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Comparison of autumn and spring sowing on performance of chickpea (*Cicer arietinum* L.) varieties

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Abstract

Sowing time and variety are two important factors which influence crop performance including chickpea. In order to investigate the effects of autumn and spring sowing dates on yield and yield components of chickpea varieties a field experiment was carried out in Shahre-Rey region, in south of Tehran, Iran during 2010/2011. The experiment was laid out in factorial arrangement on the basis of randomized complete block design with four replications which five sowing dates (October 12, November 02 and November 22 as autumn sowing dates and March 16 and April 06 as spring sowing dates) and five chickpea varieties (Arman, Azad, Hashem, ILC1799 and ILC482) were treatments. Results showed that the longer growing period of autumn-sown chickpeas affected positively characters contributing to yield such as biomass, pods per plant, seeds per pod, 100-seeds weight and harvest index, which in turn contributed to increased seed yield. Varieties had significant effects on all measured traits. Except ILC482 other varieties gave higher seed yield in autumn sowing. The degree of superiority of seed yield in autumn sowing as compared to spring was strongly affected by the environmental conditions and tolerance of varieties to cold stress. The maximum seed yield (612.8 g m^{-2}) was recorded with ILC1799 sown on November 02.

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Introduction

Chickpea (*Cicer arietinum* L.) is one of the world's most important grain legumes, and the seed is a major source of plant-based dietary protein for humans. This annual legume is a significant contributor to agricultural sustainability through N_2-fixation and as a rotation crop allowing the diversification of agricultural production systems (Gan *et al.,* 2006). It is the second major pulses after dry bean (*Phaseolus vulgaris* L.) which is grown on over 11.9 million hectares worldwide with production over 10.9 million tones. In Iran, chickpea is the most important grain legume crop which is grown on an area of 508313 hectares with total production of 239768 tons making an average of 471 kg ha^{-1}. This average yield is much lower than most of the leading countries of the world (Anonymous, 2010).

Sowing time and variety are two important factors which affecting the yield of field crops such as chickpea. The most important step towards maximizing yield of chickpea is to ensure that the phenology of the crop or cultivar is well matched to resources and constraints of the production environment (Summerfield *et al.*, 1990). Flowering time is important because environmental conditions during the reproductive phase have a major impact on final yield. The onset of flowering often determines the entire crop duration (Egli, 1998). Traditionally, the chickpea is sown in spring in order to avoid *Ascochyta* blight (*Ascochyta rabiei* Pass) and frost, both in Mediterranean and temperate regions (Ozdemir and Karadavut, 2003). Autumn sowing was not possible in the past, since the varieties cultivated by farmers were susceptible to low winter temperatures and were infected much more under autumn sowing from diseases such as *Ascochyta* blight and *Sclerotinia* sp. which are difficult to control by existing commercial fungicides. For these reasons chickpeas were sown in spring, when the crop meets heat and drought stress towards maturity resulting in low and inconsistent yields (Iliadis, 2001). One method to increase seed yield in chickpea would be to change the sowing time from spring to autumn using available breeding materials resistant to the above biotic and abiotic disorders (Hawtin and Singh, 1981; Janneli and Bozzini, 1987). It has been well documented that if the chickpea is sown in autumn, higher yield can be obtained than with traditional spring sowing in Mediterranean and dry regions. Calcagno *et al.* (1987) reported a 60% yield increase in autumn sowing over spring sowing in Italy. Singh *et al.* (1997) reported that winter-sown chickpea produced seed yield as 70% higher than spring-sown crop in Syria. Ozdemir and Karadavut (2003) revealed a 102% yield increase in autumn sowing over spring sowing in Turkey. Iliadis (2001) calculated 23-188% more seed yield for winter over spring sowing in Greece. In most of these studies the high yield potential of winter crop has been attributed to the extended growing period and favorable rainfall during winter and early spring. Low winter temperatures restrict the seedling growth of the chickpea; however, it enters a phase of rapid growth when temperatures increase in spring, the time when the soil allows spring sowing (Siddique *et al.,* 1999; O'Toole *et al.,* 2001). Rapid leaf area development allows greater photosynthesis under favorable conditions and it partitions into seed yield (Leport *et al.,* 1999). Increased biomass yield, contributed by plant height, increased branches and pods per plant, was positively correlated with seed yield (Singh *et al.,* 1990). Genetic improvement of resistance to blight and cold has been extensively studied by national and international breeding programs, and high yielding, blight-resistant cultivars have been developed for the Mediterranean region (Singh, 1997). Most experiments on chickpea adaptation to autumn sowing have also been performed in winter-dominated rainfall Mediterranean-type environments. The temperature in temperate regions is lower than in the Mediterranean region and rainfall is rather balanced during the vegetation period (Ozdemir and Karadavut, 2003). Cold tolerance is an important prerequisite for sowing the chickpea in autumn in temperate regions and there is a wide genetic variation among genotypes (Singh *et* *al.,* 1995). Optimum sowing time of chickpea vary from one variety to another and also from one region to another due to variation of agro-ecological conditions, so the aim of present study was to investigate the response of different genotypes of chickpea to autumn and spring sowing in Tehran, Iran.

