Investigation of Growth Analysis in Chickpea (Cicer arietinum L.) Cultivars under Drought Stress

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ABSTRACT

A field experiment performed in order to evaluate the effects of drought stress on growth indices of chickpea cultivars. This experiment was performed in factorial using randomized complete block design with three replications. Treatments were drought stress treatment in three levels consisting of no drought stress (control), moderate drought stress (irrigation at planting and early flowering) and severe drought stress (no irrigation) and cultivar treatment (three cultivars Azad, Grit and ILC482). Results showed that LAI, CGR, RGR and NAR reduced with increased in drought stress level. Also, LAR decreased after short time increasing. Non stress condition caused to improve growth stages and increase accumulation of dry matter and yield in chickpea. Maximum LAI, LAR and CGR obtained at 56 days after sowing under non irrigation condition, but under complete irrigation they were observed at 77 days after sowing. RGR and NAR reduced with increasing the age of the plant. Thus we concluded that drought stress decreased growth of chickpea and final yield of it.

INTRODUCTION

Chickpea (Cicer arietinum L.) is the third most important cool season food legume in the world after dry beans and peas (FAOSTAT, 2006). Chickpea is one most important grain-legume crop after soybean, bean, and pea, but contributes only 3.1% to the world grain legumes production (based on 2001 to 2006 average production of 266.5 million tons of soybean, beans, peas, chickpea, broad beans, cowpea, lentil, and pigeonpea). Over 50 countries grow chickpea; however, India, Turkey, Pakistan, Iran, Canada, Myanmar, Mexico, Ethiopia, and Australia together contribute 93.1% of the global chickpea production. Although North and Central America and Oceania together contribute only 6.2% of the world chickpea production, these regions have the highest recorded chickpea productivity (1.09 t ha⁻¹ to 1.34 t ha⁻¹). Chickpea is a self-pollinated crop, with 2n = 2x = 16 chromosomes and genome size of 732 Mb. Plant growth analysis is considered to be a standard approach to study of plant growth and productivity (Wilson, 1981). Seed yield increases in response to irrigation were related to increased TDM and crop growth rate (Husain et al., 1988) and Anwar et al. (2003a). Numerous reports indicate that irrigation more than doubles seed yields of grain legumes over unirrigated crops (i.e. water deficit conditions); narrow-leafed lupin (Lupinus angustifolius L.) (Herbert, 1977). LAI and LAD control total dry matter production and subsequently yield attributes and yield (Jirali et al. 1994). Leaf area and other growth parameters were influenced by different growth regulators in pulse crops (Ullah 2006).

The aim of this study is study on growth analysis of chickpea under drought stress.

MATERIALS AND METHODS

A field experiment was conducted at Iran. A field experiment performed in order to evaluate the effects of
drought stress on growth indices of chickpea cultivars. This experiment was performed in factorial using randomized complete block design with three replications. Treatments were drought stress treatment in three levels consisting of no drought stress (control), moderate drought stress (irrigation at planting and early flowering) and severe drought stress (no irrigation) and cultivar treatment (three cultivars Azad, Grit and ILC482). The plots were fertilized with, P, O, at the rate of 40 kg/ha as basal application. Each cultivar was planted in a 5 m long, 6-row plot. Row to row and plant - plant distance was maintained at 25 and, respectively. Seeds were placed at 3 to 5 cm depth in each row. The crop field was weeded twice to control weeds. Plant samples were taken with 10 plants from each plot. Sampling was taken each 10 days at the end of slow vegetative growth stage. The duration between sowing and first sampling was indicated as slow vegetative growth stage (SG), duration between first sampling and second sampling as linear growth stage (LG), duration between beginning and end of flowering as flowering stage (FS) and 20 days later after end of flowering stage was called grain filling stage (GF). Statistical analysis was done with standard ANOVA (Açkgöz et al., 2004). Leaf area was determined by Flaeche program (A-Kraft, 1995). The following equations were used to calculate the different growth indices (Roderick, 1990; SepetoLu and Budak, 1994):

\[
\text{LAI} = \frac{L}{P}, \quad \text{RGR} = \frac{1}{W} \frac{ dw}{ dt}, \quad \text{NAR} = \frac{1}{L} \frac{ dw}{ dt}, \quad \text{LAR} = \frac{L}{W}, \quad \text{LAD} = \text{LAI} \times \text{Number of days from beginning of flowering to maturity}, \quad \text{CGR} = \frac{1}{P} \frac{ dw}{ dt}.
\]

Where \( \text{LAI} \) = Leaf Area Index, \( \text{RGR} \) = Relative Growth Rate, \( \text{NAR} \) = Net Assimilation Rate, \( \text{LAR} \) = Leaf Area Ratio, \( \text{LAD} \) = Leaf Area Duration, \( \text{CGR} \) = Crop Growth Rate. \( W \) = Initial Dry Weight, \( dw \) = Dry Weight Production in t Days, \( dt \) = Number of Days, \( P \) = Ground Area, \( L \) = Initial Leaf Area.

