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# GENETIC VARIABILITY, CORRELATION AND PATH COEFFICIENT ANALYSIS OF CHICKPEA (*CICER ARIETINUM* L.) GENOTYPES FOR YIELD AND YIELD ATTRIBUTING TRAITS UNDER LIMITED WATER CONDITION

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**ABSTRACT**

The present research work was conducted on 28 genotypes of chickpea (*Cicer arietinum* L.) including three checks during rabi season, 2021-2022 at research farm of Birsa Agricultural University, Ranchi, Jharkhand to evaluate genetic variability, correlation and path coefficient analysis under limited water condition. The genotypes were sown in randomized block design with three replications under rainout shelter with one irrigation and restriction with natural rainfall. Results revealed that Genotypic variance was higher for yield per plot and specific leaf area, while phenotypic variance indicated substantial environmental influence across all traits. Proline content, chlorophyll content, protein content, specific leaf area, number of pods per plant, and specific leaf weight exhibited higher genotypic coefficient of variation. Heritability ranged from low to high, with specific leaf area, specific leaf weight, and proline content displaying high heritability. Path analysis revealed that initial plant stand, days to fifty per cent flowering, plant height, number of seeds per pod, hundred seed weight, wilt percent, proline content, protein content, specific leaf area, relative water content, and specific leaf weight directly affected yield per plant. Furthermore, the correlation analysis demonstrated a strong inherent relationship between traits, with genotypic correlations generally outweighing phenotypic correlations, indicating limited environmental influence in trait transmission. The study also identified a negative correlation between yield per plant and specific leaf weight.

***Key words :*** Genetic variability, Correlation, Path coefficient, Variance.

## Introduction

Chickpea (*Cicer arietinum* L.) also known as Bengal gram, is a significant grain legume crop that is self-pollinated and diploid with a chromosome number of 2n = 2x =16. Chickpea is an annual plant that grows up to 30-50 cm in height and has a branching system with pinnately compound leaves. Chickpea can fix up to 140 kg of nitrogen per hectare (Gaur *et al.*, 2010), depending on the environmental condition and management practices making it an important crop for sustainable agriculture. It is third most important grain legume crop worldwide, and is particularly vital in the semi-arid tropics and warm temperate zones. Chickpea is a major food crop in India, where it is known as chana or gram.

Water stress is a major limiting factor for chickpea cultivation, particularly in rainfed areas where the crop is heavily reliant on rainfall. Chickpea is considered to be a moderately drought tolerant crop, but prolonged water stress can have a significant impact on crop yield and quality (Singh and Reddy, 2011). Across the globe, drought stress reduces chickpea yield by 40-50% (Rani *et al.*, 2020). Genetic variation among traits is important for breeding programme and in selecting desirable genotypes for particular environment. On the other hand, an analysis of correlation between yield and yield components is essential in determining selection criteria, however, path coefficient analysis helps in determining direct and indirect effects on other traits. The purpose of this study was to estimate the total genetic variability, correlations and path analysis among some important traits for selection criteria for improving yield in different chickpea genotypes under limited water condition.

## Materials and Methods

The experimental material consists of 28 genotypes of chickpea (*Cicer arietinum* L.) including 3 checks obtained from different sources. The research was carried out at Rainout Shelter in the premises of Birsa Agricultural University, Kanke, Ranchi. The experiment was carried out in Random Block Design (RBD) with three replications to identify the suitable chickpea genotypes for moisture stress. Each plot in the replications consisted four rows occupying the area of 4.8m$^2$ (4×1.2) per row with the spacing of 30cm and 10cm between the rows and between the plants, respectively. The total experimental area was 470 m$^2$ (14×33.6). Only one irrigation was provided before flowering with restriction to natural rainfall. The fertilizer dose of Nitrogen, Phosphorus and Potassium were applied in the ratio of 25:50:25 kg/ha.

Observations of initial plant stand (IPS), days to fifty per cent flowering (DFF), days to maturity (DM), plant height (PH), number of primary branches per plant (NPB), number of secondary branches per plant (NSB), number of pods per plant (NPP), number of seeds per pod (NSP), hundred seed weight (HSW), plant stand at the time of harvesting (PSH), yield per plant (Y/Plant), yield per plot (Y/Plot), wilt per cent, proline content, chlorophyll content, protein content, specific leaf area (SLA), relative water content (RWC) and specific leaf weight (SLW) were recorded.

The recorded data were analyzed according to RBD. In order to determine the relationships between examined traits and yield per plant, correlation coefficients were calculated with the *INDOSTAT* program. The path coefficients analysis was performed by examining yield per plant as a dependent variable. In addition, genotypic and phenotypic variance (Lush, 1940), GCV and PCV (Burton, 1952), broad sense heritability (Allard, 1960) and genetic advance (Jhonson, 1955) were calculated.

## Results and Discussion

Genetic parameters of different traits recorded are given in Table 1. According to the mean values, initial plant stand, days to fifty per cent flowering, days to maturity, plant height, number of primary branches, number of secondary branches, number of pods per plant, number of seeds per pod, hundred seed weight, plant stand at the time of harvesting, yield per plant, yield per plot, wilt per cent, proline content, chlorophyll content, protein content, specific leaf area, relative water content and specific leaf weight were 65.68, 78.69, 122.58, 54.24, 2.66, 4.41, 38.25, 1.29, 21.33, 53.19, 10.86, 409.24, 20.79, 12.27, 1.76, 17.71, 124.42, 45.33 and 8.47, respectively.

