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Full Length Research Paper

The effects of different planting densities on seed yield and quantitative traits of rainfed chickpea (*Cicer arietinum L.*) varieties

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A field experiment was conducted to evaluate effect of planting density and variety on the grain yield and yield components of chickpea .The present research was conducted in the Agricultural Research Station, College of Agriculture, Islamic Azad University, Kermanshah Branch, Iran .The factorial experiment was based on complete randomized block design with four replication. In this experiment; the variety in three levels (Jam; ILC-482 and 12-60-31) and the planting density in three level 19; 28 and 57 plant.m^{-2}) were considered. Grain yield; number of pod per plant; number of grain per plant; weight of 100 grain; plant height; distance between 1st pod to soil were significantly affected by variety and density but number of branch per plant and biological yield were affected by density, and harvest index were affected by variety. Results showed that there was also a significant difference (p = 5%) in terms of the interaction of variety × planting density on the number of pod and grain per plant. The maximum photo growing degree day related to 12-60-31 variety and the maximum grain yield related to density of 28 Plant.m^{-2}

Key words: Planting density, chickpea, yield, yield components

INTRODUCTION

As one of the oldest groups of agricultural plants, food legumes are the second most important human's food supply after the cereal grains, which their grain contain 38 to 59% carbohydrate, 4.8 to 5.9% oil, 3% ash, 3% fiber, 0.2% calcium, and 0.3% phosphorus (Hulse, 1991). Chickpea (*Cicer arietinum* L.) is one of the most important food legumes in the diet of people in south and west Asia and northern Africa, which covers over 11 million hectares worldwide and annual average production is more than 8 million tones (Kumar, 2001). In Iran chickpea is the first important one among the other food legume crops because of its higher growing area and production (Banaii, 1997). Chickpea is traditionally planted in spring under rainfed condition in Mediterranean countries including Iran.

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Kermanshah province in west Iran with 200,000 ha under rainfed chickpea, is a worldwide famous place for production of high quality chickpea. Chickpea is the second strategic crop in this province after wheat under rainfed condition.Yigitoglu (2006) reported that highest seed yield of chickpea was obtained in early winter sowing and high plant density (45 plant m^{-2}). High density initially provokes fast growth of canopy in area unit which in turn ejects available stored water in soil through perspiration and causes the plant to encounter drought stress during flowering and grain-filling stages; therefore, under rainfed conditions suitable seed density must be considered for more absorption of solar energy, and improved utilization of water and soil (ICARDA, 1990). It has been revealed that yield augmentation caused by increasing seed density has been achieved by planting the genotypes with dense plant form (Saxena, 1980).

This experiment carried out on three high-pad genotypes with dense plant form indicated that varying

Table 1. Means of precipitation and temperature in Kermanshah region including vegetation period.

Months	March	April	May	June	July
Precipitation(mm)	135.3	10.1	30.4	3.1	0
Long	155.2	15.3	27.4 17.4	0.3	0
Temperature (c.)	7.3	12.8	18.2	23.2	28.1
Long	7.6	12.1	30.4	22.4	29.3

Long –time is for the period between 1975 and 2005.

Table 2. Chemical and physical characteristics of the soil (0 to 30 cm) of experimental site.

Texture	Sand (%)	Clay (%)	Silt (%)	K (ppm)	P (ppm)	N (%)	C (%)	EC(mmohs/cm)	pH
Silty clay	22	28	60	240	13.8	0.09	0.86	0.94	7.8

the number of plants per one square meter from 33 to 55 over the extensive type of pea is considered as desired density (Singh, 1981). According to Singh et al. (1988), more number of branches, number of pods on plant, 100 grains weight (GW), straw weight, and yield, were produced by dense and semi-extensive varieties with low density together with high pod erect growing varieties with high density. Saxena (1980) reported that 18.5 and 27.5 plant.m^{-2} density on three planting dates (December 4, February 2, March 6) revealed that chickpea planted with 27.5 plant.m^{-2} on December 4th, exhibited the highest yield, but there was no meaningful difference between two densities in crops planted on March 6th, perhaps the limiting factor in spring is the loss of water due to high evapotranspiration. Singh et al. (1980) reported that optimum planting density for chickpea is 35 plant m^{-2} considering the environmental conditions. But, Ahmadi and Kanoni (1994) reported optimum planting density of chickpea is 25 plant m^{-2} in north-west of Iran. The present study was therefore, undertaken to find out optimum planting density to achieve higher grain yield under environmental condition of Kermanshah province in west Iran.

