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Crop growth rate optimum leaf area index quantification and identification of suitable spacing for HDPS - a case study in cotton for Telangana

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ABSTRACT : Cotton cultivation has been steady in Telangana state in 2016 and 2017. Optimum leaf area index (LAI), maximum crop growth rate (CGR), suitable spacing and genotype have been identified in the present study in High Density Planting System (HDPS). LAI was observed to be influenced by sampling time, genotypes and spacings. Deltapine 9121 followed by WGCV 48 at 75 x 10 cm spacing recorded maximum LAI (5.0, 4.5). Maximum CGR (2.4 g/plant/day) was recorded at boll initiation with 75 x 10 cm in H 4. Optimum LAI (2.9) was recorded in H 4 between flowering to boll initiation stage (60-90 DAS). Deltapine 9121 followed by WGCV 48 in 75 x 10 cm recorded maximum boll number (8, 7.2) and boll weight (2.9, 2.5g). Decrease in spacing resulted in decreased contribution of boll number and weight to SCY. Maximum SCY was recorded in Deltapine 9121 at 75 x 10 (2888 kg/ha) followed by 60 x 10 cm (2394 kg/ha).

Key Words : Crop growth rate, HDPS, optimum leaf area index, seed cotton yield

In India in the last three years (2014-2015 to 2016-2017) area under cotton shows a decrease (128.5, 118.8 and 105 la ha) with a dwindling productivity (566, 484 and 568 kg/ha). In Telangana state in the last two years (2015-2016 to 2016-2017) little improvement was recorded in cotton area (17.1 and 17.8 la ha) and productivity (566 and 569 kg/ha) (Anonymous, 2017). *Bt* hybrids have been cultivated in the country predominantly. Farmers incur a lot of amount towards procurement of hybrid seed. The objective therefore has been to replace the hybrid technology with suitable varieties. Towards reduction of seed cost new techniques have been promoted like High Density Planting System (HDPS) also referred to as Ultra Narrow Row (UNR) spacing.

HDPS has been referred to as planting at a closer spacing than the recommended one using certain special techniques with the sole objective of obtaining maximum productivity/unit area without sacrificing quality. HDPS has been one of the most important advances in fiber production all over the world.

Agrotechniques which aim at improvement in productivity include selection of suitable genotypes and spacing. Genotypes for full expression of genetic potential have to fit into the length of growing season. Attainment of maximum leaf area, crop growth rate, dry matter accumulation and its partitioning into bolls decide the physiological efficiency and productivity. The present study was undertaken to understand the growth pattern of cotton genotypes and for identification of spacing requirement and suitable varieties *vis a vis* hybrids for Telangana state.

A field experiment was conducted at College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad representing southern Telangana agroclimatic zone during *kharif,* 2015-2016. Rainfall received in the season amounted to 763 mm. Gross plot size for each treatment was 9.0 x 2.0 m^2. Recommended dose of 90 N, 45 P_2O_5 and 45 K_2O kg/ha was applied in the form of Urea, SSP and MOP respectively. P_2O_5 was applied entirely as basal dose at the time of sowing. K_2O was applied in two splits and nitrogen was applied in three splits *viz.*, sowing, maximum vegetative stage and boll initiation stage. Experiment was laid out in split plot design with three replications, three spacings as main plots (S_1 - 75 x 10 cm, $S\text{-}_2$ - 60 x 10 cm and S_3 - 45 x 10 cm) and sub plots genotypes. Rrepresentative plants were destructively sampled from each plot at 30 DAS (square), 60 DAS (flower initiation), 90 DAS (boll formation) and 120 DAS (harvest stage). CGR was calculated to estimate the production efficiency. LAI defined as the one sided green leaf area/ unit ground surface area in broad leaf canopies was calculated for all the cotton spacings and expressed as leaf area / ground area. Yield attributes quantified included bolls / plant, boll weight (g) and seed cotton yield (SCY).

