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RESEARCH PAPER

Effect of spacing and growth regulation levels on leaf area, branches and dry matter per plant of Bt. Cotton

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Abstract : The present study aimed to evaluate the effect of spacing and growth regulation treatments on Bt. Cotton (var. "Solar 65 BG-II) during *Kharif* season of 2019-20 on clayey soils of Junagadh. The experiment comprising of 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 growth regulation levels *viz*., control, detopping at 75 DAS, Brassinosteroid (0.15 ppm) at 75 and 90 DAS, cycocel (40 ppm) at 75 and 90 DAS were laid out in split plot design with three replications. The result showed that higher leaf area per plant at 60, 90, 120 DAS and harvest; number of sympodial branches per plant at 60, 90, 120 DAS and harvest; dry matter per plant at 60, 90, 120 DAS and harvest; CGR during 30-60 DAS; CGR during 60-90 DAS and CGR during 90-120 DAS and CGR during 120 DAS-harvest were recorded significantly highest value with plant spacing 120 cm x 45 cm (S_4). However, spacing 45 cm x 30 cm (S_1) significantly increased the leaf area index per plant at 60, 90, 120 DAS and harvest. Application of cycocel (40 ppm) at 75 and 90 DAS enhanced leaf area per plant and leaf area index per plant at harvest; number of sympodial branches per plant at 90, 120 DAS and harvest; dry matter per plant at 90 DAS; CGR during 60-90 DAS; CGR during 120 DAS-harvest and RGR during 60-90 DAS. Application of brassinosteroid (0.15 ppm) at 75 and 90 DAS enhanced leaf area per plant and leaf area index per plant at 90 and 120 DAS; dry matter per plant at 120 DAS and harvest; CGR during 90-120 DAS and RGR during 90-120 DAS.

Key Words : Bt. Cotton, Spacing, Detopping, Brassinosteroid, Cycocel

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INTRODUCTION

Cotton is a major commercial and industrial crop known as "White gold" and "King of fibre crops". The cotton seeds provide protein (20 %), oil (20 %), starch (3.5 %) and their cake is used as cattle feed. Still there exists large potential for export of raw cotton and value added products.

The concept on high density (Narrow row spacing) cotton planting was initiated by Briggs *et al.* (1967). 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

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development and early canopy closure which will shade out the weed and reduce their competitiveness (Wright *et al*., 2011, Singh *et al.,* 2017a; Singh *et al.,* 2017b; Singh *et al.,* 2017c; Singh *et al.,* 2018; Tiwari *et al.,* 2018; Tiwari *et al.,* 2019a; Tiwari *et al.,* 2019b; Kour *et al.,* 2019 and Singh *et al.,* 2019). Almost 95 % Indian cotton growing farmers use genetically modified Bt. cotton hybrid and which is sown at wide spacing 120 cm × 120 cm to 90 cm × 90 cm with only 6944 to 12356 plants/ha. 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 plant requirement throughout growth period. It is important to modify shape of plant.

While under narrow spacing its challenging to reduce plant vegetative growth and earliness of reproductive growth, also increase plant strength and increase number of sympodial branches and reducing branches length throwing a challenge to reduce plant canopy growth and modify shape. To achieve this modification in plant required some important growth regulation practices.

Now-a-days, PGRs are considered as new generation agrochemicals after fertilizers, pesticides and herbicides and it is also ecofriendly to environment.

Main aim of this research is to applying PGR and performing detopping practice for the mobilization of nutrient toward the developing bolls. Plant vegetative growth is restricted and reduce plant canopy size which help in retaining higher number of bolls from early stage of crop growth, it makes plant to growth favourable under HDP. Keeping in view the above facts the present investigation was conducted to study the effect of spacing and growth regulation levels on 1eaf area, branches and dry matter per plant of *Bt.* Cotton at Junagadh Agriculture University, Junagadh with following objectives.

Material and Methods

The experiment was conducted during *Kharif* season of 2019-20 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 and 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 growth parameters *viz*., leaf area per plant, leaf area index per plant (LAI), number of sympodial branches per plant, dry matter per plant, crop growth rate (CGR) and relative growth rate (RGR) were recorded with standard process of observation.