Materials and methods

This study was conducted at the experimental farm of the Islamic Azad University of Shahre-Rey, in south of Tehran, Iran during 2010/2011. The research field is located in an arid climate where the summer is hot and dry and the winter is cool and dry. Longitude, latitude and altitude of Shahre-Rey are 51° 28´ E, 35° 35´ N, and 1000 m, respectively. Monthly temperatures and rainfall of region are presented in Table 1. The soil of experimental field was sandy clay loam with pH 7.9, nitrogen 0.11%, available phosphorus 8.4 ppm, exchangeable potassium 335 ppm and EC 2.9 mmohs cm^{-1}. The experiment was laid out in factorial arrangement on the basis of randomized complete block design with four replications which five sowing dates (October 12, November 02 and November 22 as autumn sowing dates and March 16 and April 06 as spring sowing dates) and five chickpea varieties (Arman, Azad, Hashem, ILC1799 and ILC482) were treatments. Seeds were dressed with the fungicide Bavistin before sowing to prevent seedling loss. At the same time plots were fertilized with 200 kg ha^{-1} ammonium phosphate. Each plot consisted of 6 rows 6 m long, 50 cm apart, with an intra-row distance of 10 cm. Size of each plot was 18 m^2. In each sowing date planting was down with the help of a single row hand drill on rows in depth of 3-4 cm. Crop management practices such as hand weeding, thinning and plant protection measures were done as per requirement. The autumn-sown crop matured by late May 2011 and the spring-sown crop by late June 2011 almost 1 month later. At physiological maturity, 10 plants from each plot were selected randomly from second and fifth rows, sun dried and then numbers of pods, number of seeds per pod and 100-seeds weight were determined. To determine seed yield, biomass and harvest index, plants were harvested by hand from 5 m^2 in two middle rows of each plot. Biomass was determined after drying at 75° c for 48 h. Harvest index was calculated by dividing seed yield with total biomass. Data were analyzed by MSTAT-C statistical software and the means were compared by Duncan's Multiple Range Test at the 5% probability level (Steel and Torrie, 1980).

Results

Biomass

All varieties varied significantly with regard to aboveground biomass production. ILC1799 variety produced highest biological yield (691.2 g m^{-2}) while ILC482 variety produced lowest biological yield (515.4 g m^{-2}) (Table 2). Effect of sowing date on biomass production was significant. The highest biomass (721.8 g m^{-2}) was recorded on November 02 sowing date while the lowest biomass (426.6 g m^{-2}) was observed on sowing date of October 12 (Table 2). Interaction effect between varieties and sowing dates was found as statistically significant for biomass. The maximum biomass (1234.0 g m^{-2}) was observed with ILC1799 variety sown on November 02 against the minimum biological yield (306.1 g m^{-2}) was produced in ILC482 variety sown on October 12.

