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JH Chaudhari
Narmada Irrigation Research Project, Anand Agricultural University, Khandha, Ta. Karjan, Vadodara Gujarat, India

SA Chauhan
Hill Millet Research Station, Anand Agricultural University, Dahod, Gujarat, India

MM Chaudhary
Centre for Natural Resources Management, Sardar Krushinagar Dantiwada Agricultural University, Sardarkrushinagar, Banaskanatha, Gujarat, India

Corresponding Author:
JH Chaudhari
Narmada Irrigation Research Project, Anand Agricultural University, Khandha, Ta. Karjan, Vadodara Gujarat, India

Effect of topping and nitrogen levels on growth, yield attributes and yield of *Bt* cotton under drip irrigation conditions

JH Chaudhari, SA Chauhan and MM Chaudhary

Abstract
To find out the effect of topping and different levels of nitrogen on growth, yield attributes, yield and economics of *Bt* cotton (*Gossypium hirsutum*) under drip irrigation conditions, a field experiment was conducted at Narmada Irrigation Research Project, Anand Agricultural University, Khandha for consecutive three years 2014-15, 2015-16 and 2016-17. The experiment was laid out in factorial randomized block design with three replications. Results indicated that no topping treatment (T_0) recorded significantly the highest plant height over the topping treatments T_1 (Topping at 80 DAS) and T_2 (Topping at 100 DAS). Number of bolls per plant, number of sympodia, seed cotton yield per plant and seed cotton yield were significantly influenced due to topping treatment T_2 (Topping at 100 DAS) in pooled results. Nitrogen levels treatment N_3 (320 kg N/ha) significantly influenced the plant height, number of sympodia, number of bolls per plant, seed cotton yield per plant and seed cotton yield during all the three years and in pooled results. Among the interactions of topping and nitrogen levels, treatment combination T_2N_3 produced significantly the highest number of sympodia per plant, number of bolls per plant, seed cotton yield per plant and seed cotton yield and it was at par with treatment combination T_1N_3 and T_2N_2 during the years 2015-16, 2016-17 and in pooled analysis. Among the different treatment combinations, treatment combination T_2N_3 recorded the highest net realization and BCR values over rest of the treatment combinations followed by treatment combination T_2N_2.

Keywords: topping, nitrogen levels, seed cotton yield

Introduction
Cotton is a well known important cash crop which plays an important role in the economy of the country. Due to its industrial significance, particularly in a textile industry, it is known as a 'king of fibre' and 'white gold'. Being the most important cash crop of the country, it benefits millions of people who are engaged in its cultivation, processing, manufacturing etc. In India, cotton is grown under diverse agro-climatic conditions. Among the different cotton growing countries in the world, India ranks first, but with regards to production, it is ranked second, next to China. In India, cotton is cultivated in an area of 12.66 million hectares with a production of 28.71 million bales of seed cotton (170 kg/bale) with a productivity of 386 kg per hectare (Anon., 2019) [1].

With the better understanding of plant growth habits, new agriculture practices are developed for high productivity of the crops. Production and productivity of cotton crop increased with the introduction of genetically modified *Bt* cotton in the country. For fully exploitation of the crop yield, there is a need to develop new crop management practices. Excessive vegetative growth with imbalance use of fertilizers and poor agronomic practice attribute to low productivity of cotton in India. Some situation such as high soil fertility and fertilization in irrigated area lead to more vegetative growth of the cotton crop. Growth modification practice becomes important by converting the vegetative phase of the cotton crop to the reproductive phase. This can be regulated by topping practice (Removal of apex). This reduces the height of the plant to prevent apical dominance and further vegetative growth. Removing top terminal portion by topping of cotton after prominent vegetative growth stage may be promising for encouraging growth of already formed sympodia as well as more formation and development of sympodia. Induction of higher number of sympodia and thereby increase in number of bolls are essential for yield maximization of seed cotton. Many scientists have observed a positive correlation between vegetative growth and the yield attributes of cotton crop. Nitrogen management in *Bt* cotton assumes greater importance to boost the productivity. Nitrogen is the most essential nutrient for better plant growth of cotton, which needs to be supplied in proper

time and quantities with suitable method. Application of fertilizer through drip irrigation system, consequently improves the fertilizer use efficiency compared to conventional methods of fertilizer application. Drip fertigation improve the input use efficiency and minimize production cost without affecting the productivity of crop.

With this background, field experiments was planned and conducted during 2014-15 to 2016-17 at Narmada Irrigation Research Project, Anand Agricultural University, Khandha in heavy black soils.