The functional leaves on five plants sample cut for dry matter studies were removed and grouped into three groups of small, medium and big. These graded leaves were recorded for length and breadth and actual leaf area was calculated with the formula given by Ashley *et al*. (1963). The final averaged leaf area per plant was recorded at 30, 60, 90, 120 DAS and at harvest.

$$\text{Leaf area} = (L \times W \times 0.771) \times n$$

where, L = maximum length of leaf

W = maximum breadth of leaf at one third length from the base of leaf

0.771 = leaf area constant for cotton

n = number of leaves per plant.

It is the ratio of surface leaf area (one side only) to the ground area occupied by the crop plant counted at 60, 90, 120 DAS and at harvest. Leaf area existing on unit ground area was proposed by Watson (1952). It was calculated as follows.

$$\text{LAI} = \frac{\text{Leaf area per plant (dm}^2\text{)}}{\text{Ground area per plant (dm}^2\text{)}}$$

The crop growth rate is widely used for determination of production efficiency of plant stand and enables comparison to be made between stand and communities of different types in different habitat. The values for CGR were calculated between 30-60 DAS, 60-120 DAS and 120-harvest with the help of the following formula (Cheema *et al.,* 1991).

where,

W_1 and W_2 = Weight of dry matter of plant (g/m^2) at first and second stages

t_1 and t_2 = Time in days of first and second stages.

According to Blackman (1919) the increase in dry matter of the plant is a process of continuous compound interest, wherein, the increment in any interval adds to the capital for subsequent growth. This rate of increment is known as RGR which was worked out between 30-60 DAS, 60-90 DAS, 90-120 DAS, 120-harvest as per the formula given by Fisher (1921).

where,

Log_e = Natural logarithm (base e),

W_1 and W_2 = Weight of dry matter of plant (g) at first and second stage, respectively,

t_1 and t_2 = Time in days of first and second stages.

Loge = Natural logarithm to the base 'e' = 2.3026.

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

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Effect of plant spacing levels:

Data presented in Table 1 and 2 indicated that the plant spacing of 120 cm x 45 cm (S_4) recorded significantly higher leaf area per plant at 60, 90, 120 DAS and harvest and dry matter production per plant at 60, 90, 120 DAS and harvest which was found at par with 90 cm x 30 cm spacing in case of leaf area per plant at 90 and 120 DAS and dry matter per plant at 60, 90 and 120 DAS and harvest. The increase in dry matter accumulation per plant at lower plant density might be due to the larger ground area, maximum moisture and more interception of light and less competition for nutrients due to increase number of leaves and leaf area resulting in more photosynthetic activity and more biomass accumulation through the process of plant metabolism. The results obtained in this investigation are also supported by Bhanudas (2017) and Kumar *et al.* (2017). Number of sympodial branches per plant at 60, 90, 120 DAS and harvest (Table 2) was significantly higher with 120 cm x 45 cm (S_4) plant spacing which remained at par with plant spacing 90 cm x 30 cm (S_3) in case of sympodial branches per plant at 60 DAS. The increase in number of sympodial branches in wider intra and inter row spacing of 120 cm x 45 cm was mainly due to more availability of space for lateral spread of branches and suppression of apical dominance and more chance to enhance auxiliary buds which resulted in to increased branching in lower plant density as compared

Table 1: Effect of spacing and growth regulation levels on leaf area and leaf area index per plant of Bt. cotton

