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SB Patil
1. Department of Agronomy, University of Agricultural Sciences (UAS), Dharwad, Karnataka, India
2. International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru Telangana, India

CP Mansur
Department of Agronomy, University of Agricultural Sciences (UAS), Dharwad, Karnataka, India

PM Gaur
International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru Telangana, India

SR Salkinkop
Department of Agronomy, University of Agricultural Sciences (UAS), Dharwad, Karnataka, India

SC Alagundagi
Department of Agronomy, University of Agricultural Sciences (UAS), Dharwad, Karnataka, India

Corresponding Author:
SB Patil
1. Department of Agronomy, University of Agricultural Sciences (UAS), Dharwad, Karnataka, India
2. International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru Telangana, India

Physiological and agrometeorology indices of machine harvestable chickpea genotypes in different planting density under rainfed ecosystem

SB Patil, CP Mansur, PM Gaur, SR Salkinkop and SC Alagundagi

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Abstract
The physiological and agrometeorological indices are the most precise and straightforward method to evaluate the contribution of different processes in plant development and prediction of yield. The field experiment conducted at ICRISAT, Patancheru, for two years. The results of pooled data revealed that the genotype JG-11 recorded higher SPAD values (62.27 and 63.42 at 30 and 60 days after sowing, respectively), soil moisture content (13.88%) and light absorption ratio (86.44%) and lower light transmission ratio (13.56%) as compared to tall/erect chickpea genotypes. Whereas, tall/erect genotype ICCV-11604 recorded a higher leaf relative water content (66.57 and 32.26%, respectively) at 40 and 70 days after sowing. The indices like SPAD value, leaf relative water content, and soil moisture content progressively and significantly decreased with an increase in plant density to either 20 percent or 40 percent higher than normal, and it was higher with normal plant density of 3.33 lakh ha^{-1}. On the contrary, the light absorption ratio increased with an increase in plant density as evidence of decreased light transmission through the plant canopies. A higher density of 4.66 lakh ha^{-1} noticed a higher light absorption ratio and lowered light transmission ratio (82.03 and 17.97%, respectively). However, the interaction effect of genotype and plant densities on relative water content, light absorption ratio, light transmission ratio, and soil moisture content found significant, but chlorophyll content found not significant. These indices play an important role in the final contribution to the crop yield, which helps in the selection of suitable genotypes and planting density for maximizing the chickpea production.

Keywords: Chickpea, SPAD, plant density, flowering, light absorption ratio

Introduction

Chickpea (*Cicer arietinum* L.) is the principal pulse crop and an important source of protein for millions of people in developing countries, particularly in South Asia, who are mostly vegetarian either by choice or because of economic reasons. Chickpea is rich in protein, fiber, minerals (phosphorus, calcium, magnesium, iron, and zinc) and β-carotene. Chickpea meets 80% of its nitrogen requirement from symbiotic nitrogen fixation and can fix up to 140 kg N ha^{-1} $season^{-1}$ from the air. It has biological nitrogen fixation capacity and provides a significant amount of nitrogen to subsequent crops and adds plenty of organic matter to maintain and improve soil health and fertility. Chickpea can withstand drought conditions by extracting moisture from deeper layers of the soil profile as it has deep tap root system.

The present-day tasks of agronomy derive from the necessity of satisfying the growing needs of the population for agricultural products. The agronomic sciences are called upon to develop methods that will steadily free agriculture from the effects of harmful natural factors, particularly drought. Hence, a significant role belongs to mechanization, agricultural engineering, use of chemistry, land development and seed selection, and growing. Among different agronomic production technologies, optimum plant density, and selection of appropriate genotypes suitable for mechanical harvesting are very important to increase the chickpea area and production by reducing the dependency on scarce labour for harvesting. There is a yield gap between in chickpea, and that can be bridged by using an optimized seed rate of various chickpea genotypes to improve its production [1]. The release of new genotypes has contributed a great deal towards the improvement of chickpea yields, and further tall/erect genotypes would further facilitate mechanical harvesting. But, the yield of tall/erect genotypes has comparable seed yield against semi-erect genotypes in a normal environment [2]. The yield potential of these genotypes can be further increased by providing an optimum environment by manipulating agronomic practices such as plant density and seeding rate. It supported by the field experiment conducted by Mirzaei *et al.* [3] on chickpea; the results indicated that by increasing plant densities, grain yield increased accordingly. Khourgami and Rafiee [4] also reported that an increase in plant densities from 30 to 66 plants m^{-2} increased the seed yield and biological yield of chickpea planted in dry farming conditions.

