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*Full Length Research Paper*

# Investigation of correlation analysis and relationships between grain yield and other quantitative traits in chickpea (*Cicer arietinum* L.)

**Soheil Kobraee*, Keyvan Shamsi, Behrooz Rasekhi and Saeed Kobraee**

Islamic Azad University of Kermanshah, P. O. Box: 67155-1774, Iran.

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**Understanding the relationships between chickpea (*Cicer arietinum* L.) yield and yield components is critical to utilizing these relationships effectively and thus developing desirable varieties. This research was done in order to investigate the correlation analysis and relationships between grain yield and other quantitative traits with three chickpea cultivars (Filip-84-48-c, Ilc-482 and Arman) and three sowing date (March 6, 21 and April 4). A 3 x 3 factorial experiment in randomized complete block design (RCBD) format with three replications was conducted in the research field of the Azad University of Kermanshah, during 2006. The results showed that both sowing date and cultivar had significant effects on grain yield and yield components of chickpea. Early planting chickpea produced the highest plant height, distance of first pod from the earth surface, number of sub branch, number of pods per plant, number of seeds per plant, 100-seed weight, grain yield, biological yield and harvest index. The sowing done on March 6 had the highest while April 4 had the lowest grain yield. There were significant differences between cultivars of grain yield. The highest grain yield belonged to Arman with 1067.1 kg/ha. Results showed that number of seeds per plant ($r = 0.846^{**}$), number of pods per plant ($r = 0.827^{**}$), plant height ($r = 0/813^{**}$) and biological yield ($r = 0.798^{**}$) had the highest positive correlation with grain yield. The results of path coefficient analysis revealed that number of seeds per plant had high and positive direct effects (0.76) on seed yield, but number of pods per plant was an important constituent (0.41).**

**Key words:** Chickpea, grain yield, sowing date, path analysis, quantitative traits.

## INTRODUCTION

Matching the phenology of crops to the duration of favorable conditions by selecting the most appropriate sowing date to avoid periods of stress is crucial for maximum yield (Caliskan et al., 2008) of plants. Chickpea (*Cicer arietinum* L.) is an annual grain legume crop grown mainly for human consumption. It plays an important role in human nutrition as a source of protein, energy, fiber, vitamins and minerals for large population sectors in the developing world and is considered a healthy food in many developed countries. Chickpea contains on the average 22% protein, 4.5% fat, 63% carbohydrate, 8.0% crude fibre and 2.7% ash (Miao et al., 2009). This crop is widely distributed, being grown in over 33 countries in the world including South Asia, West Asia, North and East Africa, Southern Europe, North and South America and Australia (Anbessa et al., 2007).

Yield variability is a global problem in grain legumes, which can lead to low yields (Ayaz et al., 2001). Chickpea is a crop of near Eastern origin and generally performs best with a long, warm growing season in its traditional growing environments in South Asia, the Mediterranean region and East Africa. The chickpea growing season is terminated by drought stress associated with rising temperatures and evapotranspiration and a lack of rainfall. In Western Iran, the latter part of the reproductive phase of chickpea coincides with declining temperatures and often wet conditions by late June - July, (Anbessa et al.,

*Corresponding author. E-mail: kobraee@yahoo.com. Tel: 00989188300270.

2007) when average temperatures favours flowering and subsequent abortion until temperature increases. This delay exposes chickpea to terminal drought during the critical seed filling stage (Berger, 2007). Of all phonological events, the onset of flowering is the most significant because it marks the transition of the crop from a vegetative to a reproductive mode. The duration from sowing to flowering establishes the phonological potential of the crop, while the timing of flowering determines the climatic conditions to which the crop will be subsequently exposed during the reproductive growth. Accordingly, the ability to predict time of flowering of particular cultivars when grown in different locations, seasons and weather conditions is a potentially powerful tool for breeders and agronomists attempting to optimize the choice of cultivar, sowing time and agronomic management (Lawn et al., 1995).

