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Effect of chemical defoliant on growth, yield and fibre quality of compact cotton genotypes

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Abstract: The field experiment was conducted at Main Agricultural Research Station, UAS, Dharwad during *kharif* 2013 to study the effect of chemical defoliator application on growth, yield parameters and quality of compact cotton genotypes. Treatments consisted of 12 combinations comprising of two genotypes (RAH-274 and SC-2028-22) as main plots, two spacing (45x10 cm and 45x15 cm) as sub plots with three chemical defoliator (Dropp Ultra @ 200 ml/ha, Ethrel @ 2000 ppm and Water spray) as sub sub plot treatments. Genotype, RAH-274 under 45x15 cm spacing with Ethrel @ 2000 ppm produced significantly higher seed cotton yield (2075 kg/ha) along with higher yield components than other treatment combinations. However, genotype SC-2028-22 recorded significantly higher leaf area (9.54 dm^2/plant), LAI (1.75), number of leaves per plant (3.1), leaf dry weight (14.1 g/plant) compared to RAH-274 at 18 days after defoliant spray (DADFS). Spacing of 45x15 cm recorded significantly higher growth parameters except LAI during all the stages of observation intervals over 45x10 cm. Among the defoliators, Ethrel @ 2000 ppm recorded significantly lower leaf area (3.01 dm^2/plant), LAI (0.54), number of leaves per plant (1.4) and leaf dry weight (6.9 g/plant) compared to Dropp Ultra @ 200 ml/ha. Whereas, these parameters were significantly higher under control treatment. Interaction of SC-2028-22 at spacing of 45x15 cm with water spray (control) recorded significantly higher leaf area, number of leaves and leaf dry weight except LAI over rest of the interactions.

Key words: Compact genotypes, Cotton, Defoliant, Fibre quality, Yield

Introduction

India ranks first in area in global scenario (about 33 % of the world cotton area) and second to China for production (Anon., 2014). In India, the seed cotton yield per unit area is still far below than many other cotton growing countries in the world. Among the various factors responsible for low yields of cotton in the country, low plant population and use of low potential varieties are of primary importance. Various agro techniques *viz.*, high yielding varieties, maintaining optimum plant population, use of optimum dose of nutrition, growth regulators etc. are being used for enhancing commercial cotton productivity. Among the various cultural practices, selection of cultivars, spacing and plant population are crucial factors which influence the morphological traits and yield in cotton. Defoliants are chemicals that either impact plant hormonal activity related to leaf loss or cause direct injury to leaves, both at a level that promotes leaf drop (abscission) and are often representing the final step in the production of a cotton crop. The defoliation process usually completed within 7 to 10 days, but in some situations, it may be delayed for as long as 30 days (Gwathmey and Hayes, 1997). The success of defoliation process depends on the maturity of cotton crop and prevailing weather conditions at the time of application (Muhammad *et al.,* 2002). With the emphasis on premium quality associated with cotton production, efficient defoliation is a matter of supreme concern in late season crop management (Silvertooth, 2001). Defoliants are therefore necessary to increase the harvest efficiency, reduce lodging, reduce trash and lint staining, reduce cotton seed moisture and decrease insect populations and also to remove vegetative material to facilitate one time harvesting and to synchronize the opening of the bolls. There are a range of defoliants available in the market, but the work on comparison of their speed of action, its physiological impact in relation to leaf defoliation, yield and crop value (quality) is too little.

The objective of the present study under rainfed condition was to determine the effect of chemical defoliant application on growth, yield parameters and quality of compact cotton genotypes under different planting geometry in Northern transition zone of Karnataka.

Material and methods

The field experiment was conducted at Main Agricultural Research Station, UAS, Dharwad, Karnataka during *kharif* 2013. The soil of the experimental site was medium deep black (*Vertic Inceptisols*) with neutral pH (7.50), normal electric conductivity (0.37 dS/m), medium organic carbon (4.9 g/kg). The available nitrogen (275.8 kg/ha), phosphorus (26.5 kg/ha) and available potassium (293.4 kg/ha) was low.

The experiment was laid out in split split plot design with three replications. It consisted of 12 treatment combinations comprising of two genotypes (RAH-274 and SC-2028-22) as main plot, two spacing (45x10 cm and 45x15 cm) as sub plots and three chemical defoliators [Dropp Ultra @ 200 ml/ha (Thidiazuron), Ethrel @ 2000 ppm (Ethophon) and Water spray (control)] as sub-sub plots. The seeds were sown by dibbling with spacing as per treatments. The fertilizer dose of 160:80:80 kg N, P_2O_5 and K_2O/ha was applied. The 50 per cent nitrogen and 100 per cent phosphorus and potassium were applied as basal application at the time of sowing. Remaining 50 per cent of nitrogen was top dressed at flowering stage through urea. The chemical defoliators *viz.*, Dropp Ultra @ 200 ml/ha and Ethrel @ 2000 ppm were applied as a foliar spray as per treatments when cotton crop attained 75 per cent of boll opening. Control treatment was sprayed with water only. Observations were recorded before defoliator application and continued up to 18 days after defoliator spray at every two days interval. Data on leaf count have showed high degree of variation. A linear relationship between the means and variance was observed and therefore, the data on leaf count was subjected to $\sqrt{x}$ (square root) transformation to make analysis variance valid as suggested by Bartlett (1947). The collected data were subjected statistical analysis as described by Gomez and Gomez (1984). The level of significance used in 'F' and 't' test was P=0.05. Statistical analysis of data was done using MSTAT-C software. The mean value of main plot, sub plot, sub-sub plot and interactions were separately subjected to Duncan multiple range test using the corresponding error mean sum of squares and degrees of freedom values.

