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The effects of planting density on grain filling, yield and yield components of three chick pea (*Cicer arietinum* L.) varieties in Kermanshah, Iran

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Planting density, chickpea, yield, yield components, grain filling

1 SUMMARY

A field experiment was conducted at Kermanshah in Iran to evaluate the effects of planting density and variety on grain filling, yield and yield components of chick pea. The factorial experiment was arranged in a completely randomized block design with four replications per treatment. Three varieties (Jam, ILC-482 and 12-60-31) and three levels of planting density (19, 28 and 57 plants/ m^2) were considered. The trend of grain filling, yield, yield components and agronomic characteristics (e.g. biomass yield, harvest index, number of pods per plant, number of grains per plant, number of nodes per main stem, plant height, number of branches per plant, weight of 100 grains, distance between 1st pod to soil) and phenology stages of the chickpea varieties were calculated based on photo growing degree day (PHOTO GDD). The results showed that the maximum rate of grain filling was at a density of 28 plants/m^2 and on cultivar ILC-482. Grain yield, number of pods per plant, number of grains per plant, weight of 100 grains, plant height, distance between 1st pod to soil were significantly affected by variety and density. The number of branches per plant was affected by density while the number of nodes per main stem and the harvest index were affected more by the variety. The maximum photo growing degree-day was on cultivar 12-60-31 while the maximum grain yield was at a density of 28 plants.

2 INTRODUCTION

Pulses are one of the oldest agricultural plants and are second to grains in terms of importance as sources of food. Seeds of pulses yield from 18-23% protein and can therefore play an important role in providing human protein needs. In Iran, Kermanshah region is considered to be the country's chick pea-farming center owing to annual cultivation of over 200,000 ha under dry conditions. Since it can tolerate drought well, chick pea is grown mostly under dry conditions in most of Iranian farmlands. Chick pea crop is the second most important crop in the region after wheat.

Planting patterns and density are key factors to achieving maximum yield of agricultural crops under dry farming conditions. High density provokes initial fast growth of canopy per unit area, which rapidly depletes the available water stored in the soil. This exposes the plants to drought during the next growth phases, especially at flowering and grain-filling. Therefore, under dry farming conditions the establishment of plants at the appropriate density, considering optimal absorption of solar

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energy and improved utilization of water and soil are of much importance (ICARDA, 1990).

Investigations at ICRISAT demonstrate that yield augmentation caused by increasing the density is higher with genotypes that form dense plants (Saxena, 1980).

An experiment carried out on high-pad genotypes indicated that varying the number of plants per square meter from 33 to 55, depending on the type of pea would have no adverse effects (Singh, 1981). More branches, number of pods on plant, higher 100 grains weight (GW), straw weight, and crop yield, were produced by dense and semi-extensive varieties with low density together with high-pad erect varieties with high density (Singh *et al.* 1988). The results from research done in Syria using 18.5 and 27.5 plants per sq.m on 3 planting dates (Dec 4, Feb 2, Mar 6) showed that peas at a density of 27.5 plant per sq.m at the earliest planting data had the highest yield. When planted late (March 6), there was no significant difference between the different planting densities. Perhaps the limiting factor in spring is the loss of water due to high plant transpiration (Saxena, 1980).

The objective of this experiment was to evaluate the effects of planting density and variety on grain filling, yield and yield components of chick pea.

3 MATERIALS AND METHODS

The experiment was performed on a test- farm located at Kermanshah in 2003-2004. The factorial experiment was laid out in completely randomized block design with 4 repeats during which 2 factors (plant density and cultivar) were studied. Density factor was considered at 3 levels, i.e. 19, 28 and 57 plants per m^2 and cultivar factor was considered at 3 levels, i.e. Jam, ILC 482, and 12-60-31. After pod formation, plants were sampled from all plots on every 6th day in order to measure the rate of grain filling.

