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# Screening of chickpea genotypes based on morphological and biochemical attributes and drought tolerant indices

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**Abstract**
Among different types of abiotic stresses including drought, salinity, low or high temperatures, and other environmental extremes, drought stress is reported to be one of the major factors responsible for substantial reduction in global chickpea yield. In order to screen out the best performing drought tolerant genotypes, 32 chickpea genotypes were evaluated in RBD at RPCAU, Pusa during 2019-20 and 2020-21. The experiment was conducted under normal and drought conditions during two consecutive years. Significant variations were observed among the genotypes under both the conditions for all morphological characters studied including number of branches, biological yield (g/plant), harvest Index (%), yield per plant (g) and number of pods per plant. Based on the estimates of drought tolerance indices, 14 genotypes were found to be highly drought tolerant, which include ICCX-161037, ICCX-161047, IVT (MH) C-22970, ICCX-161051, ICCX-161053, ICCX-161054, ICCX-161055, ICCX-161059, ICCX-161078, ICCX-161080, ICCX-161085, ICCX-161087, IVT (MH) C-22957 and ICCX-161100. The enzymatic activity of peroxidise and catalase as well as proline content was found to be higher among the drought tolerant genotypes under drought condition. The outcomes from the above investigation depict that adoption of these screened out drought-tolerant chick pea genotypes will help in enhancing the economy of the farming community.

**Keywords:** Chickpea, drought tolerance, enzyme activity

## Introduction
Chickpea (*Cicer arietinum* L.) often referred as "king of pulses" is a diploid ($2n=2x=16$), self-pollinated cool season legume with a genome size of 738Mb (Varshney *et al.*, 2013) [28]. Globally, it is cultivated in more than 50 countries on an area of approximately 14.56 m ha. Among chickpea growing countries, India ranks first in terms of production and productivity. Besides south Asia, it is also cultivated in other continents including Africa, European nations, Australia, North as well as South America. Based on market class, there are two kinds of chickpea desi (80% area) and kabuli (20% area) (Merga and Haji, 2019) [18]. Despite of its economic importance, during last four decades, the productivity is less than one tonn per hectare (Dixit *et al*. 2019) [4]. This plateau in productivity is due to several abiotic and biotic stresses (Roorkiwal *et al*. 2020) [22]. Abiotic stresses include drought, salinity, extreme temperatures as well as flooding, which adversely affect the production and productivity of chickpea. Among abiotic stresses, terminal drought is a major constraint to chickpea production that leads up to 50% yield losses (Gaur *et al*. 2019) [9].
Drought stress being complex in nature, several efforts were made in past in case of chickpea for understanding its genetics. In general drought escape, drought tolerance and drought avoidance traits were studied in past (Gaur *et al*. 2012) [31]. Using mini-core collection of chickpeas, the genetic variability for drought avoidance root traits were evaluated and promising germplasm lines were identified (Krishnamurthy *et al*. 2003) [15]. A large collection of germplasm lines of chickpea was evaluated for 13 traits and efforts were made to identify the drought tolerant germplasm lines (Upadhyaya *et al*. 2012) [27]. Further, a rapid screening technique provided insight into the effect of canopy temperature and its relevance to drought tolerance improvement in chickpea (Kashiwagi *et al*. 2008) [11]. Not only germplasm lines, chickpea advanced breeding lines were also evaluated for drought tolerance indices under water limited conditions (Maqbool *et al*. 2015) [16]. More recently the root traits were reported to confer enhanced grain yield under terminal drought stress (Ramamoorthy *et al*. 2021) [20].
In this study we report the evaluation of 32 select advanced breeding lines of chickpea for drought tolerance at morphological and biochemical level and report the promising lines that

can be used in chickpea breeding programs for enhancing drought tolerance.

## Materials and Methods

### Plant material

A set of 32 advanced breeding lines obtained from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru as well two local genotypes Rajendra Chana-1 and GNG 1558 were used for assessing the morphological variability in yield related traits and variability in biochemical traits under normal and drought stress conditions (Table 1).

### Evaluation of advanced breeding lines under field conditions

In order to understand the level of drought tolerance among 32 advanced breeding lines of chickpea, we evaluated these lines along with two local checks in the field under normal and drought stresses condition at Tirhut College of Agriculture, Dholi (Latitude: 25° N; Longitude: 85° E) research farm as well as at Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar (25.9780° N, 85.6488° E) during 2019-2020 and 2020-2021. After seed treatment, the seeds were sown in 4.8 m rows during second week of November in both the years. We adopted randomized block design with three replications with a spacing 30 × 10 cm. Standard crop management practices were adopted as per Gaur *et al.*, 2010 [32]. We scored number of branches per plant, biological yield, yield per plant, number of pods per plant, harvest index. For calculating biological yield, we used five plants and seed weight in grams was measured using electronic weighing balance. Harvest Index was estimated by formulae (Economic yield/Biological yield) × 100. In order to obtain, yield per plant we measured the weight of total seed from each plant.

### Biochemical characterization

### Estimation of proline content

Determination of proline content in leaf sample was based on color changes upon addition of acid ninhydrin into it. The method of estimation of proline content was given by Bates *et al.* (1973) [2]. The absorbance of the light pink colored solution was read at 520 nm against a blank prepared with containing water only.

### Estimation of catalase activity

Catalase activity is based on the colour change upon addition of hydrogen peroxide to the enzyme extract. Catalase activity was determined by the method of Aebi (1984) [1]. Catalase enzyme was determined by following the changes in absorbance reading (X) at 240 nm for 2 minutes. The enzyme activity was calculated using the extinction coefficient value of 43.6 $mM^{-1}$ $cm^{-1}$ for hydrogen peroxide.

CAT enzyme activity (unit mg-1 protein min-1) = [(X × Vt × 10.5 × dilution factor) / 43.6 x Vs] Where,
Vt = Total Volume
Vs = Sample Volume
X = Average of the changes in absorbance reading

### Estimation of peroxidase activity

The activity of Peroxidase was estimated by through the method of Chance and Maehly (1955) [2].

Units/ml enzyme of Peroxidase = (Change in $A_{420nm}$/20 sec Test – change in $A_{420nm}$/20 sec Blank) (3) (df) / (12) (0.1) (0.5)
Sec = seconds
3 = Volume (in milliliters) of assay
df = Dilution factor
12 = Extinction coefficient of 1 mg/ml of Purpurogallin at 420 $nm^2$
0.1 = Volume (in milliliters) of enzyme used units/ml enzyme
Units/mg solid= (units/ml enzyme) ÷ (mg solid/ml enzyme)
Units/mg protein = (units/ml enzyme) ÷ (mg protein/ml enzyme)
0.5 = weight of sample

### Statistical analysis

The statistical analysis of data was performed using OPSTAT (Version 9.2., Sheoran *et al.*, 1998) [26]. We also calculated drought tolerance index, drought susceptibility index and tolerance index as mentioned below
Drought Tolerance Index (DTI) was calculated as per Fernandez (1992) [7].

$$DTI = [(Yp) \times (Ys) / (YAP)^2]$$

where,
Yp = seed yield from non-stressed plot of a given genotype
Ys = seed yield from stressed plot of that genotype
YAP = average seed yield of all genotypes from the non-stress plot.