Materials and Methods

The study was carried out at Narmada Irrigation Research Project, Anand Agricultural University, Khandha (Gujarat) during *kharif* seasons of the years 2014-15, 2015-16 and 2016-17. The soil of the farm is montmorillonitic, order-vertisols and suborder *Typic Chromusterts*, which is characterized by very deep black clayey, imperfectly drained with low infiltration rate. The initial soil status showed pH - 8.39, EC - 0.31 mmhos/cm, low in organic carbon (0.45%), medium in available phosphorus (41.80 kg ha^{-1}) and high in available potassium (354 kg ha^{-1}). The experiment was laid out in factorial randomized block design. There were nine treatment combinations comprised of three treatments of topping *i.e.,* no topping, topping at 80 DAS and topping at 100 DAS and three levels of nitrogen *i.e.*,160, 240 and 320 kg N/ha, each replicated thrice. Two seeds of hybrid *Bt* Cotton-6, BG-II were dibbled per hill at a distance of 180 x 45 cm. Thinning and gap filling operations were undertaken at 15 days after sowing to maintain uniform plant population. Topping (Removal of apex) practice and nitrogen application has been carried out as per the treatments. Doses of nitrogen were applied from urea fertilizer through fertigation in four equal splits as per the treatments. The observations related to growth, yield attributes and yield were recorded and subjected to statistical analysis.

Results and Discussion

The data presented in the Table-1 revealed that plant height before topping at 80 DAS was not significantly affected due to topping treatment. However, significantly the highest plant height (132.34,132.75,134.24 and 133.10 cm during the years 2014-15, 2015-16, 2016-17 and in pooled analysis, respectively) was recorded under treatment No topping (T_0) over the topping treatments *i.e.,* Topping at 80 DAS (T_1) and Topping at 100 DAS (T_2). The reduction in plant height in topping treatments might be due to the topping practices in cotton as compared to no topping. The results corroborate the findings of Kataria and Valu (2018) [8]. Yield attributes of cotton viz., number of sympodia per plant, number of bolls per plant, seed cotton yield per plant and seed cotton yield were not significantly affected due to topping practice during the individual years 2014-15, 2015-16 and 2016-17, however, significant influenced were found in all yield attributes except number of monopodia per plant in pooled analysis. On the basis of results, significantly the highest number of sympodia per plant (20.37), number of bolls per plant (64.66), seed cotton yield per plant (186.93 g/plant) and seed cotton yield (2318 kg/ha) were recorded under treatment topping at 100 DAS (T_2) in pooled results (Table 2 and 3). Increased numbers of bolls per plant were due to the increased in numbers of sympodia. The higher seed cotton yield obtained due to increase in numbers of sympodia and retained more number of bolls per plant which ultimately produce more seed cotton yield per plant and overall seed cotton yield per unit area. Similar findings have been reported by Brar *et al.* (2000) [2], Shwetha *et al.* (2009) [11], Kataria and Valu (2018) [8] & Kumari and George (2012).

Application of nitrogen through fertigation in cotton, significantly influenced the growth, yield attributes and yield of *Bt* cotton. Plant height before topping at 80 DAS (133.61,131.78,129.47 and 131.62 cm) and plant height at last picking (133.99,132.55,132.42 and 132.98 cm) during the years 2014-15,2015-16,2016-17 and in pooled results, respectively were significantly increased due to application of 320 kg N/ha (Table 1). This might be due to impact of nitrogen on growth of cotton as it is a constitutes of enzymes, chlorophyll and proteins and responsible for vegetative growth of the plant. The results are in conformity with those reported by Gadhiya *et al*. (2009) [5] and Singh (2015) [12]. Yield attributes and seed cotton yield of *Bt* cotton showed marked improvement with increase in nitrogen level up to 320 kg/ha except number of monopodia per plant. Application of nitrogen @ 320 kg N/ha significantly increased the number of sympodia per plant (21.73, 21.67, 21.20 and 21.53), number of bolls per plant (66.42,64.89,66.47 and 65.93), seed cotton yield per plant (197.51,197.59,190.63 and 195.24 g/plant) and seed cotton yield (2450, 2415,2397 and 2421 kg/ha) during the years 2014-15,2015-16,2016-17 and in pooled results (Table 2 and 3). Increased nitrogen levels increased leaf photosynthetic rate, which might have resulted in higher accumulation of metabolites, thus increased number of sympodia, number of bolls per plant, seed cotton yield per plant and ultimately increased seed cotton yield. Similar positive response of cotton crop to nitrogen application was observed by Desai *et al.* (2014) [4], Gadhiya *et al*. (2009) [5], Chandrashekar *et al.* (2016) [3] and Nagender *et al.* (2017) [10], Singh (2015) [12] & Jena and Aladakatti (2017) [7].