MATERIALS AND METHODS

This experiment was carried out in the experimental farm located in Islamic Azad University of Kermanshah, Iran. The region is cold and semi- arid, at an elevation of 1342 m above sea level, with an annual mean precipitation of 413 mm in the 2004 to 2005 farming year.

Experiment in factorial form was conducted as basic design of complete randomized blocks with 4 replications with two factors, that is, plant density and cultivar. Planting date was 20 March. The three seed density factors were 19(D1), 28(D2), 57(D3) seed per square meter and three testing genotypes were Jam (V1), ILC 482 (V2), and (V3) 12-60-31. Before sowing, 40 kg of urea fertilizer per hectare was evenly spread on the field. The experiment consisted of 9 treatments and 36 test plots. Each plot consisted of 4 rows 4 m long. Seed was placed at 5 cm deep. Weeds were controlled by hand and no chemical poison was used to control pests. Seeds of genotypes were obtained from Dry land Agriculture Research Sub-Institute, Kermanshah, Iran.

Phenological stages including the number of days from planting to germination, flowering, pod-initiation, and maturity based on (GDD and HTU) were measured during the development of chick pea genotypes. The sum of the degree days for the completion of each phenophase were obtained by using the following formula:

$$\text{Accumulated GDD (°C day)} = \sum_{i=1}^{n}(\text{Mean} - Tb) \quad \text{(Iwata, 1984)}$$

where:

T daily mean air temperature in 0 °C = (T max + Tmin)/ 2; Tmax and Tmin are maximum and minimum air temperatures, respectively, and Tb is the base temperature. For daily mean temperatures, (Tmax _ Tmin)/2, less than the base temperature, GDD = 0, In this study ,GDD were calculated with a base temperature of near 0°C which for chickpea, dry pea, and lentil was estimated by Roberts et al. (1988), Summerfield et al. (1989) and Ney and Turc (1993).

The accumulated Heliothermal Unit (HTU) for each phenophase was determined by the following formula:

$$\text{Accumulated HTU(°C day)} = \sum_{i=1}^{n}[(T\,\text{Mean} - T\,\text{bi}) \times \text{No. of bright sunshine hours})]$$

where:

T Daily mean air temperature in 0 ^{o}C = (T max + Tmin)/ 2
Tmax and Tmin are maximum and minimum air temperatures, respectively, Tb is the base temperature (Sastry and Chakravarthy 1982).

After maturity ten complete plants were harvested from each plot to measure harvest index, number of pods and grain per plant, 100 grains weight (GW), plant height, distance of the first pod from soil and number of sub branches . Eventual harvesting from 2 centric rows of each plot was accomplished by eliminating one meter around them. The plants were harvested and threshed in 3rd July. The experimental site had silty clay soil. Soil properties and climatic data related to experimental site are summarized in Tables 1 and 2, respectively.

Table 3. The GDD and HTU on vegetative and reproductive stages.

Variety	Phenological stages	Day after planting	GDD (°C day)	HTU (°C day)
JAM	Germination	13	176.2	1273.09
	Flowering	42	581.8	4612.74
	Grain filling	45	625.4	4925.34
	Maturity	87	1408.7	14313.78
12-60-31	Germination	15	201	1279.59
	Flowering	47	653.8	5105.04
	Grain filling	51	717.9	5652.94
	Maturity	93	1532.5	15921.8
ILC-482	Germination	16	213.5	1367.09
	Flowering	46	640.3	4970.04
	Grain filling	50	700.8	4599.04
	Maturity	92	1511.5	15651.4

Analyses of variance were done utilizing MSTAT statistical program (Michigan State University, East Lansing) and mean comparisons were done using Duncan's multiple range test at a 0.05 probability level.

