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# Drought Tolerance In Chıckpea (*Cicer arietinum* L.) Genotypes

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**Abstract**

Chickpea (*Cicer arietinum* L.) is an important legume crops in Turkey. A field study in randomized complete block design was conducted to investigate drought resistance characteristics of Chickpea varieties in the Mediterranean condition (Adana province) of Turkey. Results showed that Chickpea grain yields were influenced by drought stress and genotypes without a significant interaction. Averaged across Chickpea genotypes, grain yields were significantly decreased by 43% in response to drought stress. The highest seed yield was recorded in FLIP 98-108 C and lowest in FLIP 98-42C. Among the genotypes, the FLIP 98-108 C and FLIP 98-63 C had significantly higher mean productivity, geometric mean productivity, yield index and yield stability index when compared with Aydın and Inci as control. In contrast, the FLIP 98-24 C and FLIP 98-42 C had significantly lower STI and DTE with higher values of DSI and TOL. A significantly lower values of TOL and DSI but higher values of MP, YI, YSI, STI, DTE and GMP indicated a greater drought tolerance in FLIP 98-108 C, FLIP 98-63 C, FLIP 98-128 C, FLIP 00-18 C, FLIP 98-55 C, Aydın and FLIP 98-24 C, respectively. These traits are recognized as beneficial drought tolerance indicators for selecting a stress tolerant variety. Therefore, these genotypes can be used as sources of drought tolerance in further breeding programme for evolving the drought tolerant genotypes in chickpea.

**Key words:** Chickpea, Drought, Yield Stability Index, Tolerance Index, Drought Susceptibility Index

## Introductıon

Chickpea with nearly 4.2 million da production area in Turkey is one of the world's most importatnt pulses grown in semi-arid or arid regions and sown in autumn or spring and grows during the cool wet months of winter and spring in Mediterranean-climatic regions. In both environments chickpea crops are exposed to drought during pod set and seed filling Among all factors Limiting chickpea productivity. drought affects many morphological and physiological processes assocated with plant growth and seed yield Toker and Çağırgan (1998).

Chickpea is considered one of the most drought tolerant of the cool season food legumes. the basis of its tolerance is unknown Singh (1993). For improving produvtivity in drought stressed condition. development of new chickpea cultivars with high yield potantial through identifying drought tolerance mechanism is of great important Rajaram et al. (1996). Although development of stress tolerant varieties is always a major objective of many breeding programs. breeding for tolerance to drought in chickpea is limited by lack of adeque selection criteria. On other hand. according to yield in irrigated and non-irrigated conditions. some researchers proposed some drought indices Ulemale et al.(2013), Farshadfer et al. ( 2012), Zebarjadi et al. (2011), Anwar et al. (2011). Thus. drought indices which provide a measure of drought based on yield loss under drought stressed conditions in comparision to normal conditions have been used for screening drought tolerant genotypes Mitra (2001).

Keeping in view the above research findings. the present study was carried out to investigate different drought resistance indices as well as their correlation and indentifying the potential genotypes for stress and non-stress conditions.

## Materıals and Methods

### Study Site

A 2-year field research was conductedin Adana ($35^0$18' E and $37^0$01' N; 23-m above the mean sea level), TURKEY. The research site has a typical Mediterranean climate with mild rainy winter and hot dry summer. Average meteorological data during the crop growing period (from November to June) are: 19.1, 13.3, 9.9, 11.2, 13.2, 16.5, 20.2 and 24.5 $^0$C, respectively for air temperatures, 0.0. 211.5, 79.0, 112.5, 83.0, 117.3, 30.0, and 0.0-mm, respectively for total

rainfall. The soil type of the is clay that has pH of 6.7, organic matter content 1.2%, $CaCO_3$content 23.6 % and salt content 0.09 %.