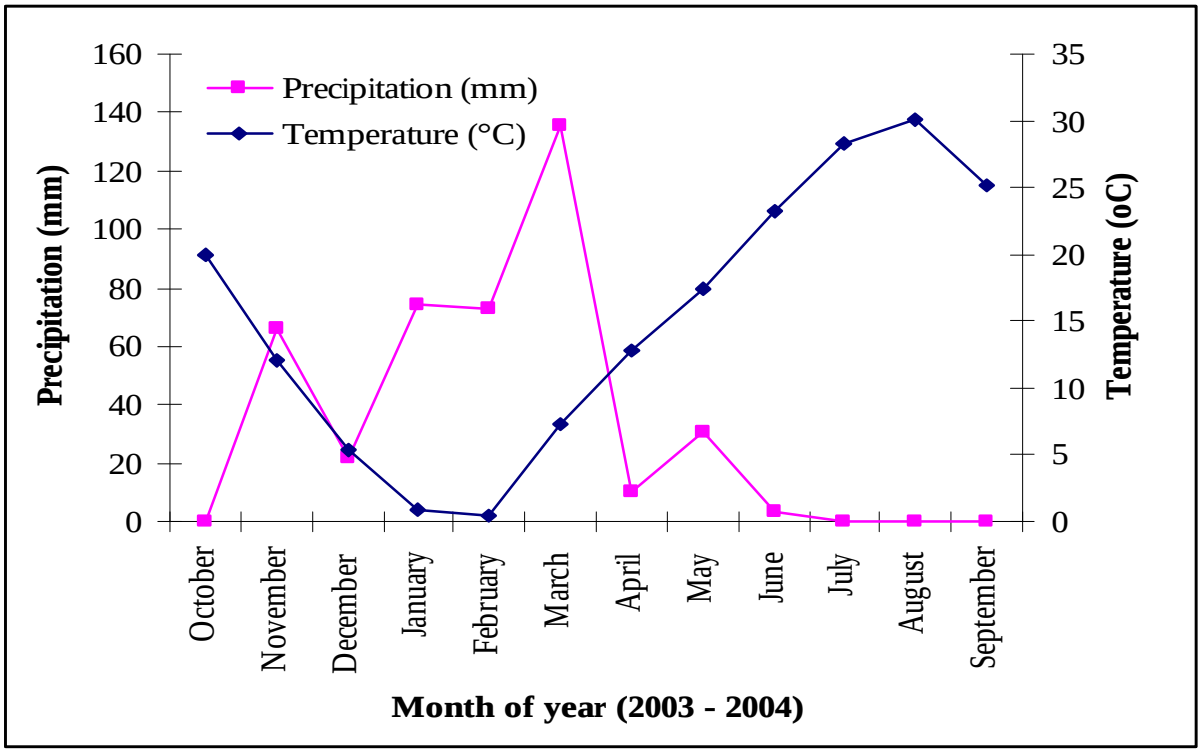

Figure 1: Mean precipitation and temperature at Kermanshah region in farming year 2003 – 2004.

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Phenology phases including the number of days from planting to germination, flowering, pod-initiation, and maturity based on (photo GDD) were measured during the development of chick pea cultivars.

Ten plants were harvested from each plot to measure the harvest index, number of pods on plant, number of grains on plant, 100 grains weight (GW), plant height, the distance of the first pod from soil, number of sub branches, and number of nodes on main stem.

Eventually 2 central rows were harvested from each plot by eliminating one meter around them.

Statistical MSTAT software was used to analyze data and means separated by the Duncan Multiple Range Test.

Table 1: Chemical and physical characteristics of the soil at the Kermanshah experimental site.

Texture	Sand %	Clay %	Silt %	K ppm	P ppm	N %	C%	EC mmohs/cm	PH	Depth (cm)
Silty clay	22	28	60	240	13.8	0.09	0.86	0.94	7.8	0-30

4 RESULTS AND DISCUSSION

The number of growth degree days (GDD) and the quantity of absorbed radiation (photo GDD) were lowest (GDD = 1408.70) and (photo GDD = 14313.78) on cultivar Jam and highest (GDD = 1532.50; photo GDD = 15921.80) on cultivar 12-60-31 (Table2).

By reducing density from 57 to 19 plants per m^2, the dry biomass yield increased, being highest for cultivar 12-60-31 at a density of 28 plants per m^2. Compared to other densities, at this plant density the effective grain-filling (log phase) takes place more rapidly.

Obviously, more than 90% of dry matter is stored in grains during this period. Owing to appropriate density, the cytokinin accumulated during the log phase allows grain to attract assimilates as an active sink and such conditions enable the grain to compete for assimilates with other sinks such as stem and leaves that are not yet withered.

Table 2: The GDD and PHOTO GDD on vegetative and reproductive stages of chick pea at Kermanshah , Iran.

Variety	Phenology stages	Days after planting	GDD	PHOTO GDD
JAM	Germination	13	176.2	1273.09
	Flowering	42	581.8	4612.74
	Grain filling	45	625.4	4925.34
	Ripening	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
	Ripening	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
	Ripening	92	1511.5	15651.4

The results obtained showed decreasing biomass yield with increasing density, which is indicative of competition between plants for water and nutrient uptake. This is in agreement with observations by Poma *et al.* (1990). The highest harvest index (55.13%) was for cultivar 12-60-31, and the difference among cultivars regarding this parameter was significant. These results correspond to those of Saxena and Sheldarke (980).