Number of pods per plant

Data indicated that pods/plant was significantly affected by varieties. The highest pods/plant (42.45) were achieved in ILC482 which it was at par with Arman and ILC1799. The lowest pods/plant (34.42) also were recorded in Hashem variety (Table 2). Sowing date had significant effect on pods/plant. The maximum and minimum pods/plant (53.69 and 30.73) were observed on November 02 and October 12 sowing dates respectively (Table 2). Significant interaction was found between varieties and sowing dates with regard to pods/plant. The highest pods/plant (80.28) were produced with ILC1799 variety sown on November 02 while the lowest pods/plant (13.43) were produced with Azad variety sown on March 16.

Number of seeds per pod

Different varieties had significant effect on seeds/pod. Hashem variety produced maximum seeds/pod (1.064) while ILC482 produced minimum seeds/pod (0.945) (Table 2). Seeds/pod was influenced by sowing date. Crop sown on November 02 produced highest seeds/pod (1.101) against crop sown on november 22 produced lowest seeds/pod (0.948) which was statistically at par with october 12 (Table 2). Interaction effect between varieties and sowing dates was significant for seeds/pod. The maximum seeds/pod (1.24) were observed with Hashem variety sown on November 02 against the minimum seeds/pod (0.702) were produced with ILC482 variety sown on November 22.

Table 1. Mean comparisons of agronomic traits of chickpea as affected by variety and sowing date.

Treatments	Biomass ($g m^{-2}$)	Pods per plant	Seeds per pod	100-Seeds weight (g)	Seed yield ($g m^{-2}$)	Harvest index (%)
Variety						
Arman	540.1 c	42.34 a	1.018 b	25.07 b	212.8 b	40.34 a
Azad	600.5 b	40.65 b	1.032 b	25.73 b	218.2 b	34.42 c
Hashem	592.5 b	34.42 c	1.064 a	22.18 c	174.4 d	27.88 e
ILC1799	691.2 a	42.19 a	0.995 c	27.12 a	249.5 a	33.09 d
ILC482	515.4 d	42.45 a	0.945 d	22.61 c	188.5 c	35.59 b
Sowing date						
October 12	426.6 e	30.73 d	0.948 c	23.79 c	141.1 d	32.22 c
November 02	721.8 a	53.69 a	1.101 a	29.28 a	333.5 a	45.20 a
November 22	696.6 b	52.58 b	0.951 c	25.73 b	258.6 b	37.14 b
March 16	489.8 d	32.89 c	1.036 b	22.32 d	165.8 c	32.80 c
April 06	604.9 c	32.17 c	1.018 b	21.60 d	144.4 d	23.96 d

Means with the same letter (s) in each column and treatment are not significantly different at probability level of 5% using DMRT.

100-Seeds weight

Effect of variety on 100-seeds weight was significant. The highest and lowest 100-seeds weight (27.12 g and 22.18 g) were recorded in ILC1799 and Hashem varieties respectively (Table 2). Sowing date had significant effect on 100-seeds weight. The maximum 100-seeds weight (29.28 g) was achieved in chickpea sown on November 02 while the minimum 100-seeds weight (21.60 g) was obtained in crop sown on April 06 which was statistically similar with March 12 (Table 2). Significant interaction was observed between varieties and sowing dates with regard to 100-seeds weight. The highest 100-seeds weight (35.99 g) was recorded with ILC1799 variety sown on November 02 while the lowest 100-seeds weight (18.76 g) was produced with ILC482 variety sown on April 06.

Table 2. Interaction effects of variety and sowing date on agronomic traits of chickpea.