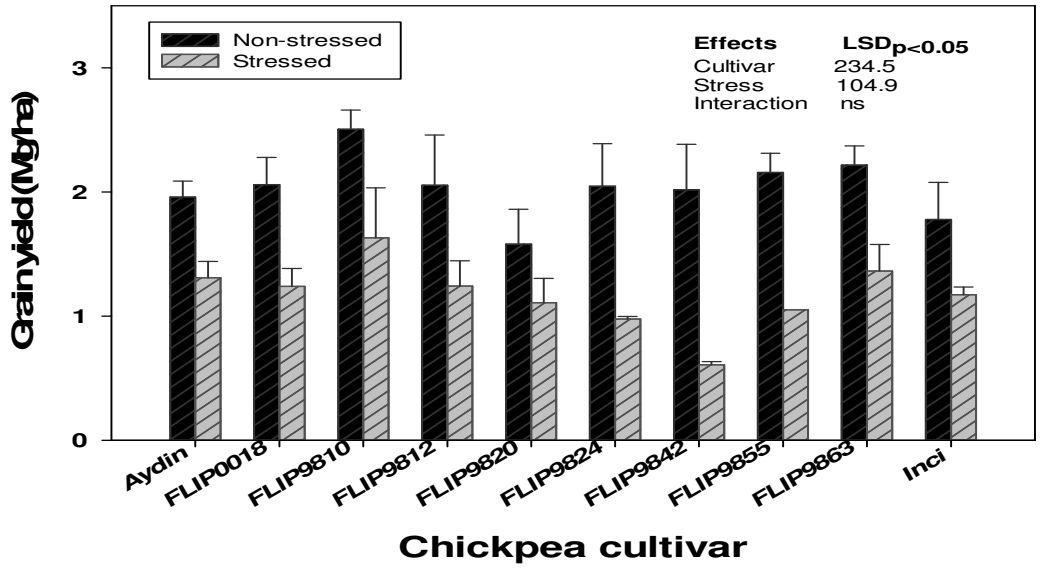


**Figure 1.** Grain Yield of Chickpea Genotypes under stressed and non-stressed conditions.

**Table 1.** Analysis of variance on drought resistance and tolerance characteristics of Chickpea.

| Drought resiatance/tolerance indices | ANOVA SS | Mean Square | F Value | P>F |
|---|---|---|---|---|
| Mean productivity (MP) | 1731039.6 | 192337.7 | 5.49 | 0.0002 |
| Geometric mean productivity (GMP) | 2150313.9 | 238923.8 | 7.61 | <0.0001 |
| Yield index (YI) | 1.907 | 0.213 | 8.88 | <0.0001 |
| Yield stability index (YSI) | 0.523 | 0.058 | 7.23 | <0.0001 |
| Drought susceptibility index (DSI) | 2.88 | 0.32 | 7.26 | <0.0001 |
| Tolerance index (TOL) | 2669956.5 | 296661.8 | 4.25 | 0.0013 |
| Stress tolerance index (STI) | 1.279 | 0.142 | 6.78 | <0.0001 |
| Drought tolerance efficiency (DTE) | 5243.7 | 582.6 | 7.27 | <0.0001 |

**Experiment and Cultural Practices**

A randomized complete block design in factorial combination of 2 stress levels x 10 Chickpea genotypes with four replications for each treatment comobnation was established. Eight chickpea varieties (such as FLIP 98-108 C, FLIP 98-128 C, FLIP 00-18 C, FLIP 98-20 C, FLIP 98-24 C, FLIP 98-42 C, FLIP 98-55 C, and FLIP 98-63 C) and two local control varieties (such as AYDIN92 and INCI) contrasting in crop cycle duration and growth habitatwere used. To evaluate the drought effects, randomly selected Chcickpea seeds were planted manually on late December, 2010 in non-stressed (control) treatment and on late March, 2011 in stressed treatment. The field was plowed prior to expermental treatments lay-out in the field with non-stressed and stress.Each replicated plot consisted of four rows with 4-m long x 45-cm apart. A standard chemical fertilization of nitrogen (40 kg/ha) and phoshorus ($P_2O_5$ 60 kg/ha) was applied at the time of seedbed preperation.