Results and discussion

Genotypic performance

Genotypes play an important role in determining the yield of a crop. The potential yield of genotypes within the genetic limit is set by the environment provided (Bradow and Bauer, 1998). Genotypes differ in their yield potential depending on many physiological processes, which are controlled by both genetic makeup of the plant and the environment. Results obtained from present experiment indicated that, genotype, RAH-274 recorded significantly higher seed cotton yield (2075 kg/ha) and increase was to the tune of 7.3 per cent over genotype SC-2028-22 (1923 kg/ha) (Table 1). Variation in yield among genotypes was also reported by Sisodia and Khamparia (2007) and Gadade *et al.* (2015). Significant higher yield and yield components per plant was observed in genotypes due to variation in the genetic constitution of the genotype which responded better with harvest of maximum number of bolls (Gadade *et al.,* 2015) and its higher efficiency in translocating the photosynthates to reproductive parts.

Photosynthetic capacity of plant is reflected on dry matter accumulation in leaves, leaf area and LAI. Throughout the growth of the crop and at 18 DADFS, dry matter accumulation in leaf, leaf area as well as LAI were significantly higher with genotype SC-2028-22 (26.45 g/plant, 28.82 dm^2/plant and 4.55, respectively) over RAH-274 (Table 2, 3 and 5). These higher values might be due to the production of higher number of leaves per plant (3.1) with SC-2028-22 compared to RAH-274 (2.5) at 18 DADFS. Leaf area being the photosynthetic surface, plays a vital role in production and availability of photosynthates for seed cotton production. The desirable differences in leaf dry matter, leaf area and LAI might have been due to the better uptake of nutrients (Krishnamurthy *et al.*, 1973).

Genotype RAH-274 recorded higher gin out turn (35.40 %), Micronaire (4.67 µg/inch) and lower fibre strength (25.16 g/tex), fibre length (26.94 mm) compared to SC-2028-22 (34.78 %, 4.51 µg/inch and 26.81 g/tex, 28.12 mm, respectively) (Table 6). Fibre elongation and fibre maturity ratio were found non significant between the genotypes. Fibre strength is influenced by both genetics and environmental conditions (Bednarz *et al.,* 2005).

Table 1. Yield and yield components of compact cotton genotypes as influenced by planting geometry and defoliator application

Treatment	Number of bolls/ plant	Mean boll weight(g)	Seed cotton yield (g/plant)	Seed cotton yield (kg/ha)
Genotypes (G)				
G_1-RAH-274	9.6a	3.82b	33.0a	2075a
G_2-SC-2028-22	8.0b	4.04a	31.0b	1923b
S.Em±	0.1	0.03	0.3	25
Planting geometry (S)				
S_1-45cm x 10cm	8.5b	3.85b	31.4b	1959b
S_2-45cm x 15cm	9.1a	4.02a	32.6a	2039a
S.Em±	0.1	0.03	0.3	22
Defoliator levels (D)				
D1-Dropp Ultra (200 ml/ha)	8.7a	3.94ab	31.6b	2009a
D2-Ethrel (2000 ppm)	8.9a	4.03a	33.9a	2086a
D3-Control	8.8a	3.82b	30.6b	1902b
S.Em±	0.1	0.05	0.5	34
Interactions (G x S x D)				
RAH-274 x 45x10 cm x Dropp Ultra	9.2b	3.67d	32.4b-d	1994 b-d
RAH-274 x 45x10 cm x Ethrel	9.2b	3.83bc	35.2ab	2111 ab
RAH-274 x 45x10 cm x Control	9.2b	3.70c-e	30.5cd	1914 b-d
RAH-274 x 45x15 cm x Dropp Ultra	9.7ab	3.80bc	31.6b-d	2122 ab
RAH-274 x 45x15 cm x Ethrel	10.2a	4.03a	36.2a	2241 a
RAH-274 x 45x15 cm x Control	10.1a	3.90ab	32.2b-d	2067 a-c
SC-2028-22 x 45x10 cm x Dropp Ultra	7.9cd	3.80bc	30.7cd	1987 b-d
SC-2028-22 x 45x10 cm x Ethrel	7.8d	4.06a	30.6cd	1955 b-d
SC-2028-22 x 45x10 cm x Control	7.9cd	4.03a	29.1d	1791 d
SC-2028-22 x 45x15 cm x Dropp Ultra	8.0cd	4.03a	31.7b-d	1932 b-d
SC-2028-22 x 45x15 cm x Ethrel	8.3c	4.20a	33.5a-c	2038 a-c
SC-2028-22 x 45x15 cm x Control	8.1cd	4.13ab	30.6cd	1837 cd
S.Em±	0.1	0.10	1.1	69

Means followed by the same letters within a column are not significantly differed by DMRT (P=0.05)

These results are supported by the findings of Bowman (2007) and Faircloth (2007) who reported that fibre strength was influenced by cultivars (Saleem *et al.,* 2010). The variation in fibre length might be due to varietal character. Similar variation in fibre quality parameters among cotton genotypes were made by Sarang *et al.* (2010); Phad *et al.* (2009), Chinchane *et al.* (2009) and Singh *et al.* (2011) at different locations of cotton growing areas in India.

