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**Dishari Biswas**
Department of Genetics and Plant Breeding, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

**Sonika Yumnam**
Department of Genetics and Plant Breeding, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

**TH Renuka Devi**
Department of Genetics and Plant Breeding, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

**Bireswar Sinha**
Department of Plant Pathology, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

**N Okendro Singh**
Department of Basic Sciences, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

**Corresponding Author:**
**Dishari Biswas**
Department of Genetics and Plant Breeding, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

# Genetic assessment for yield and its attributing traits in chickpea (*Cicer arientinum* L.) germplasms and estimation of correlation coefficient, path coefficient and cluster analysis

**Dishari Biswas, Sonika Yumnam, TH Renuka Devi, Bireswar Sinha and N Okendro Singh**

**Abstract**
Chickpea (*Cicer arietinum* L.) is one of the important pulse crop widely grown in India as a rain fed and irrigated crop. The source of genetically variable germplasm is important for a potential chickpea improvement breeding programme. In this regard, the present experiment was conducted during *Rabi* 2021 at Central Agricultural University, Research farm, Andro. To study the association between yield and other components, selected 50 germplasms along with 3 checks obtained from various sources were studied for nine quantitative traits. High GCV and PCV for the number of primary branches, number of secondary branches, number of pods per plant and seed yield per plant indicate the presence of genetic variability among the germplasm lines. High heritability has been shown by most of the characters studied. Significant and positive correlation with seed yield per plant was observed for seven characters *viz*., plant height, days to 50 % flowering, number of primary branches, number of secondary branches, number of pods per plant, number of seeds per pod and 100 seed weight. Positive direct and indirect effects of yield component traits on seed yield per plant was observed. Germplasm lines were clustered into 4 clusters where cluster III contained the maximum number of lines. Hence, these traits may serve as an effective selection criterion for yield improvement. Based on the mean performance some of the promising germplasm lines selected are D17-40, ICC-4567, D17-49, D17-45 and ICC-4418. These superior lines can be further used in hybridization programme.

**Keywords:** Chickpea, genetic variability, correlation, path coefficient analysis, heritability, cluster analysis

## Introduction
Chickpea (*Cicer arietinum* L.) is a self-pollinated, annual diploid (2n=2x= 16) species commonly known as Channa, gram or garbanzo bean, etc. It is a Rabi season leguminous crop that performs optimally at 21.1 °C to 26.6 °C at daylight hours temperature and 17.77 °C to 21.1 °C in night time temperatures. Chickpea grows successfully in cooler and dry climates being a sub-tropical and drought-resistant crop. The *Cicer* genus is composed of 9 annual and 34 perennial wild species and *C. arietinum* is the only cultivated species (Singh *et al*., 2008) [15]. In India, Chickpea is considered the "King of Pulses". This crop originated in the south-east region of Turkey and spread around the world.

Genetic variability is a pre-requisite for any crop improvement programme. The breeding methods to be adopted in the improvement of crops are in turn decided primarily by the amount of genetic variability. Assessment of genetic variability using suitable tools such as genetic coefficient of variation, heritability estimates and genetic advance is vital to improve yield as well as the quality of any crop in any breeding program. Thus, understanding of genetic variation has paramount significance for yield and its component improvement in any crop as the determined variability is a combined effect of genetic, environmental and various interactions between genes and environment where only the former is heritable.

Direct selection based on yield may not be beneficial because yield is a complex trait and is influenced by numerous environmental factors. Therefore, it is crucial to have a fundamental understanding of the type and strength of association between component qualities and yield. The correlation coefficient and path analysis provide a method for identifying the significant features influencing the dependent trait, such as seed yield, and they also help in the selection criteria for concurrently improving multiple characters and economic yield.

To evaluate the genetic variability, correlation and path analysis for yield and its attributing traits, the current study was conducted.

