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Research Article

THE EFFECT OF SOWING DATE AND PLANT DENSITYON YIELD AND YIELD COMPONENTS OF COWPEA

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ABSTRACT
Beans are among major legumes which have high percentage of protein, and are considered as one important source of plant protein in human nutrition. In addition, beans are planted in Iran in a wide area and knowing optimal farming factors can be an important step in increasing them. In order to investigate the effect of sowing date and plant density on growth physiological parameters, yield and yield components, a split plot experiment on cowpea (local cultivar) was carried out as randomized complete block design with four replications in Dehloran area in Ilam in 2010-2011. Experimental treatments included three sowing dates (July 6, July 23, and August 6) as main plots and four plant densities (17, 24, 31, and 38 plants per square meter) as sub plots. The results showed that there was a significant difference between different sowing dates and plant density in terms of their effects on traits such as number of pods per plant, number of grains per plant, number of lateral branches, number of grains per square meter, 100-grain weight, grain yield, biological yield, and harvest index. The highest grain yield in terms of sowing date was related to July 23 by the yield of 1817 kg/ha and the lowest one was related to July 6 by the yield of 1457 kg/ha, and in terms of plant density the highest grain yield belonged to density of 31 plants/m2 by 1631 kg/ha.

Keywords: *Cowpea, Sowing Date, Plant Density, Yield*

INTRODUCTION
Legumes after grains are the second source of human food and in Iran the second most important food after the wheat. Legumes' protein is four times as much as that of grains and 10 to 20 times as much as that of glandular plants (Koocheki and Bananiyan, 2002). One of the most important factors determining the yield of cowpea (Vigna sinensis L.) is appropriate sowing date. In general, climate parameters such as temperature, rainfall, day length, wind, and non-climate factors such as pests, diseases, weeds, birds, economy of production are effective in selecting appropriate sowing date (Mazaheri and Majnoon, 2005). Delay in sowing, decreases the length of vegetative and reproductive growth stages and reduces the grain yield. The decrease of grain yield in delayed sowing could be due to the fact that plant vegetative stage faces intense heat of the season which results in decrease of vegetative growth stage, production of fewer vegetative organs, decrease of assimilation, early flowering, increases of flowers' loss and infertility, and decrease of grain components yield (Sreelatha *et al.*, 1997).
Another important factor determining the yield of cowpea is optimal density. Optimal density is the density through which environmental factors (water, weather, light, and soil) are used perfectly and at the same time inter-plant and intra-plant competition is minimized so that maximum possible yield and optimal quality are achieved. On the other hand, the density should provide enough space for breeding and harvesting operations (CSIDC, 2001; Shirtliffe and Johnston, 2002). In a study conducted by Dhanjal *et al.*, (2001) on French bean, they showed that the increase of density to some extent increased the yield and further increase of density led to decrease of yield due to reduction of nutritional space and launch of competition. Another research conducted by Mousavi *et al.*, (2005) showed that the highest grain yield belonged to bean sowing date of May 8, making a space of 10 cm on each row. Moreover, Mobbaser *et al.*, (2006) investigated the effect of sowing date and density on the yield of cowpea in Ghaem Shahr and showed that the highest grain yield belonged to sowing date of April 30, and 5 cm space on the rows.
However, Hayat *et al.*, (2003) and Ayaz *et al.*, (2001) reported that the number of grains in mung bean pods changed as plant density changed and increase of density led to decrease of number of grains per

pod. Abdel Aziz *et al.*, (2004) stated that delay in planting bean (local cultivar) would lead to decrease of number of pods and number of grains per plant. Yaday and Singh (2009) reported that if Chickpea (local cultivar) is planted at densities of 25, 35, 45, 55plants/m2 and constant row space of 50 cm, the highest yield of seed will be obtained at density of 55 plants/m2.
The general purpose of this research is to study the effect of sowing date and different plant densities on yield and yield components of cowpea in Dehloran, Ilam.