While Drought susceptibility index (DSI) was calculated as per Fisher and Maurer (1978) [8].

$$DSI = [(1-Ys/Yp) /DII]$$

where,
Ys = seed yield from stressed plot of a given genotype
Yp = seed yield from non-stressed plot of the same genotype
DII = Drought intensity index, it was calculated by the following equation. DII = [1-(YAS/YAP)]

where,
YAS = average seed yield of all genotypes from the stressed plot
YAP = average seed yield of all genotypes from the non-stressed plot
Tolerance index (TI)was calculated using formula that was earlier proposed by Rosielle and Hamblin (1981) [23]

$$TOL = Yp – Ys$$

where, Yp = seed yield from non-stressed plot of a given genotype, Ys = seed yieldfrom stressed plot of the same genotype.

## Results and Discussion

In order to identify the drought tolerant advanced breeding lines, we evaluated 32 chickpea advanced breeding lines in three replications, two different location (Pusa and Dholi) under two normal and drought stress environments during two consecutive years E1 (2019-20) and E2 (2020-21).

**Mean performance of advanced breeding lines under normal and drought stress conditions**

**Number of branches**

The number of branches ranged from 9.25- 20 with general mean of the character was recorded to be 14.59±0.642 under normal condition in 2019-20. Minimum number of branches was reported in GNG-1558 (9.25). On the other hand, maximum number of branches was reported in IVT (MH) C-22957 (20) and ICCX-161078 (20). In E2, the mean values for the number of branches ranged from Rajendra Chana-1 (9.25) to ICCX-161055 (18.5). The general mean of the character was recorded to be 14.50±0.891. The pooled mean was recorded to be 14.54with the range of 9.63- 18.75. Under drought condition in E1, number of branches ranged from 7.25- 17.25with general mean of the character was recorded to be 12.48±0.537. Minimum number of branches was reported in ICCX-161086 (7.25). On the other hand, maximum number of branches was reported in IVT (MH) C-22957 (17.25).In E2, the mean values for the number of branches ranged from Rajendra Chana-1 (8.5) to IVT (MH) C-22970 (17). The general mean of the character was recorded to be 12.15±0.735. The pooled mean was recorded to be 12.31with the range of 8.38- 16.38.

**Biological Yield**

The biological yield ranged from 20- 160 g/plant with general mean of the character was recorded to be 70.53±2.64 during normal condition in 2019-20. Minimum the biological yield was reported in ICCX-161057 (20). On the other hand, maximum the biological yield was reported in ICCX-161037 (160). In E2, the mean values for the biological yield ranged from ICCX-161077 (26.67)- IVT (MH) C-22970 (159.75). The general mean of the character was recorded to be 70.40±2.191. The pooled mean was recorded to be 70.65 with the range of 25.88- 155.38. Under drought condition in E1, the biological yield ranged from 18.23- 145.00 with general mean of the character was recorded to be 59.76±2.22. Minimum biological yield was reported in ICCX-161057 (18.23). On the other hand, maximum biological yield was reported in IVT (MH) C-22970 (145). In E2, the mean values for the biological yield ranged from ICCX-161057 (21.75)- IVT (MH) C-22970 (139.88). The general mean of the character was recorded to be 55.88±2.12. The pooled mean was recorded to be 57.82 with the range of 19.99- 142.44.

**Harvest Index (%)**

Harvest index ranged from 26.96%- 40.25% with general mean of the character was recorded to be 33.85±1.63 during normal condition in 2019-20. Minimum the harvest index was reported in ICCX-161081 (26.96). On the other hand, maximum harvest index was reported in ICCX-161100 (40.25). In E2, the mean values for the harvest index ranged from ICCX-161077 (25.55)- ICCX-161047 (40.67). The general mean of the character was recorded to be 34.32±1.65. The pooled mean was recorded to be 34.04 with the range of 26.56- 39.51. Under drought condition in E1, harvest index ranged from 23.12- 39.39 with general mean of the character was recorded to be 31.85±1.44. Minimum harvest index was reported in ICCX-161077 (23.12). On the other hand, maximum harvest index was reported in ICCX-161100 (39.39). In E2, the mean values for the harvest index ranged from ICCX-161083 (21.9)- ICCX-161059 (38.88). The general mean of the character was recorded to be 29.65±1.52. The pooled mean was recorded to be 30.75 with the range of 22.51- 38.73.

**Yield per plant (g)**

The yield per plant ranged from 15.64- 51.55 with general mean of the character was recorded to be 35.86±2.928 during normal condition in 2019-20. Minimum yield per plant was reported in ICCX-161086 (15.64). On the other hand, maximum yield per plant was reported in ICCX-161053 (51.55). In E2, the mean values for the yield per plant ranged from ICCX-161086(20.02)- IVT (MH) C-22957 (49.5). The general mean of the character was recorded to be 35.34±2.036. The pooled mean was recorded to be 35.60 with the range of 17.83- 49.11. Under drought condition in E1, yield per plant ranged from 10.5- 47.25with general mean of the character was recorded to be 30.85±1.223. Minimum yield per plant was reported in ICCX-161086 (10.5). On the other hand, maximum yield per plant was reported in ICCX-161055 (47.25).In E2, the mean values for the yield per plant ranged from ICCX-161040 (11.89)- IVT (MH) C-22957 (44.78). The general mean of the character was recorded to be 30.48±1.375. The pooled mean was recorded to be 30.67with the range of 13.72- 45.05.

**Number of pods per plant**

Number of pods per plant ranged from 25.75- 48.75 with general mean of the character was recorded to be 38.55±1.412 under normal condition in 2019-20. Minimum number of pods per plant was reported in ICCX-161083 (25.75). On the other hand, maximum number of pods per plant was reported in IVT (MH) C-22957 (48.75). In E2, the mean values for the number of pods per plant ranged from ICCX-161083 (28) to IVT (MH) C-22957 (50.04). The general mean of the character was recorded to be 39.29±0.735. The pooled mean was recorded to be 38.89with the range of 26.88- 49.4. Under drought condition in E1, number of pods per plant ranged from 20.2- 46.9 with general mean of the character was recorded to be 36.00±1.281. Minimum number of pods per plant was reported in ICCX-161083 (20.2). On the other hand, maximum number of pods per plant was reported in IVT (MH) C-22957 (46.9).In E2, the mean values for the number of pods per plant ranged from ICCX-161083 (23.98) to IVT (MH) C-22970 (47.75). The general mean of the character was recorded to be 36.35±2.202. The pooled mean was recorded to be 35.96 with the range of 22.09- 47.01.

Similar findings were also observed (Waqas *et al*., 2019; Sharma *et al*., 2020) [29, 25]. In the case of irrigated conditions, less pod number observed due to more vegetative growth as a result of less light penetration and air circulation (Shan and Wang, 2017; Farooq *et al*., 2018) [24, 6].

**Peroxidase activity (Units/mg protein)**

The peroxidase activity ranged from 6.14- 8.26 with general mean of the character was recorded to be 7.76±0.27 under normal condition in 2019-20. Minimum peroxidase activity was reported in ICCX-161040(6.14). On the other hand, maximum peroxidase activity was reported in ICCX-161037, ICCX-161085, ICCX-161087, ICCX-161100 (8.26). In E2, the mean values for the peroxidase activity ranged from ICCX-161040 (6.63) to ICCX-161087 (8.39). The general mean of the character was recorded to be 7.77±0.24. The pooled mean was recorded to be 7.76 with the range of 6.38- 8.32. Under drought condition in E1, peroxidase activity

ranged from 6.63- 8.53with general mean of the character was recorded to be 7.93±0.28. Minimum peroxidase activity was reported in ICCX-161040 (6.63). On the other hand, maximum peroxidase activity was reported in ICCX-161078(8.53).In E2, the mean values for the peroxidase activity ranged from ICCX-161040 (7.22) to ICCX-161087 (8.98). The general mean of the character was recorded to be 8.35±0.25. The pooled mean was recorded to be 8.16 with the range of 6.93- 8.69.