Treatments	Leaf area per plant (dm^2) at				Leaf area index per plant at			
	60 DAS	90 DAS	120 DAS	Harvest	60 DAS	90 DAS	120 DAS	Harvest
S_1	31.68	52.64	64.73	26.85	2.3470	3.8994	4.7949	1.9886
S_2	33.96	59.25	72.84	27.05	1.8867	3.2914	4.0467	1.5030
S_3	39.91	64.77	77.38	33.07	1.4783	2.4143	2.8661	1.2247
S_4	43.84	65.55	80.03	39.28	0.8118	1.2139	1.4820	0.7275
S.E.±	1.02	1.27	1.69	0.84	0.0497	0.0700	0.1064	0.0453
C.D. (P=0.05)	3.51	4.39	5.84	2.91	0.1720	0.2422	0.3682	0.1568
G_1	35.66	56.34	69.78	28.14	1.5685	2.4463	3.0473	1.1950
G_2	37.61	58.12	72.79	28.42	1.6545	2.5471	3.2103	1.2388
G_3	38.32	64.31	78.29	34.01	1.6868	2.9403	3.5621	1.4513
G_4	37.81	63.44	74.12	35.68	1.6140	2.8853	3.3699	1.5587
S.E.±	0.93	1.26	1.37	0.65	0.0499	0.0547	0.0558	0.0276
C.D. (P=0.05)	NS	3.68	4.00	1.89	NS	0.1597	0.1629	0.0806

NS= Non-significant

to closer plant spacing. These observations are in conformity with Pendharkar *et al.* (2011) and Solanki *et al*. (2020).

Plant spacing 45 cm x 30 cm (S_1) gave significantly higher leaf area index per plant at 60, 90, 120 DAS and harvest (Table 1) over rest of the planting density, while the lowest value of LAI was observed under the spacing of 120 cm x 45 cm (S_4). In general 120 cm x 45 cm (S_4) plant spacing recorded higher values of growth constants *i.e.* CGR during 30-60 DAS, CGR during 60-90 DAS, CGR during 90-120 DAS and CGR during 120 DAS-harvest (Table 3) which was at par with plant spacing of 90 cm x 30 cm (S_3). Plant spacing of 60 cm x 30 cm also observed at par results in case of CGR during 60-90 DAS might be due to better source-sink relationship and balanced vegetative growth, early maturity and senescence of leaves might have contributed for these values of growth constants during both the years. The above results are in conformity with the findings of Paslawar *et al.* (2015).

Effect of growth regulation levels :

The experimental result revealed that leaf area and leaf area index per plant at 60 DAS (Table 1), number of sympodial branches per plant at 60 DAS (Table 2), dry matter production per plant at 60 DAS (Table 2), CGR during 30-60 DAS, RGR 30-60 DAS, RGR 120 DAS-harvest (Table 3) failed to show perceptible variation under the influence of growth regulation treatments.

Growth parameters *viz.,* dry matter production per plant at 90, 120 DAS and harvest (Table 2), CGR during 60-90 DAS (Table 3), CGR during 120 DAS-harvest (Table 3), RGR during 60-90 DAS (Table 3), leaf area per plant at 90 DAS and harvest and leaf area index at 90 DAS (Table 1) recorded higher with application of cycocel (40 ppm) at 75 and 90 DAS (G_4) and brassinosteroid (0.15 ppm) at 75 and 90 DAS (G_3). Application of cycocel (40 ppm) at 75 and 90 DAS (G_4) recorded significantly highest number of sympodial branches per plant at 90, 120 DAS and harvest (Table 2), leaf area index at harvest (Table 1). Application of cycocel excreted a significant influence on partitioning of dry matter into fruiting bodies as it resulted in significantly less dry matter allocation towards vegetative plant parts but more of it towards the fruiting bodies resulting due to reduction in the abscission of leaf, buds, bolls and promote stronger stem. The cycocel completely counteracts the effects of abscissic acid and thus reduced the shedding of reproductive structures. These

Table 2: Effect of spacing and growth regulation levels on number of sympodial branches and dry matter per plant of Bt. cotton