Variety	Sowing date	Biomass ($g\ m^{-2}$)	Pods per plant	Seeds per pod	100-Seeds weight (g)	Seed yield ($g\ m^{-2}$)	Harvest index (%)
Arman	October 12	527.1h	44.59 f	0.997 fgh	24.27 def	215.3 gh	40.79 ef
	November 02	447.3 k	34.78 jk	0.950 hij	30.47 b	201.3 hi	45.01 c
	November 22	586.4 fg	62.17 c	0.920 j	26.18 cd	299.2 e	51.00 b
	March 16	462.9 jk	36.10 jk	1.175 bc	23.36 e-h	197.1 hi	42.70 cde
	April 06	677.0 e	34.06 k	1.050 def	21.05 hi	150.9 jk	22.20 p
Azad	October 12	403.2 l	22.83 n	0.843 k	26.95 c	103.7 l	25.70 no
	November 02	615.5 f	40.81 gh	0.930 ij	31.84 b	239.4 f	38.92 fg
	November 22	1172.1 b	78.67 a	1.155 c	24.15 def	438.5 b	37.39 gh
	March 16	231.6 n	13.43 p	1.222 ab	20.14 ij	65.0 m	28.06 m
	April 06	579.9 fg	47.52 de	1.00d-h	25.55 cde	244.2 f	42.06 de
Hashem	October 12	328.9 m	23.30 n	1.056 def	23.32 e-h	115.8 l	34.93 ij
	November 02	798.5 c	67.24 b	1.240 a	23.32 e-h	389.0 c	48.71 b
	November 22	762.1 d	49.83 d	1.035 d-g	23.04 fgh	237.6 f	31.18 kl
	March 16	479.0 ijk	16.01 o	0.985 ghi	21.50 ghi	67.5 m	14.11 q
	April 06	594.2 fg	15.74 op	1.00d-h	19.74 ij	62.2 m	10.46 r
ILC1799	October 12	567.7 g	39.16 hi	1.062 de	22.92 fgh	190.4 i	33.42 jk
	November 02	1234.0 a	80.28 a	1.060 def	35.99 a	612.8 a	49.75 b
	November 22	470.6 jk	30.25 l	0.930 ij	29.98 b	168.5 j	35.84 hi
	March 16	660.3 e	34.53 jk	0.962 hij	23.81 d-g	158.5 jk	23.97 op
	April 06	523.3 h	26.73 m	0.962 hij	22.90 fgh	117.5 l	22.47 p
ILC482	October 12	306.1 m	23.77 n	0.798 k	21.47 ghi	80.4 m	26.27 no
	November 02	513.3 hi	45.33 ef	1.00e-h	24.80 c-f	225.0 fg	43.63 cd
	November 22	492.1 hij	41.95 g	0.702 l	25.28 c-f	149.3 jk	30.30 lm
	March 16	615.2 f	64.36 c	1.16c	22.77 fgh	340.8 d	55.16 a
	April 06	650.2 e	36.82 ij	1.065 d	18.76 j	146.8 k	22.60 p

Means with the same letter (s) in each column are not significantly different at probability level of 5% using DMRT.

Harvest index

Significant variation in harvest index was found among varieties of chickpea. Arman variety produced maximum harvest index (40.34%) against Hashem variety produced minimum harvest index (27.88%) (Table 2). Harvest index was affected by sowing date. Crop sown on November 02 and April 06 produced highest (45.20%) and lowest (23.96%) harvest index respectively (Table 2). Interaction effect between varieties and sowing dates was significant for harvest index. The maximum harvest index (55.16%) was obtained with ILC482 variety sown on March 16 while the minimum harvest index (10.46%) was recorded with Hashem variety sown on April 06.