According to Table 1, the highest genotypic variance was recorded for yield per plot, followed by specific leaf area. Phenotypic variance was greater than genotypic variance for all traits, indicating the influence of environmental effect. However, the phenotypic variance

**Table 1 :** Genetic parameters of twenty-eight chickpea (*Cicer arietinum* L.) genotypes under limited water condition.

| Characters | Mean ± SEM | GV | PV | GCV | PCV | h$^2$ | GA |
|---|---|---|---|---|---|---|---|
| **IPS** | 65.68 ± 4.16 | 33.80 | 85.65 | 8.85 | 14.09 | 39.50 | 7.52 |
| **DFF** | 78.69 ± 0.47 | 9.74 | 10.41 | 3.97 | 4.10 | 93.60 | 6.22 |
| **DM** | 122.58 ± 0.77 | 24.49 | 26.28 | 4.04 | 4.18 | 93.20 | 9.84 |
| **PH** | 54.24 ± 2.56 | 22.04 | 41.66 | 8.66 | 11.90 | 52.90 | 7.03 |
| **NPB** | 2.66 ± 0.22 | 0.15 | 0.29 | 14.65 | 20.28 | 52.10 | 0.58 |
| **NSB** | 4.41 ± 0.42 | 0.27 | 0.80 | 11.86 | 20.38 | 33.90 | 0.63 |
| **NPP** | 38.25 ± 3.06 | 75.66 | 91.09 | 22.76 | 24.97 | 83.06 | 16.33 |
| **NSP** | 1.29 ± 0.10 | 0.01 | 0.04 | 8.69 | 16.00 | 29.50 | 0.13 |
| **HSW (g)** | 21.33 ± 0.41 | 9.64 | 10.15 | 14.57 | 14.95 | 95.00 | 6.24 |
| **PSH** | 53.19 ± 3.37 | 28.04 | 62.21 | 9.78 | 14.71 | 44.20 | 7.12 |
| **Y/Plant (g)** | 10.86 ± 0.94 | 1.00 | 3.68 | 9.18 | 17.63 | 27.10 | 1.07 |
| **Y/Plot (g)** | 409.24 ± 39.50 | 5465.05 | 10145.9 | 18.06 | 24.61 | 53.90 | 111.77 |
| **Wilt %** | 20.79 ± 2.19 | 7.21 | 21.62 | 13.08 | 22.47 | 33.90 | 3.26 |
| **Proline content (µmol/g)** | 12.27 ± 0.47 | 27.96 | 28.61 | 43.10 | 43.60 | 97.70 | 10.77 |
| **Chlorophyll content (mg/g)** | 1.76 ± 0.05 | 0.26 | 0.27 | 29.14 | 29.52 | 97.41 | 1.04 |
| **Protein content (%)** | 17.71 ± 0.61 | 25.21 | 26.33 | 27.36 | 27.96 | 95.70 | 10.12 |
| **SLA (cm$^2$/g)** | 124.42 ± 0.87 | 954.27 | 956.55 | 24.83 | 24.86 | 99.80 | 63.56 |
| **RWC (%)** | 45.33 ± 0.53 | 50.56 | 51.4 | 15.69 | 15.82 | 98.40 | 14.53 |
| **SLW (mg/cm$^2$)** | 8.47 ± 0.07 | 3.62 | 3.64 | 22.46 | 22.51 | 99.60 | 3.91 |

**Table 2 :** Correlation of different characters for twenty-eight chickpea (*Cicer arietinum* L.) genotypes under limited water condition.

