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Performance of *Bt* and non-*Bt* cotton (*Gossypium hirsutum*) genotypes under cotton–wheat (*Triticum aestivum*) system*

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Cotton (*Gossypium hirsutum* L.) – wheat (*Triticum aestivum* L. emend. Fiori & Paol.) system in India is mainly taken in the northern zone covering the states of Punjab, Haryana and Rajasthan. The existing cotton genotypes are prone to infestation by a variety of insects and pests especially bollworms. Recently genetically modified *Bt* plants have been developed in cotton. These plants contain a gene that produces *Bt* toxin which kills the dreaded pest. These genotypes have been reported superior over the existing local varieties (Blackwell 2002). However the performance of *Bt* cotton is yet to be tested in India for their productivity and adaptability in existing cropping systems. The present study was, therefore, planned to test the performance of *Bt* and non-*Bt* cotton genotypes for crop duration and productivity under cotton-wheat system of northern plain zones.

The field experiment was conducted during 2002–03 at main research farm of Project Directorate for Cropping Systems Research, Modipuram, Meerut, Uttar Pradesh under sandy loam soil having *p*H 8.2 and organic carbon 0.38 %. *Bt* cotton hybrids 'MECH 915' and 'MECH 162' along with their non-*Bt* types and *Hirsutum* hybrids 'Omshankar' and 'LHH 144' and varieties 'Vikas' and 'H 1098' as check were grown to study their morpho-physiological traits and suitability under cotton–wheat system. Cotton genotypes were sown during mid May as main plots with three replications. These were harvested in 2 dates depending on the maturity of the crop, ie 'MECH 915' *Bt*, 'MECH 915' non-*Bt*, 'LHH 144' and 'Vikas' were harvested in mid November while 'MECH 162' *Bt*, 'MECH 162' non-*Bt*, 'Omshankar' and 'H 1098' were harvested during December first week. 'PBW 343' and 'PBW 373' wheat were sown on 20 November and 9 December after the harvest of cotton as sub plots. Observations on days to flowering, boll bursting, maturity, boll number, boll weight, sympodes, monopodes, plant height, germination, biomass, leaf area, fruiting coefficient and seed cotton yield were recorded. Leaf area was measured using automatic leaf area meter (Model LI-COR 3100) while photosynthesis was recorded on fully expanded upper third leaf using Photosynthesis System (Model LI-COR 6400). The data were statistically analysed under randomized block design for cotton and split plot design for wheat following recommended statistical methods. The productivity of cotton-wheat system was expressed in terms of wheat equivalent yield.

Among different hybrids highest germination was observed in 'Omshankar' and 'LHH 144' (99.4%) and lowest (82%) in 'MECH 915' non-*Bt* (Table 1). Biomass, height and leaf area index was higher in non-*Bt* than the *Bt* types of 'MECH 915' and 'MECH 162' at 90 and 120 days after sowing. 'MECH 162' (*Bt* and non-*Bt*) and 'MECH 915' non-*Bt* had more number of monopodial branches (5–6/plant) than the other hybrids studied (3–5/plant). Similarly the number of sympodes was relatively higher in *Bt* hybrids than other genotypes studied (Table1). The damage of fruiting bodies due to insects was relatively low in *Bt* than non-*Bt* (Table 2). Such a situation is more conducive for stimulating the reproductive growth (sympodes) and restricts vegetative growth (biomass) in *Bt* types. This resulted in higher number of bolls harvested in *Bt* as compared to Non-*Bt*. This gets support from the findings of Halemani *et al.* (2004). 'MECH 915' Bt was early for days to 50% flowering (57 days), boll bursting (92 days) and maturity (110 days) as compared to 'MECH 162' (60,99 and 209 days, respectively) and 'Omshankar' (62, 98 and 209 days after sowing, respectively) but more or less at par with 'Vikas' and 'LHH 144' (local checks). Mahyee *et al.* (2004) also observed similar results in *Bt* cotton under rainfed conditions.