**RESULTS**

The results showed that during the different growth stages, growth parameters mean values variation for severe drought stress were recorded as: \( \text{LAI} \) between 0/19 and 0/81 m\(^2\) m\(^{-2}\), \( \text{RGR} \) between 0/059 and 0/32 g g\(^{-1}\) day\(^{-1}\); \( \text{NAR} \) between 0/003 and 4/1 mg m\(^{-2}\) day\(^{-1}\); \( \text{LAR} \) between 0/011 and 0/005 m\(^2\) g\(^{-1}\); \( \text{CGR} \) between 1 and 6/2 g m\(^2\) day\(^{-1}\). Also this growth parameters mean values variation for sever control recorded as: \( \text{LAI} \) between 0/3 and 2/3 m\(^2\) m\(^{-2}\), \( \text{RGR} \) between 0/05 and 0/2 g g\(^{-1}\) day\(^{-1}\); \( \text{NAR} \) between 0/02 and 3/3 mg m\(^2\) day\(^{-1}\); \( \text{LAR} \) between 0.002 and 0.006 m\(^2\) g\(^{-1}\); \( \text{CGR} \) between 1 and 12 g m\(^2\) day\(^{-1}\). (Figure 1, 2, 3, 4 and 5). Chickpea cultivars in non-stress condition showed appreciable increase in LAI from reproductive stage to maturity (50-75 DAS) (Figure 1). The senescence of leaves was remarkably greater in severe drought stress. This finding is confirmed by Tesfaye et al. (2006), Karim and Fattah (2007). The maximum LAI was recorded at the time of pod development stage (60 DAS) in all treatments. In severe drought stress condition appreciable increase in LAI from reproductive stage to maturity (35-70 DAS) (Figure 1). LAI fell between 65 and 90 DAS in all treatments as plant had greater leaf senescence. The study revealed that LAI was recorded more during linear growth stage and during flower stage. During grain filling stage, there was decrease in leaf area and consequently in LAI. Relative growth rate (RGR) shows the amount of dry matter production with respect to the unit weight of the current dry matter of a plant over time (Neumann, 1995). RGR in supplementary irrigation treatment in chickpea was high compared to non-irrigation treatment. These results agree with those of Krishnamurthy et al, 2003. NAR was decreased with progress of chickpea growth stages (figure 2). Decrease of NAR in severe drought stress treatment was more than moderate stress and non-stress treatment. Maximum of NAR was obtained 10 day after sowing and after that The NAR was decreased until maturity (figure 2). Procedure of NAR changes showed that appreciable decreased until sowing date until maturity in non-stress condition and stress condition until the amounts of them were negative. When all leaves are exposed to full sunlight NAR remains to be highest. It also remains high when plants are small and there are few leaves to get the maximum sunlight without shading effects (Namvar et al, 2011). NAR decreases with crop growth due to mutual shading of leaves and reduced photosynthetic efficiency of older leaves (Yasari, Patwardhan, 2006).

Chickpea cultivars in non-stress condition showed appreciable increase in LAR in 40 DAS for S0 and S1 and 30 DAS for S2. After these times the procedure of LAR changes was decreased (Figure 3).

The maximum CGR was obtained at non-stress treatment and minimum of CGR was obtained at severe drought stress treatment (figure 4). The CGR was increased until 50 day after sowing and after that the CGR was decreased. The peak crop growth rate (CGR) value was observed at pod development stage (49 DAS) in non-stress condition and stress condition. Data for non-stress condition and stress condition showed appreciable the procedure of CGR changes was decreased after cross peak of it. RGR was decreased with increased in GDD of chickpea cultivars (figure 5). For RGR in non-stress condition and stress condition showed appreciable increase until 16 DAS then the procedure of RGR changes was decreased until the amounts of them were negative (Figure 5). This may be due to the fact that in the initial stages of the plant growth the ratio between alive and dead tissues is high and almost entire cells of productive organs are activity engaged in vegetative matter production and, consequently, the RGR of plants is high, while with plant aging, the metabolic activity of tissues decreases and
hence the tissues cannot contribute to the growth that results in RGR decreasing (Zajac et al., 2005).

The increasing of LAI was attributed to the rise in leaf number and total leaf area / plant (Kibe et al., 2006; Yasari, Patwardhan, 2006). CGR is regarded as the most meaningful growth function since it represents the net results of photosynthesis, respiration and canopy area interaction (Alam, Haider, 2006). As noted by Gupta and Gupta (2005), CGR is also a representative of the most common agronomic measurements such as yield of dry matter per unit land area. Starting from lower value, CGR reached a certain peak and then declined at the later stages of growth. In the present investigation, complete irrigation showed the highest CGR in inoculated (22% increase over severe stress). In general, CGR depends mainly on the amount and intensity of intercepted energy and photosynthetic efficiency of the canopy (Namvar et al, 2011). Higher CGR may be due to higher production of dry matter owing to greater LAI and higher light interception (Zajac et al., 2005). The present study showed that RGR and NAR reduced with increasing the age of the plant. Thus we concluded that drought stress decreased growth of chickpea and final yield of it.

![Figure1. Effect of drought stress on LAI in chickpea](image1)

![Figure2. Effect of drought stress on NAR in chickpea](image2)

![Figure3. Effect of drought stress on LAR in chickpea](image3)

![Figure4. Effect of drought stress on CGR in chickpea](image4)

![Figure5. Effect of drought stress on RGR in chickpea](image5)
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