**Proline content (mg $g^{-1}$ Fresh Weight)**

The proline content ranged from 7.19- 11.56 with general mean of the character was recorded to be 8.93±0.3 during normal condition in 2019-2020. Minimum proline content was reported in ICCX-161041 (7.19). On the other hand, maximum proline content was reported in IVT (MH) C-22970 (11.56). In E2, the mean values for the proline content ranged from ICCX-161057 (7.32) to IVT (MH) C-22970 (11.5). The general mean of the character was recorded to be 8.99±0.29. The pooled mean was recorded to be 8.96 with the range of 7.27- 11.53. Under drought condition in E1, proline content ranged from 8- 12.75 with general mean of the character was recorded to be 10.05±0.28. Minimum proline content was reported in ICCX-161054,ICCX-161057 (8). On the other hand, maximum proline content was reported in IVT (MH) C-22970 (12.75). In E2, the mean values for the proline content ranged from ICCX-161057 (8.07) to IVT (MH) C-22970 (12.25). The general mean of the character was recorded to be 9.72±0.3. The pooled mean was recorded to be 9.89 with the range of 8.04- 12.50.

**Catalase activity (unit mg-1 protein min-1)**

The catalase content ranged from 16.5- 20.32 with general mean of the character was recorded to be 17.93±0.58 during normal condition in 2019-20. Minimum catalase content was reported in ICCX-161099 (16.5). On the other hand, maximum catalase content was reported in ICCX-161047 (20.32). In E2, the mean values for the catalase content ranged from ICCX-161057 (16.5) to IVT (MH) C-22957 (19.89). The general mean of the character was recorded to be 17.93±0.52. The pooled mean was recorded to be **17.93** with the range of 16.75- 19.95. Under drought condition in E1, catalase content ranged from 17.88- 21.78 with general mean of the character was recorded to be 19.19±0.68. Minimum catalase content was reported in ICCX-161041 (17.88). On the other hand, maximum catalase content was reported in IVT (MH) C-22957 (21.78). In E2, the mean values for the catalase content ranged from ICCX-161041 (17.38) to IVT (MH) C-22957 (20.77). The general mean of the character was recorded to be 19.46±0.63. The pooled mean was recorded to be 19.01 with the range of 17.63- 21.28 (Table 1 and Table 2).

**Table 1:** Mean performance of thirty-two genotypes of chickpea for morphological and biochemical characters under normal and drought conditions over seasons

| | Number of branches | | | | | | Number of pods per plant | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019-2020 | | 2020-2021 | | Pooled | | 2019-2020 | | 2020-2021 | | Pooled | |
| Genotypes | N | D | N | D | N | D | N | D | N | D | N | D |
| ICCX-161033 | 17 | 15 | 16.25 | 13.75 | 16.63 | 12.66 | 33 | 31.5 | 36.5 | 29.6 | 34.75 | 30.55 |
| ICCX-161037 | 15.75 | 12.5 | 14.5 | 10.75 | 15.13 | 11.49 | 43.5 | 40.2 | 46 | 38.75 | 44.75 | 39.48 |
| ICCX-161040 | 14.25 | 10.75 | 13.5 | 11.5 | 13.88 | 12.13 | 31.75 | 29 | 33.8 | 30.25 | 32.78 | 29.63 |
| ICCX-161041 | 14 | 11 | 12.5 | 10 | 13.25 | 11.00 | 38.25 | 34 | 37.5 | 36 | 37.88 | 35.00 |
| ICCX-161047 | 17 | 13 | 15.75 | 15.5 | 16.38 | 13.59 | 45.56 | 44.8 | 42.9 | 42.25 | 44.23 | 43.53 |
| IVT (MH) C-22970 | 11 | 12 | 12.5 | 8.55 | 11.75 | 10.28 | 47.25 | 46.26 | 48.5 | 47.75 | 47.88 | 47.01 |
| ICCX-161049 | 17 | 15.75 | 18.25 | 17 | 17.63 | 14.78 | 40.5 | 38 | 42.75 | 35.55 | 41.63 | 36.78 |
| ICCX-161051 | 16 | 13.75 | 17.5 | 14.25 | 16.75 | 13.12 | 39.25 | 36.75 | 36.34 | 34 | 37.80 | 35.38 |
| ICCX-161053 | 15 | 14 | 12.75 | 15 | 13.88 | 13.88 | 46.25 | 40.2 | 44.9 | 44.86 | 45.58 | 42.53 |
| ICCX-161054 | 13 | 11.75 | 15 | 13.25 | 14.00 | 12.38 | 37.5 | 31.5 | 32.67 | 36 | 35.09 | 33.75 |
| ICCX-161055 | 14 | 12 | 13.5 | 11.75 | 13.75 | 11.88 | 44.8 | 43.8 | 43.25 | 40.25 | 44.03 | 42.03 |
| ICCX-161056 | 16 | 14.5 | 13.75 | 12.25 | 14.88 | 12.53 | 28.5 | 25.5 | 30.8 | 28 | 29.65 | 26.75 |
| ICCX-161057 | 17 | 16.75 | 18.25 | 15.3 | 17.63 | 14.10 | 32.75 | 30.5 | 35.75 | 29.75 | 34.25 | 30.13 |
| ICCX-161058 | 18 | 17.25 | 15.25 | 14.5 | 16.63 | 13.48 | 34.6 | 32.7 | 38.9 | 34 | 36.75 | 33.35 |
| ICCX-161059 | 16 | 14.8 | 17.5 | 8.54 | 16.75 | 10.61 | 42.5 | 43 | 40.75 | 41 | 41.63 | 42.00 |
| IVT (MH) C-22965 | 14 | 12 | 12.5 | 11 | 13.25 | 12.00 | 29.85 | 29.85 | 27.5 | 30.8 | 28.68 | 30.33 |
| ICCX-161077 | 10 | 11 | 13 | 9.25 | 11.50 | 10.13 | 35.75 | 30.3 | 37.75 | 34 | 36.75 | 32.15 |
| ICCX-161078 | 20 | 14.8 | 17 | 13.5 | 18.50 | 13.08 | 44.28 | 42.25 | 42.15 | 39.67 | 43.22 | 40.96 |
| ICCX-161079 | 10 | 8.5 | 11.75 | 9.8 | 10.88 | 10.53 | 30.5 | 25.8 | 33.85 | 27 | 32.18 | 26.40 |
| ICCX-161080 | 14 | 12.8 | 15.25 | 13.25 | 14.63 | 13.03 | 45.75 | 46.25 | 48.25 | 43.75 | 47.00 | 45.00 |
| ICCX-161081 | 13 | 11.25 | 14.25 | 12.5 | 13.63 | 12.00 | 40.25 | 38.6 | 43 | 32 | 41.63 | 35.30 |
| ICCX-161082 | 17 | 13.75 | 18.5 | 15.5 | 17.75 | 14.24 | 36.5 | 32.7 | 39.29 | 34.78 | 37.90 | 33.74 |
| ICCX-161083 | 14 | 12.25 | 12.5 | 11 | 13.25 | 11.63 | 25.75 | 20.2 | 28 | 23.98 | 26.88 | 22.09 |
| ICCX-161085 | 15 | 13.8 | 16.35 | 14.5 | 15.68 | 13.75 | 43.25 | 43.74 | 45.5 | 44.88 | 44.38 | 44.31 |
| ICCX-161086 | 18 | 15.75 | 16 | 10.75 | 17.00 | 11.86 | 34.5 | 32.75 | 35 | 34.9 | 34.75 | 33.83 |
| ICCX-161087 | 17 | 13.25 | 15.75 | 12 | 16.38 | 12.63 | 47.8 | 45 | 43.86 | 44.75 | 45.83 | 44.88 |
| IVT (MH) C-22957 | 20 | 11.5 | 17.5 | 15 | 18.75 | 13.95 | 48.75 | 46.9 | 50.04 | 47 | 49.40 | 46.95 |
| ICCX-161098 | 14 | 11 | 12.75 | 9.25 | 13.38 | 10.78 | 31.9 | 27.4 | 33 | 25.5 | 32.45 | 26.45 |
| ICCX-161099 | 11 | 8.75 | 13.25 | 12 | 12.13 | 12.10 | 33.6 | 31.9 | 35.25 | 33 | 34.43 | 32.45 |
| ICCX-161100 | 9.5 | 7.25 | 11 | 9.25 | 10.25 | 10.50 | 46 | 44.75 | 47 | 46.5 | 46.50 | 45.63 |
| Rajendra Chana-1 | 10 | 8.25 | 9.25 | 8.5 | 9.63 | 10.38 | 37.7 | 32.15 | 39.25 | 33.29 | 38.48 | 32.72 |
| GNG-1558 | 9.25 | 8.75 | 10.5 | 9.75 | 9.88 | 10.65 | 35.5 | 33.89 | 34.85 | 39.5 | 35.18 | 36.70 |
| MEAN | 14.59 | 12.48 | 14.50 | 12.15 | 14.54 | 12.22 | 38.55 | 36.00 | 39.21 | 36.35 | 38.89 | 36.18 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C.D. | 1.820 | 1.611 | 2.525 | 2.083 | | | 4.002 | 3.629 | 2.083 | 6.241 | | |
| SE(m) | 0.642 | 0.537 | 0.891 | 0.735 | | | 1.412 | 1.281 | 0.735 | 2.202 | | |
| C.V. | 7.627 | 6.951 | 10.645 | 10.482 | | | 6.761 | 5.754 | 10.482 | 9.728 | | |

