



Metroglyph analysis for morphological variation in chickpea (*Cicer arietinum* L.)

Karra Pravallika*, G M Lal

Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh, India

Abstract

The present investigation consists of 35 genotypes of Chickpea including one check, which were grown in the Field Experimentation Centre of the Department of Genetics and Plant breeding, SHUATS, Prayagraj during Rabi 2019 following RBD with three replications. The data were recorded on 13 characters to study the amount of genetic variability, heritability, Genetic Advance, Genetic advance as percent mean in the chickpea genotypes.

Based on the mean performance genotype ICC-4968 followed IC-244253 and Phule- 4-5 were identified as best genotypes for seed yield per plant. High significant variation was obtained for all characters studies. High heritability estimates were observed for Number of primary branches, Seed yield, harvest index followed by number of pods per plant, number of secondary branches, biological yield, number of seeds per plant, number of seeds per pod, 100 seed weight, days to 50% flowering, days to maturity, days to 50% pod setting, and plant height. High values for heritability indicates that it may be due to higher contribution of genotypic components. High genetic advance as percent of mean was recorded high for seed yield, harvest index, biological yield, number of pods per plant, number of primary branches, number of seeds per plant, number of secondary branches, number of seeds per pod, hundred seed weight, plant height, days to 50% flowering, days to 50% pod setting, days to maturity. Metroglyph analysis shows, analysis of variance indicated that significant variations among the 35 lines for thirteen characters. The scatter diagram revealed that five complexes could be distinguished on the basis of Morphological variation. Maximum number of genotypes falls in cluster I and II (11) followed by cluster III (6), cluster IV (4) and cluster V (3). The germplasm lines, IPC-97-29, ILC-0, ILC-3279, IPC-11-85, IC-244263 recorded high index score and fell into different clusters can be crossed to have maximum variability of good combination of characters. Thus, the use of these genotypes in future breeding programme is suggested. Moderate to high level of genetic diversity was obtained using D^2 statistics indicates that, this method can be used successfully in the genetic diversity analysis of chickpea. Grouping of genotypes into various clusters D^2 statistics is effectively done by Torcher's method. The 35 genotypes were grouped into five distinct clusters named as cluster I to Cluster V. These clusters comprised 31,1,1,1 and 1 number of germplasm lines. Maximum number of genotypes falls in cluster I (31). More the cluster, more will the genetic diversity and thus genotypes which are included in large distantly clusters are more significant to the further crossing programme. Clusters having small genetic distance are genetically similar from each other, and thus cannot use for crossing because of lacking the diversity.

Keywords: *Cicer arietinum* L. Metroglyph, Genetic diversity, Genetic variability, Chickpea, GCV, PCV, heritability, variability, genetic advance and D^2 analysis

Introduction

Chickpea is an integral part of an Indian agriculture since time, because of only its intrinsic value in terms of higher protein content, carbohydrates, minerals, nitrogen fixing ability and alternative crop for crop diversification. Chickpea occupies a prime position among the pulses in the country with maximum hectare production and its higher nutritive value.

Chickpea is an autogamous diploid ($2n=16$) legume. It belongs to family Fabaceae sub-family Papilionoideae. The genus *Cicer* includes 43 species, nine of which are annual, 33 are perennial and one with unspecific life cycle. Chickpea is the second most important pulse crop after dry beans. Genetic improvement in chickpea started since domestication and lot of improvement has been achieved, but crop improvement is a never-ending endeavor. It is an important winter season food legume having extensive geographical distribution. Southwest Asia and the Mediterranean particularly South-East Turkey and Syria are considered as the primary centre of origin of Chickpea (Singh *et al.* 1997). Ethiopia is regarded as secondary Centre of origin.

Furthermore, Chickpea pod covers and seed coats can also be used as fodder. India contributes major share of world's chickpea area (137.18 lakh. ha), and production (146.46 lakh tons) and the productivity is (1038.4 kg/ha) (FAOSTAT 2019). In India chickpea is cultivated mostly in as a rainfed crop. India is the largest Chickpea growing nation in the world with an area of production about 96.9 lakh. ha, the production of the country is about 110.78 lakh tones with the productivity of about 1142 kg/ha.