MATERIALS AND METHODS

Experimental Location

This research was carried out in 2010-2011 in a research field in Dehloran, Ilam, at longitude 36°32'E and latitude 23°47'N in a land with an area of 456 m2. Dehloran is about 232 m above sea level, the average annual rainfall is 233.6 mm and the average temperature is 28.97°C. The soil texture of the experiment site was loamy soil and pH = 6.3 and Ec = 4.7 ds/m-1. The experiment was conducted as split plots in the form of randomized complete block design with four replications. Treatments included three sowing dates ((July 6, July 23, and August 6) as main plots and four plant densities (17, 24, 31, and 38 plants per square meter) as sub plots. To ensure the desired densities, seeds with higher density were planted and after full establishment of plants at 3-4-leaf stage, additional plantlets were removed. Each experimental plot contained 7 sowing rows as long as 3m and as wide as 2m. To prevent the interactive effect of treatments, the space between treatments was considered to be 2 m. Planting was done manually on July 6 on the stacks. Maintaining operations including irrigation and control of weeds immediately began after sowing. Due to hot weather at the beginning of growth stage, irrigation interval was 3-4 days and then during the growth stage irrigation interval gradually increased to once a week. Weeds were cut by hand in two stages. Moreover, in order to fight the ticks 75 ml/ha Ortho Insecticide (Fenpyroximate) was used on September 5, 2010.
During the harvest at physiological maturity, in order to determine grain yield, biological yield, and grain yield components, plants of two square meters were harvested from the bottom through the middle of plots and by considering the margin. After counting the pods in harvested area, grains were separated from the pod and counted. When the samples moisture reached 12%, grain yield and biological yield were measured. In order to determine 100-grain weight, 4 100-grain samples from each plot were weighed and then the average of the samples was measured.

Statistical Analysis

At the end of the research, date were statistically analyzed using SAS software and the means were compared by Duncan's multi range test at 5% level and the diagrams were drawn by Excel software.

RESULTS AND DISCUSSION

Number of Pods per Plant

The ANOVA results showed that number of pods per plant was statistically affected by sowing date, plant density, and also interactive effects of sowing date × plant density at 1% probability level ($P<0.01$) (Table 1). Mean comparison of simple effects showed that the highest number of pods per plant was obtained on July 23. The number of pods per plant in the second sowing date that is on August 6 was significantly lower than that of July 23 and higher than that of July 6. With regard to the effect of number of pods per plant on ultimate yield, it seems like that in studied weather conditions the sowing date would have a significant effect on yield components such as number of pods per plant and with regard to Table (2) the best sowing date for obtaining the highest number of pods per plant is July 23.
Yadav (2003) in his research on cowpea found that delayed sowing would lead to decrease of number of pods per plant. Moreover, the highest number of pods per plant belonged to density of 31 plants/m2, which showed a significant increase at 5% level in comparison to densities of 17 and 38 plants/m2. According to the results, the highest number of pods per plant belonged to density of 24 plants which was not significantly different from density of 17 plants (Table 2). It seems like that the increase of sowing density over 24 plants resulted in decrease of number of pods per plant due to high competition to supply

nutrition during the growth. The highest number of pods per plant belonged to the treatment under the interactive effects of sowing date of July 23 and densities of 24 and 31 plant/m2 and the lowest number belonged to sowing date of July 6 and densities of 17 and 38 plants/m2 (Table 3). It seems like that the date of July 23 was the best sowing date in terms of number of pods per plant and medium densities had the best effect. These results can be seen in Table (3).

Number of Grains per Plant

The ANOVA results showed that number of grains per plant was significantly affected by sowing date, plant density, and interactive effects of sowing date × plant density at 1% probability level ($P<0.01$) (Table 1). Mean comparison of simple effects showed that the highest number of grains per plant was obtained in sowing date of July 23 and the lowest one on July 6 by 11 and 8.52 grains per plant respectively. In spite of significant statistical difference, the date of August 6 was just about 6% higher than the date of July 6 numerically numerically. According to the results of this research, the best sowing date in terms of producing the highest number of grains per plant is July 23 (Table 2). The highest number of grains per plant belonged to density of 31plants/m2 by 10.05 and the lowest number of grains per plant belonged to density of 17 plants/m2 by 9.2. Considering the number of pods and plants, the difference ultimately will have a significant effect on final yield. There was no significant difference between densities of 24 and 38 plants/m2 and also between densities of 17 and 38 plants/m2. The best plant density for producing the highest number of grains per plant was the density of 31 plants/m2in this research (Table 2). The interactive effects of sowing date × plant density on number of grains per plant (Table 3) indicates that early sowing and delay lead to decrease of number of grains per plant. The obtained results are consistent with the findings of Bhatt (1981).

100-Grain Weight

The results of the experiment (Table 4) showed that sowing date, plant density, and the interactive effects of sowing date × plant density had a significant effect on 100-grain weight at 1% probability level ($P<0.01$). The highest rate of 100-grain weight belonged to sowing date of July 23 by average weight of 16.27 g and the lowest one belonged to sowing date of July 6 by average weight of 12.2 g (Table 5). In studies conducted by Mahlojy *et al.,* (1999), delay in sowing led to decrease of 100-grain weight.