The greatest yield was realized with cultivar 12-60-31 at a density of 28 plants per m^2, and the difference among cultivars and various planting densities was highly significant ($P \leq 0.05$). The highest number of pods per plant (15.7), the most number of grains per plant (18.1), and the highest weight of 100 grains (32.9 g) were for cultivar 12-60-

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31 at a density of 28 plants per m^2. These findings agree with those of Savithri *et al*(1980) , Saxena *et al* (1990) and Ibrahimi (1997).

The weight of 100 grains is to a large extent dependent on plant genetic potential, and this was observed to be highest on variety 12-60-31. Although the number of sub-branches did not seem to be dependent on cultivar, in sum 7.8 was the highest number realized at a density of 19 plants per m^2.

Table 3: Analysis variance of some agronomical characteristics of chick pea at Kermanshah, Iran.

SOV	df	Plant height	Distance 1st pod to soil	No. sub-branch	No. pod per plant	No. seed per plant	100 weight seed	Seed yield	Biological yield	Harvest index
Rep	3	12.439	0.639	0.180	0.593	5.612	0.023	0.003	1.529	1.221
V	2	110.514**	68.830**	12.202**	56.504**	100.725**	10.963*	0.016*	0.386 ns	178.543*
D	2	38.935 **	78.048**	9.970**	14.912**	25.710**	19.847*	1.329*	0.567**	44.080 ns
V×D	4	5.906 ns	0.930 ns	0.359 ns	4.397*	10.103**	4.147 ns	0.077 ns	0.543 ns	53.644 ns
Error	24	5.573	0.463	0.136	5.573	0.905	2.713	0.149	0.301	22.750
C.V(%)	-	7.25	9.35	11.60	12.10	8.05	9.41	8.22	8.53	9.41

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

At low plant density, and partly due to sufficient space for growth and less competition between plants, the number of sub-branches increased. By increasing the row interval, plant height increased while the distance of the first pod from soil decreased.

The tallest plants were on cultivar 12-60-31 while the greatest distance of pod formation from soil was on cultivar Ilc-482, both at a density of 57 plants per m^2. (Table 3,4). Overall, the field experiment showed that the maximum rate of grain filling was at a density of 28 plants per m^2 and on cultivar ILC-482. Grain yield, number of pods per plant, number of grains per plant, weight of 100 grains, plant height, distance between 1st pod to soil were significantly affected by variety and density. The maximum photo growing degree day was on cultivar 12-60-31 while the maximum grain yield was at a density of 28 plants per m^2. The three chickpea varieties had good performance and can be recommended as a promising spring crop at similar climatic and soil conditions as that of this experiment.

Table 4: Comparison of means of some agronomical characteristics of chick pea at Kermanshah, Iran.

Treatments	Plant height (cm)	Distance the first pod to soil surface(cm)	No. sub-branch	No. pod per plant	No. 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	1.14B	2.078A	48.42B
V2	25.83A	15.60A	6.40A	13.30A	11.67B	30.45B	1.21B	2.229A	48.48B
V3	27.07A	13.57B	6.56A	13.40A	14.83A	32.89A	1.46B	1.872A	55.13A
D1	24B	12.27B	6.30A	10.04B	13.10B	28.58B	1.15B	1.539B	48.70A
D2	25.70A	12.77AB	6.73A	15.23A	15.93A	31.10A	1.51A	1.899B	52.53A
D3	26.60A	15.27A	8.43A	13.8A	8.83C	30.30A	0.85B	2.741A	50.81A
V1D1	23.70E	13.70B	5.00B	10.32AB	9BC	31.42A	1.08ADC	1.664CD	46.06C
V1D2	24.10DE	15.80A	6.20AB	12.40AB	12ABC	31.59A	1.08ABCD	1.936BCD	48.90C
V1D3	26.50AB	15.90A	6.10AB	14.40A	13.1ABC	28.89AB	1.07D	1.207D	50.32BC
V2D1	24.70CDE	16.70A	6.00AB	9B	7.9C	31.48A	1.3ABC	2.508ABC	49.79BC
V2D2	26.30ABC	13.50B	6.70AB	15.60A	15AB	30.70A	1.2ABCD	2.097BCD	51.54ABC
V2D3	26.50AB	16.60A	5.90AB	15.60A	18.1A	29.16AB	0.96BCD	2.082BCD	44.11C
V3D1	23.60E	13.90B	7.00AB	10.80AB	9.6BC	27.99B	1.53AB	2.623AB	50.26BC
V3D2	25.50BCD	13.50B	6.20AB	15.7A	16.6A	32.90A	1.62A	3.091A	57.99A
V3D3	28.00A	13.30B	7.80A	13.4AB	12.3ABC	27.69AB	0.87CD	1.328D	57.19AB

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.

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