The physiological growth indices are the most simple and precise method to evaluate the contribution of different processes in plant development [5] and prediction of crop yield [6]. The indices such as chlorophyll content (SPAD), leaf relative water content (RWC), light absorption ratio (LAR), light transmission ratio (LTR), and soil moisture content (SMC) are influenced by genotypes, plant density, climate and soil fertility [7]. Some experiments have shown that the optimum plant density helps for the proper utilization of solar radiation, which influences leaf area, interception and use of solar radiation, and consequently dry matter accumulation and yield [8,9]. On the other hand, to increase yield in machine harvestable chickpea genotypes must be planted at proper plant density. The growth rate depends on the ability of a crop to capture light and the efficiency of conversion of intercepted light into biomass [10]. Thus, the growth of a plant may be analyzed in terms of radiation interception and its use efficiency [11, 12]. Mirzaei *et al.* [3] investigated the effect of plant density on physiological traits in chickpea cultivars. They reported that by increasing plants per unit area resulted in an increment in leaf chlorophyll content accompanied by a reduction of light interception under the canopy. Similarly, Vaishya and Fayaz Qazi [13] reported that the greater plant population density and higher seed rate increase the competition for available nutrients, moisture and light, resulting in lower chlorophyll content. Muhammad [14] reported that a population of 200 plants m^{-2} enhanced photosynthetically active ration (PAR) interception and radiation utilization efficiency over 150 or 100 plants m^{-2}. The aim of the investigation was to study the physiological indices of machine harvestable chickpea genotypes in response to different plant densities under the rainfed ecosystem.

Materials and Methods

Experimental site and treatment details

The field experiment conducted in a black precision experimental plots of the International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru, Telangana, India, for two years (2011-13). The soil type of the ICRISAT sites was Vertisol with black clay loam texture. The physico-chemical properties of soils of the experiment conducted during *rabi* 2011-12 and 2012-13 are presented in Table 1. ICRISAT is situated in the Central Telangana Zone of Andhra Pradesh and receives a fairly well distributed mean annual rainfall of 908.01 mm. The monthly meteorological data of experimental seasons (April 2011 to March 2012 and April 2012 to March 2013) are given in Figure 1. The experiment laid out in a split-plot design with three replications. Fifteen treatment combinations were comprising five chickpea genotypes *viz.*, G_1: ICCV-11601 (tall and erect), G_2: ICCV-11602 (tall and erect), G_3: ICCV-11603 (tall and erect), G_4: ICCV-11604 (tall and erect) and G_5: JG-11 (check) in the main plot and three plant densities *viz.*, D_1: 3.33 lakhs ha^{-1} (normal plant density), D_2: 3.99 lakhs ha^{-1} (20% higher) and D_3: 4.66 lakhs ha^{-1} (40% higher) in the subplot.

Table 1: Physico-chemical properties of soil in the experimental site during 2011-12 and 2012-13.

Year	Soil texture	Sand (%)	Silt (%)	Clay (%)	pH	EC (dS m^{-1})	OC (%)	Av. N (kg ha^{-1})	Av. PO_5 (kg ha^{-1})	Av. K_2O (kg ha^{-1})
2011-12	Clayey	19.50	15.81	46.67	8.00	0.18	0.54	282.50	24.53	319.01
2012-13	Clayey	15.83	17.48	50.65	8.10	0.15	0.55	296.94	26.17	328.26

Land preparation and rising of crop

The land plowed once with mouldboard plow and later harrowed twice to bring the soil to a fine tilth. Stubbles and weeds removed from the experimental site. During the subsequent period, broad bed and furrows of 4 m length and 1.2 m breadth were prepared 2-3 weeks before sowing in allotted main plot treatments. Recommended dose fertilizers uniformly broadcasted before the layout of the experiment. Before sowing, the seeds treated with fungicide Captan @ 4 g kg^{-1} seed. Planting done on broad beds by hand dibbling the seeds up to 3 to 4 cm deep at different plant densities as per treatments (33, 39 and 46 plants m^{-2}) in 30-cm row spacing. The sowing was done during October month. All other cultivation practices carried out as per the package of practice of chickpea crop.