The area cultivated under chickpea in Uttar Pradesh is about 6.21 lakh ha, while the production of chickpea in U.P Is about 8.51 lakh tones, with the productivity about 1371 kg/ha (SOURCE: Directorate of Economics and Statistics, Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture and farmers Welfare, GOI, 2019-20).

Chickpea contains 17.7 to 38.5 per cent protein and 56.5 per cent carbohydrates besides ash, calcium, phosphorous and iron. Chickpea has got special importance in diet and is consumed in a variety of ways. It is mostly used in the form of dal (flour or parched). Chickpeas a good source of carbohydrates and proteins, which together constitutes about 80% of the total dry seed mass. The starch content of

chickpea cultivars have been reported to vary from 41 % to 50%. The crude protein content of chickpea where is from 12.4 to 31.5 percent. Chickpea contains about 6% fat which is important in vegetarian diets of resource for consumers. The protein quality is considered to be better than other pulses (Hirdyani, 2014).

Chickpea is the World's third most important winter season food legume is valued for its nutritive seeds with high protein content, (25.3-28.9%) after de-hulling. There are major types of chickpea e.g. Desi and Kabuli. Desi chickpea is consumed as whole seeds, de-hulled splits or flour while, Kabuli chickpea is generally consumed as whole grains whereas, gulabi types are roasted and consumed as parched grains. Chickpea has been recognized as a rich source of protein, vitamins and minerals in human diet and occupies a very important place in human nutrition in many developing countries. Increasing population growth has resulted in a sharp decline in the per capita availability of pulses in the recent years. Population explosion during the latter part of 20th century and early 21st century has created short fall in food grain availability and related mal-nutritional problems amongst the economically weaker sections. Globally there has not been any change in area under cultivation during the past four decades. Information on the nature and degree of genetic variability present in morphological, phenological, quality and traits associated to stresses of chickpea is an essential prerequisite of plant breeding.

To improve the production potential of this crop breeding programme should be aimed at development of high yielding varieties by combining genes from diverse sources. This helps the plant breeder in designing an ideotype and in isolation of superior genotypes from early segregating populations leading to success in crop improvement for various ecological conditions.

Variance plays an important role in crop breeding. The magnitude of variants present in crop species is importance as it provides the basic for selection. The total variation present in a population arises due to genotyping and environmental effects full stop presence of genetic variance in the breeding materials is essential for a successful plant breeding program.

The estimates of genotyping coefficient of variance (GCV) reflect the total amount of genetic variability present in the material. However the proportions of the genotyping variability which is transmitted from parents to the progeny is reflected by heritability. Broad sense heritability determines the efficiency with which genotypic variability in a breeding program. The genotypic variance and its components are influenced by the gene frequencies.

The presence of genetic variability is of utmost importance for any breeding program and due to this reason the plant breeders have emphasized the evaluation of germplasm for the improvement of crop yield as well as for utilization in further breeding programs. Evaluation of plant genetic resources is a prerequisite for which the future breeding work is based (Reddy *et al.*, 2012). In addition to genetic variation, heritability of economically important characters is essential for effective breeding programs and selection of specific traits. Heritability estimates the genetic advance in a population provides information about the expected gain in the following generations.

Metroglyph analysis and index score is semi graphic technique often used as useful trials to assess genetic variability. Divergence analysis by means of Mahalanobis's D² statistics is a powerful tool in qualifying the degree of divergence between two populations. It gives better idea about the magnitude of divergence and is independent of size of sample and provides the basis for selection of parental lines for further reading program full stop the role of Genetic diversity and its significance have been recognized for selection of desirable parents in breeding

programs to obtain transgressive segregation and high heterotic response.

Materials and Methods

The experimental materials comprised of thirty five Chickpea germplasm including check were sown on 15th November, 2019 at department of Genetics and Plant Breeding, SHUATS, Prayagraj. The experiment was laid in Randomized Complete Block Design (RBD) with three replications. inter row spacing was kept 30cm and plant to plant spacing was 10cm. the recommended crop practices were followed for raise a healthy crop. Data for 13 quantitative traits were recorded viz., Days to 50% flowering, Days to 50% pods setting, Plant height (cm), Number of primary branches per plant, Number of secondary branches per plant, Number of days to maturity, Number of seeds per plant, Number of pods per plant, Number of seeds per pod, Biological yield per plant (g), 100-Seed weight (g), Harvest index(%), Seed yield per plant(g).

