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Crop geometry and nitrogen management impacts on cotton cultivar H-1098(i) productivity

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ABSTRACT

A field investigation was undertaken to study plant geometry and nitrogen management on performance of cotton variety H-1098 (i). The experiment was conducted during *kharif* 2015 at CRS, Sirsa, Haryana, in split plot design with 3 replications consisting of four spacing of cotton crop in main plots while four levels of nitrogen in subplots. Experimental results revealed that among different crop geometries, significantly higher plant population, plant height and LAI was observed with 67.5 cm × 10 cm spacing than rest spacing's treatments however weight of boll was not affected by different plant geometry. Wider spacing (67.5 cm × 30 cm) had higher dry matter accumulation, sympodial branches and number of bolls per plant but yield of seed cotton was recorded highest under 67.5 cm × 15 cm spacing than recommended spacing (67.5 cm × 30 cm). Periodic growth parameters like plant height and leaf area index (LAI) significantly increased with 25% increase in nitrogen dose over recommended dose of nitrogen however plant population was not significantly influenced by different nitrogen doses. Higher dry matter accumulation observed with 150% recommended dose of nitrogen over rest of treatments but number of sympodial branches was maximum at 100% of recommended nitrogen dose which remained statistically at par with further increased in nitrogen doses. Seed cotton yield and the number of bolls/plant increased significantly with 125% RDN over 100% and 75% of recommended nitrogen dose.

Key words: Cotton, Growth, Nitrogen, Productivity, Spacing, Yield

Cotton is a valuable fiber crop throughout the globe, also known as "white gold". In India, cotton is cultivated on area of 12.4 million hectares with 37 million bales production and average yield of 505 kg/ha, Whereas, in Haryana its area, production and productivity are 0.66 million ha, 2.2 million bales and 571.7 kg/ha, respectively (India Stat 2017). Cotton is grown mainly for fiber use in distinct areas of the nation, thus regarded as the main agricultural commodity of textile industry, supporting Indian economy. To address the rising fiber needs of the textile sector and global trade demands, cotton production needs to be accelerated not only through the inclusion of more areas of cotton but also through a more focused emphasis on agricultural activities, including plant density and nutrient management of potential genotypes for providing livelihood and improving financial status of farmers. To reduce the struggle between plants for getting more plant nutrients and moisture, it is crucial to find out the right combination of plant densities and doses of nitrogen to attain maximum cotton yield. Fulfilment of nutritional requirements of the cotton plant is essential for increasing yield (Kalaichelvi 2009). Nitrogen is primary nutrient essential for cotton plants necessitate to supply at proper time and quantities (Giri *et al.* 2014). Productivity of cotton can significantly be enhanced by proper spacing and fertilizer doses (Kumar *et al.* 2011). Growing of desi cotton with closer plant density produced considerably highest lint yield, maximum net returns and benefit cost ratio as compared to higher plant density due to more number of picked bolls per unit area (Kumar *et al.* 2017). Therefore, knowledge of adequate plant densities and nitrogen levels is essential not only to save the input investment during cultivation, but also to augment the production through efficient utilization of resources. American variety H-1098(i) is a sympodial type cultivar which performs well under closer spacing. In view of the above, present research work undertaken with the objective to know the crop geometry and nitrogen levels impacts on growth and productivity of cotton cultivar H-1098(i).

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MATERIALS AND METHODS

The field experiment was conducted at Cotton Research Station (CRS), Sirsa, CCS Haryana Agricultural University during *kharif* 2015. Geographically, Sirsa is positioned at 29°25′ N latitude, 74°40′ E longitude and 202 m altitude and have semi-arid climate receiving less annual rainfall of 318 mm although related humidity fluctuate from 40–90% in year. Temperature ranging from freezing point (minimum) in December to 48°C (maximum) in June. During crop experiment, 205.07 mm rainfall was occurred. The experimental soil texture was loamy sand having 8.5 *p*H, 0.35% organic carbon, 0.56 dSm/m electrical conductivity, available nitrogen (low-137.0 kg/ha), available phosphorus (medium-13.4 kg/ha) and available potash (high-413 kg/ha). The experiment on cotton crop conducted in split plot design having treatments of spacing's (S1= 67.5 cm × 10 cm, S2 = 67.5 cm × 15 cm, S3= 67.5 cm × 22.5 cm and S4 = 67.5 cm × 30 cm) in main plots and nitrogen doses (75%, 100%, 125%, and 150% of the recommended dose of nitrogen) in sub plots with 3 replications in 5.4 m × 6.3 m plot size. Recommended dose of nitrogen was 87.5 kg/ha. Cotton variety H-1098 was first sympodial variety with 0-1 monopodial branches released in 1995 for Haryana. It is non-Bt hirsutum cultivar gaining popularity due to its early maturing habit and suitability for late planting condition. As per spacing, seeds were sown deep (5 cm) by hand dibbling on May 19th, 2015. According to the treatments, different nitrogen doses were applied half at squaring stage and remaining half at flowering stage through urea, however, basal application of full dose of phosphorus was applied through DAP while others practices were carried as per university guidelines. Plant population was taken by counting the number of plants per plot. The plant height (cm) was recorded from ground level to last unfolded leaf base at the top. Reading of dry matter accumulation (g/plant) was taken through dried uprooting plant without roots in a hot air oven at 65° ± 2°C. The leaf area of cotton was recorded with the help of leaf area meter and then Leaf area index (LAI) was calculated as:

$$\text{Leaf area index} = \frac{\text{Leaf area per plant}}{\text{Land area per plant}}$$

The data of crop height (cm), dry matter (g/plant) and LAI were taken from five randomly selected plants in each plot at 50 days interval after sowing up to maturity. At maturity, Fruit bearing/sympodial branches were recorded by taking randomly five plants per plot whereas, at each picking, numbers of bolls were measured from five tagged plants per plot and expressed it on per plant basis while boll weight reading obtained by computing average weight of seed cotton of ten bolls from each plot. Seed cotton yield was recorded on per plot basis in all picking and expressed as yield in kilograms (kg) per hectare. The experimental data were analyzed as per the standard statistically technique.

RESULTS AND DISCUSSION

Growth Parameters

Plant height: Effect on plant height (cm) by various treatments was measured at different time intervals during crop growth (Table 1). Significant difference was observed in plant height due to different spacing at all intervals except at 50 DAS. Spacing of 67.5 cm × 10 cm produced significantly tallest plants, viz. 112.6, 138.3 and 139.4 cm at 100, 150 DAS and at harvest, respectively as compared to 67.5 cm × 15 cm, 67.5 cm × 22.5 cm and 67.5 cm × 30 cm spacing. Taller plants were recorded with narrow spacing because of more vertical growth due to congestion of plant per unit area. Similar results were recorded by Ram

Table 1 Effect of crop geometries and nitrogen doses on plant height, dry matter accumulation and Leaf area index (LAI) of cotton, recorded at different intervals

Treatment	50 DAS			100 DAS			150 DAS			At Harvest		
	Plant height (cm)	Dry matter accumulation (g/plant)	Leaf area index	Plant height (cm)	Dry matter accumulation (g/plant)	Leaf area index	Plant height (cm)	Dry matter accumulation (g/plant)	Leaf area index	Plant height (cm)	Dry matter accumulation (g/plant)	Leaf area index
Spacing												
S1: 67.5 cm × 10 cm	52.6	19.0	0.81	112.6	86.9	1.92	138.3	117.9	2.36	139.4	131.9	0.77
S2: 67.5 cm × 15 cm	51.5	20.6	0.76	107.6	96.9	1.76	131.8	133.2	2.22	134.8	147.5	0.70
S3: 67.5 cm × 22.5 cm	50.7	22.9	0.70	104.5	109.5	1.57	128.7	142.1	2.10	131.7	158.8	0.64
S4: 67.5 cm × 30 cm	50.0	25.1	0.67	102.3	118.6	1.47	126.8	150.9	1.88	129.5	168.9	0.60
SE(m)±	1.3	0.4	0.01	0.9	1.8	0.03	1.8	1.9	0.03	0.9	2.2	0.01
CD (P=0.05)	NS	1.3	0.04	3.1	6.3	0.13	6.4	6.8	0.12	3.4	7.6	0.05
Nitrogen levels												
N1: 75% of RDN	49.6	19.7	0.71	101.3	94.8	1.55	123.8	126.7	1.97	126.3	141.7	0.61
N2: 100% of RDN	50.8	21.2	0.73	105.5	100.1	1.64	129.5	133.2	2.12	131.8	148.5	0.67
N3: 125% of RDN	51.9	22.6	0.74	109.1	105.6	1.74	135.2	139.1	2.21	137.6	155.2	0.69
N4: 150% of RDN	52.5	24.1	0.76	111.0	111.4	1.79	137.1	145.0	2.26	139.8	161.7	0.71
SE(m)±	1.2	0.5	0.01	1.1	1.5	0.02	1.7	1.1	0.03	1.5	2.0	0.01
CD (P=0.05)	NS	1.4	NS	3.2	4.5	0.08	4.9	5.8	0.09	4.5	6.1	0.03