Cotton varieties have been known to genetically produce varied leaf area. LAI was significantly influenced in HDPS by sampling time, genotypes and spacings (Table 1). LAI values showed an increase at 60 DAS (0.9 – 4.0), reached maximum at 90 DAS (1.1 to 5.0) and tapered by 120 DAS (0.7 – 2.6). Interactions between spacing and genotype proved to be significant. At 90DAS Deltapine 9121 at 75 x 10 cm spacing recorded maximum LAI (5.0) followed by WGLV 48 (4.5). AKKA-*Bt* cotton sown at 90 x 45 cm recorded high LAI (1.69) (Nalwade *et al.*, 2013). LAI values showed a decrease (0.69, 0.62) with increase in plant spacing of 90 x 60 and 180 x 30 cm (Pendharkar *et al.,* 2010). High yields were reported in genotypes with maximum leaf area (Tayade *et al.,* 2011). Production of optimum LAI with maximum CGR appears critical to improve productivity.

Biomass formed / unit area of land has more practical relevance than productivity/ plant. In terms of total dry matter production by a crop or by a crop community, LAI and photosynthetic rate appear to be the major CGR determinants. CGR/plant was significantly influenced by sampling time, plant spacings and genotypes under HDPS. CGR value was non significant after 100 DAS at all other plant spacings. Vineela *et al.,* (2013) reported wide variability in CGR which indicated the amenability of the trait towards directional selection. CGR peak was recorded at boll initiation (2.06 g/m^{-2} /day). CGR was minimum (0.5 g/m^{-2}/day) at low plant density and maximum (2.3 g/m^{-2} /day) at high plant density in 45 cm spacing in early and late sown crop respectively. Maximum CGR (2.4 g/plant/day) was recorded at boll initiation with spacing of 75 x 10 in H4 (Table 2). This indicates that sampling time, spacing, genotype and sowing time appear to be critical to attain maximum CGR. Deotalu *et al.,* (2013) reported a positive correlation where in maximum dry matter production/plant (71.04 g) was recorded in wider row spacing of 60 x 45 cm and less at spacing of 60 x 30 cm (56.71 g). Baskaran and Kavimani, (2015) reported less influence on dry matter production/plant owing to less photosynthetic rate in narrow plant spacing and less transportation of photosynthetic assimilates to the plant parts.

The present study revealed the occurrence of maximum values for CGR (2.4 g/

Table 1. LAI at different growth stages of cotton genotypes under different plant spacings

GENOTYPES	60 DAS				90 DAS				120 DAS			
	Spacings (cm)			**Mean**	Spacings (cm)			**Mean**	Spacings (cm)			**Mean**
	S1	S2	S3		S1	S2	S3		S1	S2	S3	
WGCV 48	4.0	3.2	2.0	**3.1**	4.5	3.7	2.3	**3.5**	2.6	2.2	1.4	**2.1**
NDLH 1938	3.0	3.2	1.9	**2.7**	3.5	3.1	1.9	**2.8**	2.1	1.8	1.1	**1.7**
H 4	2.8	2.7	1.4	**2.3**	2.9	2.6	1.6	**2.4**	1.7	1.6	1.0	**1.4**
SURAJ	1.8	1.7	1.2	**1.5**	2.5	2.5	1.4	**2.1**	1.5	1.5	0.8	**1.3**
ADB 39	1.6	1.5	1.0	**1.4**	2.6	2.3	1.2	**2.1**	1.5	1.4	0.7	**1.2**
ANJALI	2.2	1.8	1.2	**1.7**	2.3	2.1	1.2	**1.9**	1.4	1.3	0.7	**1.1**
ADB 542	1.9	1.5	0.9	**1.4**	2.4	2.1	1.4	**1.9**	1.4	1.2	0.8	**1.1**
NARASIMHA	4.0	3.0	1.6	**2.8**	2.1	1.8	1.1	**1.6**	1.2	1.0	0.7	**1.0**
DELTAPINE 9121	2.8	2.4	1.5	**2.2**	5.0	4.1	2.5	**3.9**	1.1	1.2	0.9	**1.1**
Mean	**2.7**	**2.3**	**1.4**		**3.1**	**2.7**	**1.6**		**1.6**	**1.5**	**0.9**	