| Characters | | IPS | DFF | DM | PH | NPB | NSB | NPP | NSP | HSW | PSH | Wilt % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **IPS** | **G** | 1 | 0.068 | -0.219 | -0.037 | 0.023 | -0.161 | 0.054 | 0.162 | -0.0270 | 0.917** | -0.255* |
| | **P** | 1 | 0.067 | -0.178 | -0.037 | 0.022 | -0.161 | 0.054 | 0.162 | -0.027 | 0.907** | -0.255* |
| **DFF** | **G** | | 1 | 0.344** | 0.089 | -0.201 | -0.227 | 0.016 | -0.178 | -0.151 | 0.179 | -0.054 |
| | **P** | | 1 | 0.328** | 0.066 | -0.181 | -0.145 | 0.009 | -0.049 | -0.139 | 0.102 | -0.058 |
| **DM** | **G** | | | 1 | 0.144 | -0.225 | -0.039 | 0.134 | -0.209 | -0.252* | -0.124 | 0.154 |
| | **P** | | | 1 | 0.118 | -0.192 | -0.064 | 0.092 | -0.123 | -0.243* | -0.119 | 0.049 |
| **PH** | **G** | | | | 1 | 0.365** | 0.274* | 0.345** | -0.061 | -0.019 | -0.132 | 0.039 |
| | **P** | | | | 1 | 0.237* | 0.258* | 0.284* | -0.019 | -0.031 | -0.028 | -0.004 |
| **NPB** | **G** | | | | | 1 | 0.444** | 0.372** | -0.233 | 0.262* | -0.019 | -0.132 |
| | **P** | | | | | 1 | 0.319** | 0.294** | -0.197 | 0.213 | -0.051 | -0.010 |
| **NSB** | **G** | | | | | | 1 | 0.404** | 0.012 | 0.236* | -0.089 | 0.094 |
| | **P** | | | | | | 1 | 0.295** | 0.053 | 0.100 | -0.159 | -0.075 |
| **NPP** | **G** | | | | | | | 1 | -0.187 | 0.290** | -0.135 | 0.124 |
| | **P** | | | | | | | 1 | -0.113 | 0.254* | 0.105 | -0.055 |
| **NSP** | **G** | | | | | | | | 1 | -0.303** | -0.209 | 0.182 |
| | **P** | | | | | | | | 1 | -0.164 | 0.130 | -0.008 |
| **HSW** | **G** | | | | | | | | | 1 | -0.203 | -0.298** |
| | **P** | | | | | | | | | 1 | -0.075 | -0.170 |
| **PSH** | **G** | | | | | | | | | | 1 | -0.241* |
| | **P** | | | | | | | | | | 1 | -0.228* |
| **Wilt %** | **G** | | | | | | | | | | | 1 |
| | **P** | | | | | | | | | | | 1 |

***Cont…***

| Characters | | Proline content | Chlorophyll content | Protein content | SLA | RWC | SLW | Y/Plant |
|---|---|---|---|---|---|---|---|---|
| **IPS** | **G** | 0.287* | -0.118 | -0.146 | -0.034 | -0.052 | -0.032 | 0.017 |
| | **P** | 0.207 | -0.056 | -0.144 | -0.208 | -0.115 | 0.187 | 0.073 |
| **DFF** | **G** | 0.199 | 0.014 | 0.075 | 0.030 | 0.042 | -0.134 | 0.205 |
| | **P** | 0.188 | 0.013 | 0.049 | 0.029 | 0.035 | -0.129 | 0.216 |
| **DM** | **G** | 0.045 | -0.132 | 0.043 | -0.050 | -0.249* | -0.040 | 0.198 |
| | **P** | 0.031 | -0.127 | 0.044 | -0.049 | -0.209 | -0.036 | 0.126 |
| **PH** | **G** | 0.009 | -0.182 | 0.307** | 0.421** | 0.227* | -0.417** | 0.262* |
| | **P** | 0.014 | -0.110 | 0.204 | 0.302** | 0.259* | -0.296** | 0.252* |
| **NPB** | **G** | 0.369** | 0.082 | 0.043 | 0.394** | 0.248* | -0.306** | 0.315** |
| | **P** | 0.268* | 0.073 | 0.008 | 0.293** | 0.170 | -0.242* | 0.007 |
| **NSB** | **G** | 0.275* | 0.008 | 0.133 | 0.233* | 0.384** | -0.114 | 0.321** |
| | **P** | 0.161 | 0.000 | 0.060 | 0.136 | 0.195 | -0.068 | 0.301** |

***Table 2 continued...***

***Table 2 continued...***

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **NPP** | **G** | 0.245* | -0.220 | 0.063 | 0.294** | 0.313** | -0.011 | 0.348** |
| | **P** | 0.119 | -0.166 | 0.077 | -0.204 | 0.307** | -0.006 | 0.296** |
| **NSP** | **G** | -0.287** | -0.325** | -0.183 | -0.452** | -0.081 | 0.410** | 0.631** |
| | **P** | -0.160 | -0.196 | -0.147 | -0.248* | -0.065 | 0.228 | 0.106 |
| **HSW** | **G** | 0.002 | -0.013 | 0.069 | 0.379** | 0.050 | -0.347** | -0.050 |
| | **P** | 0.006 | -0.014 | 0.069 | 0.371** | 0.048 | -0.340** | -0.051 |
| **PSH** | **G** | 0.277* | 0.124 | -0.021 | -0.021 | -0.190 | -0.101 | 0.362** |
| | **P** | 0.260* | -0.132 | -0.079 | -0.168 | 0.312** | 0.249* | 0.331** |
| **Wilt %** | **G** | -0.331** | 0.077 | 0.124 | -0.021 | -0.390** | -0.100 | -0.036 |
| | **P** | -0.247* | 0.036 | 0.092 | -0.015 | -0.358** | -0.055 | -0.055 |
| **Proline content** | **G** | 1 | -0.078 | -0.133 | 0.316** | 0.264* | -0.319** | 0.472** |
| | **P** | 1 | -0.069 | -0.131 | 0.312** | 0.263* | -0.316** | 0.246* |
| **Chlorophyll content** | **G** | | 1 | -0.032 | 0.355** | -0.053 | -0.247* | 0.103 |
| | **P** | | 1 | -0.035 | 0.296** | -0.049 | -0.224 | 0.052 |
| **Protein content** | **G** | | | 1 | 0.530** | 0.118 | -0.514** | 0.246* |
| | **P** | | | 1 | 0.517** | 0.125 | -0.499** | 0.145 |
| **SLA** | **G** | | | | 1 | 0.311** | -0.951** | 0.162 |
| | **P** | | | | 1 | 0.308** | -0.951** | 0.076 |
| **RWC** | **G** | | | | | 1 | -0.298** | 0.330** |
| | **P** | | | | | 1 | 0.247* | 0.275* |
| **SLW** | **G** | | | | | | 1 | -0.269* |
| | **P** | | | | | | 1 | -0.253* |
| **Y/Plant** | **G** | | | | | | | 1 |
| | **P** | | | | | | | 1 |

was highest for yield per plot followed by specific leaf area. Genotypic coefficient of variations was relatively greater for proline content, chlorophyll content, protein content, specific leaf area, number of pods per plant and specific leaf weight.