The highest rate of 100-grain weight was related to sowing density of 31 plants/m2 and the lowest rate was related to sowing density of 17 plants/m2 by the average of 13.50 g (Table 5). The lowest rate of 100-grain weight was affected by the interactive effects of sowing date of July 6 × density of 17 plants/m2 (Table 6). In a research conducted on Khomein Bean in national research station by Taheri Mazandarani (1998), it was found that the highest yield was obtained in sowing date of May 5 by 3.073 T/ha and the decrease of yield was observed in sowing dates after that which could be related to shorter vegetative and reproductive stages and consequently the decrease of number of grains per plant and 1000-grain weight in delayed sowings. Njoku and Muoneke (2008) in their research on the effect of density on cowpea found that density had no significant effect on 100-grain weight. Moshatati *et al.,* (2010) found that sowing date would have a significant effect on all yield components of cowpea.

Grain Yield

Grain yield was significantly affected by sowing date and plant density at 1% probability level ($P<0.01$) and also by interactive effects of sowing date × plant density at probability level of 5% ($P<0.05$) (Table 4).

The highest rate of grain yield belonged to sowing date of July 23 by 181.7 g/m2 (Table 5). The highest rate of grain yield also belonged to plant sowing density of 31 plants/m2 by 163.1 g/m2 and the lowest rate belonged to density of 17 plants/m2 by the average of 155.9 g/m2 (Table 5).

Salehi *et al.*, (2006) showed in their study that delay in sowing led to decrease of grain yield per hectare. Yadav (2003) stated that the highest rate of grain yield in cowpea belonged to a sowing date which was neither too early nor too late. Therefore, the highest grain yield was obtained on November 30 which was more than that of November 15 or December 15. In studying the effect of densities of 37, 32, and 17 plant/m2, Bhatt (1981) found that the highest number of grains per pod belonged to density of 32 plants/m2 which was quite consistent with the results of this research. Shivakumar *et al.,* (2002) studied

the effect of plant density on cowpea and found that as density increased, the yield components of single plant decreased due to competition. Njoku and Muoneke (2008) studied the effect of density on cowpea and found that as plant density increased, grain yield increased, too. The highest grain yield under the interactive effects of sowing date × plant density belonged to sowing dates of July 23 and densities of 24, 31, 38 plants/m2 and the lowest one belonged to sowing date of July 6 and densities of 17 and 38 plants/m2 (Table 6).

Biological Yield

The ANOVA results showed that biological yield was significantly affected by sowing date at 1% probability level ($P<0.01$) and also the interactive effects of sowing date × plant density at 5% probability level ($P<0.05$) (Table 4). The highest rate of biological yield belonged to sowing date of July 23 by 508 g/m2. The sowing date of July 23 had an increase of 6.7% than that of July 6. Salehi *et al.*, (2006) carried out a research on the reaction of grain yield and yield components of red bean to sowing date and plant density. They showed that sowing date had a significant effect on all measured traits such as the rate of straw and grain yield. In present research, sowing density of 31 plants/m2 in cowpea increased the biological yield by 515 g/m2 in comparison to other densities (Table 5).

Table 1: Analysis of variance Analysis of variance some agronomic traits in cowpea

S.O.V	df	Number of pods per plant	Grain number per plant	Grain yield
Replication	3	2.673**	0.635^{ns}	53217.14**
Sowing date(S)	2	153.74**	36.513**	593823.5**
Ea	6	0.158	0.266	4566.981
Density(D)	3	1.466**	1.472**	11316.09**
(S×D)	6	0.039**	0.099^{ns}	8433.835**
Eb	27	0.184	0.133	378.105
Cv%		3.2	3.8	12.1

*ns, not signiticant **and* significantly on probability level of 1 and 5%, respectively*

Table 2: Mean comparisons of some agronomic traits in cowpea

Treatments	Number of pods per plant	Grain number per plant	Grain yield (g/m2)
	Sowing date		
15 July	10 c	8.52 c	145.7 c
1 August	16.2 a	11 a	181.7 a
15 August	13 b	9 b	151.7 b
	Density		
17 plants per square meter	13.05 bc	9.2 c	155.9 c
24 plants per square meter	13.40 ab	9.69 b	160.3 b
31 plants per square meter	13.60 a	10.05 a	163.1 a
38 plants per square meter	12.82 c	9.44 bc	159.6 b

**: In each column and each group cares with same letter had no significant diffrences in probability level of 5% based on Dunken multiplerange test.*

The highest interactive effect of plant density and sowing date on biological yield belonged to the treatment with density of 31 plants/m2 and sowing dates of July 23, August 6, and July 6, respectively and the lowest effect was related to sowing date of July 6, August 6, and July 23 and density of 17 plants/m2 (Table 6).

