Effects of Water Stress and Pod Position on the Seed Quality of Chickpea (*Cicer arietinum* L.) Cultivars

Kazem GHASSEMI-GOLEZANI, Tahereh MOUSABEYGI, Yaeghoob RAEF, Saeid AHARIZAD

University of Tabriz, Faculty of Agriculture, Department of Agronomy and Plant Breeding, Tabriz, Iran; golezani@gmail.com

Abstract

A field experiment was carried out in 2008 to evaluate the effects of different irrigation treatments (I1, I2, and I3; irrigation after 70, 120 and 170 mm evaporation from class A pan, respectively) and pod positions (upper, lower and middle parts of the canopy) on the seed quality of four chickpea cultivars (‘Jam’, ‘Hashem’, ‘Arman’ and ‘ILC’ from Kabuli type). Seed quality as determined by means of the electrical conductivity of seed leachates, germination percentage, germination rate and seedling dry weight were not significantly affected by water stress, but mean seed weight decreased with increasing irrigation intervals. The largest seeds with the highest quality were obtained from the lower parts of the canopy. No significant interaction of irrigation versus seed position indicated that seeds of lower position had high quality under both adequate and limited irrigations. ‘ILC’ had larger and more vigorous seeds compared to other cultivars. Mean seed weight, germination percentage, germination rate and seedling dry weight had positive and significant correlation with each other. It was concluded that sorting chickpea seeds for large and uniform size after harvest could be a practical way of improving seed lot quality.

Keywords: chickpea, limited irrigation, pod position, seed quality

Introduction

Chickpea (*Cicer arietinum* L.) is one of the major pulse crops throughout the world. Most of the chickpea growing areas in Iran have cool and cold semiarid climates with terminal drought stress. In NW Iran, chickpea is sown from mid-March to the end of April and grows mainly on reserve moisture which is progressively depleted with crop growth. The crop experiences drought stress from the late vegetative stages until maturity. The intensity of drought stress varies from year to year, depending on temperature variation and the amount and distribution of rainfall (Solhani et al., 2001). Chickpea cultivars used in Iran have been subjected to little breeding work, and consequently chickpea yield is limited by climatic factors, water availability and genotype.

Germination and seedling establishment are critical stages in the plant life cycle. In crop production stand establishment determines plant density, uniformity and management options (Cheng and Bradford, 1999). In arid and semi-arid environments, the water needed for germination is available for only a short period, and consequently, successful crop establishment depends not only on the rapid and uniform germination of the seed, but also on the ability of the seed to germinate under low water availability conditions (Fischer and Turner, 1978). However, if the stress effect can be alleviated at the germination stage, chances for attaining a good crop with economic yield production would be high (Ashraf and Rauf, 2001). While the time of sowing can influence crop establishment, it also dictates the environment experienced during seed development, both within and above the crop canopy (Castillo et al., 1994).

High quality seed lots may improve crop yield in two ways: first because seedling emergence from the seedbed is rapid and uniform, leading to the production of vigorous plants and second because percentage seedling emergence is high, so optimum plant population density could be achieved under a wide range of environmental conditions (Ghassemi-Golezani, 1992). These are the main reasons for farmers, who are interested to buy and cultivate vigorous seeds. Thus, production of high quality seeds is an important strategy for seed producers. Factors other than environment can also alter seed size and quality. In non-stressed soybean plants, seeds located within the upper canopy had a higher germination percentage and a greater seedling growth rate than seeds from the lower canopy (McDonald et al., 1983).

For an indeterminate soybean cultivar, Keigley and Mullen (1986) found that seeds from the middle stem region exhibited greater seedling weight compared to seeds from other regions of the stem. Pod position can also influence the response of weight per seed to the application of supplemental water. Wallace (1986) reported that irrigation increased weight per seed and pod number in the lower canopy branches compared with similar branches on non-irrigated plants. Thus, pod position during a drought stress may be an important factor in the determination of seed physiological quality. This research was undertaken to examine the effects of pod position and water stress on chickpea seed germination and vigor.
Materials and methods

A split-split plot experiment (using RCB design) with 3 replications was conducted in 2008 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Iran (latitude 38.05°, longitude 46.17°E, altitude 1360 m). The climate is characterized by mean annual precipitation of 245.75 mm per year, mean annual temperature of 10°C, annual maximum temperature of 16.6°C and mean annual minimum temperature of 4.2°C.

Irrigation regimes (I, I₁, and I₂; irrigation after 70, 120 and 170 mm evaporation from class A pan, respectively) were located in main plots and cultivars ('Jam', 'Hashem', 'Arman' and 'ILC' from Kabuli type) were allocated to sub plots. Pod positions were considered as sub-sub plots. Seeds of chickpea cultivars were treated with 2 g.kg⁻¹ Mancozeb and then sown by hand on 24 May 2008 in 5 cm depth sandy loam soil. At the same time, plots were fertilized with 100 kg.ha⁻¹ Ammonium Phosphate. Each plot consisted of 6 rows of 4 m length, spaced 25 cm apart. All plots were irrigated immediately after sowing, but subsequent irrigations were carried out according to the treatments. Hand weeding of the experimental area was performed as required.

