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Influence of different levels of spacing and growth regulation treatments on biochemical and quality parameters of *Bt.* Cotton

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Abstract
The present investigation was carried out during *kharif* season of 2019-20 and 2020-21 on clayey soils of Junagadh (Gujarat). The experiment was laid out in split plot design with three replications from which four levels of spacing *viz.*, 45 cm x 30 cm, 60 cm x 30 cm**,** 90 cm x 30 cm**,** 120 cm x 45 cm and four levels of growth regulation *viz.*, Control, Detopping at 75 DAS**,** Brassinosteroid (0.15 ppm) at 75 and 90 DAS, Cycocel (40 ppm) at 75 and 90 DAS**.** The result revealed that leaf chlorophyll content (SPAD value) at 90, 120 DAS and at harvest and protein content in seed were recorded significantly highest value with plant spacing 120 cm x 45 cm (S_4). However, spacing 45 cm x 30 cm (S_1) recorded significantly highest seed cotton yield, oil yield and protein yield. Application of cycocel (40 ppm) at 75 and 90 DAS enhanced leaf chlorophyll content (SPAD value) at 90, 120 DAS and at harvest, seed cotton yield, oil yield, protein yield, nitrogen and protein content in seed (%). However, fiber length, fiber strength, fiber fineness and oil content in seed did not exert their significant influence by various levels of plant spacing and growth regulation.

Keywords: *Bt.* Cotton, spacing, detopping, brassinosteroid, cycocel

Introduction
Cotton is multipurpose crop that supplies basic products like fibre, oil, oil cake, hulls and lint. The highest percent of fiber, energy in the form of fat and protein found in whole cottonseed which very famous as feed for dairy cattle. The cotton seeds provide protein (20%), oil (20%), starch (3.5%) and their cake is used as cattle feed. Fibres grow from the seed coat to form a boll of cotton lint. The boll is a protective fruit when plant is grown commercially, it is stripped from the seed by ginning and the lint is then processed into cotton fibre. The seeds are about 15% value of the crop, after pressing to make oil and its cake used as animal feed (Anon. 2015-16) [1]. The seed oil extracted from the kernels, after being refined serves as a good edible and nutritious source. It can be used as cooking oil and salad dressings. It is also highly beneficial for the production of shortening and margarine. The fine quality oil extracted from cotton seeds during the extraction process is also used in cosmetic product for moisturized. Therefore, the oil is used in moisturizing lotions and bath soaps. Cotton grown for the extraction of cottonseed oil is one of major crops grown around the world for the production of oil, after soy, corn and canola used for medical purposes also. Cotton (*Gossypium* spp. L.) is one of the predominant fibre crops playing a pivotal role in agriculture, industrial development, employment generation and economy of India. Cotton is also called as "King of fiber crops" due to higher economical value among all cash crops in India.
The concept on high density (Narrow row spacing) cotton planting was initiated by Briggs *et al.* (1967) [2]. In general, lower plant densities produce high values of growth and yield attributes per plant, but yield per unit area was higher with higher plant densities. The other advantage is better light interception, efficient leaf area development and early canopy closure which will shade out the weed and reduce their competitiveness (Wright *et al*. 2011) [15].
Indian cotton growing farmer's use genetically modified Bt. cotton hybrid and which is sown at widely spacing. But the last few years' farmers are facing a problem of stagnating yields from *Bt.* cotton hybrids due to increased cost of cultivation per unit area and also due *Bt.* cotton having wide growth habit and short tap root so plant not able to uptake sufficient nutrient requirement throughout growth period, also might be due to Bt. cotton hybrid flower develop without special photoperiod or hormonal modifications due to indeterminate in growth habit. It is important to modify shape of plant.

Plant size may be reduced by genetically or chemically using PGR or agronomic practice. Thus, PGR chemicals could become another tool in the cotton producers reserve for ensuring efficient production. Research with PGRs on cotton has increased significantly during the past few years, with the major emphasis being directed primarily to the areas of improved seed germination early flower formation and development, fruit set and fruit growth and increased early fruit retention; modifying processes such as photosynthesis rate and photosynthate export from leaves in such a way that more photosynthetic products are mobilized and brought to the developing fruit improved quality and yield. Single variety may also respond differently depending on its age, the environmental conditions, its physiological state of development and its state of nutrition. PGRs are capable of increasing yield up to 25-30% under laboratory conditions, 20-25% in the field conditions (Kumar, 2001) [8]. Now-a-days, PGRs are considered as new generation agrochemicals after fertilizers, pesticides and herbicides and it is also ecofriendly to environment. Keeping in view the above facts the present investigation was conducted to study the effect of spacing and growth regulation levels on biochemical and quality parameter of *Bt.* Cotton at Junagadh Agriculture University, Junagadh with following objectives.