Chickpea growth characterictics such as emergence, flowering and podding dates were recorded in each plot in when 50% of the plants emerged, flowered and podded. While in non-stressed treatment (control), the Chickpea emergence, flowering and podding dates were 8 to 10 Feburary, 2011; 12 to 19 April, 2011; May 30 to June 10, 2011, respectively, in stressed treatment, the Chickpea emergence, flowering and podding dates were 18 to 24 April, 2011; May 25 to June 1, 2011; 5 to 12 June, 2011, respectively. All the plots were harvested at the end of the June, and the yields were recorded. Using the collected data, several drought tolerance indices such as:

tolerance index (TOL) was calculated as Yp – Ys (Rosielle and Hamblin 1981); mean productivity (MP) was calculated as (Ys + Yp) / 2 (Rosielle and Hamblin 1981); yield index (YI) was calclauted as Ys / Ŷs (Gavuzzi et al. 1997; Lin et al. 1986); yield stability index (YSI) was calculated as Ys / Yp (Bouslama and Schapaugh 1984); drought susceptibility index (DSI) was calculated as [1 - (Ys / Yp)] / [1 – (Ŷs / Ŷp)] (Fischerand Maurer 1978); stress tolerance index (STI) was calculated as (Yp * Ys) / (Ŷp)2 (Fernandez 1992); drought tolerance efficiency (DTE) was calculated as (Ys/Yp) (Fischer and Wood 1981); and geometric mean productivity (GMP) was calculated as (Yp * Ys)½ (Fernandez 1992). The Yp is mean yield of each cultivars under non-stressed condition, Ys is mean yield of each cultivars under stressed condition, Ŷp mean yield of all cultivars under non-stressed condition andŶs mean yield of all cultivars under stressed condition.

**Statiscal Analysis**

Significant differences in yield and drought tolerenace charactersitcis attributed to the effects of environmental stress on selected Chickpea genotypes were assessed using analysis of variance procedure of the SAS (2008). The block was considered as a random factor. Stress and genotypes were considered as fixed factors. For all statistical analyses, significant main and interactive effects of predictors on dependent variables were evaluated using the General Linear Model procedure and separated by the F-protected least significant different test at $p<0.05$ unless otherwise mentioned. Regression and correlation analyses were performed using SigmaPlot® to evaluate the relationship among the dependent variables in response to the effects of environmental stress.

**Table 2:** Mean values of drought tolerance indices in chickpea genotypes

| Chickpea Genotypes | MP (kg/ha) | GMP | YI | YSI (%) | DSI (kg/ha) | TOL (%) | STI | DTE |
|---|---|---|---|---|---|---|---|---|
| Aydin | 1634bc | 1598bc | 112bc | 67a | 77c | 649dc | 61bc | 67a |
| FLIP 98-108 C | 2069a | 2016a | 140a | 64ab | 83c | 873bcd | 99a | 65a |
| FLIP 98-128 C | 1649bc | 1596bc | 106bcd | 61ab | 91bc | 812bcd | 62bc | 61ab |
| FLIP 00-18 C | 1649bc | 1590bc | 106bcd | 61ab | 91bc | 820bcd | 61bc | 61ab |
| FLIP 98-20 C | 1345cd | 1323cd | 95bcd | 70a | 69c | 473d | 43cd | 70a |
| FLIP 98-24 C | 1512bcd | 1410c | 83d | 48b | 120b | 1071abc | 48cd | 49b |
| FLIP 98-42 C | 1313d | 1106d | 52e | 30c | 162a | 1409a | 30d | 31c |
| FLIP 98-55 C | 1605bcd | 1506bc | 90cd | 49b | 12b | 1104ab | 55bc | 49b |
| FLIP 98-63 C | 1790b | 1737b | 116b | 61ab | 91bc | 853bcd | 73b | 61ab |
| Inci | 1475cd | 1440c | 100bcd | 67a | 77c | 607d | 50bcd | 67a |