Effect of planting geometry

Significantly higher seed cotton yield (2039 kg/ha) was recorded with spacing of 45x15 cm (148148 plants/ha) over (1959 kg/ha) obtained with narrow spacing of 45x10 cm

Table 2. Leaf area of compact cotton genotypes as influenced by planting geometry and defoliator application

Treatments	Leaf area (dm^2/plant)									
	Before spray	Days after defoliator spray (DADFS)								
		2	4	6	8	10	12	14	16	18
Genotypes (G)										
G_1-RAH-274	29.16 b	29.03 b	28.81 b	27.88 b	24.81 b	22.34 b	15.59 b	12.71 b	9.42 b	7.87 b
G_2-SC-2028-22	32.58 a	32.52 a	32.28 a	31.17 a	27.63 a	25.21 a	19.65 a	15.03 a	11.33 a	9.54 a
S.Em±	0.27	0.35	0.40	0.30	0.41	0.34	0.36	0.37	0.28	0.16
Planting geometry (S)										
S_1-45cm x 10cm	27.75 b	27.71 b	27.62 b	26.68 b	24.36 b	22.01 b	16.02 b	12.47 b	9.86 b	8.11 b
S_2-45cm x 15cm	33.99 a	33.83 a	33.47 a	32.37 a	28.07 a	25.55 a	19.23 a	15.27 a	10.89 a	9.31 a
S.Em±	0.25	0.23	0.42	0.29	0.39	0.29	0.27	0.36	0.21	0.14
Defoliator levels (D)										
D1-Dropp Ultra (200 ml/ha)	30.93 a	30.83 ab	30.57 ab	29.61 a	26.45 b	23.63 b	16.93 b	10.96 b	6.43 b	4.33 b
D2-Ethrel (2000 ppm)	30.38 a	30.03 b	29.67 b	28.12 b	23.28 c	20.28 c	12.59 c	7.73 c	4.23 c	3.01 c
D3-Control	31.31 a	31.45 a	31.39 a	30.84 a	28.93 a	27.43 a	23.34 a	22.93 a	20.47 a	18.78 a
S.Em±	0.30	0.41	0.47	0.46	0.64	0.62	0.60	0.43	0.31	0.28
Interactions (G x S x D)										
RAH-274 x 45x10 cm x Dropp Ultra	26.30 f	26.20 f	26.00 g	25.07 h	23.00 de	20.67 e-f	12.77 d	8.33 ef	5.50 ef	3.27 de
RAH-274 x 45x10 cm x Ethrel	26.47 f	25.57 f	25.70 g	24.33 h	21.33 f	17.33 f	8.17 e	6.17 f	3.33 g	1.83 e
RAH-274 x 45x10 cm x Control	26.75 ef	27.07 ef	26.62 fg	26.07 gh	25.17 c-f	22.33 de	18.33 bc	18.77 b	17.07 bc	16.00 c
RAH-274 x 45x15 cm x Dropp Ultra	32.00 b	31.97 bc	31.93 cd	30.97 c-e	26.00 b-e	24.00 c-e	17.00 bc	12.10 cd	5.83 d-f	4.70 d
RAH-274 x 45x15 cm x Ethrel	30.79 bc	30.86 bc	29.96 c-e	28.83 e-g	23.33 d-f	20.67 ef	12.10 d	7.33 f	3.87 fg	3.23 de
RAH-274 x 45x15 cm x Control	32.63 b	32.50 b	32.67 bc	32.00 b-d	30.00 ab	29.07 ab	25.20 a	23.53 a	20.90 b	18.20 b
SC-2028-22 x 45x10 cm x Dropp Ultra	28.93 cd	29.33 c-e	29.10 d-f	28.40 e-g	26.53 b-d	23.63 c-e	18.10 bc	10.17 de	7.67 d	4.37 d
SC-2028-22 x 45x10 cm x Ethrel	28.37 de	28.10 d-f	28.09 e-g	26.67 b-d	22.03 ef	20.43 ef	14.50 cd	7.33 f	4.53 fg	3.43 de
SC-2028-22 x 45x10 cm x Control	29.69 cd	30.00 b-d	30.18 c-e	29.53 e-g	28.10 bc	27.63 a-c	24.23 a	24.07 a	21.07 ab	19.73 ab
SC-2028-22 x 45x15 cm x Dropp Ultra	36.47 a	35.83 a	35.23 ab	34.00 f-h	30.27 ab	26.23 b-d	19.87 b	13.23 c	6.73 de	5.00 d
SC-2028-22 x 45x15 cm x Ethrel	35.88 a	35.60 a	34.95 ab	32.63 bc	26.40 b-d	22.67 de	15.60 cd	10.07 de	5.17 e-g	3.53 de
SC-2028-22 x 45x15 cm x Control	36.16 a	36.23 a	36.10 a	35.78 a	32.43 a	30.67 a	25.60 a	25.33 a	22.83 a	21.17 a
S.Em±	0.60	0.83	0.94	0.92	1.29	1.24	1.21	0.86	0.61	0.56

Table 3. Leaf area index of compact cotton genotypes as influenced by planting geometry and defoliator application