High Phenotypic coefficient of variation was observed for characters like proline content, chlorophyll content, protein content, number of pods per plant, specific leaf area, yield per plot, specific leaf weight, wilt per cent, number of secondary branches and number of primary branches. Moderate phenotypic coefficient of variation was recorded for yield per plant, number of seeds per pod, relative water content, hundred seed weight, plant stand at the time of harvesting, initial plant stands and plant height. Similar results were reported by Ram *et al.* (2021), Nikita *et al.* (2021) and Kumar *et al.* (2019).

Broad sense heritability was ranged from 27.10% to 99.30%. High heritability was observed for characters specific leaf area, specific leaf weight, relative water content, proline content, chlorophyll content, protein content, hundred seed weight, days to fifty per cent flowering and days to maturity which underscores the importance of genetic improvement in breeding programs aimed at improving chickpea productivity under water stress. Moderate heritability was observed for number of pods per plant, yield per plot, plant height, number of primary branches, plant stand at the time of harvesting, initial plant stand, number of secondary branches, wilt per cent. Low heritability was observed for number of seeds per pod and yield per plant. Similar results were obtained by Kaushal *et al.* (2021), Gokani *et al.* (2020) and Mishra *et al.* (2019).

Highest genetic advance was recorded for yield per plot followed by specific leaf area suggesting that these traits under limited water condition traits are strongly

**Table 3 :** Path matrix of twenty-eight genotypes for different characters under limited water condition.

| Characters | IPS | | DFF | | DM | | PH | | NPB | | NSB | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G | P | G | P | G | P | G | P | G | P | G | P |
| IPS | **1.739** | **0.667** | 0.196 | 0.045 | -0.821 | -0.186 | -0.152 | -0.025 | 0.099 | 0.015 | -0.477 | 0.107 |
| DFF | 0.009 | 0.003 | **0.083** | **0.048** | 0.020 | 0.011 | 0.007 | 0.003 | -0.017 | -0.009 | -0.035 | -0.012 |
| DM | 0.313 | 0.036 | -0.162 | -0.029 | **-0.664** | **-0.128** | -0.290 | -0.040 | 0.196 | 0.025 | 0.026 | 0.008 |
| PH | 0.073 | -0.008 | 0.014 | 0.015 | 0.366 | 0.069 | **0.838** | **0.221** | 0.306 | 0.052 | -0.213 | -0.017 |
| NPB | -0.057 | -0.009 | 0.101 | 0.070 | 0.295 | 0.074 | -0.364 | -0.091 | **-0.998** | **-0.385** | -0.443 | -0.123 |
| NSB | -0.012 | -0.013 | -0.019 | -0.020 | -0.002 | -0.005 | -0.012 | -0.006 | 0.020 | 0.026 | **0.045** | **0.082** |
| NPP | 0.040 | 0.016 | 0.006 | 0.003 | 0.114 | 0.091 | 0.050 | 0.034 | 0.128 | 0.089 | 0.239 | 0.189 |
| NSP | -0.061 | -0.014 | 0.026 | 0.004 | 0.031 | 0.011 | 0.090 | 0.012 | 0.051 | 0.026 | -0.002 | -0.005 |
| HSW | -0.003 | 0.003 | -0.006 | 0.018 | -0.008 | 0.028 | -0.001 | 0.104 | 0.013 | 0.031 | 0.009 | -0.013 |
| PSH | -1.933 | -0.605 | -0.344 | -0.067 | 0.724 | 0.145 | 0.108 | 0.019 | 0.072 | 0.034 | 0.967 | 0.105 |
| Wilt% | -0.101 | -0.008 | -0.025 | -0.002 | 0.072 | 0.002 | 0.018 | 0.000 | -0.062 | 0.000 | 0.044 | -0.002 |
| Proline content | 0.336 | 0.077 | 0.349 | 0.109 | 0.052 | 0.012 | 0.011 | 0.005 | 0.431 | 0.101 | -0.321 | -0.061 |
| Chlorophyll content | 0.007 | -0.004 | -0.001 | 0.001 | 0.008 | -0.009 | 0.011 | -0.008 | -0.005 | 0.005 | -0.001 | 0.000 |
| Protein content | -0.077 | -0.018 | 0.118 | 0.043 | 0.013 | 0.005 | 0.096 | 0.025 | 0.013 | 0.001 | 0.042 | 0.107 |
| SLA | -0.334 | -0.057 | 0.028 | 0.008 | -0.048 | -0.013 | 0.307 | 0.052 | 0.381 | 0.080 | 0.326 | 0.037 |
| RWC | -0.225 | -0.043 | 0.018 | 0.005 | 0.099 | 0.028 | 0.098 | 0.022 | 0.094 | 0.023 | 0.266 | 0.127 |
| SLW | 0.415 | 0.048 | -0.177 | -0.033 | -0.054 | -0.009 | -0.553 | -0.076 | -0.406 | -0.059 | -0.151 | -0.017 |
| Y/Plant | 0.017 | 0.073 | 0.205 | 0.216 | 0.198 | 0.126 | 0.262 | 0.252 | 0.315 | 0.007 | 0.321 | 0.301 |