## Materials and Methods

The experimental materials comprising fifty germplasm of chickpea along with three checks were sown on 4th December, 2021 at Central Agricultural University, Research farm, Andro. The experiment was carried out in augmented design with 5 blocks. Inter row spacing was kept at 30 cm plant-to-plant spacing was 10 cm. The recommended packages and practices were followed for raising a healthy crop. Data for 9 quantitative traits were recorded viz. plant height, days to 50% flowering, days to maturity, number of primary branches, number of secondary branches, number of pods per plant, number of seeds per pod, 100 seed weight and seed yield per plant.

The days to 50 % flowering and days to maturity were accounted on a plot basis and the rest of the characters were documented from random samples of five plants from each plot. The recommended agronomic practices and crop protection measures were followed during the crop growth period. Biometrical methods were followed to estimate the genotypic and phenotypic coefficient of variation (Burton and Devane, 1953) [3], heritability in broad sense (Allard, 1960) [1], genetic advance (Johnson *et al.*, 1955) [8] and correlation and path coefficient analysis (Dewey and Liu, 1959) [5].

## Results and Discussion

### Analysis of variance

The analysis of variance (ANOVA) was estimated for the nine characters under study. Highly significant variances were observed for most of the characters studied. Hence, it justified the presence of sufficient variability among the genotypes studied.

### Mean performance

A wide range of variation in the mean performance of genotypes was observed for all the traits under study. The comparison of the mean performance of 50 entries and 3 checks revealed the existence of a very high level of variability in the evaluated germplasm collection.

### Genetic parameters

Higher phenotypic coefficients of variation, compared to genotypic coefficients of variation were recorded for all the traits studied in the present investigation, indicating the influence of the environment. Similar results were reported by Shengu *et al.* (2018) [14].

Higher PCV values were recorded for the number of primary branches, number of secondary branches, number of pods per plant and seed yield per plant. This higher value indicates the possibility of direct selection. Similar results showing higher magnitudes of PCV were recorded for seed yield per plant, biological yield per plant, seed yield per plant and seed index as reported by Srivastava *et al.* Greater degree of GCV and PCV variations were noted in seed yield per plant, 100 seed weight, secondary branches, number of pods per plant by Aswathi *et al.* (2019) [2].

Heritability in broad sense was high for all the traits while a low value of heritability was recorded only for days to 50% flowering. It might be because the experiment was conducted only at a single location and for one year. High values of heritability facilitate higher gains of selection, as the character is expected to be controlled by additive gene action which is fixable. Past studies also revealed similar results for heritability in broad sense (Nizama *et al.*, 2013; Dev *et al.*, 2017) [11, 4].

Genetic advance as a percentage of mean explains the expected gain when a simple section for a character is practiced. Higher genetic advance followed by higher heritability is desirable as these traits are usually the ones that can be selected for indirect improvement of the dependent variable. Genetic advance as percentage of mean was high for most of the traits. However, the low value of genetic gain was recorded for days to 50% maturity and Days to maturity. Similar results were also reported by Mohinullah *et al.* (2020).

High heritability coupled with genetic gain was recorded for seed yield per plant, plant height, and number of primary branches, number of secondary branches, number of pods per plant, number of seeds per pod and 100 seed weight. Present results are similar to the findings of Srivastava *et al.* (2017) [16], Zeeshan *et al.* (2012) [17], Aswathi *et al.* (2019) [2] and Babbar *et al*. (2014) [9].

### Estimation of correlation coefficients

The correlation coefficient measures the degree of symmetrical association between two variables or characters, which helps in understanding the nature and magnitude of the association between yield and its component traits.

In the present study, the correlation coefficient was computed among the nine characters. The seed yield per plant exhibited positive and highly significant correlations with plant height, days to 50% flowering, number of pods per plant, 100 seed weight and number of seeds per pod. It exhibited a negatively non-significant relationship with days to maturity. These characters emerged as important factors in influencing seed yield in chickpea. Similar results were reported in the earlier studies of Babbar *et al.* (2014) [9], Pandey *et al.* (2013) [13], Kuldeep *et al.* (2014) [9] and Noor *et al. (*2003) [12].

Most of the interrelationships showed positive and significant correlations. Among the traits plant height, number of primary branches, number of seed per pod and seed yield per plant were found to be correlated with most of the traits.