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. Flowering time is important because environmental conditions during the reproductive phase have a major impact on final yield (Rajin et al., 2003). Yield and yield components analysis provides a framework for identifying potentially useful traits for yield improvement. Traditionally, plant breeders have optimized yield largely by empirical selection with little regard for the physiological processes involved in yield formation. Selection of high yielding cultivars via specific traits requires knowledge not only of final yield but also of the many compensation mechanisms among yield components resulting from changing genotypic, environmental and management factors (Rosalind et al., 2001). In this experiment, our objective is to determine the relative importance of yield and yield components and other traits when environmental and genotype factors are varied.

## MATERIALS AND METHODS

The experiment was carried out in 2007 at the Research Field of the Faculty of Agriculture, Azad University of Kermanshah (34°23'N, 47°8' E; 1351 m elevation). The soil of the experimental areas is silty clay. Treatments consisted of three cultivars and three sowing dates. Three Kabuli chickpea cultivars developed by the International Center for Agricultural Research in the Dry Areas (ICARDA) were selected based on their wide cultivation in Iran. These cultivars were sown on three sowing dates, March 6, 21 and April 4. The experimental design was a 3 x 3 factorial experiment in randomized complete block with three replicate. The chickpea was grown under non irrigated conditions with standard cultural inputs applied consistently with local agronomic practices. Plots were fertilized with 40 kg nitrogen (N) $ha^{-1}$and 80 kg phosphorus (P) $ha^{-1}$ before planting. The land was ploughed in early spring before planting. Chickpea is usually planted in late March and harvested by hand from June to July, with a period of nearly 3.5 month for chickpea plant growth and development. The plots were maintained as weed -free by hand weeding during growing period. All seeds were inoculated with a commericial group N Brady rhizobium (Chemical Factory, Zangan, Iran) immediately before sowing. Each plot was 8 rows; 6 m in row length, 25 cm in row spacing, and with a plant density of 80 plants/ $m^2$.

Measurement and observation of examined characters were done on fire plants which had been randomly chosen in the mid - row of each plot. The following measurement and observations were made: plant height (H), distance of the first pod from earth surface (DPE), number of pods per plant (NPP), number of seeds per plant (NSP), 100 seed weight (WP), grain yield (GY), biological yield (BY) and harvest index (HI). When the plants reached maturity, they were harvested at soil level and individually partitioned into primary and secondary branches. Each primary and secondary branch was dried separately to constant weight in a forced - drought oven at 70°C and then partitioned into stem, seeds and pods. All the samples were weighed and the number of seeds determined. The harvest index at maturity was calculated from the ratio of seed dry weight to total above ground plant dry weight. The effects of examined characters on grain yield were determined using the path coefficient technique (Dewey and Lu, 1959). In order to determine the relationships between examined characters and yield, correlation coefficients were first calculated. Path coefficients were then calculated to understand the direct character effects on yield. The data were analysed as a factorial experiment in randomized complete block design using the Statistical Analysis System (SAS institute, 1999). Means were separated using Duncan's multiple range test at a significance level of 0.05.

## RESULTS

The study revealed that both sowing date and cultivar had significant effects on grain yield and yield components of chickpea. Early planting chickpea produced the highest plant height, distance of the first pod from the earth surface, number of sub branch, number of pods per plant, number of seeds per plant, 100-seed weight, grain yield, biological yield and harvest index. The results of ANOVA and the mean values of yield and yield components and other traits for cultivars and sowing dates are presented in Tables 1, 2, 3 and 4, respectively. The sowing dates, cultivars and sowing date × cultivar interaction significantly ($P < 0.01$) affected the plant height and distance of the first pod from the earth surface. These traits values increased with delay of sowing until April 4. The cultivar, Arman, had significantly higher values for plant height and distance of the first pod from earth surface. The means values were 40.5 and 28.8 cm in the earliest and latest sowing dates, respectively. Reduction in plant height with delayed sowing was reported in Auld et al. (1980) and Poma et al. (1990). Yield and all yield components significantly decreased with delay sowing. Reduction in these traits was considered to be related to the coincidence of vegetative and reproductive growth stages with higher temperatures prevailing at later plantings.