***Cont…***

| Characters | NPP | | NSP | | HSW | | PSH | | Wilt% | | Proline content | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | G | P | G | P | G | P | G | P | G | P | G | P |
| IPS | 0.203 | 0.108 | 0.722 | 0.108 | -0.163 | -0.018 | 1.710 | 0.612 | -0.376 | -0.170 | 0.500 | 0.137 |
| DFF | 0.001 | -0.002 | -0.015 | -0.002 | -0.013 | -0.007 | 0.015 | 0.005 | -0.005 | -0.003 | 0.025 | 0.014 |
| DM | -0.222 | 0.016 | 0.139 | 0.016 | 0.154 | 0.029 | 0.244 | 0.128 | -0.102 | -0.006 | -0.030 | -0.004 |
| PH | 0.122 | -0.048 | -0.509 | -0.048 | -0.016 | -0.007 | -0.046 | -0.006 | 0.033 | -0.001 | 0.008 | 0.003 |
| NPB | -0.371 | 0.114 | 0.343 | 0.114 | -0.361 | -0.093 | 0.037 | 0.020 | 0.132 | 0.004 | -0.368 | -0.103 |
| NSB | 0.018 | 0.004 | 0.001 | 0.004 | 0.011 | 0.008 | -0.022 | -0.013 | 0.004 | -0.006 | -0.012 | -0.013 |
| NPP | **0.343** | **-0.034** | 0.064 | 0.034 | 0.099 | 0.077 | 0.031 | 0.132 | 0.043 | -0.017 | 0.050 | 0.036 |
| NSP | 0.028 | -0.088 | **-0.148** | **-0.088** | 0.045 | 0.015 | -0.066 | -0.012 | -0.027 | 0.001 | 0.042 | 0.014 |
| HSW | 0.011 | 0.031 | -0.011 | 0.021 | **0.036** | **-0.127** | -0.006 | 0.110 | -0.011 | 0.022 | 0.000 | -0.001 |
| PSH | -0.175 | -0.086 | -0.873 | -0.086 | 0.344 | 0.050 | **-1.966** | **-0.659** | 0.278 | 0.150 | -0.707 | -0.171 |
| Wilt% | 0.058 | 0.000 | 0.085 | 0.000 | -0.140 | -0.005 | -0.066 | -0.007 | **0.468** | **0.031** | -0.108 | -0.004 |
| Proline content | 0.269 | 0.069 | -0.335 | -0.060 | 0.003 | 0.002 | 0.421 | 0.098 | -0.271 | -0.048 | **1.169** | **0.377** |
| Chlorophyll content | 0.013 | -0.013 | 0.019 | -0.013 | 0.001 | -0.001 | 0.014 | -0.009 | -0.005 | 0.003 | 0.005 | -0.005 |
| Protein content | 0.020 | -0.018 | -0.058 | -0.018 | 0.022 | 0.009 | -0.048 | -0.010 | 0.039 | 0.011 | -0.042 | -0.016 |
| SLA | -0.004 | -0.067 | -0.437 | -0.067 | 0.367 | 0.101 | -0.401 | -0.073 | -0.020 | -0.004 | -0.112 | -0.031 |

***Table 3 continued...***

***Table 3 continued...***

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **RWC** | 0.049 | -0.009 | -0.035 | -0.009 | 0.022 | 0.007 | -0.201 | -0.042 | -0.082 | -0.008 | 0.028 | 0.009 |
| **SLW** | -0.014 | 0.058 | 0.544 | 0.058 | -0.460 | -0.087 | 0.478 | 0.059 | -0.133 | -0.014 | 0.025 | 0.004 |
| **Y/Plant** | 0.348 | 0.296 | 0.631 | 0.106 | -0.050 | -0.051 | 0.362 | 0.331 | -0.036 | -0.055 | 0.472 | 0.246 |