| | Biological yield (g/plant) | | | | | | Harvest Index (%) | | | | | | Yield per plant (g) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019-2020 | | 2020-2021 | | Pooled | | 2019-2020 | | 2020-2021 | | Pooled | | 2019-2020 | | 2020-2021 | | Pooled | |
| Genotypes | N | D | N | D | N | D | N | D | N | D | N | D | N | D | N | D | N | D |
| ICCX-161033 | 40 | 34.5 | 41.6 | 30.38 | 40.80 | 32.44 | 33.87 | 31.56 | 34.25 | 29.75 | 34.06 | 30.66 | 26 | 23.12 | 27.5 | 22.1 | 26.75 | 22.61 |
| ICCX-161037 | 80 | 84 | 90.25 | 75.7 | 82.38 | 79.85 | 35.45 | 32.76 | 36.75 | 31.55 | 36.10 | 32.16 | 45.8 | 39.88 | 40.88 | 34.25 | 43.34 | 37.065 |
| ICCX-161040 | 30 | 29.75 | 40.5 | 25.8 | 35.25 | 27.78 | 30.12 | 28.23 | 33.45 | 29.67 | 31.79 | 28.95 | 17 | 15.55 | 25.75 | 11.89 | 21.38 | 13.72 |
| ICCX-161041 | 50 | 38.5 | 56.9 | 42.67 | 53.45 | 40.59 | 29.86 | 25.7 | 31.5 | 24.1 | 30.68 | 24.90 | 23 | 20.3 | 30.5 | 27.98 | 26.75 | 24.14 |
| ICCX-161047 | 150 | 135 | 145.88 | 100.55 | 147.94 | 117.78 | 37.85 | 36.25 | 40.67 | 33.23 | 39.26 | 34.74 | 50.66 | 46.25 | 43.25 | 41.5 | 46.96 | 43.875 |
| IVT (MH) C-22970 | 160 | 146 | 159.75 | 139.88 | 159.88 | 142.94 | 38.93 | 34.87 | 37.77 | 31.87 | 38.35 | 33.37 | 47.33 | 41.88 | 40.77 | 37.25 | 44.05 | 39.565 |
| ICCX-161049 | 88 | 67 | 91.67 | 60.5 | 89.84 | 63.75 | 31.15 | 28.56 | 28.98 | 25.78 | 30.07 | 27.17 | 34.55 | 31.34 | 35.8 | 30.25 | 35.18 | 30.795 |
| ICCX-161051 | 80 | 76 | 83.5 | 68.98 | 81.75 | 72.49 | 27.99 | 25.45 | 30.11 | 21.9 | 29.05 | 23.68 | 42.87 | 40.13 | 40.33 | 35.75 | 41.60 | 37.94 |
| ICCX-161053 | 100 | 91 | 110.78 | 85.75 | 105.39 | 88.38 | 38.15 | 35.78 | 40.55 | 32.49 | 39.35 | 34.14 | 51.55 | 44.5 | 46.66 | 42.88 | 49.11 | 43.69 |
| ICCX-161054 | 45 | 40.75 | 43.88 | 35.75 | 44.44 | 38.25 | 30.77 | 28.98 | 38.89 | 25.66 | 34.83 | 27.32 | 45.75 | 39.35 | 40.98 | 36.22 | 43.37 | 37.785 |
| ICCX-161055 | 90 | 78.85 | 98.59 | 74.25 | 94.30 | 76.55 | 36.25 | 33.56 | 37.54 | 28.99 | 36.90 | 31.28 | 47.25 | 47.25 | 42.34 | 38.5 | 44.80 | 42.875 |
| ICCX-161056 | 50 | 32.5 | 51.55 | 29.85 | 50.78 | 31.18 | 28.45 | 25.78 | 30.55 | 23.77 | 29.50 | 24.78 | 39.34 | 36.88 | 35.78 | 31.28 | 37.56 | 34.08 |
| ICCX-161057 | 20 | 18.23 | 35.5 | 21.75 | 27.75 | 19.99 | 33.75 | 31.66 | 35.22 | 29.07 | 34.49 | 30.37 | 37.9 | 30.28 | 32.65 | 28.75 | 35.28 | 29.515 |
| ICCX-161058 | 22 | 20.75 | 29.75 | 24.9 | 38.00 | 22.83 | 30.15 | 28.95 | 29.89 | 26.85 | 30.02 | 27.90 | 25.77 | 20.75 | 30.78 | 21.23 | 28.28 | 20.99 |
| ICCX-161059 | 88 | 85.76 | 83.6 | 80.75 | 85.80 | 83.26 | 39.44 | 41.25 | 38.67 | 38.88 | 39.06 | 40.07 | 49.88 | 45.44 | 47.5 | 44.66 | 48.69 | 45.05 |
| IVT (MH) C-22965 | 70 | 63.88 | 80.25 | 58.95 | 75.13 | 61.42 | 30.18 | 28.77 | 33.25 | 26.67 | 31.72 | 27.72 | 19.34 | 15.9 | 25.8 | 22.98 | 22.57 | 19.44 |
| ICCX-161077 | 30 | 23.75 | 26.67 | 25.8 | 28.34 | 24.78 | 27.56 | 23.12 | 25.55 | 21.9 | 26.56 | 22.51 | 21.89 | 15.75 | 28.75 | 23.75 | 25.32 | 19.75 |
| ICCX-161078 | 45 | 41.89 | 42.8 | 45.5 | 43.90 | 43.70 | 37.65 | 36.45 | 38.65 | 34.78 | 38.15 | 35.62 | 50.66 | 39.8 | 44.99 | 35.44 | 47.83 | 37.62 |
| ICCX-161079 | 26 | 22.18 | 30.35 | 27.88 | 28.18 | 25.03 | 29.85 | 26.13 | 30.12 | 24.12 | 29.99 | 25.13 | 18.68 | 16.3 | 22.36 | 19.67 | 20.52 | 17.985 |
| ICCX-161080 | 54 | 40.75 | 48.25 | 37.65 | 51.13 | 39.20 | 39.25 | 38.55 | 38.24 | 36.67 | 38.75 | 37.61 | 46.76 | 40.29 | 40.6 | 38.08 | 43.68 | 39.185 |
| ICCX-161081 | 50 | 46.85 | 59.98 | 49.95 | 54.99 | 48.40 | 26.96 | 29.12 | 28 | 24.88 | 27.48 | 27.00 | 35.35 | 32.78 | 31.59 | 24.78 | 33.47 | 28.78 |
| ICCX-161082 | 40 | 32.9 | 44.39 | 29.75 | 42.20 | 31.33 | 31.25 | 29.18 | 30.88 | 27.75 | 31.07 | 28.47 | 30.45 | 23.98 | 26.88 | 21.12 | 28.67 | 22.55 |
| ICCX-161083 | 55 | 49.75 | 49.2 | 55 | 52.10 | 52.38 | 33.16 | 32.54 | 35.25 | 30.45 | 34.21 | 31.50 | 19.78 | 18.75 | 24.75 | 20.89 | 22.27 | 19.82 |
| ICCX-161085 | 85 | 78.75 | 90.67 | 70.25 | 87.84 | 74.50 | 40.15 | 39.25 | 38.65 | 36.56 | 39.40 | 37.91 | 49.75 | 39.25 | 43.9 | 38.78 | 46.83 | 39.015 |
| ICCX-161086 | 89 | 85.6 | 80.34 | 78.85 | 84.67 | 82.23 | 31.88 | 33 | 29.85 | 30.25 | 30.87 | 31.63 | 15.64 | 10.5 | 20.02 | 17.75 | 17.83 | 14.125 |
| ICCX-161087 | 100 | 90.34 | 112.7 | 85.75 | 106.35 | 88.05 | 38.96 | 36.75 | 36.99 | 34.88 | 37.98 | 35.82 | 50.3 | 38.76 | 47.78 | 41.09 | 49.04 | 39.925 |
| IVT (MH) C-22957 | 95 | 92.56 | 88.9 | 86.48 | 91.95 | 89.52 | 39.25 | 40.78 | 37.78 | 36.12 | 38.52 | 38.45 | 48.66 | 40.23 | 49.5 | 44.78 | 49.08 | 42.505 |
| ICCX-161098 | 50 | 47.25 | 57.8 | 49.85 | 53.90 | 48.55 | 31.66 | 29.88 | 29.88 | 26.67 | 30.77 | 28.28 | 15.89 | 14.9 | 21.87 | 16.09 | 18.88 | 15.495 |
| ICCX-161099 | 42 | 38.9 | 49.6 | 30.25 | 45.80 | 34.58 | 32.45 | 31.77 | 31.56 | 29.55 | 32.01 | 30.66 | 29.65 | 24.78 | 31.11 | 28.78 | 30.38 | 26.78 |
| ICCX-161100 | 94 | 88.8 | 102.8 | 76.33 | 98.40 | 82.57 | 40.25 | 39.39 | 38.77 | 36.76 | 39.51 | 38.08 | 47.56 | 36.9 | 45.98 | 39.56 | 46.77 | 38.23 |
| Rajendra Chana-1 | 38 | 35.75 | 50.4 | 30.29 | 44.20 | 33.02 | 35.66 | 34.29 | 34.11 | 31.85 | 34.89 | 33.07 | 30.23 | 26.75 | 33.25 | 30.89 | 31.74 | 28.82 |
| GNG-1558 | 70 | 54.8 | 73.88 | 60.25 | 71.94 | 57.53 | 31.88 | 27.98 | 35.76 | 25.43 | 33.82 | 26.71 | 32.15 | 28.75 | 30.18 | 26.45 | 31.17 | 27.6 |
| MEAN | 66.44 | 59.79 | 70.40 | 56.13 | 68.71 | 57.96 | 33.76 | 32.07 | 34.32 | 29.65 | 34.04 | 30.86 | 35.86 | 30.85 | 35.34 | 30.48 | 35.60 | 30.67 |
| C.D. | 7.132 | 6.291 | 6.209 | 6.362 | | | 4.61 | 4.06 | 4.66 | 4.30 | | | 8.298 | 3.467 | 5.769 | 3.896 | | |
| SE(m) | 2.644 | 2.220 | 2.191 | 2.120 | | | 1.63 | 1.44 | 1.65 | 1.52 | | | 2.928 | 1.223 | 2.036 | 1.375 | | |
| C.V. | 7.180 | 6.431 | 7.833 | 6.710 | | | 8.93 | 8.26 | 10.25 | 8.20 | | | 14.144 | 6.868 | 9.978 | 7.812 | | |