Materials and Methods

The investigation was conducted during *kharif* season of 2019-20 and 2020-21 at Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) which is located at 21.5’ N latitude 70.5’ E longitude with an altitude 60 meters above the mean sea level (MSL). The experiment consisting of sixteen treatment combinations with four levels each of spacing *viz*., 45 cm x 30 cm (S_1), 60 cm x 30 cm (S_2), 90 cm x 30 cm (S_3), 120 cm x 45 cm (S_4) and growth regulation *viz*., Control (G_1), Detopping at 75 DAS (G_2), Brassinosteroid (0.15 ppm) at 75 and 90 DAS (G_3), Cycocel (40 ppm) at 75 and 90 DAS (G_4) were laid out in split plot design (SPD) with three replications. The liquid formulation of Brassinosteroid 0.04% W/W in “Godrej Duble” brand and Cycocel 50% SL in “Basf” brand obtained from Agrosiaa company. Application of Brassinosteroid 5.63 ml and cycocel 1.2 ml per 15-liter water. The soil of the experimental plot was clayey in texture, calcareous in nature and slightly alkaline in reaction (pH 7.9 and 8.1 and EC 0.33 and 0.32 dS/m) and soil was medium in available nitrogen (260-265 kg/ha), available phosphorus (28.4-34.1 kg/ha) and available potash (232-236 kg/ha). The crop was fertilized with 240-50-150 kg N-P_2O_5-K_2O/ha given as entire dose of phosphorus, potash and 60 kg of nitrogen were applied as basal application in form of urea and diammonium phosphate and muriate of potash at just before sowing in the furrow and remaining 180 kg of nitrogen was applied as top dressed in three equal split in form of urea at 30 DAS and in form of ammonium sulphate at 60 and 90 DAS. The biochemical parameters *viz*., leaf chlorophyll content (SPAD value), protein content in seed and protein yield; chemical parameter *viz*., nitrogen content in seed; quality parameter *viz*., oil content in seed, oil yield, fiber length, fiber strength and fiber fineness were recorded with standard process of observation.

Leaf chlorophyll content measured by leaf SPAD meter at 60, 90 120 DAS and harvest. Upper 4th leaf was selected from each plant and chlorophyll content was measured with help of SPAD meter (Minolta SPAD-502 Plus) by taking observations from 4-5 different places of a leave and averaged for best result.

Protein content in cotton seed was determined by multiplying nitrogen percentage by a factor 6.25 (Gassi *et al*., 1973) [4]. The modified kjeldahl method was adopted to find out nitrogen content (Jackson, 1974) [6].

Protein yield was calculated by seed cotton yield multiplied with cotton seed content of grain in each net plot and averaged for protein yield.

$$\text{Protein yield (kg/ha)} = \frac{\text{Protein content of seed (\%) x Seed cotton yield (kg/ha)}}{100}$$

The oil content (%) of seed will be determined by Nuclear Magnetic Resonance (NMR) analyzer as per the method suggested by Tiwari (1974) [14].

Oil yield (kg/ha) will be worked out with the help of following formula:

$$\text{Oil yield (kg/ha)} = \frac{\text{Seed cotton yield (kg/ha)} \times \text{Oil percentage (\%)}}{100}$$

The data was statistically analyzed using analysis of variance (ANOVA) as applicable to split plot design (Gomez and Gomez, 1984) [5].

Result and Discussion

Effect of different levels of spacing

Data presented in Table 1 and 2 indicated that the plant spacing of 120 cm x 45 cm (S_4) recorded significantly higher leaf chlorophyll content (SPAD value) at 90, 120 DAS and harvest (Table 1) and nitrogen and protein content (Table 3) in seed during the year of 2019-20, 2020-21 and in pooled results which was at par with 90 cm x 30 cm (S_3) spacing in case of leaf chlorophyll content at 90 and 120 DAS and protein content in seed during both the year and in pooled results and leaf chlorophyll content (SPAD value) at harvest during first and second year results.

