J. Cotton Res. Dev. **29** (2) 255-259 (July, 2015)

Phenology, growth and yield of *Bt* cotton as influenced by different intercrops

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ABSTRACT: A field experiment was conducted during the *kharif* 2010 and 2011 at Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana with the objective to study the growth and phenology of hybrid. Results showed that at harvest plant height, dry matter accumulation (DMA) and leaf area index (LAI) in all the *Bt* cotton based intercropping systems except *Bt* cotton + bajra fodder intercropping system was *at par* with sole *Bt* cotton. However, *Bt* cotton + bajra fodder intercropping system recorded significantly lower values for above said parameters. The *Bt* cotton+ summer moong (1+1 and 1+2) , *Bt* cotton+ bajra fodder (1+1) , *Bt* cotton+ cowpea fodder (1+2) took more number of days to flowering during both the years. During the second year, significantly more number of days were taken to boll formation in *Bt* cotton+ bajra fodder (1+1), *Bt* cotton + cowpea fodder (1+2) and *Bt* cotton + summer moong (1+1 and 1+2) intercropping systems as compared to sole *Bt* cotton. The total number of bolls and seed cotton yield obtained with *Bt* cotton + maize fodder, *Bt* cotton + cowpea fodder, *Bt* cotton + summer moong and *Bt* cotton + long melon was statistically *at par* with sole *Bt* cotton. However, *Bt* cotton + bajra fodder intercropping system recorded significant reduction in number of opened bolls and seed cotton yield.

Key words: *Bt* cotton, growth, intercropping, phenology, yield

Cotton (*Gossypium hirsutum* L.) is also known as "White Gold", occupies a premier position in the national economy of India, as it provide basic raw material for textile industry. There is a dire need to increase productivity/ unit area and/unit time. Intercropping is the best mechanism for exploiting the environment and minimizing risk and ensuring subsistence farming (Gadade *et al.,* 2006). Already about 44 per cent of the total area is cultivated in our country and there is hardly any scope to bring more area under cultivation. Thus, there is need to increase the productivity of crops/unit land area by using modern agricultural techniques. With the introduction of *Bt* cotton hybrids and high yielding, short duration, photo insensitive crop varieties in the other crops during past few years, intercropping has assumed new dimensions.

The short duration compact crops like green gram, black gram, onion and other vegetables when grown as intercrop in cotton has little or no adverse effect on the growth and development of cotton (Satish *et al.,* 2012 and Khan *et al.,* 2001). The information on the above mentioned aspects is scanty. Therefore, the present study was planned to study the growth, phenological behaviour and yield of hybrid *Bt* cotton when grown in association with non legumes like maize and bajra fodder and short compact legumes like cowpea as fodder, summer moong and along with traditionally practiced cucurbits (long melon).

MATERIALS AND METHODS

A field experiment was conducted during *kharif* 2010 and 2011 at the Research Farm Department of Agronomy, Punjab Agricultural University, Ludhiana. The soil of the experimental site was loamy sand in texture with normal soil pH (7.9) and electrical conductivity (0.20 d/Sm), low in organic carbon (0.36%), available N (130.5 kg/ha) and K (121.5 kg/ha) but high in available P (23.6 kg/ha). The total rainfall received during cropped period was

