889	18,942	42,534	34,422	2.38	1.82
Thidiazuron 150g/ha at 40 BOP	41.8	39.6	9.7 (93.7)	9.7 (93.8)	2.92	2.72	1.99	1.76	18,058	19,111	39,867	32,075	2.21	1.68
Thidiazuron 200g/ha at 40 BOP	42.0	39.7	9.7 (94.6)	9.7 (94.2)	2.85	2.70	1.97	1.75	18,227	19,279	39,118	31,529	2.15	1.64
Thidiazuron 100g/ha at 60 BOP	42.0	40.4	9.8 (95.2)	9.8 (95.1)	3.21	2.91	2.21	1.92	17,889	18,942	46,224	36,950	2.58	1.95
Thidiazuron 150g/ha at 60 BOP	42.6	40.6	9.7 (95.6)	9.8 (95.2)	3.00	2.81	2.09	1.87	18,058	19,111	42,569	35,067	2.36	1.83
Thidiazuron 200g/ha at 60 BOP	42.8	40.6	9.8 (96.4)	9.8 (96.4)	2.89	2.78	2.02	1.85	18,227	19,279	40,425	34,375	2.22	1.78
Ethrel 1.0 l/ha at 40 BOP	42.7	40.8	9.8 (95.6)	9.8 (96.2)	3.01	2.80	2.11	1.87	24,932	25,984	36,218	28,251	1.45	1.09
Ethrel 1.5 l/ha at 40 BOP	42.8	41.0	9.8 (95.9)	9.9 (97.6)	2.88	2.67	2.02	1.79	28,622	29,674	29,972	22,325	1.05	0.75
Ethrel 1.0 l/ha at 60 BOP	43.5	41.9	9.9 (98.2)	9.9 (98.1)	3.17	2.85	2.27	1.96	24,932	25,984	41,011	30,808	1.64	1.19
Ethrel 1.5 l/ha at 60 BOP	44.0	42.0	9.9 (98.7)	10.0 (98.8)	2.90	2.66	2.08	1.82	28,622	29,674	31,715	23,283	1.11	0.78
Gramoxone (paraquat) 1.0 l/ha after first picking	41.1	38.2	9.6 (91.7)	9.5 (90.1)	2.71	2.61	1.82	1.63	17,802	18,854	34,982	28,380	1.97	1.51
SEm ±	0.80	1.02	0.09	0.10	0.13	0.08	0.10	0.07						
CD(P=0.05)	2.31	2.94	0.27	0.29	NS	NS	0.29	0.21						

*Data in parenthesis are original value

Table 2. Quality parameters Bt cotton as influenced by various defoliation treatments.

Treatment	Seed index		Lint index		GOT (%)		Oil content (%)		Seed germination (%)		Fibre fineness (mg/inch)		Bundle strength (g/tex)		2.5% span fibre length (mm)	
	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009	2008	2009
Control	8.05	7.89	4.49	4.13	35.7	34.4	21.6	21.3	77.5	75.8	4.35	4.80	34.5	35.2	27.3	28.1
Thidiazuron 100g/ha at 40 BOP	8.00	7.73	4.67	4.14	36.8	34.9	20.4	20.0	78.0	76.5	4.00	3.90	36.3	37.4	27.5	27.4
Thidiazuron 150g/ha at 40 BOP	7.87	7.52	4.64	4.01	37.0	34.7	20.2	19.6	77.8	76.1	4.50	4.25	35.3	35.4	28.2	28.0
Thidiazuron 200g/ha at 40 BOP	7.58	7.50	4.26	4.07	36.0	34.9	20.1	19.4	77.3	75.7	4.25	4.45	36.1	35.0	28.0	27.6
Thidiazuron 100g/ha at 60 BOP	8.48	8.32	4.65	4.37	35.4	34.5	21.1	20.7	77.7	75.7	3.95	4.65	34.5	35.5	28.0	26.9
Thidiazuron 150g/ha at 60 BOP	8.21	8.19	4.72	4.45	36.5	35.1	20.5	20.5	78.0	75.2	3.90	4.55	33.2	35.0	27.8	28.0
Thidiazuron 200g/ha at 60 BOP	8.05	8.11	4.76	4.44	36.7	35.4	20.0	20.1	77.5	75.2	4.40	3.75	34.7	35.7	27.6	27.0
Ethrel 1.0 l/ha at 40 BOP	8.16	8.07	4.62	4.23	35.8	34.4	20.0	19.8	77.8	76.0	4.20	4.75	33.8	31.7	27.8	27.9
Ethrel 1.5 l/ha at 40 BOP	7.44	7.84	4.25	4.15	36.0	34.7	20.0	19.7	77.5	75.7	4.10	4.85	34.2	31.6	27.9	27.7
Ethrel 1.0 l/ha at 60 BOP	8.21	8.18	4.75	4.44	36.6	35.2	21.5	21.2	77.5	75.8	4.30	4.55	36.5	36.4	28.8	28.5
Ethrel 1.5 l/ha at 60 BOP	7.97	7.71	4.76	4.29	37.0	35.5	21.0	21.1	77.4	75.5	4.05	4.30	35.3	33.0	27.8	27.4
Gramoxone (paraquat) 1.0 l/ha after 1st picking	7.78	7.65	4.39	4.06	35.9	34.7	20.6	20.4	77.7	75.5	3.85	4.55	34.9	33.4	27.3	28.3
SEm ±	0.28	0.27	0.38	0.21	1.69	1.03	0.53	0.41	1.01	0.93	0.13	0.06	0.75	1.19	0.26	0.23
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

and fibre quality parameters (fibre fineness, bundle strength and 2.5% span fiber length) of Bt cotton (Table 2). Thus chemical defoliation had no adverse effect on quality of cotton fibre. Singh *et al.* (2003) also reported that seed index and lint index were not significantly affected with defoliation. Cotton defoliation with thidiazuron and ethrel at either 40 or 60 BOP stage and gramoxone (paraquat) applied after first picking had a non-significant effect on oil quality. The residual effect of defoliants on seed germination was evaluated and found that defoliants had no adverse effect on germination of cotton seeds.

Economics

The results of the present study showed that net returns (₹/ha) and B: C ratio was markedly higher with thidiazuron 100 g/ha applied at 60 BOP (Table 1) due to higher yield and less cost of cultivation in both the years of study. Although application of ethrel 1.0 l/ha at 60 BOP had resulted in maximum seed cotton yield of 2.27 and 1.96 t/ha in both the crop growth season respectively but B:C ratio is comparatively less when compared with control due to high cost of this chemical.

Present investigation showed that application of thidiazuron and ethrel resulted in significantly higher total seed cotton yield over control. Ethrel 1.0 l/ha and thidiazuron 100 g/ha applied at 60 BOP recorded the maximum total seed cotton yield. But B:C ratio of thidiazuron 100 g/ha applied at 60 BOP was higher than rest of the treatments. Different defoliation treatments did not have any harmful effect on quality parameters like seed index, lint index and ginning out-turn and fibre quality parameters.

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