The effect of sowing date and cultivar and their interaction on number of sub branch, number of pods per plant, number of seeds per plant and biological yield was significant at 1% level. The results showed that Arman variety had the highest grain yield. Simple correlation coefficients calculated among examined characteristics are shown in Table 5. Correlation analysis showed that grain yield had significantly positive correlation with plant

**Table 1.** Analysis of variance of chickpea evaluated traits.

| Source of variation | MS (Mean Squares) | | | | | |
|---|---|---|---|---|---|---|
| | d.f. | H (cm) | DPE (cm) | NS | NPP | NSP |
| Cultivar | 2 | 234.76** | 53.02** | 2.66** | 13.78** | 83.99** |
| Sowing date | 2 | 308.01** | 64.73** | 15.22** | 38.07** | 70.76** |
| Cultivar and sowing date interaction | 4 | 8.20$^{ns}$ | 9.91$^{ns}$ | 1.05$^{ns}$ | 4.02** | 8.64** |
| Coefficient of variation (%) | - | 11.91 | 18.61 | 18.67 | 8.77 | 13.35 |

*P < 0.05, **P < 0.01; ns: Non- significant; H: plant height; DPE: distance of the first pod from the earth surface; NS: number of substem; NPP: number of pods per plant; NSP: number of seeds per plant.

**Table 2.** Analysis of variance of chickpea evaluated traits.

| Source of variation | MS (Mean Squares) | | | | |
|---|---|---|---|---|---|
| | d.f. | Wp (g) | Gy (kg ha$^{-1}$) | By (kg ha$^{-1}$) | HI (%) |
| Cultivar | 2 | 2.77$^{ns}$ | 429636.95** | 2192952.22** | 179.32** |
| Sowing date | 2 | 26.85** | 24931.95** | 197227.53** | 87.46* |
| Cultivar and sowing date interaction | 4 | 3.49$^{ns}$ | 20160.80$^{ns}$ | 256534.09** | 8.66$^{ns}$ |
| Coefficient of variation (%) | - | 7.07 | 12.62 | 10.95 | 11.43 |

*P < 0.05, **P < 0.01; ns: Non- significant; WP: 100-seed weight; GY: grain yield; BY: biological yield; HI: harvest index.

**Table 3.** Effect of cultivars and sowing dates on evaluated traits.

| Source of variation | H (cm) | DPE (cm) | NS | NPP | NSP |
|---|---|---|---|---|---|
| **Cultivar** | | | | | |
| C1 | 29.8 b | 11.8 b | 3.1 b | 7.2 c | 7.0 c |
| C2 | 33.4 b | 15.0 a | 2.9 b | 8.0 b | 8.9 b |
| C3 | 39.9 a | 16.6 a | 4.7 a | 9.6 a | 13.0a |
| **Sowing date** | | | | | |
| D1 | 40.5 a | 17.2 a | 4.6 a | 10.3 a | 12.7 a |
| D2 | 23.8 b | 14.3 b | 3.3 b | 8.4 b | 9.3 b |
| D3 | 28.8 c | 11.9 b | 2.0 c | 6.2 c | 7.1 c |
| **Cultivar × sowing date** | | | | | |
| C1D1 | 35.9 bcd | 14.3 b | 3.9 b | 8.7 bc | 8.3 cd |
| C1D2 | 28.1 e | 12.7 bc | 2.7 b | 7.6 cd | 7.7 cd |
| C1D3 | 25.5 e | 8.6 c | 1.7 c | 5.3 e | 5.1 e |
| C2D1 | 39.3 abc | 16.1 b | 4.6 ab | 9.1 b | 11.6 b |
| C2D2 | 32.3 cde | 15.7 b | 2.2 c | 8.2 bc | 8.3 cd |
| C2D3 | 28.7 de | 13.2 bc | 1.9 c | 6.8 d | 6.7 de |
| C3D1 | 46.3 a | 21.4 a | 5.3 a | 13.1 a | 18.1 a |
| C3D2 | 41.1 ab | 14.6 b | 4.1 b | 9.3 b | 11.3 b |
| C3D3 | 32.4 cde | 13.9 b | 4.2 c | 6.5 de | 9.6 bc |