661.2 mm and 1257.0 mm during 2010 and 2011, respectively. The number of rainy days and amount of rainfall received during the intercropping period varied widely during the 2 years (41.5 mm, 4 rainy days in 2010 and 436.3 mm in 18 rainy days during 2011). The treatments comprised of combination of 2 planting patterns (67.5 × 75 cm (1+1) and 135 × 37.5 cm (1+ 2) and coupled with intercrops *viz.,* maize fodder, bajra fodder, cowpea as fodder, summer moong and long melon. The sole *Bt* cotton was also grown for comparison purpose, thus total number of treatments were 11 in this experiment. The experiment was laid out in randomized block design with 4 replications. The *Bt* cotton hybrid 'RCH 314' was sown by dibbling on a well prepared seedbed after heavy pre sowing irrigation on April 24 and May 7 during 2010 and 2011, respectively. The different intercrops *viz.,* maize fodder, bajra fodder, cowpea fodder, summer moong and long melon were also sown on the same day. The recommended dose of fertilizer to *Bt* cotton (150 kg N and 30 kg P_2O_5 / ha) was applied. Half of the N dose was applied first at thinning and remaining dose of N on the first flower appearance stage. All the doses of phosphorus were applied at the time of sowing as a basal dose. The recommended dose of fertilizer to intercrops was applied on area basis *i.e.* per cent of plant population accommodated as intercrop as compared to sole crop when sown on the same area. The recommended dose of fertilizer for maize fodder (87.5 kg N, 30 kg P_2O_5 and 20 kg K_2O/ ha), bajra fodder (50 kg N/ ha), cowpea fodder (18.75 kg N and 55 kg P_2O_5 / ha), summer moong (12.5 kg N, and 40 kg P_2O_5 / ha) and long melon (100 kg N, 75 kg P_2O_5 and 50 kg K_2O/ ha) were applied on area basis. In maize and bajra fodder, half nitrogen and full dose of phosphorus and potassium were applied at the time of sowing and remaining half nitrogen was applied four weeks after sowing. The whole recommended dose of fertilizer for cowpea fodder and summer moong was applied at sowing. However, in long melon 1/3rd N, whole P and K were applied at sowing, remaining two third N was applied in two equal splits, 1/3rd two weeks after sowing and 1/3rd four weeks after sowing. Two foliar sprays of potassium nitrate (N: P: K, 13:0:45) were given at weekly interval starting from flower initiation of *Bt* cotton in all the *Bt* cotton plots during 2010 and 2011. The cowpea fodder was harvested 50 DAS but maize and bajra fodder were harvested 60 DAS. The summer moong was harvested at physiological maturity (65 DAS) and long melon fruits were picked from 50 to 75 DAS. The *Bt* cotton was picked in 3 pickings from second fortnight of September to first fortnight of November during both the years. The data on phenology was recorded from 10 randomly selected, tagged plants from middle rows of each plot. The date on which 5 out of 10 randomly selected plants attained that stage was recorded as number of days.

RESULTS AND DISCUSSION

Growth of *Bt* cotton: Plant height recorded at maturity showed that except *Bt* cotton + bajra fodder (1+1 or 1+2 planting pattern) intercropping system all other intercropping systems and sole *Bt* cotton recorded plant height statistically *at par* with each other during both the years and in the pooled analysis. This behavior may be attributed to less availability of space for lateral spread of plants before harvest of intercrops due to which they grow in upright direction, but after harvest of intercrops more space was available for lateral spread of plants. Khan *et al.,* 2001 also reported that significant reduction in plant height of cotton occurred when grown in association with sesame or sorghum crop due to fast growing nature of the former and exhaustive nature of the later intercrop. However, it has been reported than short, compact legumes like green gram, black gram etc do not cause significant reduction in plant height of cotton when grown as intercrop (Khan *et al.,* 2001, Satish *et al.,* 2012). The dry matter accumulation (DMA) recorded at maturity also

revealed that except *Bt* cotton+ bajra fodder (1+1 or 1+2 planting pattern) intercropping system all other intercropping systems and sole *Bt* cotton recorded DMA *at par* with each other during both the years and in the pooled analysis (Table 1).

LAI is an important parameter of plant growth which directly influences solar radiation interception by the canopy development, photosynthesis and ultimately the yield of a crop. LAI continued to increase sharply up to 90 DAS and thereafter it reached a plateau and attained its maximum at 120 DAS during both the years (data not given). The LAI showed a sharp decline from 150 DAS till maturity during both the crop growing seasons because of shedding of leaves due to crop senescence. The final leaf area index attained in sole *Bt* cotton was statistically *at par* with Bt cotton in all other intercropping systems except in *Bt* cotton+ bajra fodder intercropping system which recorded significant reduction in LAI. Ganajaxi *et al.,* (2011) reported that intercropping of french bean for vegetable or grain purpose in cotton had no significant influence on the LAI of cotton.