and Giri (2006), Bhalerao *et al.* (2010) and Jat *et al.* (2014). Similarly, the different nitrogen doses had no significant effect on plant height (cm) at 50 DAS. The plant height significantly improved with increase in nitrogen doses upto 125% RD of nitrogen and maximum plant height observed at 150% RD of nitrogen. Although 125% and 150% RD of nitrogen had no significant difference on plant height, but these treatments were significantly higher than 75% and 100% RD of nitrogen at 100, 150 DAS and at harvest. This credit in height was due to greater accessibility of nitrogen helping cell enlargement, enhance physiological process and synthesis of more carbohydrates. The increased plant height with increased nitrogen levels was reported earlier by Narayana *et al.* (2007), Sunitha *et al.* (2010) and Doli *et al.* (2015).

Dry matter production: Dry matter accumulation was significantly influenced due to various spacing and nitrogen levels at all growth intervals (Table 1). Among different plant density, 67.5 cm × 30 cm spacing significantly produced higher dry matter accumulation/plant (25.1, 118.6, 150.9 and 168.9 g) at 50, 100, 150 DAS and the harvest of crop, respectively as compared to 67.5 cm × 10 cm, 67.5 cm × 15 cm and 67.5 cm × 22.5 cm. This was mainly due to larger ground area occupied by single plant, more nutrients availability and more light interception by leaves resulted into more photosynthetic activity and biomass accumulation. Bhalerao *et al.* (2010) and Shukla *et al.* (2014) confirmed similar results of spacing effect on dry matter accumulation. However, increasing of nitrogen application increased dry matter accumulation/plant at all growth stages of crop. Application of 150% RD of nitrogen significantly improved dry matter accumulation/plant (24.1, 11.4, 145 and 161.7 g) at 50, 100, 150 DAS and at harvest respectively over 75, 100 and 125% RD of nitrogen. Increasing levels of nitrogen from 75–150% RD of significantly increased dry matter accumulation/plant. More nitrogen application helps in significantly improvement of green leaves/plant, sympodial branches and photosynthetic activity. These observations are confirmed by the findings of Sunitha *et al.* (2010) and Rawal *et al.* (2015).

Leaf area index: Influenced of various treatments on leaf area index of cotton showed (Table 1) that LAI increased with crop age irrespective of the treatments upto 150 DAS and after that decline observed at harvest due to leaf senescence. Leaf area index was significantly higher (0.81, 1.92. 2.36 and 0.77) under 67.5 cm × 10 cm spacing at 50, 100, 150 DAS and at harvest respectively, as compared to other treatments, whereas 67.5 cm × 30 cm spacing recorded least value of LAI at different stages of crop. This plant indices determines solar energy trapping capacity of plant for photosynthesis. The results of closer spacing had maximum LAI than wider spacing, also confirmed with by Singh *et al.* (2012). However, nitrogen levels does not exhibit any significant effect on LAI at 50 DAS, but significantly higher LAI (1.74, 2.21 and 0.69) was observed up to 125% RD of nitrogen at 100, 150 DAS and at harvest respectively, over 75 and 100% RDN which was remained statistically at par with further increase in nitrogen dose. LAI increased with increasing nitrogen was due to more lateral branches enhanced leaf number. These results are also reported by Giri *et al.* (2008), Sankaranaratanan *et al.* (2011), Ghule *et al.* (2013) and Kulvir *et al.* (2014).

Yield and yield attributes

Plant population: The data (Table 2) revealed that 67.5 cm × 10 cm spacing had maximum plant population due to

Table 2 Seed cotton yield and other characters of cotton under different crop geometries and nitrogen levels

Treatment	Plant population (ha)	Sympodial branches/plant	Number of bolls/plant	Boll weight (g)	Seed cotton yield (kg/ha)
	30 DAS	At harvest			
Spacing					
S1: 67.5 cm × 10 cm	113665	9.2	7.4	3.02	2205
S2: 67.5 cm × 15 cm	77894	10.4	13.7	3.27	2438
S3: 67.5 cm × 22.5 cm	49281	10.6	15.1	3.34	2073
S4: 67.5 cm × 30 cm	39743	11.7	17.0	3.43	1971
SE(m)±	671	0.4	0.3	0.10	65
CD (P=0.05)	2322	1.4	1.2	NS	222
Nitrogen level					
N1: 75% of RDN	69568	9.3	11.9	3.02	1888
N2: 100% of RDN	71088	10.3	13.0	3.25	2127
N3: 125% of RDN	70294	10.8	14.7	3.35	2354
N4: 150% of RDN	69632	11.2	13.7	3.44	2318
SE(m)±	690	0.3	0.3	0.07	57
CD (P=0.05)	NS	1.0	0.9	0.22	167