At the maturity stage, when seed moisture content was 16-18%, seeds of the plants at 2 m² of each plot were separately detached from the upper, middle and lower parts of the canopies. Seed moisture content was determined in accordance with ISTA rules (1985). Subsequently, seeds were ambient air dried and 1000 seed weight of each sample was determined. Seed samples within separate sealed bags were then placed in a refrigerator at 3-5°C.

Seed quality tests were carried out at the Seed Technology Laboratory of Tabriz University. Four replicates of 25 seeds from each sample were treated with 2.5 g.l⁻¹ Thiram for about 1 min, before testing. Seeds of each replicate were placed between two 30 x 30 cm wetted and rolled filter papers, which were then placed in plastic bags to prevent water loss. These bags were incubated at 10±1°C for 10 days.

Results and discussion

Analysis of variance of the data showed significant effects of cultivar and pod position on 1000 seed weight, germination rate, germination percentage and seedling dry weight. Electrical conductivity of seed leachates was not significantly affected by cultivar, pod position and irrigation treatments. The effect of irrigation was only significant for 1000 seed weight. Cultivars X pod position interaction was also significant for 1000 seed weight (Tab. 1).

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of freedom</th>
<th>1000 seed weight</th>
<th>Electrical conductivity</th>
<th>Germination percentage</th>
<th>Germination rate</th>
<th>Seedling dry weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>390.48 ns</td>
<td>1.086 ns</td>
<td>1.23 ns</td>
<td>0.93 ns</td>
<td>1003.70 ns</td>
</tr>
<tr>
<td>Irrigation(I)</td>
<td>2</td>
<td>45461.34 **</td>
<td>0.594 ns</td>
<td>6.79 ns</td>
<td>9.51 ns</td>
<td>383.04 ns</td>
</tr>
<tr>
<td>Error</td>
<td>4</td>
<td>1742.87</td>
<td>0.299</td>
<td>4.55</td>
<td>5.51</td>
<td>3392.59</td>
</tr>
<tr>
<td>Cultivar (C)</td>
<td>3</td>
<td>27553.90 **</td>
<td>0.209 ns</td>
<td>90.36 **</td>
<td>244.06 **</td>
<td>83095.06 **</td>
</tr>
<tr>
<td>I°C</td>
<td>6</td>
<td>1596.73 ns</td>
<td>0.147 ns</td>
<td>6.47 ns</td>
<td>8.39 ns</td>
<td>442.69 ns</td>
</tr>
<tr>
<td>Error</td>
<td>18</td>
<td>652.69</td>
<td>0.135</td>
<td>4.27</td>
<td>4.17</td>
<td>2951.85</td>
</tr>
<tr>
<td>Position (P)</td>
<td>2</td>
<td>5319.68 **</td>
<td>0.098 ns</td>
<td>55.26 **</td>
<td>52.48 **</td>
<td>9603.70 **</td>
</tr>
<tr>
<td>ΓP</td>
<td>4</td>
<td>318.40 ns</td>
<td>0.064 ns</td>
<td>1.12 ns</td>
<td>2.73 ns</td>
<td>2059.26 ns</td>
</tr>
<tr>
<td>CP</td>
<td>6</td>
<td>937.39 **</td>
<td>0.167 ns</td>
<td>1.35 ns</td>
<td>1.84 ns</td>
<td>1198.77 ns</td>
</tr>
<tr>
<td>ΓC/P</td>
<td>12</td>
<td>333.41 ns</td>
<td>0.137 ns</td>
<td>1.15 ns</td>
<td>1.10 ns</td>
<td>1283.95 ns</td>
</tr>
<tr>
<td>Error</td>
<td>48</td>
<td>311.273</td>
<td>0.130</td>
<td>1.58</td>
<td>1.87</td>
<td>1246.30</td>
</tr>
<tr>
<td>CV (%)</td>
<td>5.76</td>
<td>1.6</td>
<td>1.31</td>
<td>4.73</td>
<td>7.14</td>
<td></td>
</tr>
</tbody>
</table>

*** Significant at P≤0.05 and P≤0.01, respectively

---

EC (µs/cm/g) = [(EC₁/SW₁) + (EC₂/SW₂)]/2
Mean 1000 seed weight significantly decreased as the severity of water stress increased (Fig. 1). The highest 1000 seed weight, germination rate, germination percentage and seedling dry weight were obtained for seeds of lower position, but no significant differences in quality parameters of upper and middle seeds were observed (Tab. 2).

‘ILC’ was a superior cultivar in mean 1000 seed weight, germination rate and seedling dry weight. These traits in ‘Jam’ and ‘Hashem’ cultivars were statistically similar. The lowest seed quality parameters were observed in ‘Arman’ (Tab. 3). No significant differences in 1000 seed weight of ‘Jam’ and ‘Hashem’ at different plant positions were observed. However, in ‘Arman’ and ‘ILC’, mean 1000 seed weight of lower plant position was significantly higher than that of middle and upper positions (Fig. 2).