| | Peroxidase activity | | | | | | Proline (micro gram per gram of leaf sample) | | | | | | Catalase content | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2019-2020 | | 2020-2021 | | Pooled | | 2019-2020 | | 2020-2021 | | Pooled | | 2019-2020 | | 2020-2021 | | Pooled | |
| Genotypes | N | D | N | D | N | D | N | D | N | D | N | D | N | D | N | D | N | D |
| ICCX-161033 | 7.67 | 7.85 | 7.58 | 7.98 | 7.62 | 7.92 | 9.38 | 9.55 | 9.50 | 9.66 | 9.44 | 9.72 | 17.20 | 18.40 | 17.50 | 18.88 | 17.35 | 18.64 |
| ICCX-161037 | 7.67 | 7.98 | 7.71 | 8.12 | 7.69 | 8.05 | 9.69 | 10.50 | 9.72 | 10.80 | 9.70 | 10.65 | 17.80 | 19.00 | 18.00 | 19.25 | 17.90 | 19.13 |
| ICCX-161040 | 6.14 | 6.63 | 6.63 | 6.90 | 6.38 | 6.77 | 7.81 | 9.02 | 8.18 | 9.04 | 8.00 | 8.96 | 17.40 | 18.00 | 17.00 | 18.56 | 17.20 | 18.28 |
| ICCX-161041 | 7.67 | 7.71 | 7.67 | 7.85 | 7.67 | 7.78 | 7.19 | 9.62 | 7.35 | 8.73 | 7.27 | 9.00 | 17.22 | 17.88 | 16.50 | 18.00 | 16.75 | 17.94 |
| ICCX-161047 | 7.67 | 7.85 | 7.58 | 7.71 | 7.62 | 7.78 | 10.00 | 11.25 | 10.45 | 11.25 | 10.23 | 11.25 | 17.40 | 19.22 | 17.40 | 19.59 | 17.40 | 19.41 |
| IVT (MH) C-22970 | 6.77 | 7.17 | 7.17 | 7.31 | 6.97 | 7.24 | 11.56 | 12.75 | 11.50 | 12.00 | 11.53 | 12.38 | 18.00 | 18.95 | 18.88 | 19.00 | 18.44 | 18.98 |
| ICCX-161049 | 7.38 | 7.44 | 7.38 | 7.71 | 7.38 | 7.58 | 8.44 | 9.50 | 8.60 | 10.12 | 8.52 | 9.81 | 17.60 | 18.60 | 17.50 | 21.43 | 17.55 | 19.03 |
| ICCX-161051 | 7.71 | 7.98 | 7.84 | 7.98 | 7.78 | 7.98 | 8.13 | 9.80 | 8.25 | 10.25 | 8.19 | 10.03 | 16.80 | 19.00 | 16.80 | 19.00 | 16.80 | 19.00 |
| ICCX-161053 | 8.26 | 8.39 | 8.12 | 8.39 | 8.19 | 8.39 | 10.00 | 11.75 | 10.56 | 12.85 | 10.28 | 12.30 | 18.00 | 20.00 | 18.00 | 19.50 | 18.00 | 19.75 |
| ICCX-161054 | 7.85 | 8.12 | 7.85 | 8.12 | 7.85 | 8.12 | 7.81 | 8.00 | 8.50 | 9.47 | 8.16 | 8.56 | 17.32 | 19.20 | 18.20 | 19.80 | 18.00 | 19.50 |
| ICCX-161055 | 8.12 | 8.39 | 8.12 | 8.39 | 8.12 | 8.39 | 9.69 | 10.88 | 9.88 | 11.00 | 9.78 | 10.94 | 19.30 | 19.86 | 18.50 | 20.50 | 18.90 | 20.18 |
| ICCX-161056 | 7.67 | 7.71 | 7.58 | 7.85 | 7.62 | 7.78 | 8.75 | 8.96 | 8.54 | 9.01 | 8.65 | 8.90 | 17.50 | 19.50 | 17.88 | 20.25 | 17.69 | 19.88 |
| ICCX-161057 | 7.85 | 7.98 | 7.85 | 7.98 | 7.85 | 7.98 | 7.50 | 8.00 | 7.32 | 8.65 | 7.41 | 8.44 | 16.66 | 18.44 | 17.25 | 18.00 | 16.96 | 18.22 |
| ICCX-161058 | 7.22 | 7.31 | 7.04 | 7.17 | 7.13 | 7.24 | 8.13 | 9.10 | 8.45 | 9.50 | 8.29 | 9.30 | 17.00 | 18.24 | 16.88 | 17.50 | 16.94 | 17.87 |
| ICCX-161059 | 7.98 | 8.26 | 7.98 | 8.12 | 7.98 | 8.19 | 10.31 | 11.50 | 9.85 | 11.50 | 10.08 | 11.50 | 18.60 | 20.56 | 19.25 | 19.98 | 18.93 | 20.27 |
| IVT (MH) C-22965 | 7.71 | 7.85 | 7.58 | 7.85 | 7.65 | 7.85 | 8.75 | 9.50 | 8.89 | 10.00 | 8.82 | 9.75 | 17.20 | 18.88 | 17.80 | 19.00 | 17.50 | 18.94 |