Observations recorded

The physiological indices like chlorophyll content (SPAD) and leaf relative water content (RWC) recorded during the investigation. The chlorophyll content recorded during both the year of experimentation. The chlorophyll content in the third leaves from the top taken in randomly selected five plants in each plot by using SPAD chlorophyll meter (KONICA MINOLTA SPAD-502 plus) and the average of reading taken as SPAD value. The RWC was determined only during the second year by sampled 8 to 10 young fully expanded leaflets at 40 and 70 DAS. Each leaflet represents a different plant. Each sample placed in an airtight poly cover and immediately placed in a picnic cooler but not frozen on ice. Samples brought to the laboratory immediately. In the laboratory, sampled leaflets weighed to obtain fresh weight (FW). The FW obtained from each sample was above the minimum of 0.5 g recommended by Clausen and Kozlowski [15], after which the sample was immediately kept in de-ionized water for 4 hr under normal room light and temperature. After hydration, the leaflets took out of the water and well dried of any surface moisture quickly and lightly with filter/tissue paper and immediately weighed to obtain fully turgid weight (TW). Samples then oven-dried at 70±5°C for 48 hr and weighed to determine sample dry weight (DW). The following calculation given by Barr and Weatherley [16] used to determine RWC.

$$RWC\ (\%) = \frac{FW - DW}{TW - DW} \times 100$$

The light intensity was measured in chickpea canopy only during the second-year experimentation by using an AccuPAR Ceptometer (Model E-240-LP 80, Manufactured by Decagon Devices, Inc. USA). The Ceptometer positioned beneath the canopy across the plot rows, perpendicular to the row length. It recorded both the light intensity above (I_0) and below (I) the canopy readings simultaneously between 1130 and 1400 h solar time at the flowering stage. LTR and LAR calculated by using following formula [17] and expressed in percentage.

$$LTR\ (\%) = \frac{I}{I_0} \times 100$$

LAR = 100 - LTR

The soil moisture content (SMC) determined during both the years by gravimetrically after oven drying the samples to a constant weight at 105 ^{0}C for 24 hours and expressed in percentage on an oven-dry weight basis. Soil samples were taken from 0-30 cm layers in each treatment at 50 days after sowing, and after harvest of crop using a soil tube/tube auger.

Data analysis

The data recorded on different physiological and agrometeorological parameters during the investigation subjected to Fisher's method of analysis of variance. The interpretation of data made as per the procedure given by Gomez and Gomez [18].