Phenology of *Bt* cotton: The number of days taken to flowering was significantly influenced by intercropping systems (Table 2). *Bt* cotton + summer moong (1+1 and 1+2), *Bt* cotton + bajra fodder (1+1), *Bt* cotton + cowpea fodder (1+ 2) took more number of days to flowering during both the years. However, in the first year, *Bt* cotton + long melon (1+1), *Bt* cotton + maize fodder (1+ 2) also took more number of days to flowering as compared to sole *Bt* cotton. Late flowering in cotton under different intercropping systems may be attributed to competition for growth resources by intercrops. Similar findings were reported by Satish *et al.,* (2012) where they observed that *Bt* cotton + green gram and *Bt* cotton + black gram intercropping systems took significantly more number of days to attain flowering as compared to *Bt* cotton + soybean intercropping system. Number of days taken to boll formation did not differ significantly in different intercropping systems in the first year. But in the second year, *Bt* cotton + bajra fodder (1+ 1), *Bt* cotton + cowpea fodder (1+ 2) and *Bt* cotton + summer moong (1+ 1 and 1+ 2) took significantly more number of days to boll formation as compared to sole *Bt* cotton. Significant more number of days were taken to boll opening stage in *Bt* cotton + maize fodder (1+ 1 and 1+ 2), *Bt* cotton + bajra fodder (1+ 1), *Bt* cotton + summer moong (1+ 1 and 1+ 2) and *Bt* cotton + long melon (1+ 2) intercropping systems as compared to sole *Bt* cotton in the first year. But in the second year, *Bt* cotton + bajra fodder (1+ 1) and *Bt* cotton + summer

Table 1. Final plant height, dry matter accumulation and LAI of *Bt* cotton as influenced by intercropping systems

Treatment	Plant height (cm)			Dry matter accumulation (q /ha)			Leaf area index (LAI)		
	2010	2011	**Pooled**	2010	2011	**Pooled**	2010	2011	**Pooled**
Bt cotton+ Maize (1+ 1)	102.5	102.6	**102.5**	46.2	52	**49.1**	2.85	2.65	**2.75**
Bt cotton+ Bajra (1+ 1)	75.1	80.6	**77.8**	26.5	31.5	**29**	1.52	1.5	**1.51**
Bt cotton+ Cowpea (1+ 1)	95.1	98.3	**96.7**	46.1	52	**49**	2.79	2.68	**2.74**
Bt cotton+ Summer moong (1+ 1)	104.1	111.2	**107.7**	49.3	55	**52.1**	2.67	2.63	**2.65**
Bt cotton+ Long melon (1+ 1)	95.4	110.8	**103.1**	50.4	55.5	**52.9**	2.49	2.79	**2.64**
Bt cotton+ Maize (1+ 2)	106	101.9	**104**	46.1	52.1	**49.1**	2.95	2.58	**2.76**
Bt cotton+ Bajra (1+ 2)	77.4	83.2	**80.3**	27.3	32.4	**29.8**	1.49	1.2	**1.35**
Bt cotton+ Cowpea (1+ 2)	98.9	109.2	**104.1**	46.7	56.6	**51.6**	2.9	2.82	**2.86**
Bt cotton+ Summer moong (1+ 2)	103.4	110.4	**106.9**	47.7	55.9	**51.8**	2.72	3.05	**2.88**
Bt cotton+ Long melon (1+ 2)	103.8	101.4	**102.6**	48.5	54	**51.2**	2.88	2.87	**2.87**
Sole *Bt* cotton	98.8	104.3	**101.5**	49.5	55.2	**52.3**	2.61	2.73	**2.67**
CD (p=0.05)	12.8	10.9	**8.3**	3.5	3.7	**2.5**	0.73	1.07	**0.64**

Table 2. Effect of different intercrops on phenology, yields attributes and seed cotton yield of *Bt* cotton