Treatments	Before spray	Leaf Area Index (LAI) Days after defoliator spray (DADFS)								
		2	4	6	8	10	12	14	16	18
Genotypes (G)										
G_1-RAH-274	5.30 b	5.27 b	5.24 b	5.06 b	4.53 b	4.06 b	2.80 b	2.29 b	1.71 b	1.43 b
G_2-SC-2028-22	5.90 a	5.90 a	5.86 a	5.66 a	5.04 a	4.62 a	3.61 a	2.74 a	2.09 a	1.75 a
S.Em±	0.05	0.06	0.06	0.05	0.08	0.07	0.07	0.07	0.06	0.02
Planting geometry (S)										
S_1-45cm x 10cm	6.17 a	6.16 a	6.14 a	5.93 a	5.41 a	4.89 a	3.56 a	2.77 a	2.19 a	1.80 a
S_2-45cm x 15cm	5.04 b	5.01 b	4.96 b	4.80 b	4.16 b	3.79 b	2.85 b	2.26 b	1.61 b	1.38 b
S.Em±	0.04	0.04	0.07	0.06	0.07	0.06	0.07	0.07	0.05	0.03
Defoliator levels (D)										
D1-Dropp Ultra (200 ml/ha)	5.60 a	5.60 ab	5.55 ab	5.38 a	4.84 b	4.32 b	3.08 b	1.97 b	1.20 b	0.78 b
D2-Ethrel (2000 ppm)	5.52 a	5.44 b	5.39 b	5.11 b	4.25 c	3.70 c	2.29 c	1.39 c	0.77 c	0.54 c
D3-Control	5.68 a	5.72 a	5.70 a	5.60 a	5.27 a	4.99 a	4.25 a	4.19 a	3.74 a	3.44 a
S.Em±	0.06	0.07	0.09	0.09	0.11	0.12	0.11	0.08	0.06	0.05
Interactions (G x S x D)										
RAH-274 x 45x10 cm x Dropp Ultra	5.84 b	5.82 bc	5.78 c-e	5.57 c-e	5.11 bc	4.59 b-d	2.84 de	1.85 d-f	1.22 e	0.73 ef
RAH-274 x 45x10 cm x Ethrel	5.88 b	5.68 cd	5.71 c-e	5.41 c-e	4.74 c	3.85 d-f	1.81 f	1.37 fg	0.74 fg	0.48 f
RAH-274 x 45x10 cm x Control	5.94 b	6.02 bc	5.92 b-d	5.79 b-d	5.59 ab	4.96 bc	4.07 b	4.17 b	3.79 b	3.56 b
RAH-274 x 45x15 cm x Dropp Ultra	4.74 d	4.74 e	4.73 gh	4.59 gh	3.85 de	3.56 ef	2.52 de	1.79 d-f	0.86 e-g	0.70 ef
RAH-274 x 45x15 cm x Ethrel	4.56 d	4.57 e	4.44 h	4.27 h	3.4 6e	3.06 g	1.79 f	1.09 g	0.57 g	0.41 f
RAH-274 x 45x15 cm x Control	4.83 d	4.81 e	4.84 f-h	4.74 f-h	4.44 cd	4.31 c-e	3.73 bc	3.49 c	3.10 c	2.70 d
SC-2028-22 x 45x10 cm x Dropp Ultra	6.43 a	6.52 a	6.47 ab	6.31 ab	5.90 a	5.25 b	4.02 b	2.26 d	1.70 d	0.97 e
SC-2028-22 x 45x10 cm x Ethrel	6.30 a	6.24 ab	6.24 a-c	5.93 a-c	4.90 bc	4.54 b-d	3.22 cd	1.63 ef	1.01 ef	0.76 ef
SC-2028-22 x 45x10 cm x Control	6.60 a	6.67 a	6.71 a	6.56 a	6.24 a	6.14 a	5.39 a	5.35 a	4.68 a	4.39 a
SC-2028-22 x 45x15 cm x Dropp Ultra	5.40 c	5.31 d	5.22 e-g	5.04 e-g	4.48 cd	3.89 d-f	2.94 de	1.96 d-c	1.00 ef	0.74 ef
SC-2028-22 x 45x15 cm x Ethrel	5.32 c	5.27 d	5.18 e-g	4.83 f-h	3.91 de	3.36 fg	2.31 ef	1.49 e-g	0.77 fg	0.52 f
SC-2028-22 x 45x15 cm x Control	5.36 c	5.37 d	5.35 d-f	5.30 d-f	4.80 c	4.54 b-d	3.79 bc	3.75 bc	3.38 c	3.14 c
S.Em±	0.12	0.14	0.19	0.18	0.23	0.24	0.21	0.16	0.12	0.11

Table 4. Number of leaves of compact cotton genotypes as influenced by planting geometry and defoliator application

