Effects of water supply on field performance of chickpea (*Cicer arietinum* L.) cultivars

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**Abstract**

In order to investigate the effects of water supply (I₁, I₂, I₃ and I₄: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) on yield and yield components of three chickpea (*Cicer arietinum* L.) cultivars (Azad, Arman and Jame), a split plot experiment (using randomized complete block design) with three replications was conducted in 2012. Pods per plant, grains per plant, 100 grains weight, biological yield, grain yield and harvest index decreased with decreasing water supply. Azad was a superior cultivar in grains per pod, 100 grain weight, plant biomass, grain yield and harvest index, compared with Arman and Jam. The superiority of Azad in grain yield was more evident under normal irrigation conditions. Differences between Arman and Jam in grains per pod, 100 grains weight and biological yield were not significant. Therefore, yield and yield components of chickpea can be reduced under water stress, depending on the severity of stress and cultivar.

**Keywords:** Chickpea, Grain yield, Plant biomass, Water stress

**Introduction**

Chickpea is an important grain legume in the world and constitutes 20% of the pulses production (FAO, 2004). It is traditionally cultivated in marginal areas (Rao et al., 2002) and grown in semi-arid regions (Labidi et al., 2009). Major producing countries include India, Pakistan and Iran (FAO, 2010).

Drought is a major abiotic stress that severely affects food production world-wide. It was reported that water deficit results in nearly 50% of the variation in chickpea production caused by both biotic and abiotic stress factors (Saxena, 1987). Water deficit is an important factor limiting growth and productivity of the crops in a large part of the agricultural areas in the world (Borsani, et al., 200; Micheletto, et al., 2007). Drought stress is a serious problem in Iran, because rainfalls are poorly distributed over the growing season and stop before plant growth completion and chickpea is traditionally planted towards the end of the rainy season and generally grown on progressively declining soil moisture residual and increasing temperature (Ganjeali et al., 2011).

Photosynthesis and cell growth are the primary processes which are affected by water stress (Munns et al., 2006). The flowering and pod setting stages appear to be the most sensitive stages to drought (Nayyar et al., 2006). Water stress during flowering and grain filling caused 50-80% reductions in grain yield due to restrictions in photosynthesis (Leport et al., 1999). Chickpea is more sensitive to water stress during reproductive stages and consequently experiences substantial yield loss (Turner et al., 2001; Nayyar et al., 2005). Water limitation at these stages leads to flower abortion, poor pod set and formation of infertile pods (Davies et al., 1999).

The effect of drought stress on growth and yield depends on function of genotype, duration of stress, weather conditions, growth and developmental stages of crops (Robertson and Holland, 2004). Moderate to high drought stress reduced plant biomass, number of pods and seeds, days to maturity, harvest index, grain yield and grain weight in common bean (Ghassemi-Golezani and Mardfar, 2008), soybean (Demirtas et al., 2010) and pinto bean (Ghassemi-Golezani et al., 2010). Mensah et al. (2006) and Hong et al. (1985) reported that drought stress resulted in stunted growth and reduced grain yield of sesame (*Sesamum indicum* L.). This research was carried out to evaluate the extent of the effects of water limitation on yield and yield components of three chickpea cultivars.
Materials and Methods

This research was conducted in 2012 at the Research Farm of the Faculty of Agriculture, University of Tabriz, Tabriz, Iran (Latitude 38° 05’ N, Longitude 46° 17’ E, Altitude 1360 m above sea level) to evaluate effects of water supply (I$_1$, I$_2$, I$_3$ and I$_4$: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) on yield and yield components of three chickpea (Cicer arietinum L.) cultivars (Azad, Arman and Jam). The climate is characterized by mean annual precipitation of 245.75 mm per year and mean annual temperature of 10°C.