| ICCX-161077 | 7.98 | 7.98 | 7.85 | 8.12 | 7.92 | 8.05 | 9.06 | 9.11 | 8.98 | 9.65 | 9.02 | 9.38 | 16.50 | 18.50 | 17.00 | 19.33 | 16.75 | 18.92 |
| ICCX-161078 | 8.12 | 8.53 | 8.12 | 8.53 | 8.12 | 8.53 | 9.56 | 10.25 | 9.45 | 10.55 | 9.51 | 10.40 | 18.80 | 19.50 | 18.50 | 20.05 | 18.65 | 19.78 |
| ICCX-161079 | 7.98 | 7.98 | 7.85 | 7.98 | 7.92 | 7.98 | 8.75 | 9.88 | 8.92 | 10.12 | 8.84 | 10.00 | 17.88 | 19.25 | 18.25 | 19.75 | 18.13 | 19.50 |
| ICCX-161080 | 8.12 | 8.26 | 8.12 | 8.26 | 8.12 | 8.26 | 10.00 | 11.25 | 9.46 | 11.00 | 9.73 | 11.13 | 19.00 | 20.04 | 18.85 | 19.57 | 18.93 | 19.81 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ICCX-161081 | 7.71 | 7.85 | 7.85 | 7.98 | 7.78 | 7.92 | 8.13 | 9.75 | 8.45 | 9.00 | 8.29 | 9.38 | 17.12 | 18.64 | 16.80 | 19.25 | 16.96 | 18.95 |
| ICCX-161082 | 7.59 | 7.71 | 7.59 | 7.71 | 7.59 | 7.71 | 8.44 | 9.88 | 8.12 | 10.07 | 8.28 | 9.88 | 17.70 | 18.98 | 17.45 | 20.00 | 17.58 | 19.49 |
| ICCX-161083 | 7.98 | 7.98 | 8.12 | 8.26 | 8.05 | 8.12 | 7.81 | 9.00 | 8.00 | 8.85 | 7.91 | 8.93 | 18.01 | 19.12 | 17.78 | 18.56 | 17.90 | 18.84 |
| ICCX-161085 | 8.26 | 8.39 | 7.98 | 8.39 | 8.12 | 8.39 | 10.31 | 11.75 | 9.89 | 12.04 | 10.10 | 12.00 | 18.72 | 19.88 | 18.90 | 20.05 | 18.65 | 19.97 |
| ICCX-161086 | 7.44 | 7.58 | 7.58 | 7.71 | 7.51 | 7.65 | 8.13 | 9.68 | 8.00 | 9.90 | 8.06 | 9.79 | 17.00 | 18.15 | 16.75 | 18.75 | 16.88 | 18.45 |
| ICCX-161087 | 8.26 | 8.39 | 8.39 | 8.53 | 8.32 | 8.46 | 10.00 | 11.50 | 9.55 | 12.00 | 9.78 | 11.75 | 19.20 | 20.48 | 18.75 | 22.14 | 18.98 | 20.74 |
| IVT (MH) C-22957 | 8.12 | 8.26 | 8.12 | 8.26 | 8.12 | 8.26 | 9.69 | 10.25 | 10.45 | 10.00 | 10.07 | 10.13 | 20.00 | 21.78 | 19.89 | 20.15 | 19.95 | 20.97 |
| ICCX-161098 | 7.67 | 7.71 | 7.58 | 7.71 | 7.62 | 7.71 | 7.81 | 9.56 | 8.23 | 9.25 | 8.02 | 9.41 | 20.32 | 19.11 | 18.25 | 19.11 | 18.03 | 19.11 |
| ICCX-161099 | 7.67 | 7.85 | 7.67 | 7.85 | 7.67 | 7.85 | 8.13 | 9.23 | 7.93 | 9.88 | 8.03 | 9.56 | 18.00 | 19.00 | 17.98 | 18.67 | 17.99 | 18.84 |
| ICCX-161100 | 8.26 | 8.39 | 8.12 | 8.39 | 8.19 | 8.39 | 9.69 | 10.98 | 9.38 | 10.25 | 9.53 | 10.98 | 18.80 | 19.89 | 19.33 | 20.00 | 19.07 | 19.95 |
| Rajendra Chana-1 | 7.85 | 8.12 | 7.98 | 8.12 | 7.92 | 8.12 | 8.44 | 9.86 | 8.52 | 10.01 | 8.48 | 9.94 | 18.10 | 19.05 | 17.67 | 18.85 | 17.89 | 18.95 |
| GNG-1558 | 7.98 | 8.03 | 8.01 | 8.26 | 7.98 | 8.12 | 8.75 | 10.00 | 8.90 | 9.56 | 8.83 | 9.78 | 17.60 | 18.85 | 18.05 | 19.75 | 17.83 | 19.30 |
| MEAN | 7.76 | 7.93 | 7.77 | 7.98 | 7.76 | 7.96 | 8.93 | 10.05 | 8.99 | 10.19 | 8.96 | 10.12 | 17.93 | 19.19 | 17.92 | 19.44 | 17.89 | 19.27 |
| C.D. | 0.75 | 0.79 | 0.68 | 0.71 | | | 0.84 | 0.79 | 0.81 | 0.84 | | | 1.64 | 1.92 | 1.46 | 1.77 | | |
| SE(m) | 0.27 | 0.28 | 0.24 | 0.25 | | | 0.30 | 0.28 | 0.29 | 0.30 | | | 0.58 | 0.68 | 0.52 | 0.63 | | |
| C.V. | 6.35 | 6.56 | 5.73 | 5.85 | | | 5.46 | 5.77 | 5.18 | 6.11 | | | 5.99 | 6.53 | 5.33 | 5.95 | | |