RESULTS, DISCUSSION AND CONCLUSION

Growth degree days and the quantity of absorbed radiation by various chickpea genotypes indicate that the lowest amounts of GDD 1408.70(°C day)) and HTU 14313.78(°C day) were observed in Jam genotype and the highest values, that is, 1532.50(°C day) and 15921.80(°C day) were observed in 12-60-31 genotype, respectively (Table 3).

By reducing density from 57 to 19 plant.m^{-2}, the dry yield of biomass increased the highest by the cultivar 12-60-31 and density of 28 plant.m^{-2} compared to other densities.

Saini and Faroda (1998) reported seed yield increase of Kabuli chickpea up to 36% with plant density increase from 20 to 35 plant m^{-2} in semi-arid northern India. Similarly, Beech and Leach (1989) showed that a plant density of 40 plant m^{-2} was required to obtain maximum seed yields. The difference among cultivars in terms of harvest index is meaningful and the highest harvest index (55.13%) is related to cultivar 12-60-31, these results correspond to those of (Saxena and Sheldarke, 1980; Katiyar, 1980; Poma et al., 1990) works.

The difference among cultivars and various planting densities is so meaningful that the highest yield was allotted to cultivar 12-60-31 and density of 28 plant .m^{-2}. with respect to the number of pods, number of grains on plant, and 100 GW in plant. There was a meaningful difference among cultivars and different planting densities so that the greatest number of pods on plant (15.7), the most number of grains of plant (16.6), and the highest weight of 100 grains (31.9 g) were associated with cultivar 12-60-31 and density of 28 plant.m^{-2} that corresponds to Jettner et al. (1999), Saxena et al. (1990), Singh et al. (1988) and Savithri et al. (1980) works. A hundred grain weight is, of course, to a lot extent, dependent on plant genetic potential observed with cultivar 12-60-31.

Although the number of sub-branches was not affected by cultivar, in sum 7.8 was the largest number of sub-branches allocated to it with density of 19 plant.m^{-2}. With low density and due to sufficient space for growing, the number of sub-branches gets increasing. Singh et al. (1988) have examined the effects of density and planting date on the number of sub-branches and stated that the number of sub-branches decreases with the increase in density and with delayed planting.

The most elevated height of plant, and the highest distance of pod formation from soil were allotted to cultivar 12-60-31, density of 57 plant.m^{-2}, and cultivar ILC-482, at the same plant density respectively. Cultivar Jam with a density of 19 plant.m^{-2} and row interval of 52.5 cm demonstrated the farthest distance from soil, which is equal to 3.3 cm in conjunction with sub-branches (Tables 4, 5, 6 and 7). Parvez et al. (1989) in soybean reported that plant height increased slightly with increase in planting density.

Results showed that there was also a significant difference in terms of the interaction of variety × planting density on the number of pod and grain per plant. In conclusion, the maximum photo growing degree day related to the variety 12-60-31 and the maximum grain yield was found in the plant density of 28 plant.m^{-2}.

Table 4. Analyses variance of some agronomical characteristics.