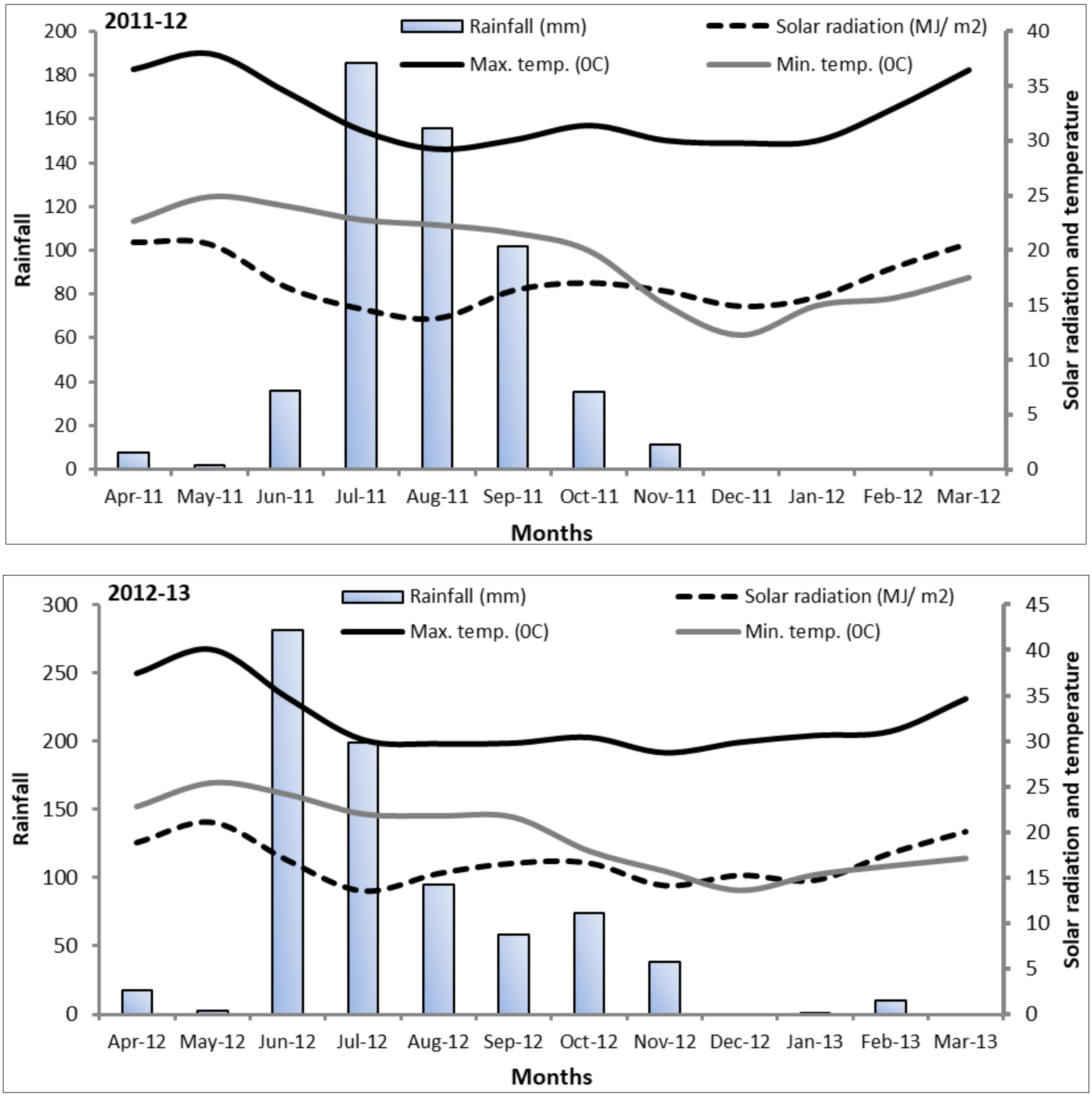

Fig 1: Monthly meteorological data of experimental seasons (2011-12 and 2012-12)

Results and Discussion

The data on the physiological indices like chlorophyll content (SPAD) and leaf relative water content (RWC) and agrometeorological indices like light transmission ratio (LTR), light absorption ratio (LAR) and soil moisture content (SMC) recorded at different growth stages was significantly differed due to chickpea genotypes, plant densities and their interaction effect. These physiological and agrometeorological parameters result in the performance of chickpea genotypes suitable for machine harvesting at different plant densities and play an important role in final contribution to the crop yield. The results of the present experiment discussed here.

Chlorophyll content (SPAD value)

The chlorophyll content measured in SPAD value at 30 and 60 days after sowing as influenced by genotypes, plant density, and interaction effect are presented in Table 2. The pooled data of two years on chlorophyll content (SPAD value) differed significantly at 30 and 60 days after sowing due to genotypes. The genotype, JG-11 showed significantly higher SPAD value (62.27 and 63.42) as compared to other genotypes at both the stages, respectively. Among the tall genotypes, ICCV-11601 found superior with a higher SPAD value (58.98 and 60.04) at both 30 and 60 days after sowing, respectively, and which was statistically on par with ICCV-11604 (58.44 and 59.13, respectively). Similarly, during 2012-13, the trend of SPAD value influenced by genotypes was similar at 60 days after sowing, while during 2011-12, JG-11 (62.71) was on par with ICCV-11601 (60.17) at 30 days after sowing. It is practically established that photosynthesis provides the energy for plant growth and development. Chloroplasts are the organelles on which the photosynthetic activities of the plant are centered, and chlorophyll is the primary light-absorbing pigment in the photosynthetic process. Chlorophyll is therefore, an indispensable component of photosynthetic reactions. These results are in accordance with Hosseini *et al*. [19]. Concerning plant density, the SPAD value decreases due to increased plant density only at 60 days after sowing, but it was not significant at 30 days after sowing. The higher SPAD value noticed in normal plant density of 3.33 lakh ha^{-1} (60.53) than a higher plant density of 3.99 and 4.66 lakh ha^{-1} (59.40 and 58.11, respectively) at 60 DAS. A similar trend observed during the individual year of 2011-12 and 2012-13 experimentation. This may probably because of less dense plant population provided a better opportunity to the plant to utilize the limited resources like moisture, nutrients, and light in a better way, which intern resulted in higher chlorophyll content. These finding are in agreement with the previously studied by Vaishya and Fayaz Qazi [13], Mansur *et al.* [20] and Alizade *et al.* [21]. They also reported that plant density decreases, leading to the increased chlorophyll content of leaves in chickpea crop. The interaction effect was non-significant at both the stages of crop growth. However, a numerically higher SPAD value observed with the interaction of JG-11 x 3.33 lakh ha^{-1} plant density (62.96 and 64.87) at 30 and 60 days after sowing, respectively). A similar trend also observed during the individual years of experimentation (2011-12 and 2012-13).