Biometrical analysis were followed to estimate Analysis of variance (ANOVA) Fisher and Yates (1936), Genotypic and Phenotypic Co-efficient of Variation (Burton and De vane, 1952), heritability in broad sense (Lush, 1940), genetic advance (Johnson *et al.*, 1955) Metroglyph and index score analysis (Anderson 1957) and D² analysis (Mahalanobis 1928).

Whereas, for characters such as days to 50% flowering and days to maturity data was recorded on plot basis. Data was subjected to the analysis of variance followed by Anderson's Metroglyph technique to study the patterns of morphological variations in different genotypes. Thirty five genotypes were represented. Two most variable characters, harvest index and number of seeds per plant were selected for X and Y axis, respectively. Except these traits, other traits were represented as rays on the glyph, where each glyph represented a genotype, thus, forming a scatter diagram. Tocher's method was used to produce percent contribution of each trait towards genetic diversity.

Results and Discussion

The analysis of variance revealed significant differences among the genotypes for all the characters under study (Table 1). Thus, it indicated considerable amount of genetic variability among thirty five Chickpea germplasm.

Estimation of Genetic Parameters

Heritability, Genotypic Co-efficient of variation (GCV), Phenotypic Co-efficient of variation (PCV), Genetic Advance (GA), Genetic Advance as percentage of mean GA(%) for all the yield contributing traits are shown in Table 2. PCV was higher than the corresponding GCV for all the characters indicating that there was an influence of the environment.

According to Deshmukh *et al.* (1986) PCV and GCV values greater than 20% are regarded as high, whereas values less than 10% are considered to be low and values between 10% and 20% to be moderate. High PCV and GCV is recorded for Seed yield per plant (37.679 and 35.904), Harvest index (32.72 and 30.626) Biological yield (28.365 and 26.147) No. of pods per plant (27.28 and 25.439). Where, as moderate PCV and GCV were recorded Number of seeds per pod (18.671 and 16.623), Number of secondary branches (19.911 and 18.439), Hundred seed weight (20.158 and 16.897) Number of primary branches (20.954 and 19.998) and No. of seeds per plant (22.797 and 20.803) where as the lowest PCV and GCV were observed for Plant height (13.53 and 7.59), Days to 50% flowering (6.236 and 4.977), Days to 50% pod setting (5.237 and 3.442) and Days to maturity (2.427 and 1.647). The high estimates of GCV

and PCV for these traits suggested the possibility of yield improvement through selection of these characters.

High GCV for Seed yield per plant (35.904), Harvest index (30.626), Biological yield (26.147) and Number of pods per plant (25.439).

The estimates of genotypic coefficient of variation reflect the total amount of genotypic variability, the proportion of this genotypic variability, which transmitted from parents to the progeny, is reflected through heritability. The traits studied performed high heritability ranging from (63.7% to 91.1%). Among the traits studied the highest heritability was recorded by Number of primary branches (91.1%), Seed yield per plant (90.8%), Harvest index (87.6%), Number of pods per plant (87%), Number of secondary branches (85.8%), Biological yield (85%), Number of seeds per pod (79.3%) and Days to 50% flowering (63.7%). The traits studied performed moderate heritability ranging from (31.5% to 46.1%). Among the traits studied the moderate heritability was recorded by Plant height (31.5%), days to 50% pod setting (41.8%) and Days to maturity (46.1%) (Table 2). The genetic advance as percent of mean was higher for Seed yield per plant (70.477), Harvest index (59.051), Biological yield (49.651), Number of pods per plant (48.87), Number of primary branches (39.317), Number of seeds per plant (39.105), Number of secondary branches (35.176) and Number of seeds per pod (30.487). In present study high heritability coupled with genetic advance as percent of mean recorded for number of primary branches, seed yield per plant, Harvest index, Number of pods per plant, number of secondary branches, Biological yield, Number of seeds per plant, number of seeds per pod. So direct selection of these characters based on phenotypic expression by simple selection method would be effective due to accumulation of more additive genes leading to further improvement.