Treatments	Before spray	Number of leaves per plant								
		Days after defoliator spray (DADFS)								
		2	4	6	8	10	12	14	16	18
Genotypes (G)										
G_1-RAH-274	7.3b*(53.8)**	7.2b (52.2)	6.9b (47.2)	6.7b (44.6)	6.2b (38.1)	5.3b (29.0)	4.5b (22.2)	3.7b (16.4)	3.0b (12.6)	2.5b (9.5)
G_2-SC-2028-22	7.7a (59.7)	7.6a (57.7)	7.2a (52.4)	7.0a (48.4)	6.5a (42.3)	6.0a (36.0)	5.1a (27.6)	4.4a (21.5)	3.6a (16.0)	3.1a (12.9)
S.Em±	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.03
Planting geometry (S)										
S_1-45cm x 10cm	7.4b (55.0)	7.4b (54.1)	7.0b (48.8)	6.7b (45.0)	6.2b (38.1)	5.4b (29.7)	4.6b (22.6)	3.8b (17.3)	3.0b (13.0)	2.6b (9.9)
S_2-45cm x 15cm	7.6a (58.5)	7.5a (55.8)	7.1a (50.9)	6.9a (47.9)	6.5a (42.3)	5.9a (35.3)	5.1a (27.3)	4.3a (20.6)	3.5a (15.6)	3.0a (12.6)
S.Em±	0.01	0.02	0.02	0.02	0.01	0.01	0.02	0.02	0.03	0.01
Defoliator levels (D)										
D1-Dropp Ultra (200 ml/ha)	7.3a (57.3)	7.4a b (55.0)	7.0ab (49.9)	6.8b (46.5)	5.9b (39.4)	5.6b (31.4)	4.8b (23.1)	4.0b (16.1)	2.7b (7.7)	1.9b (3.7)
D2-Ethrel (2000 ppm)	7.6a (56.4)	7.3b (54.2)	7.2b (48.4)	6.6c (44.0)	6.8c (35.2)	4.9c (24.0)	3.5c (12.4)	2.2b (5.1)	1.5c (2.5)	1.2c (1.4)
D3-Control	7.5a (56.5)	7.5a (55.7)	7.1a (51.2)	7.0a (48.9)	6.3a (46.2)	6.5a (42.0)	6.3a (39.3)	6.0a (35.7)	3.7a (32.7)	5.3a (28.3)
S.Em±	0.02	0.03	0.04	0.03	0.04	0.04	0.07	0.05	0.04	0.03
Interactions (G x S x D)										
RAH-274 x 45x10 cm x Dropp Ultra	7.2gh (51.3)	7.2ef (51.3)	6.8d (46.3)	6.5fg (42.0)	5.9e (34.4)	4.9fg (24.4)	4.3e (18.2)	3.2g (10.5)	1.8f (3.3)	1.4h (2.1)
RAH-274 x 45x10 cm x Ethrel	7.1h (51.1)	7.1f (50.4)	6.7d (45.0)	6.4g (40.8)	5.5f (30.0)	4.1h (16.7)	2.7g (7.4)	1.8j (3.3)	0.9h (0.9)	0.6i (0.4)
RAH-274 x 45x10 cm x Control	73fg (52.6)	7.2ef (51.7)	6.9cd (47.2)	6.8cd (45.9)	6.5cd (42.7)	6.1d (37.1)	6.0b (36.2)	5.6c (31.9)	5.6b (30.9)	4.6d (21.6)
RAH-274 x 45x15 cm x Dropp Ultra	7.5de (56.7)	7.2ef (52.4)	6.9cd (48.2)	6.8cd (46.7)	6.3d (39.9)	5.6e (31.2)	4.6de (21.4)	3.5f (12.5)	2.1e (4.6)	1.7g (3.0)
RAH-274 x 45x15 cm x Ethrel	7.5de (55.7)	7.3de (53.4)	6.8d (46.5)	6.6ef (43.2)	5.9e (35.0)	4.8g (22.8)	3.2f (10.4)	2.3i (5.5)	1.7f (2.8)	1.3h (1.7)
RAH-274 x 45x15 cm x Control	7.4ef (55.3)	7.4cd (54.3)	7.1bc (50.0)	7.0ab (48.8)	6.8ab (46.7)	6.4bc (41.6)	6.3ab 40.0)	5.9b (34.7)	5.7ab (32.9)	5.3c (28.5)
SC-2028-22 x 45x10 cm x Dropp Ultra	7.7bc (58.8)	7.6ab (57.9)	7.2b (51.1)	6.8cd (46.7)	6.3d (40.0)	5.6e (31.5)	4.9d (23.7)	4.3e (18.2)	3.0d (8.8)	1.9f (3.8)
RAH-274 x 45x15 cm x Ethrel	7.6cd (57.9)	7.5bc (56.3)	7.1bc (50.9)	6.7de (44.9)	6.0e (35.6)	5.1f (26.2)	3.5f (12.3)	2.0j (4.1)	1.4g (1.9)	1.4h (1.8)
RAH-274 x 45x15 cm x Control	7.6cd (58.1)	7.6ab (57.1)	7.2b (52.2)	7.1a (49.9)	6.8ab (46.1)	6.5b (42.3)	6.1b (37.8)	6.0b (36.0)	5.7ab (32.0)	5.5b (29.8)
RAH-274 x 45x15 cm x Dropp Ultra	7.7bc (59.9)	7.6ab (58.4)	7.3ab (53.8)	7.1a (50.7)	6.6bc (43.2)	6.2cd (38.5)	5.4c (29.1)	4.8d (23.3)	3.7c (13.9)	2.4e (5.9)
RAH-274 x 45x15 cm x Ethrel	7.8ab (61.1)	7.5bc (56.7)	7.1bc (51.0)	6.9bc (47.2)	6.3d (40.0)	5.5e (30.5)	4.4e (19.5)	2.7h (7.5)	2.1e (4.4)	1.7g (2.9)
RAH-274 x 45x15 cm x Control	7.9a (62.5)	7.7a (59.6)	7.5a (55.5)	7.1a (51.0)	7.0a (49.1)	6.9a (47.2)	6.6a (43.2)	6.3a (40.0)	5.9a (35.1)	5.8a (33.4)
S.Em±	0.04	0.06	0.07	0.06	0.08	0.08	0.15	0.10	0.09	0.05