Within treatment means followed by the same letter are not significantly different at P < 0.05 according to Duncan's multiple range test. H: plant height; DPE: distance of the first pod from the earth surface; NS: number of substem; NPP: number of pods per plant ; NSP: number of seeds per plant; C1, C2 and C3 : Filip-84-48-c, ILC-482 and Arman cultivars; D1, D2 and D3: March 6, 21 and April 4, respectively.

height ($r = 0.813^{**}$), distance of the first pod from earth surface ($r = 0.639^{**}$), number of sub branch ($r = 0.627^{**}$), number of pods per plant ($r = 0.827^{**}$), number of seeds per plant ($r = 0.846^{**}$), biological yield ($r = 0.798^{**}$) and

**Table 4.** Effect of cultivars and sowing dates on evaluated traits.

| Source of variation | Wp (g) | Gy (kgha$^{-1}$) | By (kgha$^{-1}$) | HI (%) |
|---|---|---|---|---|
| **Cultivar** | | | | |
| C1 | 24.23 a | 633.8 c | 1150.3 c | 29.50 b |
| C2 | 24.66 a | 802.4 b | 1568.0 b | 31.59 b |
| C3 | 25.23 a | 1067.1 a | 2134.7 a | 38.05 a |
| **Sowing date** | | | | |
| D1 | 25.90 a | 1001.5 a | 2068.6 a | 36.23 a |
| D2 | 25.57 a | 834.8 b | 1651.5 b | 32.92 ab |
| D3 | 22.76 b | 668.3 c | 1134.7 c | 30.00 b |
| **Cultivar × sowing date** | | | | |
| C1 D1 | 24.11 abc | 807.6 cd | 1300.3 ef | 31.66 bc |
| C1 D2 | 26.23 ab | 598.4 de | 1201.5 ef | 28.72 c |
| C1 D3 | 22.47 c | 511.4 e | 949.2 g | 28.13 c |
| C2 D1 | 26.71 ab | 902.0 c | 2006.0 bc | 36.47 ab |
| C2 D2 | 24.82 abc | 796.7 cd | 1698.7 cd | 30.70 bc |
| C2 D3 | 22.47 c | 703.6 cd | 1013.4 fg | 27.61 c |
| C3 D1 | 26.90 a | 1301.4 a | 2901.9 a | 40.56 a |
| C3 D2 | 25.70 abc | 1112.0 b | 2049.3 b | 39.34 a |
| C3 D3 | 23.46 bc | 806.7 cd | 1463.0 de | 34.26 abc |

Within treatment means followed by the same letter are not significantly different at p<0.05 according to Duncan's multiple range test. Wp: 100-seed weigth; Gy: grain yield; By: biological yield; HI: harvest index.
C1, C2 and C3, Filip-84-48-c, ILC-482 and Arman cultivars; D1, D2 and D3 : March 6, 21 and April 4, respectively.