TOL= Tolerance index : Yp - Ys; Mean productivity (MP) : (Ys + Yp)/2; Yield stability index (YSI) : Ys / Yp; Yield index (YI) : Ys/Ŷs; Stress tolerance index (STI) :(Yp*Ys)/(Ŷp)2; Drought susceptibility index (DSI) : 1 - (Ys / Yp) / 1 - (Ŷs / Ŷp) ; Drought tolerance efficiency (DTE): (Ys/ Yp); Geometricmean productivity (GMP): (Yp * Ys)½ ; Yp is mean yield of each cultivars under non-stressed condition; Ys is mean yield of each cultivars under stressed condition; Ŷp mean yield of all cultivars under non-stressed condition and Ŷs mean yield of all cultivars under stressed condition.

**Result and Dıscussıon**

Chickpea grain yields were influenced by drought stress and genotypes without a significant interaction (Figure 1). Averaged across Chickpea genotypes, grain yields were significantly decreased by 43% in response to drought stress (Figure 1). The results indicated that crop yields under stress was lower in all genotypes than under non-stressed conditions. Crop yields were significantly varied by Chickpea genotypes, when averaged across environmental stress levels. The highest seed yield was recorded in FLIP 98-108 C and lowest in FLIP 98-42 C. While the FLIP 98-108 C had highest yield under both stressed and non-stressed conditions, the FLIP 98-40C had the lowest yield under non-stressed condition and and the FLIP 98-42 C had the lowest yield under stressed condition.

Analysis of variance showed that there were significant differences among the Chickpea genotypes drought resistance and tolerance characteristics (Table 1). Among the drought resistance and tolerance characteristics, there were highly significant variations in GMP, YI, YSI, DSI, DTE and STIcompared with MP and TOL of Chickpea.