Gi-Gj	SE(G)-0.003	CD(G)-0.012	Gi-Gj	SE(G)-0.002	CD(G)-0.012	Gi-Gj	SE(G)-0.003	CD(G)-0.012
Si-Sj	SE(S)-0.002	CD(S)-0.007	Si-Sj	SE(S)-0.002	CD(S)-0.007	Si-Sj	SE(S)-0.001	CD(S)-0.006
GiSi-GiSj	SE(G x S)-0.004	CD(G x S)-0.013	GiSi-GiSj	SE(G x S)-0.004	CD(G x S)-0.013	GiSi-GiSj	SE(G x S)-0.003	CD(G x S)-0.010
GiSi-GjSi	SE(G x S)-0.004	CD(G x S)-0.016	GiSi-GjSi	SE(G x S)-0.004	CD(G x S)-0.016	GiSi-GjSi	SE(G x S)-0.004	CD(G x S)-0.015

Table 2. CGR at different growth stages of cotton genotypes under different plant spacings

GENOTYPES	60 DAS				90 DAS				120 DAS			
	Spacings			**Mean**	Spacings			**Mean**	Spacings			**Mean**
	S1	S2	S3		S1	S2	S3		S1	S2	S3	
WGCV 48	1.3	1.1	0.8	**1.1**	2.1	1.8	1.6	**1.8**	1.2	1.1	0.9	**1.1**
NDLH 1938	1.1	1.0	0.8	**1.0**	2.3	1.2	1.5	**1.7**	1	0.9	0.7	**0.9**
H 4	0.8	0.6	0.8	**0.7**	2.4	1.7	1.6	**1.9**	1.1	1	0.8	**1.0**
SURAJ	0.8	0.5	0.7	**0.7**	2.2	1.8	1.1	**1.7**	1.1	1	0.8	**1.0**
ADB 39	0.7	0.4	0.6	**0.6**	1.7	1.5	1.0	**1.4**	1.2	1.1	0.9	**1.1**
ANJALI	0.9	0.5	0.5	**0.6**	1.3	1.2	1.0	**1.2**	1	0.9	0.7	**0.9**
ADB 542	0.8	0.5	0.5	**0.6**	1.3	1.2	1.1	**1.2**	0.8	0.6	0.5	**0.6**
NARASIMHA	0.7	0.4	0.4	**0.5**	1.1	0.9	0.9	**1.0**	0.9	0.7	0.4	**0.7**
DELTAPINE 9121	0.9	0.5	0.5	**0.6**	1.8	1.7	1.4	**1.6**	0.7	0.7	0.5	**0.6**
Mean	**0.8**	**0.6**	**0.6**		**1.8**	**1.4**	**1.2**		**1.0**	**0.9**	**0.7**	

Gi-Gj	SE(G)-0.003	CD(G)-0.012	Gi-Gj	SE(G)-0.002	CD(G)-0.012	Gi-Gj	SE(G)-0.003	CD(G)-0.012
Si-Sj	SE(S)-0.002	CD(S)-0.007	Si-Sj	SE(S)-0.002	CD(S)-0.007	Si-Sj	SE(S)-0.001	CD(S)-0.006
GiSi-GiSj	SE(G x S)-0.004	CD(G x S)-0.013	GiSi-GiSj	SE(G x S)-0.004	CD(G x S)-0.013	GiSi-GiSj	SE(G x S)-0.003	CD(G x S)-0.010
GiSi-GjSi	SE(G x S)-0.004	CD(G x S)-0.016	GiSi-GjSi	SE(G x S)-0.004	CD(G x S)-0.016	GiSi-GjSi	SE(G x S)-0.004	CD(G x S)-0.015

