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# PERFORMANCE EVALUATION OF CHICKPEA GENOTYPES UNDER DROUGHT STRESS IN ARID ZONE OF THAL

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***Abstract*** *Chickpea (Cicer arietinum L.) is the second most important legume crop in terms of area and third in terms of production after beans and peas worldwide. It belongs to the Fabaceae family. It is a good source of quality protein. Along with proteins, it is rich in fiber and minerals (phosphorus, calcium, magnesium, iron, and zinc) and vitamins. The yield of chickpeas is less due to the shortage of water. The present study aimed to analyze seven chickpea genotypes for identifying resistant/tolerant genotypes against drought, which could be directly introduced as commercial varieties and used for future breeding for resistance against drought in Thal Region. The experimental treatments included seven chickpea genotypes. A randomized complete block design was used for experimentation. The experiment was replicated three times and laid down in the experimental area with complete randomization. There were three blocks: one controlled, the second was semi-drought, and the third was drought. Statistical data analysis demonstrated that all the chickpea genotypes had significant differences for all recorded traits. According to the results, two varieties (TG-1620 and TGX-228) are tolerant to drought stress. These two varieties perform well in the biological yield. Therefore, these genotypes can be used as germplasm in further breeding programs to develop drought-tolerant genotypes in chickpea.*

**Keywords:** *Phenotypic Characterization, Arid, Drought, Chickpea*

## Introduction

Chickpea (Cicer arietinum L.) is a vital pulse crop known for its significant contributions to human health by providing protein and fiber. It belongs to the Fabaceae family and holds the second position in cultivation area and third in production among all pulses (Varshney et al., 2013). Cultivated in over 50 countries (Rajeev et al., 2021), chickpea's global production reached 15 million metric tons (MMT) in 2020 (Shahbandeh, 2022). India leads in production and area, contributing approximately 70.7% to worldwide chickpea production (Samriti et al., 2020). The availability of pulses largely relies on the successful cultivation of chickpea and mungbean. Any setbacks in these crops can lead to a decline in pulse availability. In Pakistan, chickpea is grown across about 2.2 million hectares, with Thal being the main region encompassing Layyah, Bhakkar, and parts of Mianwali, Khushab, and Jhang districts (FAOSTAT, 2020). It has a well-developed tap-root system, with frequent adjacent branches and nodules extending in all directions. It is also an important crop in nitrogen fixation, it fixes atmospheric nitrogen into ammonia in the presence of *Rhizobium* bacteria by nodule formation. Roots infiltrate deeper than 120cm. Therefore, it is also grown to increase soil fertility (Khan et al., 2015).

Drought is a complex form of abiotic stress that affects crop plants in various ways. It leads to morphological, physiological, and biochemical changes, such as reduced growth, lower chlorophyll content, increased hydrogen peroxide levels resulting in lipid peroxidation and membrane damage, and elevated ascorbic acid and proline (Gunes et al., 2008). Drought often coincides with high solar radiation, high temperatures, sandy soils, and strong winds, further exacerbating plant damage, especially during critical reproductive stages. During the grain filling period, drought stress and high temperatures can reduce seed size by interfering with assimilate translocation, ultimately leading to lower grain yield per plant (Kosgei et al., 2021). Approximately one-third of the world's potentially cultivable land is estimated to suffer from insufficient water supply, resulting in periodic crop yield reductions due to drought (Gunes et al., 2008). As a result, drought stress and inadequate water availability pose significant challenges in semi-arid and arid regions, impacting the attainment of satisfactory crop yields.

In chickpeas, drought is a major problem due to the texture of the soil. Water leaches down in the sandy soil and is not available for proper growth of crops, which ultimately causes various problems like yield losses, a decrease in the number of pods, short plant height, and lack of chlorophyll *a,* and *b.* Due to these issues, different researchers are working on drought-tolerant varieties by breeding and changing the genetic material of plants to make them resistant to drought. This research aims to find the resistant varieties of chickpeas suitable for the arid climate of Layyah with the help of different morphological parameters of seven different chickpea cultivars which determine their response to drought stress. The study's hypothesis is there may be a positive or negative correlation between varieties and treatments. The objectives of this study are to characterize the drought tolerance variability in chickpeas, to find the changes of some morphological traits under drought stress in different cultivars, and to identify the relationships between drought and plant performance.

**Material and methods**

To evaluate the diversity of chickpea germplasm in the arid climate of Thal and to check the effect of drought on different chickpea cultivars, the experiment was conducted at Tarar Farms, Fatehpur, Layyah, Punjab, Pakistan ($31.2^{O}$ N, $71.2^{O}$ E). The soil of the experimental location was sandy loam with a pH of 6.5-7.5. Physiochemical properties of soil are (sand 61.4%, silt 21.3%, clay 16.3%, bulk density 1.28 $gcm^{-3}$, and texture class is sandy loam). The area falls in a subtropical climate characterized by warm summers and cool winters, having a long-term average rainfall of ≤ 200 mm.