Metroglyph Analysis

The analysis of variance indicated significant variation among the 35 genotypes for thirteen characters. The scatter diagram revealed that five complexes could be distinguished on the basis of morphological variation (Table 3 and Fig.2). Table 4 represents the index scores and signs used for thirteen characters for Metroglyph analysis. Complex I was characterized by low harvest index with low number of seeds. This group comprised 11 lines. The check PUSA-362 is included in this complex. The Complex II was containing 11 lines and characterized by high harvest index with moderate number of seeds. Complex III which comprised of 6 lines and characterized by high harvest index with high number of seeds. Complex IV which comprised of 4 lines and was characterized by Low harvest index with low number of seeds. Complex V which comprised of 3 lines and was characterized by moderate harvest index with moderate number of seeds.

The total index score was varied from 21 to with a mean of 25.5. It indicates that germplasm lines were having variations. In the present investigation, it is interesting to note that high seed yielding genotypes were found with highest index score. Among the 35 germplasm lines, the genotypes, ICC-4968, IPC-97-29, ILC-3279, Phule-4-5, IC-244263, NBEG-3, RVG-202 were observed as high yielder and identified for higher index score.

Genetic Diversity

The cluster formation was done following Tocher's method as described by Rao (1952). The clustering pattern obtained on the basis of magnitude of D^2 values studies are presented in Table 11 and Fig. 4. The 35 chickpea germplasm lines were grouped into five clusters which revealed that the genotypes varied significantly for all the characters studied indicating considerable variability in the germplasm. The cluster I have 31 genotypes followed by cluster II (1), cluster III (1), cluster IV (1) and cluster V (1). The average inter-cluster and intra-cluster D^2 values are presented in Table 12. The maximum inter cluster distance (D^2) was observed between the cluster IV and V (141.7) followed by cluster III and V (134.68), cluster II and V (123.18). The lowest distance was observed between cluster IV and I (45.52). The intra cluster distance ranged from 0.00 to 36.66. The maximum intra cluster distance was recorded in cluster I (36.66) whereas, all remaining clusters have 0.00 distance. The cluster I showed maximum inter cluster distance with cluster V (122.57) followed by cluster II (56.470). It has minimum inter cluster distance with cluster I (36.66). Cluster II recorded maximum inter cluster distance from cluster V (123.18), followed by cluster III (93.67). The minimum inter cluster distance was recorded between cluster IV (71.59).

Greater the divergence between the two clusters, wider is the genetic diversity in the genotypes. The crosses involving the parents with extreme divergence have also been reported to exhibit decrease in heterosis. Therefore, while selecting the parents by considering the genetic diversity, their performance and cluster mean for the characters also need due consideration in the crop improvement programme. In the present investigation, the cluster means for the thirteen characters studied are presented in Table 7.

The cluster mean for days to 50 per cent flowering varied from 85.33 (III) – 90.00(IV). The cluster mean for days to 50 per cent pod setting varied from 98.00(V)-107.00(II). The cluster means for days to maturity ranged between 148.33(V)-156.33(II). The highest cluster mean for plant height was 80.00 cm, which was observed in cluster (III) and lowest for cluster II (65.33). The cluster mean for the number of primary branches per plant ranged from 2.60 (cluster IV) to 1.33 (cluster II). The cluster mean for secondary branches per plant ranged between 4.40 (cluster III) and 10.27 (cluster IV).

The cluster mean for number of pods per plant was maximum in cluster II (107.60) and it was minimum in cluster III (50.13). The cluster mean for number of seed per pod was maximum in cluster III (1.73) and it was minimum in cluster IV (1.33). The cluster mean for number of seeds per plant was minimum in cluster III (85.93) and it was maximum in cluster II (161.73). The cluster mean for hundred seed weight was maximum in cluster IV (21.33) and minimum in case of cluster V (16.00). The cluster mean for biological yield was maximum in cluster IV (76.40) and minimum in case of cluster III (26.80). The cluster mean for harvest index was maximum in cluster V (108.85) and minimum in case of cluster IV (24.56). The cluster mean for seed yield per plant was maximum in cluster V (56.26) and minimum in case of cluster III (17.53).