The 1000 seed weight was positively and significantly (p≤0.01) correlated with germination rate, germination percentage and seedling dry weight. However, electrical conductivity of seed-steep water negatively and not significantly correlated with other parameters. Germination percentage, germination rate and seedling dry weight had also significant and positive correlation with each other (Tab. 4).

Reduction in mean seed weight of chickpea with increasing water limitation (Fig. 1), could result from the stimulation of seed maturity under stress as reported in lentil (Erskine and Ashkar, 1993), chickpea (Silim and Saxena, 1993), wheat (Li et al., 2000), barley (Samarah, 2005) and common bean (Ghassemi-Golezani and Mazloomi-Oskooyi, 2008). Seed quality as measured by electrical conductivity of seed leachates, germination percentage, germination rate and seedling dry weight was not significantly affected by water stress (Tab. 1). Similarly, Ghassemi-Golezani et al. (1997) reported that water stress has no significant effect on seed quality of maize and sorghum, but it can considerably reduce seed yield. This is also supported by previous reports on soybean (Vieira et al., 1992) and common bean (Ghassemi-Golezani and

---

**Tab. 2. Mean seed quality parameters of chickpea affected by pod position**

<table>
<thead>
<tr>
<th>Pod position</th>
<th>1000 seed weight (g)</th>
<th>Germination percentage</th>
<th>Germination rate (per day)</th>
<th>Seedling dry weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up</td>
<td>0.280±0.06b</td>
<td>94.7±0.36b</td>
<td>0.280±0.52b</td>
<td>481.1±10.57b</td>
</tr>
<tr>
<td>Middle</td>
<td>0.284±0.14b</td>
<td>95.1±0.35b</td>
<td>0.284±0.52b</td>
<td>490.0±10.31b</td>
</tr>
<tr>
<td>Low</td>
<td>0.303±0.08b</td>
<td>97.0±0.43b</td>
<td>0.303±0.52b</td>
<td>512.8±11.55b</td>
</tr>
</tbody>
</table>

Different letters at each column indicating significant differences at P≤0.05

---

**Tab. 3. Mean seed quality parameters for chickpea cultivars**

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>1000 seed weight (g)</th>
<th>Germination percentage</th>
<th>Germination rate (per day)</th>
<th>Seedling dry weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Jam’</td>
<td>308.9±4.66b</td>
<td>95.7±0.24b</td>
<td>0.289±0.23b</td>
<td>497.8±4.69b</td>
</tr>
<tr>
<td>‘Hashem’</td>
<td>309.4±6.73b</td>
<td>96.7±0.39b</td>
<td>0.294±0.39b</td>
<td>503.0±10.66b</td>
</tr>
<tr>
<td>‘Arman’</td>
<td>264.9±9.73b</td>
<td>93.0±0.38b</td>
<td>0.249±0.46b</td>
<td>421.5±9.89b</td>
</tr>
<tr>
<td>‘ILC408’</td>
<td>342.8±7.81b</td>
<td>97.19±0.39b</td>
<td>0.322±0.40b</td>
<td>556.3±8.34b</td>
</tr>
</tbody>
</table>

Different letters at each column indicating significant differences at P≤0.05

---

Fig. 1. Mean 1000 seed weight under different irrigation regimes I1, I2 and I3: irrigation after 70, 120 and 170 mm evaporation from class A pan, respectively

Fig. 2. Mean 1000 seed weight of chickpea cultivars affected by pod position C1, C2, C3 and C4: ‘Jam’, ‘Hashem’, ‘Arman’ and ‘ILC’, respectively
Tab. 4. Correlation coefficients of various seed quality parameters in chickpea

<table>
<thead>
<tr>
<th>Trait</th>
<th>1000 seed weight</th>
<th>Electrical conductivity</th>
<th>Germination percentage</th>
<th>Germination rate</th>
<th>Seedling dry weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000 seed weight</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td>-0.279</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germination percentage</td>
<td>0.770**</td>
<td>-0.042</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germination rate</td>
<td>0.815**</td>
<td>-0.007</td>
<td>0.943**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Seedling dry weight</td>
<td>0.829**</td>
<td>-0.028</td>
<td>0.868**</td>
<td>0.970**</td>
<td>1</td>
</tr>
</tbody>
</table>

** Significant at P≤0.01

References


Ghassemi-Golezani, K., A. Soltani and A. Atashi (1997). The effect of water limitation in the field on seed quality of maize.

Conclusions

Water stress has no significant effect on seed quality of chickpea cultivars, but it can significantly reduce seed size. Seeds of lower position have a high quality under both full and limited irrigation conditions. Therefore, sorting chickpea seeds for a large and uniform size after harvest could improve seed lot quality.

References