***Cont…***

| Characters | Chlorophyll content | | Protein content | | SLA | | RWC | | SLW | |
|---|---|---|---|---|---|---|---|---|---|---|
| | G | P | G | P | G | P | G | P | G | P |
| **IPS** | -0.206 | -0.038 | -0.429 | -0.096 | -0.600 | -0.139 | -0.904 | -0.211 | 0.545 | 0.125 |
| **DFF** | 0.001 | 0.001 | 0.031 | 0.017 | 0.002 | 0.001 | 0.004 | 0.002 | -0.011 | -0.006 |
| **DM** | 0.088 | 0.016 | -0.028 | -0.006 | 0.033 | 0.006 | -0.152 | -0.027 | 0.127 | 0.005 |
| **PH** | -0.153 | -0.024 | 0.257 | 0.045 | 0.353 | 0.067 | 0.190 | 0.035 | -0.349 | -0.066 |
| **NPB** | -0.082 | -0.028 | -0.042 | -0.003 | -0.393 | -0.113 | -0.217 | -0.066 | 0.306 | 0.189 |
| **NSB** | 0.000 | 0.000 | 0.006 | 0.005 | 0.011 | 0.011 | 0.017 | 0.016 | -0.005 | -0.006 |
| **NPP** | -0.076 | -0.050 | 0.022 | 0.023 | -0.001 | -0.001 | 0.039 | 0.029 | -0.004 | -0.002 |
| **NSP** | 0.048 | 0.017 | 0.027 | 0.013 | 0.067 | 0.022 | 0.012 | 0.006 | -0.061 | -0.020 |
| **HSW** | -0.001 | 0.002 | 0.003 | -0.009 | 0.014 | -0.047 | 0.002 | -0.006 | -0.013 | 0.043 |
| **PSH** | 0.447 | 0.088 | 0.301 | 0.052 | 0.816 | 0.177 | 0.913 | 0.206 | -0.709 | -0.151 |
| **Wilt%** | 0.036 | 0.001 | 0.058 | 0.003 | -0.010 | -0.001 | -0.089 | -0.002 | -0.047 | -0.002 |
| **Proline content** | -0.091 | -0.026 | -0.156 | -0.050 | -0.135 | -0.042 | 0.074 | 0.024 | 0.022 | 0.006 |
| **Chlorophyll content** | **-0.060** | **0.068** | 0.002 | -0.002 | -0.001 | 0.001 | 0.003 | -0.003 | -0.008 | 0.108 |
| **Protein content** | -0.010 | -0.004 | **0.314** | **0.123** | 0.166 | 0.064 | 0.037 | 0.015 | -0.161 | -0.062 |
| **SLA** | 0.014 | 0.004 | 0.513 | 0.140 | **0.967** | **0.271** | 0.300 | 0.184 | -0.920 | -0.258 |
| **RWC** | -0.023 | -0.007 | 0.051 | 0.017 | 0.134 | 0.042 | **0.433** | **0.136** | -0.108 | -0.034 |
| **SLW** | 0.168 | 0.032 | -0.682 | -0.128 | -1.261 | -0.243 | -0.332 | -0.063 | **1.327** | **0.256** |
| **Y/Plant** | 0.103 | 0.052 | 0.246 | 0.145 | 0.162 | 0.076 | 0.330 | 0.275 | -0.269 | -0.273 |

influenced by genetics and could be effectively improved through selection. Similar results were observed by Sadeghzadeh-ahari *et al.* (2018), Dashti *et al.* (2018), Mahajan *et al.* (2016) and Kumar *et al.* (2016). Moderate genetic advance was observed for number of pods per plant, relative water content, proline content and protein content which indicates that these traits are influenced by genetics to a moderate extent and could be improved through selection, but the improvement may not be as significant as for other traits with high genetic advance. Similar results were reported by El-harty *et al.* (2021) and Mirzaei *et al.* (2019). Low genetic advance was observed for days to maturity, initial plant stand, plant stand at the time of harvesting, plant height, hundred seed weight, days to fifty per cent flowering, specific leaf weight, wilt per cent, yield per plant chlorophyll content, number of secondary branches, number of primary branches and number of seeds per pod which implies that selection of these traits may not result in significant improvement in the phenotype under limited water condition. Similar results were reported by Alghamdi *et al.* (2020).

## Correlation coefficient analysis

The correlation studies showed that for almost all the characters genotypic correlation were higher than phenotypic correlation (Table 2), suggesting a strong inherent relationship between different traits and that environmental factors have not played much role in transmission of traits. However, in some cases genotypic coefficient of correlation were obtained lower than the phenotypic coefficient of correlation which indicates that although there is a strong inherent association between the various characters, phenotypic expression of correlation is reduced under the influence of environment. Results showed that genotypic and phenotypic coefficient of correlation of yield per plant was found positive and highly significant to characters like plant height, number of pods per plant, number of secondary branches, number of seeds per pod, plant stand at the time of harvesting, proline content and relative water content and significant positive correlation was observed with protein content. Similar results were seen in Kamkar *et al.* (2022), Yadav *et al.* (2021), Amini *et al.* (2021) and Maurya *et al.* (2021). Negative and significantly correlated with SLW. This may be because plants with thicker and denser leaves may have a lower photosynthetic activity and lower available resources for yield under water stress which was supported by Yadav *et al.* (2020) and Sadeghipour *et al.* (2018).