### Estimation of path coefficient analysis

Path coefficient is a tool to partition the observed correlation coefficient into direct and indirect effects of yield components on the seed yield to provide a picture of character association for formulating an efficient selection strategy. In this study it is carried out to estimate the direct and indirect contribution of various plant characters to seed yield per plant. Highest positive direct effect on seed yield per plant was exerted by number of pods per plant. Following this plant height, 100 seed weight and number of seeds per pod had also shown a positive direct correlation. A significant positive association of seed yield per plant with number of pods per plant and 100 seed weight was also reported by Pandey *et al.* (2013) [13].

### Cluster analysis

Hierarchical cluster analysis grouped all the experimental germplasm lines into four distinct clusters and resulted in a dendrogram (Jha and Shil, 2015) [7]. The genotypes of higher intra and inter-cluster distances have more genetic divergence (Janghel *et al.*, 2020) [6]. These lines from different clusters

can be selected based on the interest of the characters to be improved. Cluster II had the highest mean values for number of primary branches, number of secondary branches, number of pods per plant and number. Cluster III had maximum cluster mean for plant height, 100 seed weight and Seed yield per plant. Cluster IV had the lowest mean values for most of the characters.

In K means clustering, germplasm lines were clustered into 4 clusters on the basis of observed distance among the clusters and the genotypes within clusters. Where cluster II consisted of the maximum number of germplasm lines followed by cluster IV. At intra- cluster level the maximum value was recorded for cluster III followed by cluster I, cluster II, and cluster IV. The average inter-cluster value was minimum between cluster II and cluster IV. Maximum average -cluster value was observed between cluster IV and III.

**Table 1:** Analysis of variance for 9 different characters in 50 chickpea germplasm lines

| Mean sum of squares | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Source** | **Degrees of freedom** | **Plant Height (cm)** | **Primary Branches** | **Secondary Branches** | **100 seed weight** | **50 % Flowering** | **Days to maturity** | **No. of pods** | **No. of seeds per pod** | **Seed Yield** |
| Block (Ignoring Treatments) | 4 | 55.17** | 1.07** | 21.49** | 15.11* | 15.82 | 13.17* | 52.98** | 0.09$^{ns}$ | 7.04** |
| Treatment (eliminating Blocks) | 52 | 25.16* | 0.55** | 5.02* | 14.5** | 7.82 | 6.48* | 15.06** | 0.08* | 0.88** |
| Treatment: Check | 2 | 4.3 | 1.35** | 0.1 | 127.98 ** | 9.8 | 6.2 | 4.47* | 0.01 | 0.69** |
| Treatment: Test and Test vs. Check | 50 | 26* | 0.52 ** | 5.21** | 9.96* | 7.74 | 6.49 | 15.48** | 0.08* | 0.89** |
| Residuals | 8 | 6.27 | 0.1 | 0.14 | 3.1 | 8.63 | 1.95 | 0.69 | 0.03 | 0.01 |

**Table 2:** Estimation of genetic parameters for nine quantitative characters in fifty germplasm of chickpea.

| Traits | Mean | GCV | GCV Category | PCV | PCV Category | ECV | hBS | hBS Category | GA | GAM | GAM Category |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant height (cm) | 32.43 | 15.22 | Medium | 17.06 | Medium | 7.72 | 79.53 | High | 9.08 | 27.99 | High |
| Days to 50 % flowering | 74.82 | 0.55 | Low | 3.97 | Low | 3.93 | 1.91 | Low | 0.12 | 0.16 | Low |
| Days to maturity | 120.15 | 1.96 | Low | 2.27 | Low | 1.16 | 73.89 | High | 4.17 | 3.47 | Low |
| Number of primary branches | 2.75 | 26.05 | High | 28.53 | High | 11.61 | 83.43 | High | 1.35 | 49.09 | High |
| Number of secondary branches | 5.21 | 45.7 | High | 46.27 | High | 7.24 | 97.55 | High | 4.85 | 93.12 | High |
| Number of pods per plant | 12.07 | 31.19 | High | 31.94 | High | 6.87 | 95.38 | High | 7.58 | 62.85 | High |
| Number of seeds per pod | 1.5 | 15.98 | Medium | 19.2 | Medium | 10.65 | 69.27 | High | 0.41 | 27.44 | High |
| 100 seed weight (g) | 16.03 | 17.37 | Medium | 19.87 | Medium | 9.67 | 76.35 | High | 5.02 | 31.3 | High |
| Seed yield per plant | 2.37 | 51.07 | High | 51.33 | High | 5.07 | 99.02 | High | 2.49 | 104.85 | High |