**Experimental material**

To identify the tolerant cultivars against drought, seven varieties were tested: (Bittle-2016, Kabuli TG-1805, TG-1616, TGX-228, TG-1620, TG-1500, TGX-1767). The research was conducted using seven chickpea genotypes (Bittle-2016, Kabuli TG-1805, TG-1616, TGX-228, TG-1620, TG-1500, TGX-1767) that differed in their resistance levels to drought and were used as varietal components of the treatments. A randomized complete block design was used to experiment. The experiment was divided into 3 blocks and each genotype was replicated three times in each block and laid down at the experimental site with complete randomization. The plant-to-plant distance was maintained at 10 cm and the row-to-row distance was maintained at 30 cm. The total number of plants in $1^{st}$ replication was 5 and the other $2^{nd}$ replications contain 4 plants each. The water needed depends on the soil type and the weather (amount of rain, humidity, and temperature). The first irrigation is done before sowing and the second after 7 days. Third, irrigation was done at pods formation. Standard irrigation, plant production, and protection measures were carried out accordingly.

**Data collection**

Data were collected from each plant in the field. The number of pods and number of buds were counted from all the plants in the field area. After the harvest, 3 plants were selected randomly from each replication of each block for plant height (cm), number of branches, number of seeds per plant, and biological yield (g). For statistical analysis, MS Excel 2019 is used for the mean comparison of seven varieties, correlation, and path analysis. Statistix 8.1 software analyzes variance (ANOVA) at 5% probability values.

**Results and discussion**

Drought stress changes the biological yield parameter, leading to different responses of seven chickpea varieties to drought conditions. According to

***Table 1***, the number of pods per plant was affected by drought in all chickpea varieties, but the best performance regarding the number of pods per plant was TG-1500. It performs better under drought and semi-drought conditions, followed by Bittle-2016 and TG-1620. The number of buds per plant were affected by drought in all chickpea varieties. Still, the results show that regarding the number of buds per plant, TG-1500 performs better under drought and semi-drought conditions, followed by Bittle-2016, TG-1620, and TG-1616, respectively under drought and semi-drought. Drought in all chickpea varieties affected the number of seeds per plant, but the best performance regarding this parameter was shown by bittle-2016 and TG-1620. These varieties performed well under drought and semi-drought conditions, followed by TG-1616. The number of branches was affected by drought in all chickpea varieties, but TGX-228 and TG-1616 perform better than all others under drought and semi-drought conditions. TG-1620 was susceptible to drought for the number of branches in drought and semi-drought conditions. Plant height was also affected along with other traits due to drought in all chickpea varieties, but the best performance regarding plant height shows TGX-1767 and TG-1616 perform better under drought. Under semi-drought conditions, Kabuli TGK-1805 also performs well. The biological yield was affected by drought in all chickpea varieties, but the best performance regarding biological yield shows TG-1620 performs better under drought followed by TGX-228 and TG-1767, respectively.

***Table 1: Mean comparison of all varieties***

| GENOTYPES | TREATMENT | NB | NP | NOB | PH | S/P | B.Y |
|---|---|---|---|---|---|---|---|
| **G1** | T1 | 52 | 38.33 | 8 | 73.69 | 35.7 | 24 |
| **G1** | T2 | 27 | 25 | 6 | 59.27 | 27.7 | 16.7 |
| **G1** | T3 | 20.9 | 18 | 4.3 | 49.11 | 16.7 | 11.3 |
| **G2** | T1 | 46.6 | 33.47 | 7 | 59.69 | 46.3 | 25.3 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **G2** | T2 | 22.47 | 20.67 | 6 | 52.07 | 24.7 | 18.7 |
| **G2** | T3 | 17.13 | 16.17 | 6 | 46.57 | 18 | 16 |
| **G3** | T1 | 35.2 | 29.93 | 7.3 | 63.93 | 31.7 | 19.3 |
| **G3** | T2 | 21.53 | 18.46 | 5.3 | 56.3 | 21.3 | 12.7 |
| **G3** | T3 | 18.2 | 16.67 | 5.3 | 52.91 | 14 | 12 |
| **G4** | T1 | 36.87 | 31.33 | 7.3 | 62.65 | 44.7 | 27 |
| **G4** | T2 | 29.8 | 27.28 | 5.7 | 55.03 | 28.7 | 17.7 |
| **G4** | T3 | 15.13 | 14.67 | 5.7 | 49.59 | 25.3 | 12 |
| **G5** | T1 | 31 | 26.87 | 5.3 | 55.46 | 30.7 | 19.13 |
| **G5** | T2 | 20.73 | 18.71 | 5.3 | 49.53 | 25 | 14 |
| **G5** | T3 | 19.13 | 15.19 | 5 | 47.41 | 20.3 | 14 |
| **G6** | T1 | 37 | 26.87 | 6.3 | 55.88 | 59.3 | 32.3 |
| **G6** | T2 | 29 | 24.67 | 6 | 52.07 | 29 | 15.3 |
| **G6** | T3 | 22.13 | 17.13 | 5.7 | 50.37 | 23 | 14 |
| **G7** | T1 | 32.63 | 29.53 | 5.7 | 51.64 | 35 | 17.3 |
| **G7** | T2 | 30.73 | 27.88 | 4.3 | 45.27 | 26.7 | 14 |
| **G7** | T3 | 23.6 | 21.71 | 4 | 42.33 | 18 | 8 |