Leaf relative water content (RWC)

The RWC is probably the most apt measure of plant water status in terms of the physiological consequence of cellular water deficit. It expresses the relative amount of water present in the plant tissues [22]. In this study, the RWC was higher at 40 days after sowing but was drastically decreased at a later stage (70 days after sowing), indicating the reduction of turgidity in the plant (Table 3).

The RWC varied significantly among the genotypes, it was higher in tall genotype ICCV-11604 recorded at both 40 and 70 days after sowing (66.57 and 32.26%, respectively) and which was at par with ICCV-11602 (65.06%) and ICCV-11601 (64.93%), but values were significantly lower in JG-11 (58.09%) at 40 days after sowing, while at 70 DAS, ICCV-11601 (30.66%) was on par with ICCV-11604 and lower values with ICCV-11602 (24.29%). This kind of variation among genotypes might be due to better root development leading to higher water absorption, which helped in maintaining plant tissue towards turgid condition for a long time. The RWC and loss of turgidity are associated with water stress tolerance in chickpea cultivars before flowering and pod formation periods [23]. The varietal variation for RWC is in line with the finding of some of the previous studies conducted by Sharma-Natu *et al.* [24] and Kayan and Turhan [23]. Also, Verma *et al.* [25] observed varietal variations in different physiological traits of chickpea, and they revealed that 'Awarodi' and 'Udai' varieties being at par with each other for RWC and proved significantly superior over KGD-1168.

With respect to plant density, the RWC varied significantly at 40 and 70 DAS. Planting at normal density of 3.33 lakh ha^{-1} recorded significant higher RWC at 40 and 70 DAS (67.90 and 33.76%, respectively) as compared to the higher plant density of 3.99 lakh ha^{-1} (64.03 and 28.58%, respectively) and 4.66 lakh ha^{-1} (59.66 and 23.21%, respectively). Similar findings obtained by Suresh *et al.* [26] in pigeonpea. They reported that the crop in lower plant density had higher relative water content in comparison with higher plant densities at flowering and pod development stages irrespective of the irrigation treatments imposed. In case of interaction effect, the ICCV-11604 x 3.33 lakh ha^{-1} plant density recorded significant higher RWC (70.28% and 36.34%) at 40 and 70 days after sowing, respectively which was at par with ICCV-11601 x 3.33 lakh ha^{-1} (68.81%), ICCV-11603 x 3.33 lakh ha^{-1} (68.30%) and ICCV-11602 x 3.33 lakh ha^{-1} plant density (67.53%) at 40 days after sowing. At 70 days after sowing, ICCV-11601 x 3.33 lakh ha^{-1} (35.41%) and JG-11 x 3.33 lakh ha^{-1} (35.01%) was at par. However, lower values observed with JG-11 x 4.66 lakh ha^{-1} (51.19 and 18.23%, respectively).

Table 2: Chlorophyll content (SPAD value) of chickpea genotypes as influenced by plant density under the rainfed ecosystem.