The experiment was arranged as split plot on the basis of randomized complete block design in three replicates, with the irrigation treatment (I$_1$, I$_2$, I$_3$ and I$_4$: irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively) in main plots and chickpea cultivars (Azad, Arman and Jam) in sub plots. Each plot had 6 rows of 5 m length, spaced 25 cm apart. Seeds were treated with Benomyl at a rate of 2 g/kg before sowing. The seeds were then sown by hand on 14 May 2012 in 4 cm depth of a sandy-loam soil. All plots were irrigated immediately after sowing, but subsequent irrigations were carried out according to the treatments. Weeds were controlled by hand during crop growth and development as required.

At maturity, 10 plants from each plot were harvested and pods per plant, grains per pod, grains per plant, 100 grain weight, grain yield, biological yield and harvest index were determined. Analysis of variance appropriate to the experimental design was conducted, using MSTATC software. Means of each trait were compared according to Duncan multiple range test at $p\leq0.05$. Excel software was used to draw figures.

Results and Discussion

Analyses of variance of the data for grain yield, yield components and harvest index showed that pods per plant, grains per plant, 100 grain weight, biological yield, grain yield and harvest index were significantly affected by irrigation and cultivar. Grains per pod did not differ significantly among irrigation treatments, but it was significantly varied among cultivars. The interaction of irrigation × cultivar was only significant for grain yield per unit area (Table 1).

Table 1. Analyses of variance of the data for grain yield, yield components and harvest index of chickpea cultivars under different irrigation treatments

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>Pods per plant</th>
<th>Grains per pod</th>
<th>Grains per plant</th>
<th>100 Grains weight</th>
<th>Biological yield</th>
<th>Grain yield</th>
<th>Harvest index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>86.370</td>
<td>0.225</td>
<td>660.723</td>
<td>20.439</td>
<td>5865.55</td>
<td>1026.493</td>
<td>3.925</td>
</tr>
<tr>
<td>Irrigation(I)</td>
<td>3</td>
<td>254.261</td>
<td>0.124</td>
<td>231.461</td>
<td>105.131</td>
<td>13471.779</td>
<td>19961.108</td>
<td>378.155</td>
</tr>
<tr>
<td>Ea</td>
<td>6</td>
<td>25.685</td>
<td>0.257</td>
<td>46.065</td>
<td>16.346</td>
<td>13589.922</td>
<td>116.758</td>
<td>6.394</td>
</tr>
<tr>
<td>Cultivar (C)</td>
<td>2</td>
<td>650.136</td>
<td>0.876</td>
<td>252.261</td>
<td>41.922</td>
<td>12583.496</td>
<td>8428.530</td>
<td>46.374</td>
</tr>
<tr>
<td>P°C</td>
<td>6</td>
<td>11.652</td>
<td>0.051</td>
<td>14.775</td>
<td>8.790</td>
<td>256.444</td>
<td>215.456</td>
<td>1.716</td>
</tr>
<tr>
<td>Eb</td>
<td>16</td>
<td>15.051</td>
<td>0.039</td>
<td>7.182</td>
<td>3.738</td>
<td>600.332</td>
<td>76.914</td>
<td>1.771</td>
</tr>
<tr>
<td>CV%</td>
<td></td>
<td>12.36</td>
<td>1.422</td>
<td>9.19</td>
<td>7.42</td>
<td>5.22</td>
<td>3.65</td>
<td>2.62</td>
</tr>
</tbody>
</table>

*, ** Significant at $p\leq0.05$ and $p\leq0.01$, respectively

Pods per plant, grains per plant, 100 grains weight, biological yield, grain yield and harvest index decreased with decreasing water supply (Table 2). Similar result in chickpea was report by Ghassemi-Golezani et al. (2012). Reduction in grain number was due to a decrease in pod formation and an increase in pod abortion (Fang et al., 2009; Ghassemi-Golezani et al., 2012). Irrigation disruption at pod filling can decrease grain filling duration (Ghassemi-Golezani et al., 2009) and photosynthate mobilization to grains, thereby decreasing grain weight (Sadeghipour, 2008).