Treatment	Days to						Total bolls/ plant		Un opened bolls/ plant		Seed cotton yield (q/ ha)	
	Flowering		Boll formation		Boll opening							
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Bt cotton+ Maize (1+ 1)	78.3	75.6	93	90.9	135.5	132.4	33.3	33	3.9	2.6	17	18
Bt cotton+ Bajra (1+ 1)	80.5	77.4	95	93.9	138	135.7	21.7	23.7	3.1	3	9.4	11.3
Bt cotton+ Cowpea (1+ 1)	78.5	76.8	95.4	92.8	133.4	131.5	32.7	34.6	4.1	3.2	16.3	18.1
Bt cotton+ Summer moong (1+ 1)	82.5	80.3	100.5	97	144	141.5	35.6	37.3	4.5	4.2	17.7	19.7
Bt cotton+ Long melon (1+1)	80.8	76.8	95.8	92.8	134.5	130.3	36.9	39.5	5.4	4.5	18.2	21.1
Bt cotton+ Maize (1+ 2)	80.3	77.1	95.5	93.3	136	131.8	32.9	32.9	3.2	3.5	17.1	17.7
Bt cotton+ Bajra (1+ 2)	78	76.3	94.8	92.1	133.8	129.1	22.1	23.3	3.1	2.3	9.5	11.4
Bt cotton+ Cowpea (1+ 2)	80.3	77.6	95.8	94.1	133.3	129.6	32.1	38.5	2.7	3.7	17.1	20.6
Bt cotton+ Summer moong (1+ 2)	81	78	96.3	94.3	142	134	33.2	37.6	3.6	3.6	17.3	20.3
Bt cotton+ Long melon (1+ 2)	78.8	75.7	94.3	91.2	135	131.7	33.4	36.4	3.4	4	17.4	20.1
Sole *Bt* cotton	77.3	75.3	93.6	90.5	131.1	130	34.8	37.1	3.7	4.1	18	20.2
P=0.05	2.9	1.9	NS	3.3	3.6	5.5	6.3	6.1	NS	NS	3.3	3.7

moong (1+ 1) took significantly more number of days to boll opening stage as compared to sole *Bt* cotton.

Yield attributes and yield: The total number of bolls/plant was relatively higher in *Bt* cotton intercropped with long melon, summer moong as well as sole *Bt* cotton as compared to cotton intercropped with maize fodder and cowpea fodder (Table 2). Though, it failed to reach the level of significance. Further, it was observed that minimum and significantly lower number of bolls/plant (21.7 and 23.7 during 2010 and 2011, respectively) were noticed in *Bt* cotton + bajra fodder intercropping system. The decreased total bolls/plant in this treatment was attributed to severe competition imposed by bajra fodder on *Bt* cotton as visible from reduced plant height and dry matter accumulation which ultimately lead to reduced canopy size and lower bolls/plant. These results corroborate the findings of Aladakatti *et al.,* (2011) where cotton + sunflower intercropping resulted in significant reduction in bolls/plant as compared to sole *Bt* cotton. The unopened bolls/plant was not significantly affected in various intercropping systems.

The seed cotton yield was *at par* in all the intercropping systems except *Bt* cotton + bajra fodder (1+1 and 1+2). However, the minimum seed cotton yield of 9.41 and 11.30 q/ ha was recorded in *Bt* cotton + bajra fodder (1+1) intercropping system during 2010 and 2011, respectively. The reduction in seed cotton yield in all the intercropping systems except *Bt* cotton + bajra fodder varied from 1.8 to 9.2 per cent in 2010 and 2.4 to 12.3 per cent during 2011 as compared to sole *Bt* cotton. In *Bt* cotton + bajra fodder (1+1) the highest reduction in seed cotton yield was recorded which was 47.7 and 44.1 per cent during 2010 and 2011, respectively. While in *Bt* cotton + bajra fodder (1+2), the reduction was 47.1 and 43.6 per cent as compared to sole *Bt* cotton in first and second year, respectively. The results showed that all other intercrops except bajra fodder had no adverse effect on the *Bt* cotton yield. The various growth and yield contributing characters like plant height, leaf area and bolls/plant were significantly reduced in *Bt* cotton + bajra fodder which eventually decreased the seed cotton yield significantly. This was attributed to fast growing nature of bajra which influence the growth and development of *Bt* cotton by posing severe competition for light, nutrients, space and moisture. However, maize

fodder did not significantly influence the seed cotton yield due to its erect growth, which caused less hindrance to *Bt* cotton for light interception. Summer moong and cowpea fodder as intercrops showed synergistic effect on *Bt* cotton yield by fixing atmospheric nitrogen and provided better nutrition to the cotton plants. The results confirm the findings of Khan *et al.,* 2001.

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Recieved for publication : September 18, 2013
Accepted for publication : July 9, 2014