Table 1: Analysis of variance (ANOVA) among 35 chickpea genotypes for 13 quantitative traits

| S. No | Features | Mean Sum of Squares | | |
|-------|-------------------------|------------------------|----------------------|-----------------|
| | | Replications (d. f=02) | Treatments (d. f=34) | Error (d. f=68) |
| 1 | Days to 50% flowering | 2.086 | 66.922** | 10.684 |
| 2 | Days to 50% pod setting | 13.552 | 56.29** | 17.866 |
| 3 | Days to maturity | 13.295 | 26.439** | 7.423 |
| 4 | Plant height | 12.756 | 149.218** | 62.759 |

| | | | | |
|----|---------------------------|---------|------------|--------|
| 5 | No. of primary branches | 0.066 | 0.427** | 0.014 |
| 6 | No. of secondary branches | 1.388 | 5.352** | 0.281 |
| 7 | No. of pods per plant | 45.526 | 1217.214** | 57.934 |
| 8 | No. of seeds per pod | 0.088 | 0.221** | 0.018 |
| 9 | No. of seeds per plant | 486.248 | 1570.867** | 98.616 |
| 10 | Biological yield | 153.773 | 559.949** | 31.176 |
| 11 | Hundred seed weight | 4.919 | 42.399** | 5.242 |
| 12 | Harvest index | 459.136 | 564.049** | 25.399 |
| 13 | Seed yield per plant | 29.992 | 185.859** | 6.072 |

Table 2: Estimation of genetic parameters performed by 35 genotypes for 13 quantitative characters of Chickpea

| Characters | GCV | PCV | Heritability (%) (Broad sense) | GA | GA as % mean |
|---------------------------|--------|--------|--------------------------------|--------|--------------|
| Days to 50% flowering | 4.977 | 6.236 | 63.7 | 7.118 | 8.182 |
| Days to 50% pod setting | 3.442 | 5.237 | 41.8 | 4.764 | 4.582 |
| Days to maturity | 1.647 | 2.427 | 46.1 | 3.52 | 2.303 |
| Plant height | 7.59 | 13.53 | 31.5 | 6.204 | 8.774 |
| No. of primary branches | 19.998 | 20.954 | 91.1 | 0.73 | 39.317 |
| No. of secondary branches | 18.439 | 19.911 | 85.8 | 2.48 | 35.176 |
| No. of pods per plant | 25.439 | 27.28 | 87 | 37.763 | 48.87 |
| No. of seeds per pod | 16.623 | 18.671 | 79.3 | 0.477 | 30.487 |
| No. of seeds per plant | 20.803 | 22.797 | 83.3 | 41.642 | 39.105 |
| Biological yield | 26.147 | 28.365 | 85 | 25.21 | 49.651 |
| Hundred seed weight | 16.897 | 20.158 | 70.3 | 6.077 | 29.177 |
| Harvest index | 30.626 | 32.72 | 87.6 | 25.836 | 59.051 |
| Seed yield per plant | 35.904 | 37.679 | 90.8 | 15.196 | 70.477 |

Table 3: 35 genotypes into different complexes in scattered diagram

| Complex | Name of complex | No. of lines | Name of lines | Range and average score |
|---------|--|--------------|--|-------------------------|
| I | Low Harvest index with low number of seeds | 11 | IPC-04-52, ICCV-16317, JG-24, BGD-72, IPC-05-66, IPC-11-09, NBEG-1121, PUSA-362, RVS-5949, IPC-3070, IPC-94-94 | 21-28 (24.63) |
| II | High harvest index with moderate Number of seeds | 11 | RSG-963, JG-130, BG-212, IPC-08-103, Phule-4-5, NBEG-3, ICC-4958, KPG-59, IPC-05-59, Anethyst, IPCK-15614 | 21-28 (25.18) |
| III | High harvest index with high Number of seeds | 6 | ILC-0, ICC-4968, JGM-7, IC-244263, RVG-202, IPC-04-01 | 24-29 (26.83) |
| IV | Low harvest index with high number of seeds | 4 | ILC-3279, ICC-10768, IPC-2000-33, IPC-97-29 | 27-30 (28.5) |
| V | Moderate harvest index with moderate number of seeds | 3 | IPC-1185, IPCK-97-67, JG-31416 | 28-29 (28.33) |