**Path coefficient analysis**

The path analysis reveals whether the association of these characters with yield is due to their direct effect on yield or is a consequence of their indirect effect via other component characters. It is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects. It helps in determining yield contributing characters and thus is useful in indirect selection. Genotypic path analysis revealed positive direct effect of the characters initial plant stand, days to fifty per cent flowering, plant height, number of seeds per pod, hundred seed weight, wilt percent, proline content, protein content, specific leaf area, relative water content and specific leaf weight. Out of which number of secondary branches, number of pods per plant, proline content, protein content and relative water content showed significant and positive correlation with yield per plant (Table 3). This indicates that under limited water condition characters like proline content and relative water content should be taken into consideration and breeders should focus on selecting genotypes with these traits to improve chickpea yield under water stress conditions. Highest direct effect on yield per plant was observed by initial plant stand followed by specific leaf weight and proline content. Similar results were observed by Kumar *et al.* (2017). Phenotypic path analysis showed direct positive effect was showed by the characters initial plant stand, days to fifty per cent flowering, plant height, number of secondary branches, wilt per cent, proline content, chlorophyll content, protein content, specific leaf area, relative water content and specific leaf weight. Out of these plant height, number of secondary branches, proline content and relative water content showed significant positive correlation with yield per plant out of which highest direct effect was observed by initial plant stand followed by proline content and number of secondary branches suggesting that these characters are important as stress highlights and as potential selection criteria in breeding programs for developing cultivars tolerant to water stress. This result was in agreement with the findings reported by Mahajan *et al.* (2017), Singh *et al.* (2019) and Yadav *et al.* (2017).

## Conclusion

Genotypic variance was higher for yield per plot and specific leaf area, while phenotypic variance indicated substantial environmental influence across all traits. Proline content, chlorophyll content, protein content, specific leaf area, number of pods per plant and specific leaf weight exhibited higher genotypic coefficient of variations, highlighting their potential for genetic improvement. Yield per plot, specific leaf weight and proline content demonstrated high phenotypic coefficient of variation, underscoring their significance in breeding programs for enhancing chickpea productivity. Heritability ranged from low to high, with specific leaf area, specific leaf weight and proline content displaying high heritability, indicating their suitability for genetic enhancement.

The correlation analysis demonstrated a strong inherent relationship between traits, with genotypic correlations generally outweighing phenotypic correlations, indicating limited environmental influence in trait transmission. The study also identified a negative correlation between yield per plant and specific leaf weight, potentially due to thicker and denser leaves affecting photosynthetic activity and resource availability under limited water condition.

Furthermore, Path analysis revealed that initial plant stand, days to fifty per cent flowering, plant height, number of seeds per pod, hundred seed weight, wilt percent, proline content, protein content, specific leaf area, relative water content and specific leaf weight directly affected yield per plant. Traits like number of secondary branches, number of pods per plant, proline content, protein content, and relative water content showed significant positive correlations with yield per plant, making them crucial for improving chickpea yield under limited water conditions.

Overall, these findings contribute valuable insights for developing drought-tolerant chickpea cultivars, thereby addressing challenges related to water scarcity and ensuring sustainable agricultural productivity. The agreement with previous research further reinforces the importance of proline content and relative water content as key targets in breeding programs for enhancing chickpea yield under water stress conditions.

## References

Alghamdi, S.S., Al-Faifi S.A. and Migdadi H.M. (2018). Impact of water stress on growth, yield and water use efficiency of chickpea (*Cicer arietinum* L.) under arid environment. *J. Environ. Biol.*, **39(1)**, 155-162.

Allard, R.W. (1960). Principles of Plant Breeding. *Jhon Wiley and Sons*, Inc., New York, 213-233.

Amini, F. and Esmailpour B. (2021). Effect of drought stress on protein content and antioxidant enzymes activity of chickpea (*Cicer arietinum* L.) genotypes. *J. Crop Sci. Biotechnol.*, **24** (3): 231-238.

Burton, G.W. (1952). Quantitative inheritance in grasses. *Proceedings of 6th International Grassland Congress*, **1**, 227-283.

Dashti, H., Sabaghpour S.H. and Khamssi N. (2018). Evaluation of genetic variability and heritability of some agronomic traits in chickpea genotypes under drought stress condition. *J. Plant Breed. Crop Sci.*, **10(9)**, 229-236.

El-Harty, E.H., Al-Suhaibani N.A., Elsayed A.H.M. and Alzahrani A.H. (2021). Combininig ability analysis and genetic parameters for drought tolerance traits and yield in chickpea (*Cicer arietinum* L.). *J. Plant Growth Regul.*, **40(1)**, 159-173.

Gaur, P.M., Tripathi S., Gowda C.L., Rao G.V., Sharma H.C., Pande S. and Sharma M. (2010). *Chickpea Seed Production Manual.* Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute- for the Semi-Arid Tropics. 28 pp.

Gokani, S.J., Patel H.R., Solanki R.K. and Dobariya K.L. (2020). Genetic variability, heritability and genetic advance for drought tolerance traits in chickpea (*Cicer arietinum* L.). *Int. J. Chem. Stud.*, **8 (2)**, 16-19.

Jhonson, H.W., Robinson H.F. and Comstock (1955). Genotypic and phenotypic correlations in soybeans and their implication in selection. *Agron. J.*, **47**, 477-483.

Kamkar, B., Zarei M. and Tabrizi L. (2022). Effects of water stress and foliar application of proline and potassium nitrate on the yield and some physiological characteristics of chickpea (*Cicer arietinum* L.). *J. Plant Nutr.*, **45 (1)**, 196-208.