* Figures indicating $\sqrt{x}$ transformation values, ** Figures in parenthesis are indicating original values

Means followed by the same letters within a column are not significantly differed by DMRT (P=0.05)

Table 5. Effect of planting geometry and defoliator application on leaf dry weight of compact cotton genotypes at various intervals

Treatments	Leaf dry weight (g/plant)									
	Before spray	Days after defoliator spray (DADFS)								
		2	4	6	8	10	12	14	16	18
Genotypes (G)										
G_1-RAH-274	27.0b*(20.7)**	26.7b (20.2)	24.0b (16.5)	23.2b (15.6)	22.3b (14.5)	19.9b (11.8)	17.0b (9.3)	14.2b (7.2)	12.5b (6.0)	11.7b (5.2)
G_2-SC-2028-22	29.8a (24.8)	29.7a (24.6)	26.3a (19.7)	25.5a (18.6)	23.3a (15.7)	22.7a (15.0)	19.9a (12.1)	17.3a (9.7)	14.7a (7.5)	14.1a (7.0)
S.Em±	0.3	0.3	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.1
Planting geometry (S)										
S_1-45cm x 10cm	28.0b (22.0)	27.5b (21.5)	24.8b (17.7)	23.9b (16.5)	22.2b (14.3)	20.5b (12.5)	17.6b (9.8)	15.1b (7.8)	13.0b (6.0)	12.4b (5.1)
S_2-45cm x 15cm	28.9a (23.5)	28.9a (23.3)	25.4a (18.5)	24.8a (17.7)	23.4a (15.8)	22.1a (14.3)	19.4a (11.6)	16.5a (9.0)	14.1a (7.2)	13.4a (6.8)
S.Em±	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.2
Defoliator levels (D)										
D1-Dropp Ultra (200 ml/ha)	28.7a (23.1)	28.4a (22.7)	24.9a (17.8)	24.3ab (17.0)	22.8b (15.1)	21.3b (13.2)	18.0b (9.7)	14.6b (6.6)	10.6b (3.5)	9.0b (2.6)
D2-Ethrel (2000 ppm)	28.2a (22.4)	27.9ab (21.9)	24.5b (17.3)	23.6b (16.1)	20.8c (12.7)	18.3c (10.0)	13.0c (5.2)	9.1c (2.6)	7.4c (1.7)	6.9c (1.4)
D3-Control	28.4a (22.7)	28.4a (22.6)	26.0ab (19.2)	25.2a (18.2)	24.7a (17.5)	24.3a (17.0)	24.4a (17.2)	23.7a (16.1)	22.8a (15.0)	22.8a (15.0)
S.Em±	0.4	0.3	0.4	0.4	0.2	0.2	0.3	0.3	0.2	0.2
Interactions (G x S x D)										
RAH-274 x 45x10 cm x Dropp Ultra	26.1d (19.4)	25.9c (19.0)	23.2d (15.5)	22.5cd (14.7)	21.9ef (14.0)	18.9h (10.5)	16.4d (8.0)	10.7e (3.5)	8.3d (2.1)	7.0fg (1.5)
RAH-274 x 45x10 cm x Ethrel	26.6cd (20.0)	25.0c (17.9)	23.3d (15.7)	22.0c (14.1)	20.2g (12.0)	16.2i (7.8)	10.1f (3.1)	7.3f (1.6)	6.2e (1.2)	4.8h (0.7)
RAH-274 x 45x10 cm x Control	26.6cd (20.1)	26.5c (19.9)	24.5bc (17.2)	23.3b-d (15.7)	23.5cd (15.9)	22.2de (14.3)	22.6b (14.8)	21.9b (13.9)	21.9b (13.9)	21.8b (13.8)
RAH-274 x 45x15 cm x Dropp Ultra	28.8a-c(23.2)	28.3b (22.5)	23.9cd (16.4)	23.8b-d (16.3)	22.7de (14.8)	20.8fg (12.6)	15.9d (7.5)	13.1d (5.1)	8.7d (2.3)	7.3fg (1.6)
RAH-274 x 45x15 cm x Ethrel	26.7cd (20.2)	26.3c (19.7)	23.9cd (16.6)	23.4b-d (15.8)	20.8fg (12.6)	17.9h (9.5)	12.3e (4.6)	8.2f (2.1)	7.2de (1.6)	6.2g (1.2)
RAH-274 x 45x15 cm x Control	27.6bc 21.5)	28.2b (22.3)	24.9bc (17.7)	24.3a-d (17.0)	24.9b (17.7)	23.5c (15.9)	24.9a (17.8)	24.2a (16.9)	22.6b (14.8)	23.1a (15.4)
SC-2028-22 x 45x10 cm x Dropp Ultra	29.7ab (24.6)	29.6ab (24.4)	25.7a-d (18.8)	25.1a-c (18.0)	23.3cd (15.6)	22.0ef (14.0)	18.9c (10.5)	16.9c (8.5)	12.1c (4.4)	9.9d (3.0)
SC-2028-22 x 45x10 cm x Ethrel	29.3ab (23.9)	29.0ab (23.5)	25.6a-d (18.7)	24.6a-d (17.3)	20.1g (11.8)	18.8h (10.4)	13.3e (5.3)	10.0e (3.0)	7.6de (1.8)	7.8ef (1.9)
SC-2028-22 x 45x10 cm x Control	29.5ab (24.2)	29.3ab (24.0)	26.6a-c (20.1)	26.1ab (19.4)	24.2bc (16.8)	24.9b (17.7)	24.3a (16.9)	23.8a (16.3)	22.2b (14.3)	22.9ab(15.1)
SC-2028-22 x 45x15 cm x Dropp Ultra	30.2a (25.3)	29.5ab (24.2)	26.8ab (20.4)	25.9ab (19.1)	23.4cd (15.8)	23.3cd (15.7)	21.0b (12.8)	17.5c (9.1)	13.1c (5.2)	11.7c (4.1)
SC-2028-22 x 45x15 cm x Ethrel	30.3a (25.4)	30.3a (25.5)	25.2a-d (18.2)	24.5a-d (17.2)	22.3de (14.4)	20.3g (12.1)	16.2d (7.8)	10.9e (3.6)	8.7d (2.3)	8.9de (2.4)
SC-2028-22 x 45x15 cm x Control	30.1a (25.2)	30.6a (25.6)	27.9a (21.8)	27.0a (20.7)	26.3a (19.6)	26.7a (20.2)	25.9a (19.1)	24.7a (17.5)	24.4a (17.1)	23.4a (15.7)
S.Em±	0.7	0.5	0.8	0.9	0.4	0.4	0.6	0.5	0.5	0.4