Table 4: The range variability and class intervals of various characters

| Character | Range of Mean | Score 1 | Sign | Score 2 | Sign | Score 3 | Sign |
|--|-----------------|---------|------|-----------------|------|---------|------|
| | | Value < | | Value from - to | | Value > | |
| Days to 50% flowering | 72.33 - 98.00 | 82.28 | ○ | 82.28 - 91.72 | ○ | 91.72 | ○ |
| Days to 50% pod setting | 96.00 - 113.00 | 99.63 | ○ | 99.63 - 108.29 | ○ | 108.29 | ○ |
| Days to maturity | 146.00 - 158.00 | 149.87 | ○ | 149.87 - 155.81 | ○ | 155.81 | ○ |
| Plant height (cm) | 54.60 - 89.47 | 63.68 | ○ | 63.68 - 77.78 | ○ | 77.78 | ○ |
| Number of primary branches per plant | 1.20 - 2.60 | 1.48 | ○ | 1.48 - 2.23 | ○ | 2.23 | ○ |
| Number of secondary branches per plant | 4.40 - 10.27 | 5.72 | ○ | 5.72 - 8.39 | ○ | 8.39 | ○ |
| Number of pods per plant | 40.00 - 108.00 | 57.13 | ○ | 57.13 - 97.42 | ○ | 97.42 | ○ |
| Number of seeds per pod | 1.07 - 2.00 | 1.29 | ○ | 1.29 - 1.84 | ○ | 1.84 | ○ |
| Number of seeds per plant | 63.27 - 161.73 | 83.61 | ○ | 83.61 - 129.37 | ○ | 129.37 | ○ |
| 100 seed weight (g) | 13.00 - 29.33 | 17.07 | ○ | 17.07 - 24.59 | ○ | 24.59 | ○ |
| Biological yield per plant (g) | 23.87 - 76.40 | 37.11 | ○ | 37.11 - 64.44 | ○ | 64.44 | ○ |
| Harvest index (%) | 24.56 - 108.85 | 30.04 | ○ | 30.04 - 57.46 | ○ | 57.46 | ○ |
| Seed yield per plant (g) | 11.14 - 56.26 | 13.69 | ○ | 13.69 - 29.43 | ○ | 29.43 | ○ |

Table 5: Grouping of 35 chickpea genotypes into 5 clusters by Torcher’s method

| Clusters | No. of genotypes | Genotypes |
|----------|------------------|---|
| I | 31 | ICC-4958, IPC-97-29, JGM-7, JG-31416, IPCK-97-67, ICC-10768, IPC-04-52, ICCV-16317, IPC-05-59, ILC-3279, IPC-1185, KPG-59, IPC-08-103, IPC-2000-33, NBEG-3, IPC-05-66, RVS-5949, IPC-11-09, IPC-3070, IPCK-15614, IPC-04-01, RVG-202, IC-244263, JG-130, RSG-963, BG-212, Phule-4-5, NBEG-1121, JG-24, IPC-94-94, PUSA-362, |
| II | 1 | ILC-0 |
| III | 1 | Anethyst |
| IV | 1 | BGD-72, |
| V | 1 | ICC-4968 |

Table 6: Intra and inter cluster distances in chickpea

| Cluster Means | | | | | | | | | | | | | |
|---------------|-------|--------|--------|---------|------|-------|--------|-------|--------|---------|--------|--------|---------|
| Clusters | DF50 | DP50 | DM | PH (cm) | NPB | NSB | NPP | NSPod | NSP | HSW (g) | BY (g) | HI (%) | SYP (g) |
| 1 Cluster | 86.90 | 103.91 | 152.81 | 70.75 | 1.87 | 6.97 | 76.00 | 1.57 | 104.21 | 21.06 | 50.71 | 41.55 | 20.65 |
| 2 Cluster | 89.67 | 107.00 | 156.33 | 65.33 | 1.33 | 8.40 | 107.60 | 1.53 | 161.73 | 18.00 | 50.40 | 44.22 | 22.00 |
| 3 Cluster | 85.33 | 106.33 | 153.33 | 80.00 | 1.47 | 4.40 | 50.13 | 1.73 | 85.93 | 20.67 | 26.80 | 65.54 | 17.53 |
| 4 Cluster | 90.00 | 106.00 | 154.33 | 68.07 | 2.60 | 10.27 | 91.20 | 1.33 | 109.67 | 21.33 | 76.40 | 24.56 | 18.67 |
| 5 Cluster | 86.00 | 98.00 | 148.33 | 69.00 | 1.53 | 7.60 | 99.67 | 1.67 | 139.40 | 16.00 | 51.53 | 108.85 | 56.26 |