Interaction effect of topping and nitrogen levels significantly influenced the number of sympodia per plant, number of bolls per plant, seed cotton yield per plant and seed cotton yield. However, non-significant effects were observed with respect to plant height and number of monopodia per plant. The interaction effect between topping and nitrogen levels with respect to number of sympodia per plant, number of bolls per plant, seed cotton yield per plant and seed cotton yield were found non-significant during the year 2014-15. However, significantly the highest number of sympodia per plant (25.73,23.47 and 24.02) and number of bolls per plant (71.27, 69.27 and 70.67) were observed under treatment combination T_2N_3 *i.e.,* Topping at 100 DAS and application of 320 kg N ha^{-1} during the years 2015-16, 2016-17 and in pooled analysis, respectively, and it was statistically at par with treatment combinations T_1N_3 *i.e.,* Topping at 80 DAS and application of 320 kg N ha^{-1} and T_2N_2 *i.e.,* Topping at 100 DAS and application of 240 kg N ha^{-1} during the year 2016-17 (Table 4 and 5). Similarly, significantly the highest seed cotton yield per plant (205.77, 196.58 and 204.75 g/plant) and seed cotton yield (2525, 2473 and 2549 kg/ha) were recorded under treatment combination T_2N_3 *i.e.,* Topping at 100 DAS and application of 320 kg N ha^{-1} during the years 2015-16, 2016-17 and in pooled analysis, respectively which were remained statistically at par with treatment combinations T_1N_3 *i.e.,* Topping at 80 DAS and application of 320 kg N ha^{-1} and T_2N_2 *i.e.,* Topping at 100 DAS and application of 240 kg N ha^{-1} (Table 6 and 7). The increase in yield attributes and yield of *Bt* cotton might be due to the effect of topping practice in cotton which inhibited plant growth of cotton and

subsequently promoted lateral growth including sympodial branches and boll numbers and ultimately increase seed cotton yield. While, application of higher dose of nitrogen to the crop through fertigation might utilized maximum nitrogen which resulted in adequate food supply through source to sink of cotton which reflected on yield attributes and yield of cotton. The results are in agreement with the results of Brar *et al.* (2000) [2] and Hallikeri *et al.* (2010) [6].

Economics

The data on gross and net realization as well as BCR presented in Table-8 revealed that among the different treatment combinations, treatment combination T_2N_3 recorded the maximum net realizations (₹62,993) and BCR value (2.77) followed by treatment combination T_2N_2.

Table 1: Effect of topping and nitrogen levels on growth of *Bt* cotton under drip irrigation conditions

Treatments	Plant height (cm) before topping				Plant height (cm) at last picking			
	2014-15	2015-16	2016-17	Pooled	2014-15	2015-16	2016-17	Pooled
Topping (T)								
T_0: No Topping	126.04	125.61	122.87	124.84	132.34	132.75	134.24	133.10
T_1:Topping at 80 DAS	128.41	126.77	124.81	126.67	123.70	123.27	124.16	123.70
T_2:Topping at 100 DAS	131.27	127.67	125.54	128.16	125.17	123.04	123.84	124.02
S.Em. ±	2.43	2.38	2.25	1.36	2.40	2.29	2.13	1.31
C.D. at 5%	NS	NS	NS	NS	7.19	6.88	6.37	3.75
Nitrogen levels (N)								
N_1 : 160 kg N ha^{-1}	124.07	122.91	120.38	122.45	121.26	121.08	124.27	122.20
N_2 : 240 kg N ha^{-1}	128.05	125.37	123.38	125.60	125.96	125.42	125.54	125.64
N_3 : 320 kg N ha^{-1}	133.61	131.78	129.47	131.62	133.99	132.55	132.42	132.98
S.Em. ±	2.43	2.38	2.25	1.36	2.40	2.29	2.13	1.31
C.D. at 5%	7.27	7.14	6.74	3.88	7.19	6.88	6.37	3.75
Interaction								
T x N	NS	NS	NS	NS	NS	NS	NS	NS
Y x T	NS	NS	NS	NS	NS	NS	NS	NS
Y x N	NS	NS	NS	NS	NS	NS	NS	NS
Y x T x N	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	5.66	5.64	5.42	5.58	5.66	5.45	5.01	5.38