* Figures indicating transformation values, ** Figures in parenthesis are indicating original values

Means followed by the same letters within a column are not significantly differed

Table 6. Quality properties of compact genotypes as influenced by planting geometry and defoliator application

Treatments	Fibre quality properties						
	Micronaire (µg/inch)	Fibre strength(g/tex)	Fibre length (mm)	G.O.T (%)	Uniformity ratio (%)	Maturity ratio (%)	Fibre elongation (%)
Genotypes (G)							
G_1-RAH-274	4.67 a	25.16 b	26.94 b	35.40 a	82.09 a	0.70 a	6.51 ab
G_2-SC-2028-22	4.51 ab	26.81 a	28.12 a	34.78 ab	83.88 a	0.67 a	6.60 a
S.Em±	0.07	0.23	0.16	0.24	0.91	0.68	0.03
Planting geometry (S)							
S_1-45cm x 10cm	4.48 b	25.71 ab	27.23 a	34.57 b	82.93 a	0.67 a	6.49 ab
S_2-45cm x 15cm	4.72 a	26.27 a	27.83 a	35.60 a	83.04 a	0.69 a	6.61 a
S.Em±	0.04	0.21	0.23	0.18	0.36	0.02	0.03
Defoliator levels (D)							
D1-Dropp Ultra (200 ml/ha)	4.60 ab	25.84 a	27.04 a	34.86 a	83.38 a	0.61 ab	6.53 a
D2-Ethrel (2000 ppm)	4.45 a	25.44 a	27.92 a	35.19 a	82.81 a	0.68 a	6.55 a
D3-Control	4.73 a	26.69 a	27.63 a	35.23 a	82.78 a	0.76 a	6.58 a
S.Em±	0.08	0.45	0.33	0.38	0.52	0.04	0.03
Interactions (G x S x D)							
RAH-274 x 45x10 cm x Dropp Ultra	4.65 a-c	23.99 c	26.75 b-d	34.60 a	83.23 a-d	0.60 a	6.40 e
RAH-274 x 45x10 cm x Ethrel	4.50 a-c	24.86 bc	27.08 a-d	35.30 a	81.33 cd	0.70 a	6.43 e
RAH-274 x 45x10 cm x Control	4.46 bc	24.99 bc	25.52 d	35.06 a	79.87 d	0.77 a	6.43 e
RAH-274 x 45x15 cm x Dropp Ultra	4.93 ab	24.92 bc	26.07 cd	35.68 a	83.57 a-c	0.63 a	6.47 de
RAH-274 x 45x15 cm x Ethrel	4.50 ac	26.19 a-c	28.41 ab	35.73 a	81.70 b-d	0.70 a	6.77 a
RAH-274 x 45x15 cm x Control	5.00 a	26.02 a-c	27.81 a-c	36.06 a	82.87 a-d	0.80 a	6.53 c-e
SC-2028-22 x 45x10 cm x Dropp Ultra	4.55 ac	25.83 a-c	27.91 a-c	34.08 a	84.57 a-c	0.59 a	6.53 c-e
SC-2028-22 x 45x10 cm x Ethrel	4.18 c	27.07 ab	28.03 a-c	34.42 a	85.37 a	0.64 a	6.43 e
SC-2028-22 x 45x10 cm x Control	4.55 ac	27.50 ab	28.06 a-c	33.99 a	83.23 a-d	0.73 a	6.73 ab
SC-2028-22 x 45x15 cm x Dropp Ultra	4.28 c	28.60 a	27.41 a-d	35.07 a	82.17 a-d	0.61 a	6.70 a-c
SC-2028-22 x 45x15 cm x Ethrel	4.63 a-c	23.63 c	28.18 a-c	35.30 a	82.83 a-d	0.68 a	6.57 b-e
SC-2028-22 x 45x15 cm x Control	4.89 ab	28.23 a	29.12 a	35.80 a	85.13 ab	0.73 a	6.63 a-d
S.Em±	0.15	0.90	0.66	0.76	1.05	0.08	0.07

Means followed by the same letters within a column are not significantly differed by DMRT (P=0.05)

(222222 plants/ha) (Table 1). This was mainly due to plant population per unit area which might be optimum for better yield attributes compared to the yield attributes recorded under narrow spacing. With increase in planting density the yield per unit area generally increased to an upper limit or optima later plateaus and ultimately declines. The optimum plant density under this parabolic relationship will depend upon the genotype characteristics, properties of soil, climatic parameters and management regime (Silvertooth *et al.,* 1999).