Plant spacing 45 cm x 30 cm (S_1) gave significantly higher seed cotton yield, oil yield (Table 2) and protein yield (Table 3) during the year of 2019-20, 2020-21 and in pooled results, which remain at par with 60 cm x 30 cm (S_2) during first year results of seed cotton yield, oil yield and protein yield and in case of pooled results of protein yield. Plant spacing of 90 cm x 30 cm (S_3) also observed at par results in protein yield of first year. In general, lower plant densities produce high values of growth and yield attributes per plant, but yield per unit area was higher with higher plant densities. The above results are in conformity with the findings of Kumar *et al.* (2017) [9] and Solanki *et al*. (2020) [13].

The different parameters *viz.* leaf chlorophyll content at 60 DAS (Table 1), oil content (Table 2), fiber quality characters *viz.*, fiber length, fiber fineness and fiber strength (Table 4) failed to show perceptible variation under the influence of different plant spacing. The differences in quality parameters in plant densities are obvious because fiber properties are primarily governed by genetic makeup of hybrid cotton coupled with soil and climatic interaction, which modify the ultimate expression of fiber properties. This is in conformation of results represented by Gacche and Gokhale (2017) [3].

Effect of different growth regulation levels

Leaf chlorophyll content (SPAD value) at 90, 120 DAS and harvest (Table 1), seed cotton yield, oil yield (Table 2), protein content and protein yield (Table 3) were recorded significantly highest with application of cycocel (40 ppm) at 75 and 90 DAS (G_4) during the year of 2019-20, 2020-21 and in pooled results, which was found at par with application of brassinosteroid (0.15 ppm) at 75 and 90 DAS (G_3) in case of leaf chlorophyll content at 90 DAS in pooled results and in first year results of leaf chlorophyll content at 120 DAS. Seed cotton yield, oil yield and protein yield observed at par with treatment G_3 (brassinosteroid (0.15 ppm) at 75 and 90 DAS). However, detopping practice also observed at par results in case of protein content in seed during first and second year. Katariya and Khanpara (2011) [7] reported that cycocel treated cotton plants have increase plant root-shoot ratio which helps to uptake the nutrients and larger photo synthetically sink for carbohydrates and other metabolites due to enhanced single boll weight which ultimately reflected in higher seed cotton yield. The present findings are in close agreement with results obtained by Shekar *et al*. (2015), and Rao *et al*. (2015) [12, 11].

Leaf chlorophyll content at 60 DAS (Table 1) fiber length, fiber fineness and fiber strength (Table 4) were not influenced significantly by different growth regulation treatments because fiber properties are primarily governed by genetic makeup of hybrid cotton coupled with soil and climatic interaction, which modify the ultimate expression of fiber properties Modino *et al*. (2004) [10].

Plate 1: General view of field experimental site during 2019-20 and 2020-21

Table 1: Effect of spacing and growth regulation levels on seed cotton yield and leaf chlorophyll content of *Bt.* Cotton

Treatments	Leaf chlorophyll content (SPAD value) at											
	60 DAS			90 DAS			120 DAS			Harvest		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
S_1	42.69	42.04	42.36	54.02	52.38	53.20	64.92	63.38	64.15	47.92	46.81	47.36
S_2	40.38	40.36	40.37	57.74	57.40	57.57	69.42	72.40	70.91	50.75	52.05	51.40
S_3	39.77	38.75	39.26	59.26	60.40	59.83	72.78	73.60	73.19	52.76	54.56	53.66
S_4	39.16	38.77	38.97	65.06	60.88	62.97	75.08	77.39	76.24	56.58	58.55	57.56
S.Em.±	1.26	1.22	0.88	1.71	1.21	1.05	1.61	1.73	1.18	1.56	1.72	1.16
C.D. at 5%	NS	NS	NS	5.93	4.18	3.23	5.56	5.98	3.63	5.41	5.94	3.58
G_1	39.93	39.69	39.81	50.25	54.41	52.33	65.67	64.08	64.88	46.67	44.88	45.78
G_2	39.26	39.41	39.33	56.33	54.85	55.59	69.76	71.13	70.44	50.35	50.48	50.41
G_3	40.66	40.24	40.45	63.27	59.05	61.16	72.17	73.42	72.79	52.83	56.09	54.46
G_4	42.15	40.58	41.36	66.22	62.75	64.49	74.60	78.14	76.37	58.17	60.51	59.34
S.Em.±	1.18	1.15	0.82	1.36	1.18	1.89	1.35	1.53	1.02	1.30	1.49	0.99
C.D. at 5%	NS	NS	NS	3.98	3.45	8.52	3.94	4.47	2.91	3.80	4.35	2.82