Treatment	Chlorophyll content (SPAD value)					
	30 DAS			60 DAS		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
Genotype (G)						
G_1: ICCV-11601	60.17	57.78	58.98	60.72	59.36	60.04
G_2: ICCV-11602	57.22	56.51	56.87	57.86	56.67	57.27
G_3: ICCV-11603	56.74	56.26	56.50	57.29	56.48	56.88
G_4: ICCV-11604	58.58	58.30	58.44	59.47	58.78	59.13
G_5: JG-11 (Check)	62.71	61.83	62.27	63.84	62.99	63.42
S.Em±	0.94	1.11	0.73	0.81	0.82	0.58
C.D. (P=0.05)	3.08	3.63	2.19	2.65	2.67	1.73
Plant density (D)						
D_1: 3.33 lakh ha^{-1} (Normal)	59.60	58.68	59.14	61.08	59.97	60.53
D_2: 3.99 lakh ha^{-1} (20% higher)	59.04	58.14	58.59	59.90	58.91	59.40
D_3: 4.66 lakh ha^{-1} (40% higher)	58.61	57.59	58.10	58.53	57.69	58.11
S.Em±	0.51	0.41	0.33	0.48	0.60	0.38
C.D. (P=0.05)	ns	ns	ns	1.40	1.76	1.09
Genotype x plant density (GxD)						
G_1D_1	60.65	58.34	59.50	62.00	60.57	61.28
G_1D_2	60.19	57.73	58.96	60.80	59.41	60.11

G_1D_3	59.67	57.27	58.47	59.38	58.11	58.74
G_2D_1	57.72	57.00	57.36	59.04	57.70	58.37
G_2D_2	57.25	56.57	56.91	57.93	56.75	57.34
G_2D_3	56.68	55.98	56.33	56.61	55.57	56.09
G_3D_1	57.24	56.73	56.99	58.46	57.43	57.95
G_3D_2	56.70	56.22	56.46	57.34	56.49	56.92
G_3D_3	56.28	55.83	56.06	56.06	55.50	55.78
G_4D_1	59.07	58.75	58.91	60.55	59.80	60.17
G_4D_2	58.65	58.30	58.47	59.52	58.85	59.19
G_4D_3	58.01	57.85	57.93	58.35	57.70	58.03
G_5D_1	63.33	62.60	62.96	65.37	64.37	64.87
G_5D_2	62.39	61.88	62.13	63.90	63.05	63.48
G_5D_3	62.42	61.01	61.72	62.24	61.57	61.90
S.Em±	1.13	0.91	0.73	1.06	1.34	0.85
C.D. (P=0.05)	ns	ns	ns	ns	ns	ns

Ns: Non significant; DAS: Days after sowing

Light absorption and transmission ratio (LAR and LTR)

The growth rate depends on the ability of a crop to capture light and the efficiency of conversion of intercepted light into biomass [10]. Thus, the growth of a plant may be analyzed in terms of radiation interception and the efficiency of utilization of intercepted radiation [11,12]. The results of Table 4 indicate the LAR and LTR recorded at the flowering stage as influenced by genotypes, plant density, and interaction effect. Genotypes had a significant influence on LAR and LTR. The significantly higher LAR and lower LTR observed with genotype JG-11 (86.44% and 13.56%, respectively) as compared to other tested genotypes, which might be due to maximum canopy spread in JG-11 [27]. Among the tall genotypes, ICCV-11603 (80.11 and 19.89%, respectively) and ICCV-11601 (79.15 and 20.85%, respectively) were superior genotypes.

Table 3: Leaf relative water content (RWC) of chickpea genotypes as influenced by the plant density during 2012-13 under the rainfed ecosystem.

Treatment	**Leaf relative water content (RWC, %)**	
	40 DAS	**70 DAS**
Genotype (G)		
G_1: ICCV-11601	64.93	30.66
G_2: ICCV-11602	65.06	24.29
G_3: ICCV-11603	64.66	28.69
G_4: ICCV-11604	66.57	32.26
G_5: JG-11 (Check)	58.09	26.68
S.Em±	0.59	0.70
C.D. (P=0.05)	1.92	2.29
Plant density (D)		
D_1: 3.33 lakh ha^{-1} (Normal)	67.90	33.76
D_2: 3.99 lakh ha^{-1} (20% higher)	64.03	28.58
D_3: 4.66 lakh ha^{-1} (40% higher)	59.66	23.21
S.Em±	0.41	0.48
C.D. (P=0.05)	1.20	1.41
Genotype x plant density (GxD)		
G_1D_1	68.81	35.14
G_1D_2	65.01	30.74
G_1D_3	60.96	26.09
G_2D_1	67.53	29.35
G_2D_2	65.20	24.32
G_2D_3	62.46	19.20
G_3D_1	68.30	32.96
G_3D_2	64.68	28.72
G_3D_3	61.00	24.38
G_4D_1	70.28	36.34
G_4D_2	66.74	32.28
G_4D_3	62.68	28.16
G_5D_1	64.58	35.01
G_5D_2	58.51	26.82
G_5D_3	51.19	18.23
S.Em±	0.91	1.07
C.D. (P=0.05)	2.68	3.15