Seed-cotton yield was significantly higher in 'MECH 915' *Bt* (2.25 tonnes/ha) followed by 'MECH 915' non-*Bt* (2.16 tonnes/ha) and 'MECH 162' (1.91 tonnes/ha) than other local *Hirsutum* hybrid and variety (1.56 –1.76 tonnes/ha) (Table 2). This was associated with boll number (r = 0.35) and fruiting coefficient (r = 0.638) which were also higher in 'MECH 915' *Bt* (Table 2). 'MECH 915' *Bt* was

*Short note

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Table 1 Morpho-physiological traits of different *Bt* and non-*Bt* cotton genotypes

Treatment	Germination (%)	Dry matter per plant (g)		Leaf area index		Plant height (cms)	Monopodes/plant bursting	Sympodes/plant	50% flowering	50% boll	Maturity (days)
		90 DAS	120 DAS	90 DAS	120 DAS						
'MECH 915' *Bt*	97.2	160.3	153.6	2.3	1.8	87.7	2.5	47.5	57.0	92.0	111
'MECH 915' non-*Bt*	82.2	165.5	200.2	2.6	1.8	106.7	4.9	61.9	59.0	99.3	183
'MECH 162' *Bt*	97.2	130.2	205.8	3.1	2.5	106.0	5.5	66.1	60.3	99.3	209
'MECH 162' non-*Bt*	97.8	144.4	263.9	3.3	3.0	121.0	5.3	66.7	62.7	102.7	209
'OmShankar'	99.4	125.2	156.2	2.2	2.2	105.0	3.9	46.3	61.7	98.0	209
'LHH 144'	99.4	142.8	188.6	2.3	1.9	115.3	3.4	37.3	57.7	98.0	183
'Vikas'	85.0	93.9	106.0	2.8	2.6	103.3	4.9	51.6	59.0	99.3	183
'H 1098'	91.9	126.4	142.8	3.5	3.1	124.7	4.0	40.9	60.3	102.7	209
CD ($P = 0.05$)	6.95	34.7	44.0	0.84	NS	14.04	1.46	15.76	2.34	3.59	NS

DAS, Days after sowing; NS, Non-significant

relatively early and contributed more than 75% of yield in first picking (Table 2). This further indicates early setting of bolls in this genotype. Further the photosynthesis rate was higher in the *Bt* types and was related to lesser level of physiological shedding (%) in these genotypes (Fig 1). The relation between increase in the yield with early boll setting and higher partioning coefficient was also indicated in earlier studies including various genetically modified crops (Qaim and Zilberman 2003).

Depending on the maturity of the crop hybrid 'MECH 915' *Bt*, 'MECH 915' non-*Bt*, 'LHH 144' and 'Vikas' were harvested in mid November while 'MECH 162' *Bt*, 'MECH 162' non-*Bt*, 'Omshankar' and 'H 1098' were harvested in December first week. 'PBW 343' and 'PBW 373' wheat were sown after the harvest of cotton. Biomass, leaf area and yield of wheat was reduced (9–13 %) with the late sowing of wheat (Table 3). Higher biomass and leaf area was observed in 'PBW 373' as compared to 'PBW 343'. Highest yield of wheat (5.4 tonnes/ha) was observed with 'PBW 343' under timely sown conditions while lowest yield (4.1 tonnes/ha) was observed in 'PBW 373' under late sown conditions. Cotton–wheat system productivity (wheat equivalent yield,

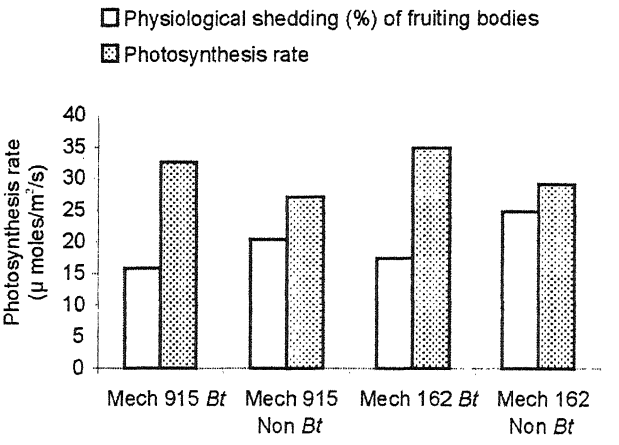

Fig 1 Photosynthesis rate and level of physiological shedding (%) in the *Bt* and non-*Bt* genotypes

WEY) was also reduced (16 %) with the late sowing of wheat (Table 3). WEY was highest (12.1 tonnes/ha) with 'MECH 915' *Bt* cotton – 'PBW 343' wheat system and lowest (8.9 tonnes/ha) with 'MECH 162' non-*Bt* cotton – 'PBW 343' wheat system. Late planting of wheat in cotton