Treatments	No. of sympodial branches per plant at				Dry matter per plant (g) at			
	60 DAS	90 DAS	120 DAS	Harvest	60 DAS	90 DAS	120 DAS	Harvest
S_1	7.30	10.13	12.87	13.59	72.83	144.42	178.00	194.42
S_2	7.60	10.94	14.02	14.99	75.58	158.92	197.92	218.83
S_3	8.61	11.87	14.99	16.27	86.25	185.50	247.58	269.67
S_4	8.99	12.43	15.41	16.89	91.67	197.58	261.25	293.75
S.E.±	0.24	0.28	0.35	0.37	2.72	5.59	7.52	7.76
C.D. (P=0.05	0.83	0.98	1.23	1.29	9.41	19.34	26.01	26.87
G_1	7.87	10.92	13.61	14.53	81.25	152.50	181.42	197.33
G_2	8.08	11.25	14.42	15.57	81.08	170.50	224.17	243.08
G_3	8.24	11.08	13.99	15.10	80.83	179.25	245.83	272.00
G_4	8.30	12.13	15.28	16.54	83.17	184.17	233.33	264.25
S.E.±	0.19	0.24	0.31	0.37	1.83	5.34	4.78	5.21
C.D. (P=0.05	NS	0.70	0.90	1.08	NS	15.58	13.95	15.21

NS= Non-significant

Table 3 : Effect of spacing and growth regulation levels on leaf area and leaf area index per plant of Bt. cotton

Treatments	CGR (g/day) during				RGR (g/g/day) during			
	30-60 DAS	60-90 DAS	90-120 DAS	120-harvest	30-60 DAS	60-90 DAS	90-120 DAS	120-harvest
S_1	2.206	2.386	1.119	0.547	0.0800	0.0229	0.0069	0.0029
S_2	2.292	2.778	1.300	0.697	0.0803	0.0246	0.0072	0.0033
S_3	2.623	3.308	2.069	0.736	0.0813	0.0252	0.0096	0.0029
S_4	2.790	3.531	2.122	1.083	0.0815	0.0253	0.0092	0.0038
S.E.±	0.096	0.229	0.184	0.101	0.0024	0.0018	0.0008	0.0004
C.D. (P=0.05)	0.333	0.794	0.637	0.348	NS	NS	NS	NS
G_1	2.475	2.375	0.964	0.531	0.0819	0.0206	0.0059	0.0029
G_2	2.462	2.981	1.789	0.631	0.0811	0.0246	0.0089	0.0027
G_3	2.457	3.281	2.219	0.872	0.0809	0.0264	0.0104	0.0032
G_4	2.517	3.367	1.639	1.031	0.0794	0.0265	0.0078	0.0041
S.E.±	0.06	0.17	0.14	0.086	0.0014	0.0011	0.0007	0.0004
C.D. (P=0.05)	NS	0.50	0.41	0.251	NS	0.0032	0.0020	NS

NS= Non- significanct

observations are in conformity with Katariya and Khanpara (2011).

Application of brassinosteroid (0.15 ppm) at 75 and 90 DAS (G_3) recorded significantly highest leaf area and leaf area index per plant at 120 DAS (Table 1), CGR during 90-120 DAS and RGR 90-120 DAS (Table 3) might be due to the fact that brassinosteroids plays crucial role in diverse aspects of plant biology including cell elongation, cell division, photo-morphogenesis, stomatal and vascular differentiation which ultimately enhanced leaf area per plant that leads to more accumulation of photosynthesis. The similar findings were supported by Schumacher and Chory, (2000). Performing of detopping practice at 75 DAS (G_2) also observed at par results in case of number of sympodial branches per plant at 120 DAS and harvest (Table 2), dry matter production per plant at 90 DAS (Table 2), CGR 60-90 DAS, RGR 60-90 DAS and RGR 90-120 DAS (Table 3).

Conclusion:

Based on the finding of the investigation it may be concluded that leaf area per plant and number of sympodial branches observed higher with wider row spacing of 120 cm x 45 cm (S_4) so ultimately increase growth parameter leads to enhanced dry matter per plant but leaf area index per plant significantly highest with 45 cm x 30 cm (S_1) spacing in *Bt.* Cotton. Application of cycocel (40 ppm) at 75 and 90 DAS (G_4) increased number of sympodial branches per plant, leaf area and leaf area index per plant at harvest and dry matter per plant at 90 DAS. Application of brassinosteroid (0.15 ppm) at 75 and 90 DAS (G_3) enhanced the leaf area and leaf area index per plant at 90 and 120 DAS and dry matter per plant at 120 DAS and harvest.

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