Table 3. Yield attributes and seed cotton yield of cotton genotypes under HDPS

GENOTYPES	Boll numbr				Boll weight (g)				Seed cotton yield (kg/ha)			
	Spacings (cm)			**Mean**	Spacings (cm)			**Mean**	Spacings (cm)			**Mean**
	S1	S2	S3		S1	S2	S3		S1	S2	S3	
WGCV 48	7.2	5.9	4.4	**5.8**	2.5	2.2	2.1	**2.3**	2169	1918	1761	**1949**
NDLH 1938	6.8	5.4	4.3	**5.5**	2.5	2.2	1.9	**2.2**	2016	1738	1519	**1758**
H 4	6.8	5.3	4.2	**5.4**	2.4	2.1	1.6	**2.0**	1921	1602	1271	**1598**
SURAJ	6.4	5.7	4.1	**5.4**	2.4	2.2	1.9	**2.1**	1784	1801	1471	**1685**
ADB 39	6.4	4.6	3.8	**4.9**	2.3	2.1	1.5	**2.0**	1728	1412	1113	**1418**
ANJALI	6.4	4.8	3.8	**5.0**	2.3	2.0	1.5	**1.9**	1362	1058	**1356**	
ADB 542	6.9	5.4	4.2	**5.5**	2.4	2.1	1.7	**2.1**	2060	1722	1438	**1740**
NARASIMHA	5.7	4.8	3.8	**4.8**	2.2	2.0	1.5	**1.9**	1644	1450	1160	**1418**
DELTAPINE 9121	8.0	6.0	4.6	**6.2**	2.9	2.6	2.1	**2.5**	2888	2394	2000	**2427**
Mean	**6.7**	**5.3**	**4.1**		**2.5**	**2.1**	**1.8**		**1984**	**1711**	**1421**	

Gi-Gj	SE(G)-0.003	CD(G)-0.012	Gi-Gj	SE(G)-0.002	CD(G)-0.012	Gi-Gj	SE(G)-0.003	CD(G)-0.012
Gi-Gj	SE(G)-0.31	CD(G)-0.91	Si-Sj	SE(S)-0.05	CD(S)-0.14	GiSi-GiSj	SE(G x S)-0.14	CD(G x S)-0.41
GiSi-GjSi	SE(G x S)-0.33	CD(G x S)-0.97	Gi-Gj	SE(G)-0.03	CD(G)-0.08	Si-Sj	SE(S)-0.04	CD(S)-0.10
GiSi-GiSj	SE(G x S)-0.11	CD(G x S)-0.30	GiSi-GjSi	SE(G x S)-0.09	CD(G x S)-0.26	Gi-Gj	SE(G)-30.42	CD(G)-30.26
Si-Sj	SE(S)-31.13	CD(S)-32.37	GiSi-GiSj	SE(G x S)-25.39	CD(G x S)-24.12	GiSi-GjSi	SE(G x S)-25.53	CD(G x S)-24.56

plant/day) at LAI (2.9) in H4 (optimum LAI) between flowering to boll initiation stage (60-90 DAS). Deltapine 9121 hybrid showed typical character of growth cessation at 90 DAS making it amenable for complete maturity of all bolls (Janaki Ramulu, 2016). Cotton being an indeterminate crop, initiation of flowers signals cessation of vegetative structures. This also facilitates diversion of assimilates to sinks. Favourable nutrient or moisture conditions that favour new growth facilitate new or additional sinks. This coupled with high dry matter partitioning resulted in high yields in Deltapine 9121 and WGCV 48.

Present study revealed that spacing and genotypes influenced the SCY. Jadhav *et al.,* (2015) reported that boll weight to be significantly influenced by plant geometries. Singh *et al.,* (2012) reported a positive correlation of SCY with plant geometries. Alse and Jadhav (2011) reported maximum boll weight (3.48 g) in wider spacing of 150 x 36 cm, followed by 120 x 45 cm (3.28 g) and 180 x 30 cm (3.10 g). Deltapine 9121 followed by WGLV-48 in 75 x 10 cm spacing recorded maximum boll number (8, 7.2) and boll weight (2.9, 2.5g). Decrease in spacing resulted in decreased contribution of boll to SCY (Table 3). Maximum SCY was recorded in Deltapine 9121 at 75 x 10 (2888 kg/ha). Aziz *et al.* (2011) however reported decreased yield with wider spacing of 90 × 45 cm (960 kg/ha).

Wider spacing of 75 x 10 cm enabled full expression of seed cotton yield of Deltapine 9121 followed by WGCV 48. Optimum LAI was recorded in H 4 that resulted in improved yield and yield attributes.

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