**Table 5.** Pearson correlation coefficients among some phonological and agronomic traits in chickpea.

| Character | H (cm) | DPE (cm) | NS | NPP | NSP | WP (g) | GY (kgha$^{-1}$) | BY (kgha$^{-1}$) | HI (%) |
|---|---|---|---|---|---|---|---|---|---|
| H | 1.00 | 0.585** | 0.731** | 0.766** | 0.784** | 0.583** | 0.813** | 0.802** | 0.650** |
| DPE | | 1.00 | 0.564** | 0.773** | 0.802** | 0.223ns | 0.639** | 0.775** | 0.619** |
| NS | | | 1.00 | 0.776** | 0.705** | 0.583** | 0.627** | 0.684** | 0.578** |
| NPP | | | | 1.00 | 0.869** | 0.517** | 0.827** | 0.870** | 0.633** |
| NSP | | | | | 1.00 | 0.455* | 0.846** | 0.812** | 0.711** |
| WP | | | | | | 1.00 | 0.392* | 0.467* | 0.286$^{ns}$ |
| GY | | | | | | | 1.00 | 0.798** | 0.826** |
| BY | | | | | | | | 1.00 | 0.819** |
| HI | | | | | | | | | 1.00 |

*P < 0.05, **P < 0.01; ns: non-significant. H: plant height; DPE: distance of the first pod from earth surface; NS: number of sub stem; NPP: number of pods per plant; NSP: number of seeds per plant; WP:100 - seed weight; GY: grain yield; BY: biological yield; HI: harvest index.

harvest index (r = 0.826$^{**}$) at 1% level and with 100- seed weight (r = 0.392$^{*}$) at 5% level. Therefore, results indicated that grain yield had high and positive correlation with number of seeds per plant, number of pods per plant and plant height. The relationships determined by path analysis among the examined characteristics in the research are shown in Table 6. The results of path coefficient analysis revealed that number of seeds per plant had high and positive direct effects (0.76) on seed yield, but number of pods per plant was also an important constituent (0.41). Soil test results are shown in Table 7.

Overall, as can be seen from correlation coefficients and path analysis, number of seeds per plant has important role in variation of yield and selection for effective increase of yield (Figures 2 - 4).

## DISCUSSION

Chickpea is one of the most important crops in rainfed condition of Iran and play important role in rotation with rainfed wheat and barley. Many variables influence plant

**Table 6.** Path coefficient analysis for chickpea seed yield components.

| | Direct effect | Indirect effect | | | |
|---|---|---|---|---|---|
| | | NS | NPP | NSP | WP |
| NS | - 0.067 | - | - 0.052 | - 0.047 | - 0.039 |
| NPP | 0.41* | 0.318* | - | 0.356** | 0.212 |
| NSP | 0.76*** | 0.536** | 0.66** | - | 0.346* |
| WP | - 0.19 | - 0.111 | - 0.099 | - 0.086 | - |
| Residual | 0.281 | | | | |

***, **, *Significant at the 0.001, 0.01 and 0.05 probability level, respectively.
NS: number of substem; NPP: number of pods per plant; NSP, number of seeds per plant; WP: 100-seed weigth.

**Table 7.** Soil properties for 0-30 cm depth for the research location.

| Soil properties | 0 - 30 cm depth |
|---|---|
| Organic matter (%) | 2.4 |
| Available N (%) | 0.13 |
| Silt (%) | 48.8 |
| $P_2O_5$ (ppm) | 9.6 |
| Sand (%) | 7.7 |
| pH | 7.1 |
| $K_2O$ (ppm) | 580 |
| Clay (%) | 43.5 |