GCV = Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, ECV=Environmental coefficient of variation, hBS= Heritability broad sense, GA= Genetic Advance, GAM= Genetic advance as percent mean value.

**Table 3:** Correlation coefficient for yield and its attributing traits in fifty chickpea germplasm.

| | PH | DFF | DM | PB | SB | NP | NS | SY | SW |
|---|---|---|---|---|---|---|---|---|---|
| PH | 1.000 | 0.231 | -0.237 | 0.033 | 0.265 | 0.561** | 0.121 | 0.669** | 0.213 |
| DFF | 0.231 | 1.000 | -0.264 | 0.021 | -0.284* | -0.066 | 0.177 | 0.290* | 0.216 |
| DM | -0.237 | -0.264 | 1.000 | 0.102 | 0.069 | 0.163 | 0.185 | -0.103 | -0.275* |
| PB | 0.033 | 0.021 | 0.102 | 1.000 | 0.394** | 0.331* | 0.298* | 0.257 | 0.006 |
| SB | 0.265 | -0.284* | 0.069 | 0.394** | 1.000 | 0.688** | 0.159 | 0.251 | -0.113 |
| NP | 0.561** | -0.066 | 0.163 | 0.331* | 0.688** | 1.000 | 0.269 | 0.621** | -0.057 |
| NS | 0.121 | 0.177 | 0.185 | 0.298* | 0.159 | 0.269 | 1.000 | 0.343* | -0.068 |
| SY | 0.669** | 0.290* | -0.103 | 0.257 | 0.251 | 0.621** | 0.343* | 1.000 | 0.310* |
| SW | 0.213 | 0.216 | -0.275* | 0.006 | -0.113 | -0.057 | -0.068 | 0.310* | 1.000 |

PH- Plant Height(cm), DFF- Days to 50% flowering, DM- Days to maturity, PB- Number of Primary Branches, SB- Number of Secondary Branches, NP- Number of pods per plant, NS- Number of seeds per pod, SW- 100 seeds weight(g), SY- Seed yield per plant, PY- Plot yield

**Table 4:** Direct (diagonal) and indirect effects of yield component traits on seed yield per plant, in 50 chickpea germplasm lines.

| | PH | DFF | DM | PB | SB | NP | NS | SW |
|---|---|---|---|---|---|---|---|---|
| PH | 0.31737340 | 0.021947939 | 0.013395750 | 0.0034212264 | -0.05705243 | 0.30174141 | 0.02081952 | 0.047447100 |
| DFF | 0.07346633 | 0.094814750 | 0.014912722 | 0.0021751199 | 0.06108375 | -0.03537342 | 0.03039580 | 0.048093602 |
| DM | -0.07528028 | -0.025036666 | -0.056475012 | 0.0106023540 | -0.01487748 | 0.08740817 | 0.03191858 | -0.061377069 |
| PB | 0.01041331 | 0.001977860 | -0.005742422 | 0.1042710064 | 0.08474072 | 0.17809878 | 0.05133050 | 0.001386025 |
| SB | 0.08408553 | -0.026895412 | -0.003901774 | 0.0410329115 | -0.21533935 | 0.37012298 | 0.02732201 | -0.025226988 |
| NP | 0.17804046 | -0.006235428 | -0.009177442 | 0.0345253262 | -0.14817766 | 0.53788164 | 0.04633551 | -0.012626082 |
| NS | 0.03839456 | 0.016746266 | -0.010474382 | 0.0311005138 | -0.03418727 | 0.14482020 | 0.17209630 | -0.015063463 |
| SW | 0.06748822 | 0.020436710 | 0.015534964 | 0.0006477125 | 0.02434650 | -0.03043709 | -0.01161834 | 0.223127048 |