Number of leaves, leaf area and leaf area index play vital role in determining the photosynthetic capacity of plant and dry matter production. Leaf area index gives a fairly good idea of the photosynthetic surface. Significantly higher number of leaves per plant and leaf area was produced under 45x15 cm spacing at 18 DADFS (12.6 and 9.31 dm^2/plant, respectively) as compared to spacing of 45x10 cm (9.9 and 8.11 dm^2/plant, respectively) (Table 2 and 4). This might be attributed to the fact that growth and development of leaves was suppressed in closer spacing with higher plant population. Further, area occupied by each plant was less in closer than wider spacing. Similar findings of suppression of production and expansion of leaves at higher densities were noticed by Aher *et al.* (1980) and Manjappa *et al.* (1997) in cotton crop. However, higher LAI was noticed with narrow spacing of 45x10 cm during all the observation intervals. Even with the increased leaf area per plant at wider spacing the reduction in leaf area index was observed mainly due to the reduced plant population. This is in consonance with the earlier findings of Devendra Singh *et al.* (2011) and Brodrick *et al.* (2013).

Influence of defoliator application

Among the defoliators, application of Ethrel @ 2000 ppm recorded significantly higher seed cotton yield (2086 kg/ha) as compared to water spray (1902 kg/ha) and it was on par with Dropp Ultra @ 200 ml/ha (2009 kg/ha) (Table 1). Seed cotton yield increased to tune of tune of 3.7 per cent and 8.8 per cent over Dropp Ultra @ 200 ml/ha and control, respectively. Seed cotton yield is governed by number of factors, which have a direct or indirect impact. The factors which have direct influence on seed cotton yield are the yield components. Higher seed cotton yield per plant may be because of production of higher mean boll weight (4.03 g) (Table 1) and synchronized boll opening which was due to increased ethylene production within a boll to hasten opening and speed up dry out of fully opened bolls. Ethrel accelerates boll dehiscence by increasing ethylene level in cotton leaves (Suttle, 1985). Light penetration is also improved by leaf removal. These crop conditions lead to early and higher opening of bolls (Malik *et al.,* 1991).

Two days after defoliator application there was a drastic defoliation as stages advanced, however, at 18 DADFS significantly lower number of leaves per plant was recorded with Ethrel @ 2000 ppm (1.2) followed by Dropp Ultra @ 200 ml/ha (1.9) compared to control (5.3) (Table 4). There was significant reduction in leaf area with Ethrel @ 2000 ppm at 18 DADFS (3.01 dm^2/plant) over Dropp Ultra @ 200 ml/ha (4.33 dm^2/plant) and control (18.78 dm^2/plant) (Table 2). Whereas significantly higher leaf area index was recorded under control treatment (3.44) than Dropp Ultra @ 200 ml/ha (0.78) and Ethrel @ 2000 ppm (0.54) (Table 3). Application of Ethrel promotes senescence and abscission by promoting the synthesis of cell wall degrading enzymes *viz.,* cellulose and dehydrogenase (Kader, 1985). Hence, application of chemical defoliator in the later crop growth stages resulted in defoliation with less number of leaves and leaf area. Accelerate leaf defoliation occurs by increasing ethylene level in cotton leaves (Suttle, 1985). The water spray (control) treatment took more days for defoliation of leaves naturally and reduced significantly higher number of leaves per plant, leaf area and leaf area index during all the observation intervals.

Environment accounted more for fibre quality variations than agronomic practices and defoliants. In the present study also none of the fibre quality parameters (Micronaire, Fibre strength, Fibre length, GOT, Uniformity ratio, Maturity ratio and Fibre elongation) were affected by chemical defoliator application (Table 6). These results are in agreement with findings of Anon. (2009).

Interaction effects

Interaction of RAH-274 grown at spacing of 45x15 cm with application of Ethrel @ 2000 ppm recorded significantly higher seed cotton yield (2241 kg/ha) over rest of interactions. However, it was on par with combination of Dropp Ultra @ 200 ml/ha (2122 kg/ha) and control (water spray) (2067 kg/ha) (Table 1). This was mainly due to the higher yield components *viz.,* number of bolls (10.2), mean boll weight (4.03 g) and yield per plant (36.2 g/plant). However, leaf area, number of leaves per plant and leaf dry weight recorded significantly higher with the interaction of SC-2028-22 at spacing of 45x15 cm under control treatment (21.17 dm^2/plant, 5.8 and 23.4 g/plant, respectively) compared to other interactions.

Conclusion

Genotype, RAH-274 grown at spacing of 45x15 cm with defoliant Ethrel @ 2000 ppm recorded significantly higher seed cotton yield (2241 kg/ha) with higher yield components *viz.*, seed cotton yield (36.2 g/plant) and mean boll weight (4.03 g) under rainfed condition.

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