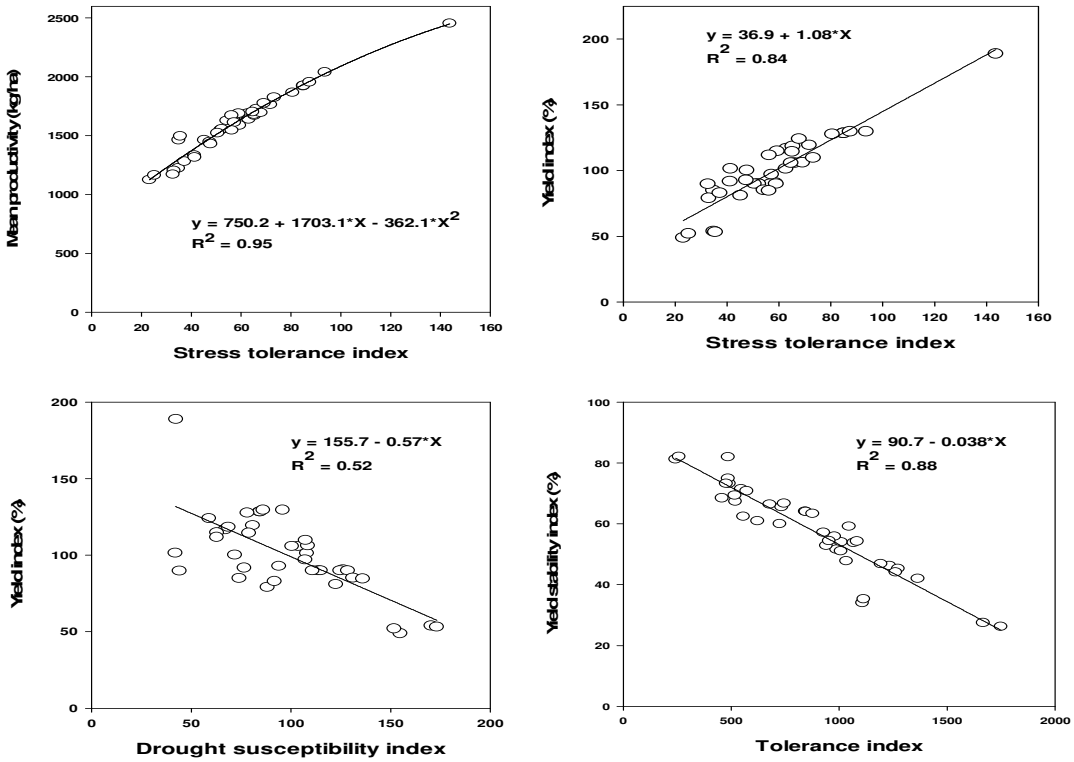


**Figure 2.** Regression and correlation analysis

Among the genotypes, the FLIP 98-108 C and FLIP 98-63 C had significantly higher mean productivity, geometric mean productivity, yield index and yield stability index when compared with Aydın and Inci as control. The FLIP 98-128 C, FLIP 00-18 C, FLIP 98-55 C and FLIP 98-24 C have shown intermediate response. In contrast, the FLIP 98-42 C, FLIP 98-20 C and Inci have shown poor response. Both FLIP 98-108 C and FLIP 98-63 C had higher values of STI and DTE with similar values of tolerance index (TOL) and drought susceptibility index (DSI) as compared with Aydin and Inci. In contrast, the FLIP 98-24 C and FLIP 98-42 C had significantly lower STI and DTE with higher values of DSI and TOL (Table 2).

When plotted, stress tolerance index of Chickpea significantly and non-linearly accounted for 95% of the variability in mean productivity index of Chickpea (Figure 2a). Moreover, stress tolerance index linearly accounted for 84% of the variability in yield index of Chickpea (Figure 2b). In contrast, drought susceptibility index linearly and inversely accounted for 52% of the variability in yield index of Chickpea (Figure 2c). Likewise, tolerance index linearly and negatively accounted for 88% of the variability in yield stability index of Chickpea (Figure 2d).

Lower values of TOL and DSI but higher values of MP, YI, YSI, STI, DTE and GMP indicated a greater drought tolerancein FLIP 98-108 C, FLIP 98-63 C, FLIP 98-128 C, FLIP 00-18 C, FLIP 98-55 C, Aydin and FLIP 98-24 C, respectively. These traits wereidentified as the most suitable drought tolerance indicators for selecting FLIP 98-108 C and FLIP 98-63 C as the stress tolerant Chickpea varieties. Therefore, these genotypes can be used as sources of drought tolerance in further breeding program for evolving the drought tolerant genotypes in chickpea. Similar result was reported by Anwar et al. (2011), Khakwani et al. (2011), Zebarjadi et al. (2011), Farshadfer et al. (2012), Raman et al., (2012),Deshmukh and Mate (2013), and Ulemale et al. (2013) in several crops includign Chickpea.

**Conclusıons**

Results showed that environmental stress had significant varibale effects on grain yield of selected Chickpea genotypes.While the FLIP 98-108 C had highest yield under both stressed and non-stressed conditions, the FLIP 98-40 C had the lowest yield under non-stressed condition and and the FLIP 98-42 C had the lowest yield under stressed condition. Significantly higher values of MP, YI, YSI, STI, DTE and GMP with an associated decrease in TOL and DSIvalues suggested a greater drought tolerancein FLIP 98-108 C, FLIP 98-63 C, FLIP 98-128 C, FLIP 00-18 C, FLIP 98-55 C, Aydin and

FLIP 98-24 C, respectively. It is recommended that FLIP 98-108 C and FLIP 98-63 C are the most stress tolerant Chickpea varieties which could be suitable to grow in the Mediterranean region of Turkey.

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