Kaushal, N., Gupta K., Bhandari K., Kumar S., Thakur J.K. and Bhat K.V. (2021). Assesment of Genetic variability, heritability and genetic advance for drought tolerance traits in chickpea (*Cicer arietinum* L.). *J. Crop Improvement*, **35 (1)**, 57-77.

Kumar, R., Kumar V. and Singh K.N. (2016). Heritability, genetic advance and correlation studies for yield and its components in chickpea (*Cicer arietinum* L.) under normal and water-stress conditions. *Legume Res.- An Int. J.*, **39 (3)**, 416-421.

Kumar, R. and Kumar S. (2017). Genetic variability, heritability and genetic advance for yield and yield components in chickpea under rainfed conditions. *Int. J. Curr. Microbiol. Appl. Sci.*, **6(9)**, 2145-2150.

Kumar, S., Suresh B.G., Kumar A. and Lavanya G.R. (2019). Genetic variability, Correlation and Path Coefficient Analysis in Chickpea (*Cicer arietinum* L.) for Yield and its Component Traits. *Int. J. Curr. Microbiol. Appl. Sci.*, **8 (12)**, 2341-2352.

Lush, J.L. (1940). Inter-sire correlation and regression of offsprings on dams as a method of estimating heritability of characters. *Proc. Amer. Soc. Anim. Prod.*, **33**, 293-301.

Mahajan, R.L., Gomase V.S. and Kajjari N.B. (2016). Assessment of genetic variability, heritability and genetic advance for yield and its contributing traits in chickpea (*Cicer arietinum* L.) under rainfed condition. *J. Appl. Nat. Sci.*, **8 (2)**, 893-897.

Mahajan, S., Tuteja N. and Deshmukh R. (2017). Path coefficient analysis of yield and its components in chickpea under moisture stress. *Int. J. Chem. Stud.*, **5(4)**, 1637-1640.

Maurya, R.P., Singh R. and Bhatt B.P. (2021). Study on correlation and path analysis for yield and yield components in chickpea (*Cicer arietinum* L.) under rainfed condition. *Legume Res.*, **44 (2)**, 167-171.

Mirzaei, A., Habibi D. and Javadi T. (2019). Genetic variability and heritability of agronomic traits in chickpea (*Cicer arietinum* L.) genotypes under drought stress condition. *Biologia*, **74(3)**, 265-271.

Mishra, P.K., Mishra R.K. and Singh A.K. (2019). Genetic variability, heritability and genetic advance for drought tolerance traits in chickpea (*Cicer arietinum* L.). *Legume Res.*, **42(4)**, 536-540.

Nikita, G. and Lal G.M. (2021). Genetic Variability, Correlation and Path Coefficient Analysis for Yield and its Component Traits in Chickpea (*Cicer arietinum* L.). *Res. J. Sci. Technol.*, **doi:** 10.52711/2349-2988.2022.00009.

Ram, L., Baralya B., Choudhary A.K. and Kachouli B. (2021). Assessment of Variability and Genetic Parameters in Agro-Physiological Traits of Chickpea (*Cicer arietinum* L.) under Rainfed condition. *Int. J. Plant Soil Sci.*, **7**, 619-626.

Rani, A., Devi P., Jha U.D., Sharma K.D., Siddique H.M. and Nayyar H. (2020). Developing Climate Resilient Chickpea Involving Physiological and Molecular Approaches with a Focus on Temperature and Drought Stresses. *Front. Plant Sci*. **doi:** 10.3389/fpls.2019.01759.

Sadeghipour, O., Koocheki A., Soltani A. and Mahdi Nejad H. (2018). Yield and yield components of chickpea cultivars under drought stress and normal conditions. *J. Crop Product. Processing*, **8(3)**, 59-73.

Sadeghzadeh-ahari, D., Khodadadi M., Sabaghnia N. and Kharabian-Masouleh A. (2018). Genetic Analysis of yield and yield components in chickpea under water stress conditions. *Legume Res.*, **41(1)**, 106-112.

Singh, K.B and Reddy K.N. (2011). Chickpea yield losses due to terminal drought in South Asia. In: Vadez, J., Krishnamurthy K. and Srivastava N. (Eds.), *Crop Yield Response to water*, pp. 213-220. Wiley-Blackwell.

Singh, V., Singh P., Kumar A. and Nath S. (2018). Estimation of genetic variability parameters in chickpea (*Cicer arietinum* L.) germplasm. *J. Pharmacog. Phytochem.*, **7 (2)**, 1204-1206.

Yadav, R.S., Sehgal D., Vadez V., Kumar A.R., Pande S. and Sharma K.K. (2017). Drought sensitivity in grain legumes during reproduction and grain filling. *J. Agron. Crop Sci.*, **203(2)**, 81-102.

Yadav, S., Sharma S.K., Singh P. and Singh D.K. (2020). Physiological and biochemical characterization of chickpea genotypes under water stress conditions. *J. Pharmacog. Phytochem.*, **9(2)**, 2488-2491.

Yadav, S.S., Yadav S.K., Singh A.K. and Yadav R.S. (2021). Correlation and path analysis in chickpea (*Cicer arietinum* L.) genotypes. *Legume Res.*, **44(4)**, 571-576.