**Table 2:** Mean, range and coefficient of variation of morphological and biochemical characters in chickpea under normal condition

| Characters | | Mean±S.E | Range | CV |
|---|---|---|---|---|
| Biological yield (g/plant) | E1 | 66.44±2.644 | 20- 160 | 7.18 |
| | E2 | 70.40±2.191 | 26.67- 159.75 | 7.833 |
| Harvest Index (%) | E1 | 33.76±1.63 | 26.96- 40.25 | 8.93 |
| | E2 | 34.32±1.65 | 25.55- 40.67 | 10.25 |
| Yield per plant (g) | E1 | 35.86±2.928 | 15.64- 51.55 | 14.144 |
| | E2 | 35.34±2.036 | 20.02- 49.5 | 9.978 |
| Number of branches | E1 | 14.59±0.642 | 9.25- 20 | 7.627 |
| | E2 | 14.50±0.891 | 9.25- 18.5 | 10.645 |
| Number of pods per plant | E1 | 38.55±1.412 | 25.75- 48.75 | 6.761 |
| | E2 | 39.21±0.735 | 27.5- 50.04 | 10.482 |
| Peroxidase activity | E1 | 7.76±0.27 | 6.14- 8.26 | 6.35 |
| | E2 | 7.77±0.24 | 6.63- 8.39 | 5.73 |
| Proline Content | E1 | 8.93±0.3 | 7.19- 11.56 | 5.46 |
| | E2 | 8.99±0.29 | 7.32- 11.5 | 5.18 |
| Catalase content | E1 | 17.93±0.58 | 16.5- 20.32 | 5.99 |
| | E2 | 17.92±0.52 | 16.5- 19.89 | 5.33 |

E1: 2019-2020; E2: 2020-2021

**Drought tolerant Indices**

Drought tolerance indices were estimated based upon the seed yield per plant of genotypes under drought condition in comparison to the normal condition. Three indices, namely, Drought Tolerant Index (DTI), Drought Susceptibility Index (DSI) and Tolerance Index (TI) were estimated and compared amongst the genotypes under evaluation in the present study.

Based on the results of estimated Drought Tolerant Index, the 32 genotypes were categorised into highly drought tolerant, low drought tolerant and moderately drought tolerant. Accordingly, the highly drought tolerant genotypes include ICCX-161037, ICCX-161047, IVT (MH) C-22970, ICCX-161051, ICCX-161053, ICCX-161054, ICCX-161055, ICCX-161059, ICCX-161078, ICCX-161080, ICCX-161085, ICCX-161087, IVT (MH) C-22957 and ICCX-161100. Genotypes with low drought tolerant index or highly drought susceptible include ICCX-161033, ICCX-161040, ICCX-161041, ICCX-161058, IVT (MH) C-22965, ICCX-161077, ICCX-161079, ICCX-161082, ICCX-161083, ICCX-161086, ICCX-161098, ICCX-161099 and GNG-1558. On the other hand, genotypes with moderate drought tolerant index includes ICCX-161049, ICCX-161056, ICCX-161057, ICCX-161081 and Rajendra Chana-1.

Based on the results of estimated Drought Susceptibility Index (DSI), the 32 genotypes were categorised into highly drought susceptible, less drought susceptible and moderately drought susceptible. Accordingly, the highly drought susceptible genotypes include ICCX-161040, ICCX-161058, ICCX-161077, ICCX-161082 and ICCX-161086. Genotypes with low drought susceptible index include ICCX-161047, IVT (MH) C-22970, ICCX-161051, ICCX-161053, ICCX-161055, ICCX-161056, ICCX-161080 and Rajendra Chana-1. On the other hand, genotypes with moderate Drought Susceptibility Index includes ICCX-161033, ICCX-161037, ICCX-161041, ICCX-161049, ICCX-161054, ICCX-161057, ICCX-161059, IVT (MH) C-22965, ICCX-161078, ICCX-161079, ICCX-161081, ICCX-161078, ICCX-161083, ICCX-161085, ICCX-161087, IVT (MH) C-22957, ICCX-161098, ICCX-161099 and ICCX-161100. Based on the results of estimated Tolerance Index (TI), the 32 genotypes were categorised into High Tolerance Index, Less Tolerance Index and Moderate Tolerance Index. Accordingly, the High Tolerance Index genotypes include ICCX-161037, ICCX-161040, ICCX-161058, ICCX-161078, ICCX-161082, ICCX-161085, ICCX-161087, IVT (MH) C-22957 and ICCX-161100. Genotypes with low Tolerance Index include ICCX-161041, ICCX-161047, ICCX-161051, ICCX-161055, ICCX-161056, ICCX-161059, IVT (MH) C-22965, ICCX-161079, ICCX-161083, ICCX-161086, ICCX-161098, ICCX-161099 and Rajendra Chana-1. On the other hand, genotypes with moderate Tolerance Index includes ICCX-161033, IVT (MH) C-22970, ICCX-161049, ICCX-161053, ICCX-161054, ICCX-161057, ICCX-161077, ICCX-161080, ICCX-161081 and GNG-1558 (Table 3).

From the above investigation, it can be inferred that genotypes with higher drought tolerant index are highly

drought tolerant and are having lower levels of drought susceptibility index.