PH- Plant Height(cm), DFF- Days to 50% flowering, DM- Days to maturity, PB- Number of Primary Branches, SB- Number of Secondary Branches, NP- Number of pods per plant, NS- Number of seeds per pod, SW- 100 seeds weight(g), SY- Seed yield per plant, PY- Plot yield

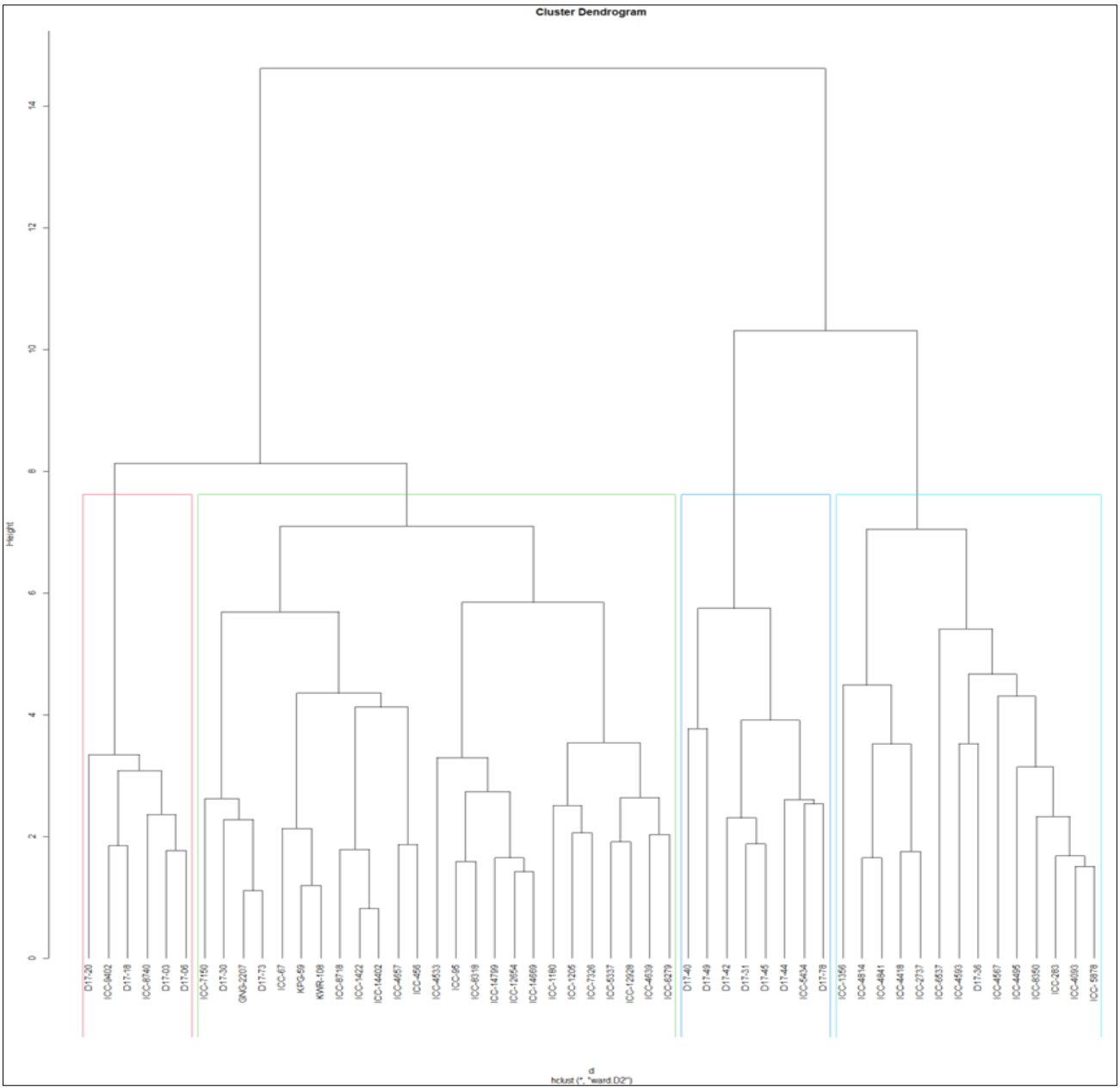


**Table 5:** Average intra (BOLD) and inter-cluster values in 50 chickpea germplasm lines.

| | Cluster I | Cluster II | Cluster III | Cluster IV |
|---|---|---|---|---|
| Cluster I | 3.094228 | 4.333957 | 4.853694 | 3.711250 |
| Cluster II | 4.333957 | 3.664538 | 4.566017 | 5.096512 |
| Cluster III | 4.853694 | 4.566017 | 3.354899 | 4.486152 |
| Cluster IV | 3.711250 | 5.096512 | 4.486152 | 2.523938 |

**Table 6:** Cluster wise mean value for seed yield and its contributing traits

| | PH | DFF | DM | PB | SB |
|---|---|---|---|---|---|
| Cluster I | -0.61018912 | -0.4215793 | 0.3560075 | -0.3369512 | -0.3624930 |
| Cluster II | 0.33032947 | -0.3730902 | 0.2748689 | 0.7461142 | 0.9918408 |
| Cluster III | 1.37584740 | 0.8810751 | -0.7393627 | 0.1082003 | 0.1415436 |
| Cluster IV | -0.06277731 | 1.4523572 | -1.1389085 | -0.4812366 | -0.9926324 |

| | NP | NS | SW | SY |
|---|---|---|---|---|
| Cluster I | -0.5094401 | -0.2398564 | -0.047562349 | -0.5917924 |
| Cluster II | 1.0416742 | 0.4577794 | -0.661292431 | 0.4030509 |
| Cluster III | 0.5927556 | 0.1349803 | 1.312549274 | 1.5932849 |
| Cluster IV | -1.0982470 | -0.2487242 | -0.008873573 | -0.5990300 |

PH- Plant Height(cm), DFF- Days to 50% flowering, DM- Days to maturity, PB- Number of Primary Branches, SB- Number of Secondary Branches, NP- Number of pods per plant, NS- Number of seeds per pod, SW- 100 seeds weight(g), SY- Seed yield per plant, PY- Plot yield