DAS: Days after sowing

There was a belief that the conversion efficiency is controlled genetically [28], but environmental factors and variety, climatic changes, plant arrangement, and soil fertility play a vital role in photosynthesis [29,30]. Similar findings have been reported by Tarimo and Blamey [31] in peanut. The variation among the chickpea genotypes was contradictory to the results of Prasad *et al.* [32] and Leach and Beech [33], who observed no significant difference in the light interception.

The data on planting density had also a significant influence on LAR and LTR. The LAR by plant canopies increased with an increase in plant density as evidence of decreased LTR through the plant canopies. Planting chickpea at a higher density of 4.66 lakh ha^{-1} noticed significantly higher LAR and lowered LTR (82.03 and 17.97%, respectively). In contrast, lower plant densities of 3.99 lakh ha^{-1} recorded 79.65 and 20.35%, and 3.33 lakh ha^{-1} of 77.44 and 22.56% LAR and LTR respectively. Similar results reported by Muhammad [14], Leach and Beech [33], Dhingra *et al.* [34] and Reddy [35]. Similarly, in chickpea crop, Kamel *et al.* [36] reported that an increase in plant density increased in relative growth rate, which indicates higher LAR. The interaction of genotypes x plant density was significant for LAR and LTR. The treatment JG-11 x 4.66 lakh ha^{-1} recorded higher LAR (89.07%) and lowered LTR (10.93%) followed by JG-11 x 3.99 lakh ha^{-1} (86.35 and 13.65%, respectively). However, significantly lower LAR and higher LTR noticed with ICCV-11602 x 3.33 lakh ha^{-1} interaction (73.51 and 26.49%, respectively).

Soil moisture content (SMC)

The data on SMC recorded at flowering and harvesting as influenced by genotypes, plant density, and interaction effect are presented in Table 5. The pooled data on SMC (%) recorded at the flowering stage and harvest of chickpea differed significantly due to genotypes. At flowering, JG-11 recorded significantly highest SMC (13.88%), and it was on par with ICCV-11604 (13.66%), but showed its superiority over all other genotypes. Similarly, at harvest also, JG-11 recorded significant highest value. However, it was lower with ICCV-11601 at both the stages (12.64 and 9.77%, respectively). The higher SMC in the treatment might be due to better root development, which resulted in higher water absorption. Further, higher moisture content with JG-11 with more canopy spread leading to a decreased in evaporation [27]. A similar trend was noticed during 2011-12 and 2012-13 at harvest, while during 2012-13 effect of genotypes on SMC was non-significant at the flowering stage.

Table 4: Light transmission and absorption ratio at flowering stage of chickpea genotypes as influenced by the plant density during 2012-13 under the rainfed ecosystem.

Treatment	Light transmission ratio (LTR,%)	Light absorption ratio (LAR,%)
Genotype (G)		
G_1: ICCV-11601	20.85	79.15
G_2: ICCV-11602	24.30	75.70
G_3: ICCV-11603	19.89	80.11
G_4: ICCV-11604	22.88	77.12
G_5: JG-11 (Check)	13.56	86.44
S.Em±	0.71	0.71
C.D. (P=0.05)	2.31	2.31
Plant density (D)		
D_1: 3.33 lakh ha^{-1} (Normal)	22.56	77.44
D_2: 3.99 lakh ha^{-1} (20% higher)	20.35	79.65
D_3: 4.66 lakh ha^{-1} (40% higher)	17.97	82.03
S.Em±	0.18	0.18
C.D. (P=0.05)	0.53	0.53
Genotype x plant density (GxD)		
G_1D_1	23.05	76.95
G_1D_2	20.93	79.07
G_1D_3	18.56	81.44
G_2D_1	26.49	73.51
G_2D_2	24.39	75.61
G_2D_3	22.02	77.98
G_3D_1	22.18	77.82
G_3D_2	19.87	80.13
G_3D_3	17.61	82.39
G_4D_1	24.99	75.01
G_4D_2	22.92	77.08
G_4D_3	20.74	79.26
G_5D_1	16.10	83.90
G_5D_2	13.65	86.35
G_5D_3	10.93	89.07
S.Em±	0.40	0.40
C.D. (P=0.05)	1.18	1.18