Decreasing grain yield per unit area due to water deficit was attributed to reductions in pods and grains per plant, biological yield and 100 grain weight (Table 2). These results confirm previous field studies with chickpea that water deficit reduces biological and grain yields (Behboudian et al., 2001; Ghassemi-Golezani et al., 2008; Bahavar et al., 2009; Niairi-Khamssi et al., 2010, 2011). Silvius et al. (1977) stated that the effects of water stress on soybean yield appeared to be related to limited availability of photosynthe and nitrogen for translocation to developing seed.

Azad was a superior cultivar in grains per pod, 100 grain weight, plant biomass, grain yield and harvest index, compared with Arman and Jam (Table 2). Azad produced less, but larger grains, leading to higher grain yield per unit area under all irrigation treatments. The superiority of Azad in grain yield was more evident under well-watering than under limited irrigation conditions (Figure 1). Differences between Arman and Jam in grains per pod, 100 grains weight and biological yield were not significant. Grains per pod only varied among cultivars and water stress had no significant effect on this trait (Table 2). Therefore,
environmental factors had little effect on grains per pod and it is mainly influenced by genotypes. Similar result was reported by Ghassemi-Golezani et al. (2012) for chickpea.

Table 2. Means of the grain yield, yield components and harvest index of chickpea for irrigation treatments and cultivars

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Pods per Plant</th>
<th>Grains per pod</th>
<th>Grains per plant</th>
<th>100 Grains weight (g)</th>
<th>Biological yield (g m⁻²)</th>
<th>Grain yield (g m⁻²)</th>
<th>Harvest Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I₁</td>
<td>37.61 a</td>
<td>1.530 a</td>
<td>35.04 a</td>
<td>29.04 a</td>
<td>518.4 a</td>
<td>286.2 a</td>
<td>55.16 a</td>
</tr>
<tr>
<td>I₂</td>
<td>33.76 ab</td>
<td>1.499 a</td>
<td>31.33 ab</td>
<td>28.37 a</td>
<td>475.4 b</td>
<td>258.7 b</td>
<td>54.36 a</td>
</tr>
<tr>
<td>I₃</td>
<td>28.36 bc</td>
<td>1.319 a</td>
<td>26.81 b</td>
<td>25.16 ab</td>
<td>459.3 bc</td>
<td>240.5 c</td>
<td>52.36 a</td>
</tr>
<tr>
<td>I₄</td>
<td>25.80 c</td>
<td>1.288 a</td>
<td>23.48 b</td>
<td>21.59 b</td>
<td>425.2 c</td>
<td>175.4 d</td>
<td>41.21 b</td>
</tr>
<tr>
<td>Cultivars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Azad</td>
<td>24.26 c</td>
<td>1.583 a</td>
<td>24.26 c</td>
<td>28.18 a</td>
<td>506.6 a</td>
<td>270.3 a</td>
<td>52.94 a</td>
</tr>
<tr>
<td>Arman</td>
<td>38.96 a</td>
<td>1.122 b</td>
<td>33.34 a</td>
<td>24.73 b</td>
<td>446.3 b</td>
<td>220.3 c</td>
<td>49.10 c</td>
</tr>
<tr>
<td>Jam</td>
<td>30.92 b</td>
<td>1.254 b</td>
<td>29.90 b</td>
<td>25.21 b</td>
<td>456 b</td>
<td>230.1 b</td>
<td>50.28 b</td>
</tr>
</tbody>
</table>

Different letters in each column indicate significant difference at P≤0.05.

I₁, I₂, I₃, I₄: Irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively.

Figure 1. Mean grain yield of chickpea cultivars under different irrigation treatment
I₁, I₂, I₃, I₄: Irrigation after 70, 100, 130 and 160 mm evaporation from class A pan, respectively

Conclusion

Water limitation reduces grain yield in chickpea cultivars due to reductions in grains per plant and grain weight. Pods per plant, grains per plant, 100 grains weight, biological yield, grain yield and harvest index of chickpea can be reduced under water stress, depending on the severity of stress and cultivar. Azad is a high yielding cultivar under all irrigation treatments.

References