In the case of irrigated conditions, less pod number observed due to more vegetative growth as a result of less light penetration and air circulation (Shan and Wang, 2017; Farooq *et al*., 2018) [24, 6]. In the case of chick pea crop, the activity of peroxidase is also observed by (Khadraji *et al*., 2016) [13]. According to their findings, higher concentration of ascorbic acidis minimized by the activity of peroxidase which function as a defensive system for the plant. Similar finding was also observed by Fan *et al*. (2017) [5] in the cucumber leaves. Increase in peroxidase activity under drought condition has also been reported by Wu *et al.*, 2014 [30] in chickpea. Hydrogen peroxide scavenge hydrogen peroxide and form water and oxygen reported. Enhancement was observed in the activity of Catalase in tolerant chickpea genotypes compared to susceptible genotypes (Raheleh *et al.*, 2012) [19]. Similar observations were also observed by Khoiwal *et al.* (2017) [14]. They also concluded that the tolerant genotype of chick pea maintained highest harvest index, minimum reduction in seed yield and having maximum efficiency and minimum susceptibility index of drought under rainfed condition. Tolerance indices proved to be best criteria for the selection of drought tolerant genotypes. The results of the present investigation are in good agreement with the earlier finding (Sharma, 2020) [25].

**Table 3:** Estimates of drought tolerance indices of chickpea genotypes

| | 2019-2020 | | | 2020-2021 | | | POOLED | | |
|---|---|---|---|---|---|---|---|---|---|
| **Genotypes** | **DTI** | **DSI** | **TI** | **DTI** | **DSI** | **TI** | **DTI** | **DSI** | **TI** |
| ICCX-161033 | 0.47 | 0.79 | 2.88 | 0.49 | 1.40 | 5.4 | 0.48 | 1.10 | 4.14 |
| ICCX-161037 | 1.42 | 0.92 | 5.92 | 1.12 | 1.16 | 6.63 | 1.27 | 1.04 | 6.28 |
| ICCX-161040 | 0.21 | 0.61 | 1.45 | 0.25 | 3.84 | 13.86 | 0.23 | 2.23 | 7.66 |
| ICCX-161041 | 0.36 | 0.84 | 2.7 | 0.68 | 0.59 | 2.52 | 0.52 | 0.71 | 2.61 |
| ICCX-161047 | 1.82 | 0.62 | 4.41 | 1.44 | 0.29 | 1.75 | 1.63 | 0.46 | 3.08 |
| IVT (MH) C-22970 | 1.54 | 0.82 | 5.45 | 1.22 | 0.62 | 3.52 | 1.38 | 0.72 | 4.49 |
| ICCX-161049 | 0.84 | 0.66 | 3.21 | 0.87 | 1.11 | 5.55 | 0.85 | 0.89 | 4.38 |
| ICCX-161051 | 1.34 | 0.46 | 2.74 | 1.15 | 0.81 | 4.58 | 1.25 | 0.63 | 3.66 |
| ICCX-161053 | 1.78 | 0.98 | 7.05 | 1.60 | 0.58 | 3.78 | 1.69 | 0.78 | 5.42 |
| ICCX-161054 | 1.40 | 1.00 | 6.4 | 1.19 | 0.83 | 4.76 | 1.29 | 0.91 | 5.58 |
| ICCX-161055 | 1.59 | 0.62 | 4.1 | 1.31 | 0.65 | 3.84 | 1.45 | 0.63 | 3.97 |
| ICCX-161056 | 1.13 | 0.45 | 2.46 | 0.90 | 0.90 | 4.5 | 1.01 | 0.67 | 3.48 |
| ICCX-161057 | 0.89 | 1.44 | 7.62 | 0.75 | 0.85 | 3.9 | 0.82 | 1.14 | 5.76 |
| ICCX-161058 | 0.42 | 1.39 | 5.02 | 0.52 | 2.22 | 9.55 | 0.47 | 1.80 | 7.29 |
| ICCX-161059 | 1.76 | 0.64 | 4.44 | 1.70 | 0.43 | 2.84 | 1.73 | 0.53 | 3.64 |
| IVT (MH) C-22965 | 0.24 | 1.27 | 3.44 | 0.47 | 0.78 | 2.82 | 0.36 | 1.03 | 3.13 |
| ICCX-161077 | 0.27 | 2.00 | 6.14 | 0.55 | 1.24 | 5.00 | 0.41 | 1.62 | 5.57 |
| ICCX-161078 | 1.57 | 1.53 | 10.86 | 1.28 | 1.52 | 9.55 | 1.42 | 1.52 | 10.21 |
| ICCX-161079 | 0.24 | 0.91 | 2.38 | 0.35 | 0.86 | 2.69 | 0.29 | 0.88 | 2.54 |
| ICCX-161080 | 1.47 | 0.99 | 6.47 | 1.24 | 0.44 | 2.52 | 1.35 | 0.72 | 4.50 |
| ICCX-161081 | 0.90 | 0.52 | 2.57 | 0.63 | 1.54 | 6.81 | 0.76 | 1.03 | 4.69 |
| ICCX-161082 | 0.57 | 1.52 | 6.47 | 0.45 | 1.53 | 5.76 | 0.51 | 1.52 | 6.12 |
| ICCX-161083 | 0.29 | 0.37 | 1.03 | 0.41 | 1.11 | 3.86 | 0.35 | 0.74 | 2.45 |
| ICCX-161085 | 1.52 | 1.51 | 10.5 | 1.36 | 0.83 | 5.12 | 1.44 | 1.17 | 7.81 |
| ICCX-161086 | 0.13 | 2.35 | 5.14 | 0.28 | 0.81 | 2.27 | 0.21 | 1.58 | 3.71 |
| ICCX-161087 | 1.52 | 1.64 | 11.54 | 1.57 | 1.00 | 6.69 | 1.54 | 1.32 | 9.12 |
| IVT (MH) C-22957 | 1.52 | 1.24 | 8.43 | 1.77 | 0.68 | 4.72 | 1.65 | 0.96 | 6.58 |
| ICCX-161098 | 0.18 | 0.45 | 0.99 | 0.28 | 1.89 | 5.78 | 0.23 | 1.17 | 3.39 |
| ICCX-161099 | 0.57 | 1.17 | 4.87 | 0.72 | 0.53 | 2.33 | 0.64 | 0.85 | 3.60 |
| ICCX-161100 | 1.36 | 1.60 | 10.66 | 1.46 | 1.00 | 6.42 | 1.41 | 1.30 | 8.54 |
| Rajendra Chana-1 | 0.63 | 0.82 | 3.48 | 0.82 | 0.51 | 2.36 | 0.73 | 0.66 | 2.92 |
| GNG-1558 | 0.72 | 0.76 | 3.4 | 0.64 | 0.88 | 3.73 | 0.48 | 1.10 | 4.14 |

DTI- Drought Tolerance Index; DSI- Drought susceptibility index; TI -Tolerance index

## Conclusion and Recommendations

The increased yield attributes along with the highest activity of catalase, peroxidase and proline content among the biochemical attributes and minimum reduction in seed yield, maximum DTI, minimum DSI and highest HI among chick pea genotypes are the indicators for the efficiency of drought tolerance among the evaluated chick pea genotypes. Based on these results, it can also be inferred that the chick pea genotypes viz. ICCX-161037, ICCX-161047, IVT (MH) C-22970, ICCX-161051, ICCX-161053, ICCX-161054, ICCX-161055, ICCX-161059, ICCX-161078, ICCX-161080, ICCX-161085, ICCX-161087, IVT (MH) C-22957 and ICCX-161100 are the highly drought tolerant chick pea genotypes which can give higher yield under both drought or irrigated condition. Besides, the outcomes from the above investigation depict that adoption of these screened out drought-tolerant chick pea genotypes will help in enhancing the economy of the farming community.

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