Plant density also significantly influenced on SMC both at flowering and harvesting stages. The SMC progressively and significantly decreased with an increase in plant density to either 20 percent or 40 percent higher than normal, and it was significantly higher with normal plant density of 3.33 lakh ha^{-1} at flowering and after harvest (10.88 and 7.85%, respectively). This was mainly because of dense stand, using soil moisture more rapidly due to more number of plants per unit area for their metabolic activities. These results in conformity with Reddy [35]. A similar trend followed during the individual years of experimentation. The interaction effect of genotypes and plant density on SMC was also significant but only at the harvest stage. The interaction of JG-11 x 3.33 lakh ha^{-1} plant density recorded significantly higher SMC (12.11%) at harvesting but was at par with ICCV-11603 and ICCV-11602 at 3.33 lakh ha^{-1} plant density (11.57 and 11.29%, respectively). In comparison, lower moisture content observed with ICCV-11601 at 4.66 lakh ha^{-1} plant density (8.65%). A similar trend found during the individual years of experimentation (2011-12 and 2012-13).

Table 5: Soil moisture content in chickpea genotypes as influenced by plant density under the rainfed ecosystem.

Treatment	Soil moisture content (%)					
	Flowering stage			After harvest		
	2011-12	2012-13	Pooled	2011-12	2012-13	Pooled
Genotype (G)						
G_1: ICCV-11601	11.59	13.69	12.64	9.21	10.32	9.77
G_2: ICCV-11602	11.69	13.68	12.69	9.50	10.73	10.12
G_3: ICCV-11603	12.15	14.07	13.11	10.25	11.11	10.68
G_4: ICCV-11604	12.73	14.58	13.66	9.37	10.35	9.86
G_5: JG-11 (Check)	13.01	14.74	13.88	10.35	11.35	10.85
S.Em±	0.25	0.29	0.19	0.21	0.19	0.14
C.D. (P=0.05)	0.82	ns	0.57	0.70	0.62	0.43
Plant density (D)						
D_1: 3.33 lakh ha^{-1} (Normal)	13.58	15.46	14.52	10.88	11.89	11.38
D_2: 3.99 lakh ha^{-1} (20% higher)	12.27	14.21	13.24	9.76	10.80	10.28
D_3: 4.66 lakh ha^{-1} (40% higher)	10.86	12.79	11.83	8.58	9.64	9.11
S.Em±	0.19	0.18	0.13	0.22	0.23	0.16
C.D. (P=0.05)	0.56	0.54	0.38	0.66	0.68	0.46
Genotype x plant density (GxD)						
G_1D_1	12.77	14.90	13.84	10.32	11.49	10.90
G_1D_2	11.64	13.75	12.70	9.19	10.33	9.76
G_1D_3	10.36	12.42	11.39	8.13	9.16	8.65
G_2D_1	13.01	15.01	14.01	10.70	11.87	11.29
G_2D_2	11.79	13.75	12.77	9.64	10.87	10.26
G_2D_3	10.27	12.29	11.28	8.16	9.45	8.80
G_3D_1	13.34	15.29	14.31	11.20	11.95	11.57
G_3D_2	12.33	14.23	13.28	10.22	11.12	10.67
G_3D_3	10.77	12.70	11.74	9.32	10.27	9.79
G_4D_1	14.06	15.82	14.94	10.56	11.52	11.04
G_4D_2	12.62	14.54	13.58	9.40	10.38	9.89
G_4D_3	11.53	13.38	12.45	8.15	9.17	8.66
G_5D_1	14.71	16.27	15.49	11.61	12.62	12.11
G_5D_2	12.96	14.79	13.87	10.32	11.28	10.80
G_5D_3	11.37	13.17	12.27	9.13	10.16	9.64
S.Em±	0.42	0.41	0.29	0.50	0.52	0.36
C.D. (P=0.05)	ns	ns	ns	1.47	1.52	1.02

Ns: Non significant

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