Table 2: Effect of spacing and growth regulation levels on seed cotton yield, oil content in seed and oil yield of *Bt.* Cotton

Treatments	Seed cotton yield (kg/ha)			Oil content in seed (%)			Oil yield (kg/ha)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
S_1	2908	3192	3050	19.69	19.39	19.54	573.65	617.80	595.73
S_2	2732	2757	2745	19.87	20.07	19.97	542.42	553.37	547.90
S_3	2436	2520	2478	20.06	20.08	20.07	489.02	505.28	497.15
S_4	2070	2086	2078	20.50	20.22	20.36	423.57	422.51	423.04
S.Em.±	64	61	44	0.37	0.41	0.27	12.07	13.28	8.97
C.D. at 5%	220	212	136	NS	NS	NS	41.77	45.95	27.65
G_1	2273	2373	2323	19.49	19.56	19.52	440.89	462.67	451.78
G_2	2439	2548	2493	20.02	20.31	20.17	487.12	516.44	501.78
G_3	2646	2690	2668	20.35	20.01	20.18	537.43	538.90	538.17
G_4	2788	2945	2867	20.27	19.88	20.07	563.22	580.95	572.08
S.Em.±	56	47	36	0.33	0.35	0.24	12.07	12.45	8.67
C.D. at 5%	163	137	104	NS	NS	NS	35.24	36.35	24.66

Table 3: Effect of spacing and growth regulation levels nitrogen and protein content in seed and protein yield of *Bt.* cotton

Treatments	Nitrogen content in seed (%)			Protein content in seed (%)			Protein yield (kg/ha)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
S_1	1.655	1.689	1.672	10.34	10.56	10.45	301.66	338.25	319.95
S_2	1.726	1.761	1.743	10.79	11.01	10.90	295.01	303.61	299.31
S_3	1.809	1.810	1.810	11.31	11.32	11.31	275.79	285.11	280.45
S_4	1.829	1.888	1.859	11.43	11.80	11.62	237.14	246.52	241.83
S.Em.±	0.036	0.037	0.026	0.23	0.23	0.16	11.32	7.78	6.87
C.D. at 5%	0.125	0.127	0.079	0.78	0.80	0.50	39.16	26.92	21.16
G_1	1.676	1.710	1.693	10.47	10.69	10.58	236.57	251.73	244.15
G_2	1.762	1.784	1.773	11.01	11.15	11.08	268.72	283.15	275.94
G_3	1.749	1.780	1.765	10.93	11.13	11.03	288.57	297.20	292.89
G_4	1.832	1.874	1.853	11.45	11.71	11.58	315.73	341.40	328.57
S.Em.±	0.036	0.031	0.024	0.22	0.20	0.15	8.96	7.48	5.84
C.D. at 5%	0.104	0.092	0.067	0.65	0.57	0.42	26.15	21.83	16.59

Table 4: Effect of spacing and growth regulation levels on fiber quality perameters of *Bt.* Cotton

Treatments	Fiber length (mm)			Fiber strength (g/tex)			Fiber fineness (Micronaire value)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
S_1	30.04	29.66	29.85	29.75	28.18	28.97	4.38	4.19	4.28
S_2	30.26	30.07	30.16	29.04	28.20	28.62	4.61	4.44	4.52
S_3	30.85	31.09	30.97	30.08	30.71	30.40	4.40	4.64	4.52
S_4	30.74	31.38	31.06	29.66	29.63	29.64	4.51	4.71	4.61
S.Em.±	0.58	0.69	0.45	0.78	1.00	0.63	0.12	0.14	0.09
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
G_1	30.65	30.51	30.58	29.37	28.82	29.09	4.53	4.53	4.53
G_2	30.67	30.73	30.70	29.84	28.87	29.36	4.37	4.41	4.39
G_3	30.41	30.70	30.55	29.96	29.97	29.96	4.39	4.47	4.43
G_4	30.17	30.26	30.21	29.36	29.07	29.21	4.60	4.58	4.59
S.Em.±	0.53	0.53	0.38	0.46	0.45	0.32	0.09	0.09	0.06
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

On the basis of two-year field experimentation, it seems quite logical to conclude that higher seed cotton yield, oil yield, protein yield and leaf chlorophyll content (SPAD value) from *Bt*. cotton var. (Solar 65 BG-II) can be secured by sowing the crop at 45 cm x 30 cm spacing and application of cycocel (40 ppm) at 75 and 90 DAS on clayey soil under south Saurastra agro-climatic zone.

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