Table 2: Effect of topping and nitrogen levels on yield attributes of *Bt* cotton under drip irrigation conditions

Treatments	Number of monopodia/plant				Number of sympodia/plant				Number of bolls/plant			
	2014-15	2015-16	2016-17	Pooled	2014-15	2015-16	2016-17	Pooled	2014-15	2015-16	2016-17	Pooled
Topping (T)												
T_0 : No Topping	2.62	2.60	2.46	2.56	19.87	18.87	18.89	19.21	62.89	60.58	61.18	61.55
T_1:Topping at 80 DAS	2.64	2.67	2.58	2.63	20.27	19.47	20.07	19.93	63.04	61.91	62.71	62.56
T_2 :Topping at 100 DAS	2.64	2.76	2.65	2.68	20.58	20.11	20.43	20.37	65.40	63.56	65.02	64.66
S.Em. ±	0.07	0.07	0.08	0.04	0.45	0.64	0.56	0.32	1.12	1.12	1.06	0.63
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	0.91	NS	NS	NS	1.81
Nitrogen levels (N)												
N_1 : 160 kg N ha^{-1}	2.60	2.56	2.51	2.55	19.49	18.02	18.63	18.71	62.13	60.04	60.71	60.96
N_2 : 240 kg N ha^{-1}	2.62	2.71	2.53	2.62	19.49	18.76	19.56	19.27	62.78	61.11	61.73	61.87
N_3 : 320 kg N ha^{-1}	2.69	2.76	2.65	2.70	21.73	21.67	21.20	21.53	66.42	64.89	66.47	65.93
S.Em. ±	0.07	0.07	0.08	0.04	0.45	0.64	0.56	0.32	1.12	1.12	1.06	0.63
C.D. at 5%	NS	NS	NS	NS	1.34	1.92	1.69	0.91	3.35	3.35	3.18	1.81
Interaction												
T x N	NS	NS	NS	NS	NS	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.
Y x T	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Y x T x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	7.67	8.30	9.10	8.36	6.60	9.87	8.56	8.41	5.25	5.40	5.05	5.24

Table 3: Effect of topping and nitrogen levels on yield attributes and yield of *Bt* cotton under drip irrigation conditions

Treatments	Seed cotton yield/plant (g)				Seed cotton yield (kg/ha)			
	2014-15	2015-16	2016-17	Pooled	2014-15	2015-16	2016-17	Pooled
Topping (T)								
T_0 : No Topping	178.57	178.53	175.59	177.56	2196	2192	2214	2201
T_1:Topping at 80 DAS	186.64	179.86	180.19	182.23	2299	2208	2224	2244
T_2 :Topping at 100 DAS	195.61	181.91	183.27	186.93	2418	2243	2292	2318
S.Em. ±	5.04	3.69	3.23	2.34	65.5	43.5	40.26	29.45
C.D. at 5%	NS	NS	NS	6.69	NS	NS	NS	84.17
Nitrogen levels (N)								
N_1 : 160 kg N ha^{-1}	178.21	161.72	167.78	169.24	2190	1995	2075	2087
N_2 : 240 kg N ha^{-1}	185.10	180.99	180.64	182.24	2273	2233	2258	2255
N_3 : 320 kg N ha^{-1}	197.51	197.59	190.63	195.24	2450	2415	2397	2421

S.Em. ±	5.04	3.69	3.23	2.34	65.5	43.5	40.26	29.45
C.D. at 5%	15.11	11.05	9.69	6.69	196.5	130.3	120.71	84.17
Interaction								
T x N	NS	Sig.	Sig.	Sig.	NS	Sig.	Sig.	Sig.
Y x T	NS	NS	NS	NS	NS	NS	NS	NS
Y x N	NS	NS	NS	NS	NS	NS	NS	NS
Y x T x N	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	8.09	6.14	5.39	6.68	8.53	5.89	5.38	6.79

Table 4: Interaction effect of topping and nitrogen levels on number of sympodia per plant of *Bt* cotton under drip irrigation conditions