Seed yield

Different varieties had significant effect on seed yield. The highest seed yield (249.5 g m^{-2}) and the lowest seed yield (174.4 g m^{-2}) were obtained by ILC1799 and Hashem varieties respectively (Table 2). Effect of sowing date on seed yield was significant. The maximum seed yield (333.5 g m^{-2}) was recorded on November 02 sowing date against the minimum seed yield (141.1 g m^{-2}) was observed on October 12 sowing date which was at par with April 06 (Table 2). Significant interaction was found between varieties and sowing dates with regard to seed yield**.** The highest seed yield (612.8 g m^{-2}) was produced with ILC1799 variety sown on November 02 while the lowest seed yield (62.2 g m^{-2}) was produced with Hashem variety sown on April 06.

Discussion

The present study showed that different chickpea varieties had significant effect on all measured traits. Variability in chickpea genotypes for yield and yield components also had been reported by other researchers (Yucel and Anlarsal, 2008; Iliadis, 2001; Chaitanya and Chandrika, 2006; Rajin Anwar *et al.,* 2003). We also found that all characteristics were affected by sowing dates. The highest biomass production (721.8 g m^{-2}), pods per plant (53.69), seeds per pod (1.101), 100-seeds weight (29.28 g), harvest index (45.20%) and seed yield (333.5 g m^{-2}) were recorded on November 02 sowing date as mid autumn sowing (Table 2). The highest number of pods per plant in the mid autumn sowing was as a result of extended vegetative and reproductive growth stages. This result is agreement with findings of Ozdemir and Karadavut (2003), Singh and Bejiga (1990) and Valimohammadi *et al.* (2007). The lower number of seeds per pod in spring sowing, early and late autumn sowing dates was because of encounter of flowering and fertilization stages with high and low temperatures respectively. Similarly Chaitanya and Chandrika (2006) also reported higher number of seeds per pod in November 01 as compared to other sowing times.

Similar to our results, Ozdemir and Karadavut (2003) found that autumn sowing increased 100-seeds weight of chickpea by an average of 10% over spring sowing and revealed that this result was due to the moderate temperature regime during the seed filling stage. Chickpea sown on November 02 produced highest biomass and harvest index. These results are in agreement with the findings of Chaitanya and Chandrika (2006). In any given environment, grain yield in any crop is a function of biomass and harvest index. Hence the grain yield can be increased either by increasing the biomass or harvest index or both. On the other hand for maximum yield to be attained a pulse crop should have a high biomass with a high harvest index (Hedge *et al.,* 2007). Optimization of inputs at the farm level would maximize biomass production as well as increasing harvest index (Pandey *et al.,* 2000). Shoot biomass accumulation is considered an important trait to attain high seed yield in grain legumes (Rosales-Serna *et al.,* 2004). Pulses productivity is relatively low for their poor dry matter partitioning into grains as compared with vegetative matter (Ur-Rehman *et al.,* 2005). High harvest index is very important for increasing yield potential in crops because it is sensitive to environmental variations (Ghafoor *et al.,* 2000). However, a high vegetative growth is not always a symptom for high chickpea yield. Dry matter redistribution is highly variable in different chickpea genotypes (Leport *et al.,* 1999). We observed that some of the varieties which had lower biomass had higher harvest index than the others. These varieties such as Arman and ILC482 have a greater ability to forward photosynthates into the seeds.

The higher yields given by the autumn-sown chickpea, as compared with the traditional spring-sown crop, appear to be the result of increased biomass production occurring as the result of a longer period of vegetative growth (Keatinge and Cooper, 1983; Saxena, 1984). They also reported that, the reproductive phase (flowering and grain filling) of autumn-sown chickpea is longer than that of spring-sown chickpea. This allows the crop to match with more favorable thermal and moisture conditions, which contributes to higher biomass and seed yields. Nonetheless we observed that in very early autumn sowing date (October 12) in addition to plant lodging, flowering was encountered with low temperature and so biomass, yield and yield components were reduced (Table 2). In late autumn sowing date (November 22) also we found that growth and yield of crop decreased due to frost damage. We concluded that the advantages associated with autumn sowing can be lost if environmental conditions are unfavorable. Under the temperate climate, frost could be detrimental to late autumn sowing, because it usually occurs during the early stages of vegetative growth. Spring sowing usually allows a crop to escape frost danger, unless there is a late frost. Both spring and autumn-sown chickpea may experience water shortages in the later part of the crop's growth. However, rained autumn-sown chickpea is less likely to face drought during flowering and grain filling than spring-sown chickpea. This may be due to the fact that earlier crop growth results in a higher leaf area, and therefore, more photosynthesis, biomass production and growth during the period when there is a lower vapor pressure deficit, so allowing earlier maturity and escape from the later drought (Oweis *et al.,* 2004). Previous researchers reported that temperatures below the optimum delayed the emergence and sometimes caused poor crop stand in the chickpea (Auld *et al.,* 1988; O'Toole *et al.,* 2001).