SOV	df	Plant height(cm)	Distance of the first pod to soil surface(cm)	No. of sub-branch	No. of pod per plant	No. of seed per plant	100 weight grain(g)	Grain yield	Biological yield(g/plant)	Harvest index (%)
Rep	3	12.561	0.629	0.170	0.593	5.612	0.023	0.003	1.529	1.221
V	2	111.512**	68.839**	12.212 ns	56.304**	100.725**	10.963*	0.016	0.386 ns	178.543*
D	2	39.945**	77.148**	9.979**	14.811**	25.710**	19.847*	1.329*	0.567**	44.080 ns
V×D	4	5.908 ns	0.839 ns	0.369 ns	4.391*	10.103**	4.147 ns	0.077 ns	0.543 ns	53.644 ns
Error	24	5.654	0.477	0.126	5.563	0.905	2.713	0.149	0.301	22.750
C.V (%)	-	7.43	9.65	11.69	12.09	8.05	9.41	8.22	8.53	9.41

NS,*and**:Non-significant at p<0.05, significant at 5 and 1% level of probability, respectively. V, D and V×D: variety, planting density and variety × planting density, respectively.

Table 5. Comparison of means some agronomical characteristics for three varieties.

Variety	Plant height (cm)	Distance of the first pod to soil surface (cm)	No. of sub - branch	No. of pod per plant	No. of seed per plant	100 weight seed (g)	Seed yield (g/plant)	Biological yield (g/plant)	Harvest index (%)
V1	26.40B	15.13A	5.76A	12.38A	11.37B	30.64B	4.14B	8.078A	48.42B
V2	25.83A	15.60A	6.40a	13.30a	11.67B	30.45B	4.21B	8.103A	48.48B
V3	27.07A	13.57B	6.56A	13.40a	14.83A	32.89A	4..29B	7.909A	55.13A

V1: Jam, V2: ILC 482, V3:12-60-31 varieties.

Table 6. Comparison of means some agronomical characteristics for three planting densities.

Variety	Plant height (cm)	Distance of the first pod to soil surface (cm)	No. of sub-branch	No. of pod per plant	No. seed per plant	100 weight seed (g)	Seed yield (g/plant)	Biological yield (g/plant)	Harvest index (%)
D1	24B	12.27B	6.30A	10.04B	13.10B	28.58B	4.15B	8.539B	48.70A
D2	25.70A	12.77AB	6.73A	15.23A	15.93A	31.10A	4.71A	8.899B	52.53A
D3	26.60A	15.27A	8.43A	13.8A	10.83C	30.30A	4.35B	9.041A	50.81A

Table 7. Comparison of means some agronomical characteristics for interaction variety × planting density.

Variety	Plant height (cm)	Distance of the first pod to soil surface (cm)	No. of sub - branch	No. of pod per plant	No. of grain per plant	100 weight seed (g)	Grain yield (g/plant)	Biological yield (g/plant)	Harvest index (%)
V1D1	23.70E	13.70B	5.00B	10.32AB	9CD	31.42A	4.32CD	7.16BCD	46.06C
V1D2	24.10DE	15.80ª	6.20AB	14.40A	10BCD	31.59A	4.32CD	9.10BC	48.90BC
V1D3	26.50AB	15.90A	6.10AB	12.40AB	13.1ABC	28.89AB	4.28CD	8.51BC	50.32ABC
V2D1	24.70CDE	16.70ª	6.00AB	9B	12.9B	31.48A	5.20BC	10.61ABC	49.79BC
V2D2	26.30ABC	13.50B	6.70AB	15.60A	15AB	30.70A	6.48A	11.36AB	52.54A
V2D3	26.50AB	16.60A	5.90AB	15.60A	11.1BCD	29.16AB	3.48D	8.72BC	44.11C
V3D1	23.60E	13.90B	7.00AB	10.80AB	12.6BC	29.99B	5.81B	11.2AB	48.26BC
V3D2	25.50BCD	13.50B	6.20AB	15.7A	16.6A	31.90A	ª5.92B	10.91ABC	49.99A
V3D3	28.00A	13.30B	7.80A	13.4AB	13.3ABC	31.39A	6.12A	12.24A	50.19AB

In each column with similar letter(s) are not significantly different at the 5% level of probability(DMRT) V, D and V×D:variety ,planting density and variety × planting density, respectively.V1: Jam,V2: ILC 482,V3:12-60-31 varieties &D1: 19,D2: 28 , D3: 57 plant.m^{-2}.

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