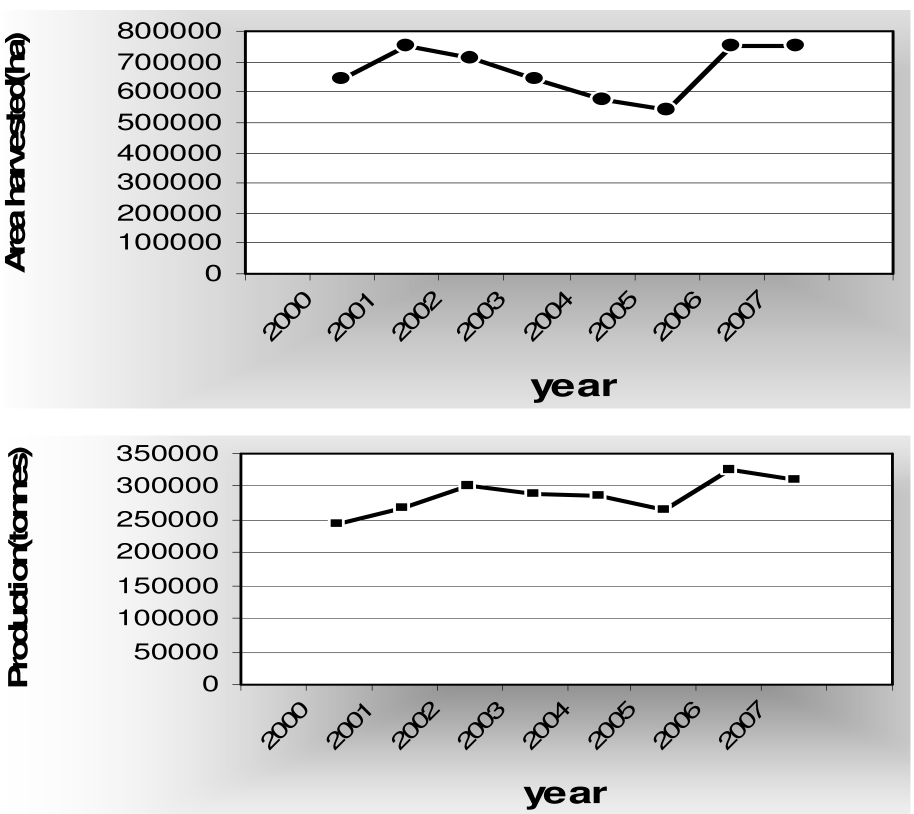


**Figure 1.** Trend of changes area harvested and production chickpea in the Iran (2000 - 2007). Source: Fao Statistics Division.