Under autumn sowing the varieties started to flowering earlier than under spring sowing. It seems that variety plays a role in the degree in which the change of sowing season from spring to autumn influenced flowering initiation. Autumn sowing increased the flowering duration of the varieties in comparison with spring sowing. Plant maturity of all the varieties averaged 30 days earlier in autumn sowing than in spring. Above results are comparable to the findings of Iliadis (2001). All the varieties except ILC482 in autumn sowing gave higher seed yields than in spring, indicating ILC482 variety was susceptible to low temperature and is suitable for spring sowing but other varieties are appropriate for autumn sowing. However the highest seed yield was produced from autumn sowing (November 02) with ILC1799 variety. Among the varieties the greatest response to autumn sowing was by 'Azad, Hashem and ILC1799' although 'ILC1799' was the most productive. Such differing reactions of chickpea varieties for seed yield in autumn sowing has also been reported by Calcagno *et al.* (1987) and Saxena (1984).

For getting success with the winter sowing of chickpea it is necessary that the cultivars have high level of tolerance to cold and resistance to *Aschochyta* blight (Saxena and Singh, 1987; Reddy and Singh, 1990; Singh and Reddy, 1996; Toker and Cagiran, 2003; Gan *et al.,* 2006).

The superiority of the autumn-sown crops is mainly due to the matching crop phenology with the availability of optimum temperature and moisture regimes. Ozdemir and Karadavut (2003) reported that autumn-sown chickpea genotypes were at their mid-vegetative stages while the spring-sown seeds were emerging from the soil. After a long wait at the seedling stage, autumn-sown crops quickly started to develop photosynthetic surfaces, a larger crop canopy, and more branches and reproductive nodes in favorable temperature on a very moist soil over a longer duration. On the other hand, our results showed that for the spring-sown crop, plants produced fewer yield components, biomass and harvest index, causing a yield decrease. Improved cultivars as those in the present experiment except ILC482 were resistant to cold. The influence of temperature on growth and development varies according to genotype. In spring sowing, temperature increases during June restricted adequate reproductive growth, shortened flowering and the seed-filling stage and caused shorter harvest index and yield. The higher seed yields in autumn sowing clearly showed that changing the sowing time of chickpeas from spring to autumn is profitable (Iliadis, 2001; Ozdemir and Karadavut, 2003; Sarno *et al*., 1987; Calcagno *et al*., 1987; Singh *et al*., 1997). In fully agreement with the present experiment Chaitanya and Chandrika (2006) among 4 sowing dates (October 15, November 01, November 15 and December 01) found that November 01 sown-chickpea produced higher yield attributes and yield in India.

Conclusion

The present study confirms previous results showing that mid autumn sowing improves the productivity of chickpea, as compared with spring and very early and late autumn sowing. Autumn sowing in comparison with spring increased seed yield due to higher biomass, harvest index and yield components. The degree of superiority of seed yield in autumn sowing over spring was strongly influenced by the climatic conditions and tolerance of varieties to cold stress. It became obvious from the results that only with resistant varieties can autumn sowing seed yield superiority be ensured. All varieties except ILC482 gave higher seed yield in autumn sowing. The highest seed yield was obtained with ILC1799 sown on November 02.

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