Interaction of spacing and nitrogen was non-significant (S × N= NS) higher seed rate followed spacing of 67.5 cm × 15 cm, 67.5 cm × 22.5 cm and 67.5 cm × 30 cm, similar results were also reported by Singh and Rathore (2007) and Devraj *et al.* (2011). However, variations in plant population of cotton were not significant due to different nitrogen levels at 30 DAS. Similar finding were found by Devraj *et al.* (2011) and Modhvadia *et al.* (2012).

Number of sympodial branches: At maturity, 67.5 cm × 30 cm crop spacing recorded maximum sympodial branches/plant (11.7), significantly higher than 67.5 cm × 10 cm spacing (9.2) but statistically at par with spacing of 67.5 cm × 22.5 cm (10.6) and 67.5 cm × 15 cm (10.4). Wider spacing had good aeration, more interception of light and minimal nutrients competition between plants. Similar results were confirmed by Kumar *et al.* (2011). However, sympodial branches/plant increased up to 100% RD of nitrogen. The maximum sympodial branches/plant (11.2) were observed at 150% RDN which was higher significantly than 75% RDN (9.3) but was at par with 100% RD (10.3) and 125% RD of nitrogen. Significantly higher sympodial branches/plant was observed with 100% RDN over 75% RDN. Same results were also given by Kumar *et al.* (2011) and Modhvadia *et al.* (2012).

Number of bolls/plant: Wider spacing of 67.5 cm × 30 cm produced higher number of bolls/plant (17.0) than rest of 67.5 cm × 22.5 cm (15.1) and 67.5 cm × 15 cm (13.7) and 67.5 cm ×10 cm (7.4) spacing (Table 2). This happened due to more space for growth, development and interception of solar radiation. Bhalerao and Gaikwad (2010), Kumar *et al.* (2010) and Nehra and Yadav (2012) also confirmed similar results, whereas, maximum bolls number per plant (14.7) were observed at 125% RD of nitrogen which was at par with 150% RD of nitrogen but significantly higher over 75 and 100% RD of nitrogen. Number of bolls per plant increased from 75–125% RD of nitrogen. Results were confirmed earlier by Devraj *et al.* (2011) and Gadade *et al.* (2015).

Boll weight: Boll weight was not affected significantly by different spacing, however numerically maximum weight of boll (3.43) was attained with 67.5 cm × 30 cm spacing. Similar findings agreed by Ram and Giri (2006) and Paslawar *et al.* (2014). In case of different doses of nitrogen, 100% RDN application gave significantly higher weight of boll (3.25 g) than 75% RDN which was at par with further increase in nitrogen doses, however, 150% RD of nitrogen had maximum boll weight (3.44 g). The observations were conformity with Doli *et al.* (2015).

Seed cotton yield: Significantly higher yield (2438 kg/ha) of cotton was obtained with 67.5 cm × 15 cm spacing than recommended spacing of 67.5 cm × 30 cm (1971 kg/ha) due to more plants/unit area. Similar data were confirmed by Pawar *et al.* (2010). Seed cotton yield decreased with 67.5 cm × 10 cm due to both inter-plant and intra-plant competition cause reduction of yield/plant reported by Reddy and Reddy (2010). Application of 125% RD of nitrogen recorded maximum yield (2354 kg/ha), which was significantly higher than 75% RD (1888 kg/ha) and 100% RD of nitrogen (2127 kg/ha) but statistically at par with 150% RDN (2318 kg/ha). This was due to application of higher dose of N which increased number of bolls/plant, boll weight and yield/plant resulted into increased seed cotton yield/ha. Similar results were revealed by Asewar *et al.* (2013).

Present investigation concluded that cotton cultivar H-1098(i) can be growing at of 67.5 cm × 15 cm spacing and fertilized with 125% RD of nitrogen (109.37 kg N/ha). Nitrogen should apply in split dose with half nitrogen broadcasted at squaring stage and remaining half dose of nitrogen can give at flowering stage for achieving higher seed cotton yield under the soil deficient in nitrogen, medium in phosphorus and high in potash.

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