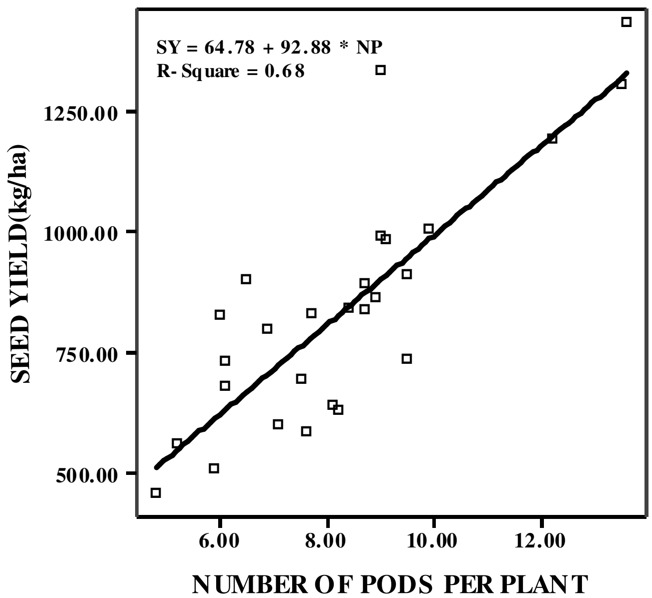


**Figure 1.** Relationship between yield and number pods per plant.

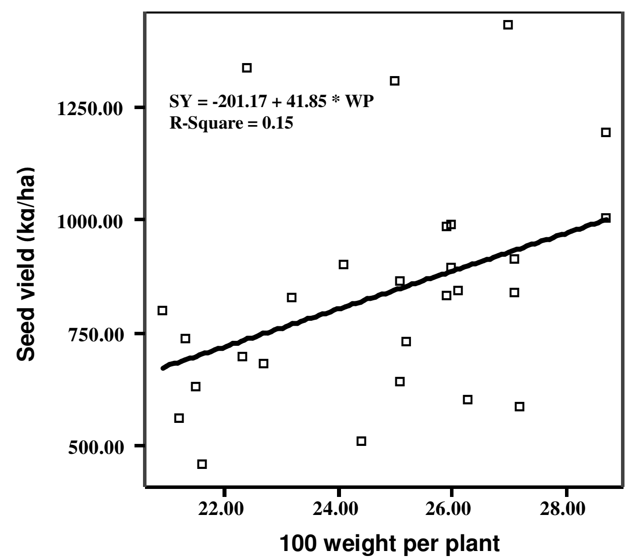


**Figure 4.** Relationship between yield and 100 weight per plant.

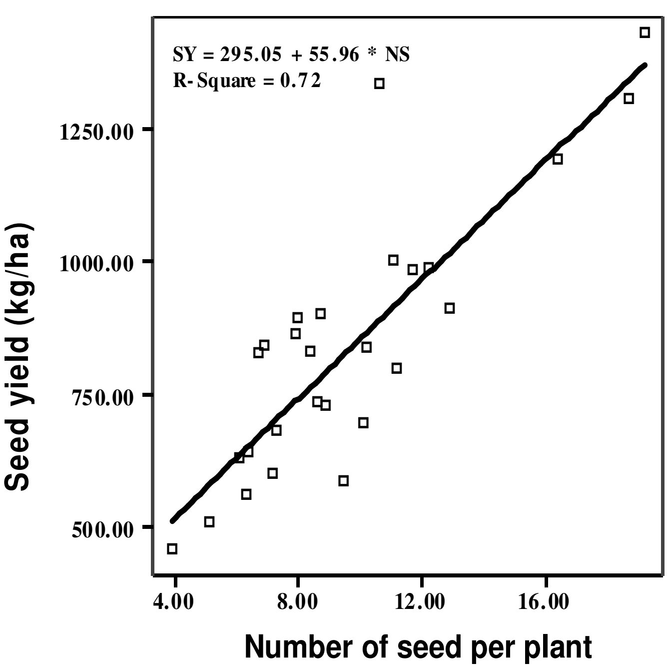


**Figure 3.** Relationship between yield and number of seeds per plant.

growth and development, including day-length, the amount of solar energy received and temperatures during the growing season, etc. Temperatures of over 30 - 32°C limit chickpea yield by hastening maturity (Nielsen, 2001). Lopez-Bellido et al., (2004) reported that the high temperatures from flowering to maturity of late-sown varieties led to reduced seed size and lower yield. Chickpea seed yield correlates significantly with total rainfall received during the preceding fallow period and during crop growth. Therefore, crop management practices such as cultivar selection, time of sowing and duration of cultivar's life cycle may influence the growth, yield and seed quality. Sowing date is an important production component that can be manipulated to counter the adverse effects of environmental stress. This is accomplished through shifting sowing so that any stress caused by environment is avoided during the critical stages of plant growth (Caliskan et al., 2008). Optimum time of flowering is a major component of crop environmental adaptation (Subbarao et al., 1995). Time of flowering and maturity is often affected by both temperature and photoperiod (Anwar, 2003). Flowering time is important because environmental condition during the reproductive phase have a major impact on final yield. Planting dates were used in this study as a means to change the rate of plant emergence and delay the time of flowering. Additionally, delay in emergence and flowering force the plant to experience different environmental conditions under which they flower and set pods and seed. Delay planting was caused by high temperature during reproductive development which decreased seed yield of chickpea by decreasing the number of seeds per plant and weight per seed primarily and the harvest index secondarily (Wang et al., 2006).

## Conclusion

It has been shown that determination of the optimum Sowing date for chickpea is very crucial for better crop yields. Understanding relationships among chickpea (*C. arietinum* L.) yield and yield components is critical to utilizing these relationships effectively and developing desirable varieties. Results showed that the number of seeds per plant with direct effect (0.76) was the greatest factor affecting grain yield. Therefore, for selection programs for improving grain yield in chickpea genotypes, number of seeds per plant can be use as a selection index.

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