Table 3: interactions of some agronomic traits in cowpea

Treatments	Number of pods per plant	Grain number per plant	Grain yield (g/m2)
S1 × D1	10 ef	8.20 f	140.10 g
S1 × D2	10.1 e	8.40 ef	140.90 def
S1 × D3	10.1 e	9 de	140.90 def
S1 × D4	9.80 f	8.20 f	140.20 fg
S2 × D1	16.10 bc	10.40 c	170.80 b
S2 × D2	16.20 ab	11.20 ab	180.10 a
S2 × D3	16.90 a	11.88 a	180.10 a
S2 × D4	15.9 c	11 bc	180.10 a
S3 × D1	13 d	8.60 def	140.50 ef
S3 × D2	13 d	9 de	145 de
S3 × D3	13 d	9.10 d	150.8 c
S3 × D4	13 d	9 de	150 d

**: In each column and each group cares with same letter had no significant diffrences in probability level of 5% based on Dunken multiplerange test.*

Table 4: Analysis of variance some agronomic traits in cowpea

S.O.V	df	Grain 100 weight	Biological yield	Harvest index
Replication	3	18.522**	1164.402**	1.001**
Sowing date(S)	2	69.496 **	69743.578 **	7.09 **
Ea	6	1.621	9068.6	1.01
Density(D)	3	2.136 **	14109.33 **	6.05 **
(S×D)	6	0.153 **	19586.417 *	4.002 *
Eb	27	0.184	3325.86	0. 9
Cv%		3	10.7	3.1

*ns, not signiticant **and* significantly on probability level of 1 and 5%, respectively.*

Harvest Index

As it is observed in Table 4, harvest index was significantly affected by sowing date, plant density, and interactive effects of sowing date × plant density. Mean comparisons showed that the highest rate of harvest index belonged to sowing date of July 23 by 53.76%. Treatments with sowing dates of august 6 and July 6 were ranked in next steps and were not significantly different from each other (Table 5). The

highest rate of harvest index belonged to density of17 plants/m2 by 32.47%. The other densities had lower rate of harvest index and were significantly different from density of 17 plants/m2 (Table 5).

Table 5: Mean comparisons of some agronomic traits in cowpea

Treatments	Grain 100 weight (g)	Biological yield (g/m2)	Harvest index (%)
		Sowing date	
15 July	12.2 c	495 c	29.43 b
1 August	16.27 a	508 a	35.76 a
15 August	13.98 b	604 b	25.11 b
		Density	
17 plants per square meter	13.50 c	480 d	32.47 a
24 plants per square meter	14.10 b	506 c	31.67 b
31 plants per square meter	14.50 a	515 a	31.66 b
38 plants per square meter	13.9 bc	509 b	31.35 b

**: In each column and each group cares with same letter had no significant diffrences in probability level of 5% based on Dunken multiplerange test.*

Table 6: Interactions of some agronomic traits in cowpea

Treatments	Grain 100 weight (g)	Biological yield (g/m2)	Harvest index (%)
S1 × D1	11.80 f	370 g	شذ 37.86
S1 × D2	12.10 ef	499 d	28.23 b
S1 × D3	12.40 de	510 c	27.62 b
S1 × D4	12 f	499 d	28.09 b
S2 × D1	16 a	480 e	28.09 b5.58 a
S2 × D2	16.10 a	510 c	35.31 ab
S2 × D3	16.10 a	530 a	33.98 ab
S2 × D4	16.10 a	510 c	35.31 ab
S3 × D1	12.30 de	470 f	29.89 ab
S3 × D2	13.80 bc	510 c	28.43 b
S3 × D3	13.80 bc	520 b	29 b
S3 × D4	13 cd	510 c	29.41 b

**: In each column and each group cares with same letter had no significant diffrences in probability level of 5% based on Dunken multiplerange test.*

The highest rate of harvest index under the interactive effects of sowing date × plant density belonged to sowing date of July 23 and density of 17 plants/m2 and the lowest rate belonged to sowing date of July 6 and August 6 and densities of 31, 24, 38 plants/m2 (Table 6).

Conclusion

The present research showed that density of 31plants/m2 had the highest number of pods per plant, number of grains per plant, number of lateral branches, number of grains per square meter, 100-grain weight, grain yield, biological yield, and harvest index. On the other hand, the crops with the highest density of plants produced the highest grain yield in area unit. Therefore, in order to determine optimal

density in cowpea, it is necessary to consider environmental conditions of the region. In semiarid weather conditions, sowing date of July 23 and density of 31plants/m2 can produce appropriate economic yield for cowpeas.

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