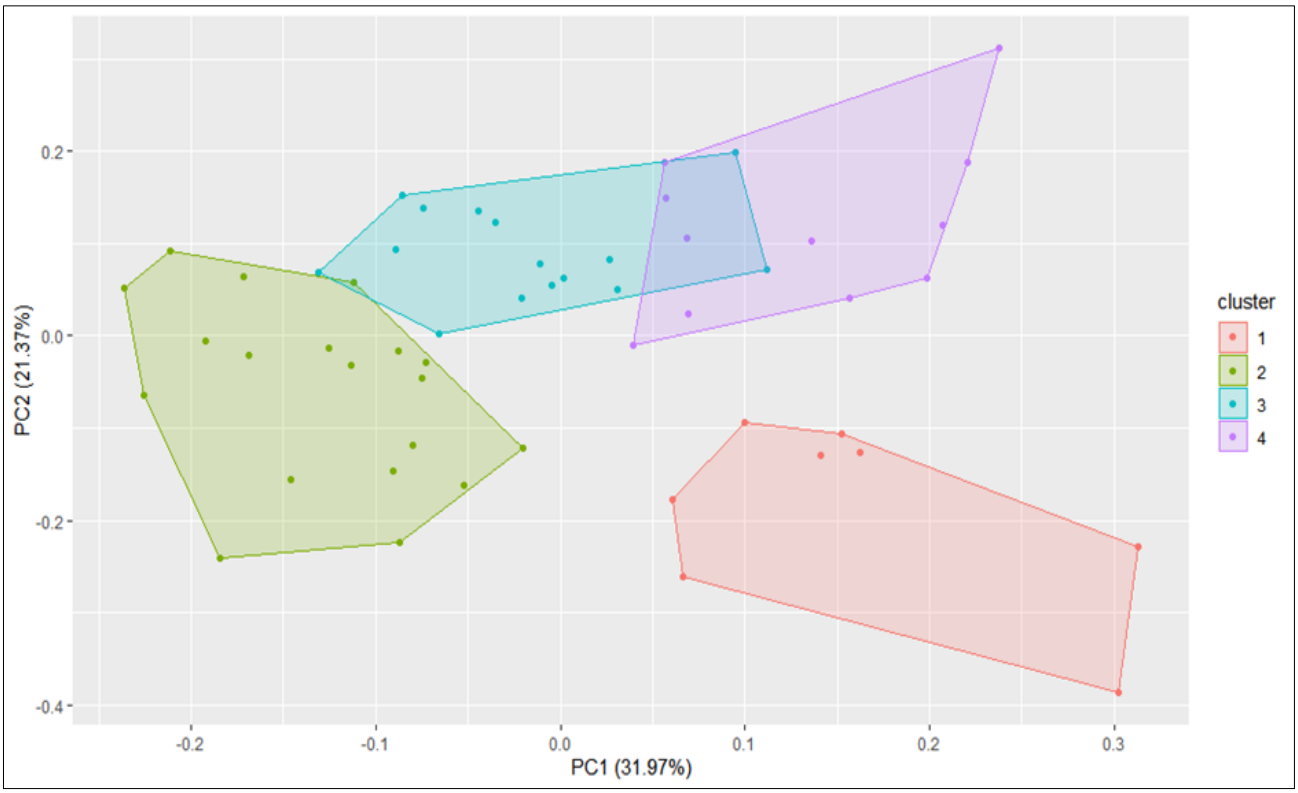


**Fig 2:** K means plot

**Table 7:** Average intra and inter-cluster values in 53 chickpea germplasm lines.

| CLUSTER | Cluster I | Cluster II | Cluster III | Cluster IV |
|---|---|---|---|---|
| **Cluster I** | **3.51893** | | | |
| Cluster II | 4.46168 | 3.202486 | | |
| Cluster III | 4.567409 | 4.472135 | 3.354899 | |
| Cluster IV | 4.546033 | 3.658448 | 5.164912 | 2.675629 |

**Table 8:** Cluster wise mean values

| CLUSTER | PH | DFF | DM | PB | SB |
|---|---|---|---|---|---|
| Cluster I | 0.4098396 | -0.4939128 | 0.3174241 | 0.59051301 | 1.0356976 |
| Cluster II | -0.3128517 | 0.5771202 | -0.1759007 | 0.01381693 | -0.5739559 |
| Cluster III | 1.3758474 | 0.8810751 | -0.7393627 | 0.10820027 | 0.1415436 |
| Cluster IV | -0.7645260 | -0.7868499 | 0.3539000 | -0.62792686 | -0.3046579 |

| CLUSTER | NP | NS | SW | SY |
|---|---|---|---|---|
| Cluster I | 1.1554454 | 0.4845778 | -0.768360373 | 0.4584471 |
| Cluster II | -0.6970496 | 0.4182585 | -0.001971905 | -0.4134150 |
| Cluster III | 0.5927556 | 0.1349803 | 1.312549274 | 1.5932849 |
| Cluster IV | -0.5154244 | -1.0648577 | -0.034015361 | -0.8046159 |

## Conclusion

The present investigation highlighted the differential potentials of the 50chickpea germplasm studied where ICC-4567, ICC-1356, ICC-2737, ICC-4093, ICC-5434, ICC-5878, ICC-8350, D17-36, D17- 40, D17-42, D17-44, D17-45 and D17-49 were found to possess superior seed yield than the best check. ICC-4567 possessed other important trait like number of primary and secondary branches, number of pods per plant and number of seeds per pod; ICC-2737 for number of secondary branches and number of pods per plant; D17-40 for plant height, days to maturity and 100 seed weight; D17-45 for number of seeds per pod and D17-49 for number of seeds per pod and 100 seed weight. Therefore, these germplasms may be carried forward for multilocational trials for testing their stability and adaptability across the environments.

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