Treatments	**Number of sympodia/plant (2015-16)**			**Number of sympodia/plant (2016-17)**			**Number of sympodia/plant (pooled)**		
Nitrogen(N) / Topping (T)	**N_1**	**N_2**	**N_3**	**N_1**	**N_2**	**N_3**	**N_1**	**N_2**	**N_3**
T_0	18.40	19.20	19.00	19.27	18.07	19.33	19.02	19.18	19.42
T_1	18.87	19.27	20.27	19.53	19.87	20.80	19.09	19.58	21.13
T_2	16.80	17.80	25.73	17.10	20.73	23.47	18.03	19.04	24.04
S.Em±	1.11			0.978			0.833		
C.D. at 5%	3.33			2.93			2.71		
C. V. %	9.87			8.56			8.41		

Table 5: Interaction effect of topping and nitrogen levels on number of bolls per plant of *Bt* cotton under drip irrigation conditions

Treatments	**Number of bolls/plant (2015-16)**			**Number of bolls/plant (2016-17)**			**Number of bolls/plant (pooled)**		
Nitrogen(N) / Topping (T)	**N_1**	**N_2**	**N_3**	**N_1**	**N_2**	**N_3**	**N_1**	**N_2**	**N_3**
T_0	60.53	60.47	60.73	60.00	61.27	62.27	60.98	61.55	62.11
T_1	61.87	61.20	62.67	62.53	57.73	67.87	62.22	60.44	65.00
T_2	57.73	61.67	71.27	59.60	66.20	69.27	59.69	63.62	70.67
S.Em±	1.93			1.84			1.10		
C.D. at 5%	5.80			5.50			3.14		
C. V. %	5.40			5.05			5.24		

Table 6: Interaction effect of topping and nitrogen levels on seed cotton yield per plant of *Bt* cotton under drip irrigation conditions

Treatments	**Number of seed cotton yield/plant (g) (2015-16)**			**Number of seed cotton yield/plant (g) (2016-17)**			**Number of seed cotton yield/plant(g) (pooled)**		
Nitrogen(N) / Topping (T)	**N_1**	**N_2**	**N_3**	**N_1**	**N_2**	**N_3**	**N_1**	**N_2**	**N_3**
T_0	175.28	175.77	184.55	172.07	175.17	179.53	174.27	175.23	183.19
T_1	159.30	177.82	202.45	173.49	171.27	195.79	171.04	177.85	197.79
T_2	150.58	189.38	205.77	157.78	195.46	196.58	162.39	193.65	204.75
S.Em±	6.38			5.60			4.06		
C.D. at 5%	19.13			16.78			11.59		
C. V. %	6.14			5.39			6.68		

Table 7: Interaction effect of topping and nitrogen levels on seed cotton yield of *Bt* cotton under drip irrigation conditions

Treatments	**Seed cotton yield (kg/ha) (2015-16)**			**Seed cotton yield (kg/ha) (2016-17)**			**Seed cotton yield (kg/ha) (pooled)**		
Nitrogen(N) / Topping (T)	**N_1**	**N_2**	**N_3**	**N_1**	**N_2**	**N_3**	**N_1**	**N_2**	**N_3**
T_0	2152	2158	2266	2160	2223	2259	2158	2175	2269
T_1	1988	2183	2454	2111	2103	2458	2104	2184	2444
T_2	1847	2359	2525	1953	2450	2473	1998	2406	2549
S.Em±	75.29			69.74			51.00		
C.D. at 5%	225.73			209.09			145.78		
C. V. %	5.89			5.38			6.79		

Table 8: Economics of different combination treatment of *Bt* cotton under drip irrigation conditions (Average of three years)

Treatment combinations	Seed cotton yield (kg ha^{-1})	Gross realization (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net realization (₹ ha^{-1})	BCR
T_0N_1	2158	91715	36530	55185	2.51
T_0N_2	2175	92438	37632	54806	2.46
T_0N_3	2269	96433	38740	57693	2.49
T_1N_1	2104	89420	36830	52590	2.43
T_1N_2	2184	92820	37932	54888	2.45
T_1N_3	2444	103870	39040	64830	2.66
T_2N_1	1998	84915	36830	48085	2.31
T_2N_2	2406	102255	37932	64323	2.70
T_2N_3	2549	108333	39040	69293	2.77

Note: Selling price of seed cotton: 42.5 ₹/ kg

Conclusion

From the results of three years experimental study, it can be concluded that, topping practice in *Bt* cotton plant (removal of apex) at 100 days after sowing and fertilization of crop with 240 kg N/ha in four equal splits *i.e*. 60 kg N/ha in basal and remaining 180 kg N/ha in three equal splits at one month interval through fertigation gave higher yield with reduction in cost of cultivation in *Bt* cotton grown on heavy black soil condition.

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