Table 2 Yield related traits of different *Bt* and non-*Bt* cotton genotypes

Treatment	Fruiting coefficient (120 DAS)	Bolls /plant	Boll wt (g/plant)	Yield (%) at different pickings				Yield (tonnes/ ha)	Fruiting bodies damaged / 5 plants up to 95 DAS
				I	II	III	IV		
'MECH 915' Bt	0.579	28.0	3.2	75.6	19.3	2.8	2.3	2.25	6.8
'MECH 915' non-Bt	0.339	25.4	3.5	57.2	20.8	15.0	7.1	2.16	10.2
'MECH 162' Bt	0.331	25.2	3.1	46.6	17.7	10.6	25.0	1.91	7.3
'MECH 162' non-Bt	0.250	22.3	3.2	52.3	15.1	8.7	24.0	1.91	12.2
'LHH 144'	0.367	28.6	3.4	51.7	17.4	17.7	13.2	1.76	4.5
'Om Shankar'	0.263	23.3	3.2	59.5	16.0	10.6	13.9	1.58	9.7
'Vikas'	0.331	25.3	3.2	52.9	24.6	14.4	8.0	1.56	8.9
'H 1098'	0.248	23.1	3.1	45.4	19.6	19.9	15.2	1.76	4.9
CD ($P = 0.05$)	0.92	NS	NS					0.34	NS

DAS, Days after sowing; NS, non-significant

Table 3 Biomass, leaf area index (LAI) and yield of wheat and wheat equivalent yield (WEY) of cotton-wheat system as influenced by different genotypes of cotton and wheat

Cotton Genotype	Wheat Genotype									WEY (tonnes/ha)		
	Biomass (tonnes/ha)			LAI (90 DAS)			Yield (tonnes/ha)					
	'PBW 343'	'PBW 373'	Mean	'PBW 343'	'PBW 373'	Mean	'PBW 343'	'PBW 373'	Mean	'PBW 343'	'PBW 373'	Mean
'MECH 915' Bt	13.36	13.66	13.51	4.0	4.8	4.4	5.40	5.06	5.23	12.11	11.77	11.94
'MECH 915' non-Bt	12.79	13.07	12.93	3.7	4.6	4.2	5.12	5.09	5.10	11.55	11.52	11.54
'LHH 144'	12.50	13.65	13.07	4.1	4.2	4.1	4.77	5.52	5.14	10.48	11.22	10.85
'Vikas'	12.93	13.22	13.08	3.8	4.3	4.1	5.12	5.23	5.17	10.19	10.30	10.25
'MECH 162' Bt	11.21	11.21	11.21	3.6	3.4	3.5	4.68	4.14	4.41	9.94	9.39	9.67
'MECH 162' not Bt	11.35	11.06	11.21	3.6	3.3	3.5	4.20	4.43	4.31	8.90	9.13	9.02
'Om Shankar'	12.36	12.50	12.43	4.7	4.4	4.6	4.48	4.77	4.63	9.15	9.43	9.29
'H 1098'	12.07	13.22	12.64	4.5	3.7	4.1	4.45	4.93	4.69	9.13	9.61	9.37
Mean	12.32	12.69		4.01	4.10		4.78	4.89		10.18	10.30	
	Cotton	Wheat	Inter-action	Cotton	Wheat	Inter-action	Cotton	Wheat	Inter-action	Cotton	Wheat	Inter-action
CD ($P = 0.05$)	10.9	NS	NS	0.87	NS	NS	0.44	NS	NS	0.98	NS	NS

DAS, Days after sowing; NS, non-significant; WEY, wheat equivalent yield

wheat system in northern Pakistan often reduced wheat yield and overall productivity of the system (Sheikh *et al.* 2003).

SUMMARY

A field experiment was conducted during 2002-03 to test the performance of *Bt* and non-*Bt* cotton hybrids 'MECH 915' and 'MECH 162' under cotton–wheat system. Highest germination was observed in 'Om Shankar' (99.4%). Vegetative growth was higher in non-*Bt* than the *Bt* types due to high number of monopods (5-6 per plant) while sympodes (fruiting branch) were relatively higher (about 50 per cent) in *Bt* hybrids. 'MECH 915' *Bt* was early for days to 50 per cent flowering (57 days) and boll bursting (92 days) and maturity (111 days), as compared to 'MECH 162' (60,99 and 209 days, respectively). Seed-cotton yield was highest (2.25 tonnes/ha) in 'MECH 915' *Bt* than 'MECH 162' (1.91 tonnes/ha) and local *hirsutum* hybrid and variety (1.56 to 1.76 tonnes/ha). Late sowing of wheat reduced biomass, leaf area and yield of wheat (9 to 13 %) and system productivity (16 %). WEY was highest (12.11 tonnes/ha) with 'MECH 915' *Bt* (cotton) – 'PBW 343' (wheat) system.

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