**Correlation**

The correlation analysis of the collected data showed that there are highly positive significant differences among the traits of chickpea varieties. The NOB showed non-significant differences with plant length and branches per plant (**Table 2**)

***Table 2: Correlation analysis***

| | *BY* | *NOB* | *NS* | *NB* | *NP* |
|---|---|---|---|---|---|
| **NOB** | 0.608 | | | | |
| **NS** | 0.906 | 0.473 | | | |
| **NB** | 0.196 | 0.172 | 0.156 | | |
| **NP** | 0.373 | 0.416 | 0.389 | 0.073 | |
| **PH** | 0.627 | 0.704 | 0.512 | 0.0319 | 0.452 |

BY: biological yield, PL: plant length, S/P: seeds per plant, B/P: branches per plant, NOP: no. of pods, NOB: no of buds

**Path coefficient analysis**

According to path coefficient analysis, all traits' direct and indirect effects positively affect chickpeas' biological yield except the number of buds per plant, which negatively affect biological yield, as shown in **Figure 1**.

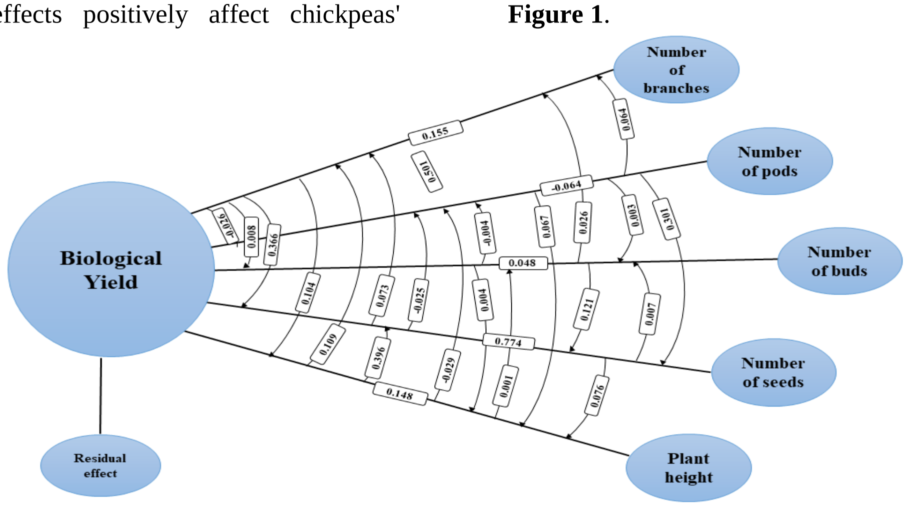


***Figure 1: Path coefficient analysis***

The findings indicate that crop yields were consistently lower under stress conditions than non-stress conditions across all genotypes. Among the Chickpea genotypes, grain yields experienced a significant reduction in response to drought stress. When considering different stress levels, there were notable differences in yield performance among chickpea genotypes, with Kabuli TG-1805 showing the highest yield losses. However, TG-1620, TG1415, and Bittle-2016 exhibited better yield per plant performance despite the drought stress. Furthermore, drought stress significantly impacted various characteristics including plant height, number of pods, number of branches, biological yield, and yield per plant. Previous studies have shown that drought stress negatively affects morphological parameters such as plant height, branches, dry weight, root length, leaf characteristics, and seed production. Stress during seedling, early blooming, and pod development stages can also lead to substantial production losses. The correlation analysis revealed significant intrinsic relationships between the tested traits, with strong connections and significance observed among variables such as number of seeds, branches, pods, plant height, and biological yield. These strong relationships suggest additive gene activity less influenced by environmental changes. Furthermore, several positive and important relationships were identified, while one was found to be negative and insignificant. These intrinsic links provide valuable insights into the associations between various combinations of traits.

**Conclusion**

According to the results, three varieties (TGX-228, TG-1767, and Kabuli TG-1620) are tolerant to drought stress. Therefore, these genotypes can be used as sources of drought tolerance in further breeding programs for evolving the drought-tolerant genotypes in chickpeas.

**Declaration**

**Conflict of interest**

The researchers affirm that there were no financial or commercial ties that might be seen as a potential conflict of interest throughout the research's execution.

**Data Availability statement**

All data generated or analyzed during the study have been included in the manuscript.

**Ethics approval and consent to participate**

These aspects are not applicable in this research.

**Consent for publication**

Not applicable

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**AUTHORS' CONTRIBUTIONS**

'Adil Hussain' designed the study, 'Adil Hussain', 'Zain ul Abideen', and 'Mohammad Usama' conducted the experiment and collected data, 'Adil Hussain and Zain ul Abideen' performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. 'Khalida Naheed', 'Maria Kareem', and 'Arzaf Rafique' managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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