DF50-Days to 50% flowering, DP50- Days to 50% pod setting, DM- Days to maturity, PH-Plant height, NPB- Number of primary branches, NSB-Number of secondary branches, NPP-Number of pods per plant, NSPod- Number

of seeds per pod, NSP- Number of seeds per plant, HSW- Hundred seed weight, BY- Biological yield, HI- Harvest index, SYP- Seed yield per plant

Table 7: Cluster mean value for 13 characters in chickpea genotypes

| Cluster Distances | | | | | |
|-------------------|-----------|-----------|-----------|-----------|-----------|
| | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | Cluster 5 |
| Cluster 1 | 36.660 | 56.470 | 56.040 | 45.520 | 122.570 |
| Cluster 2 | | 0.000 | 93.670 | 71.590 | 123.180 |
| Cluster 3 | | | 0.000 | 92.620 | 134.680 |
| Cluster 4 | | | | 0.000 | 141.700 |
| Cluster 5 | | | | | 0.000 |

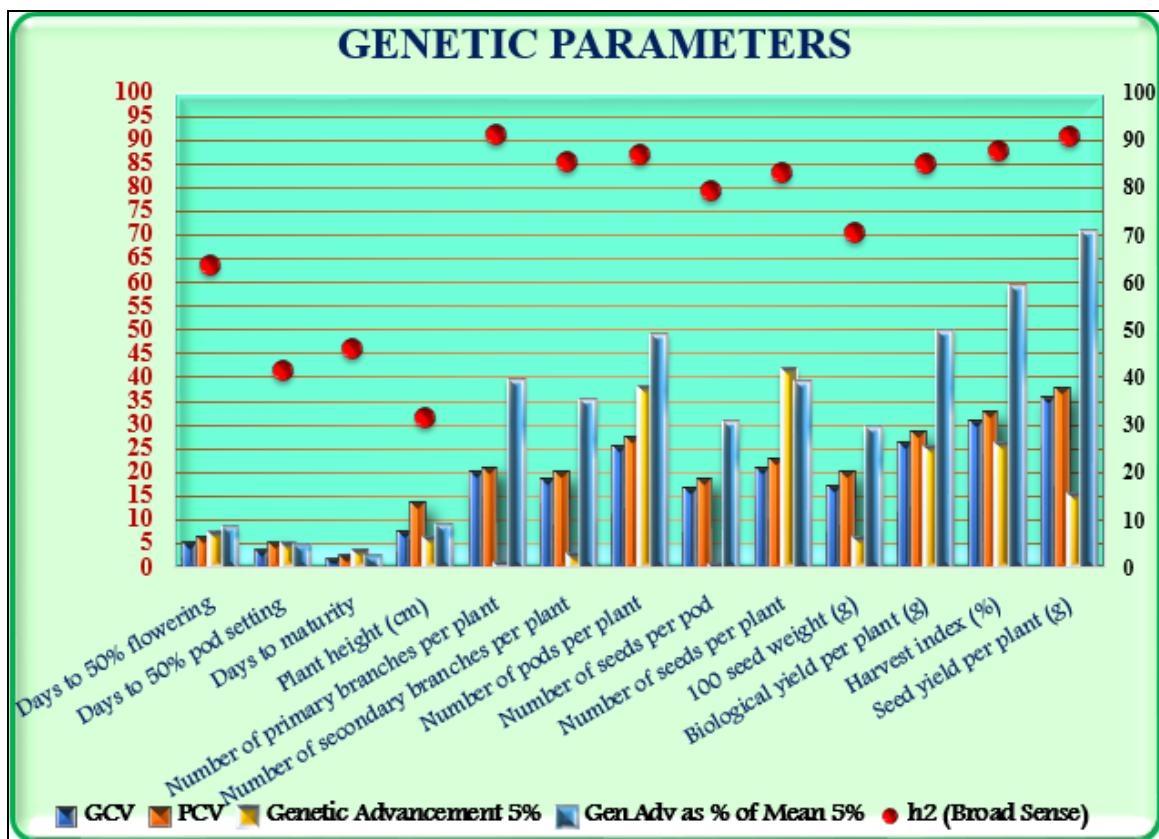


Fig 1: Histogram representation of relationship among the GCV, PCV, Heritability, Genetic advance, Genetic Advance as percent of mean

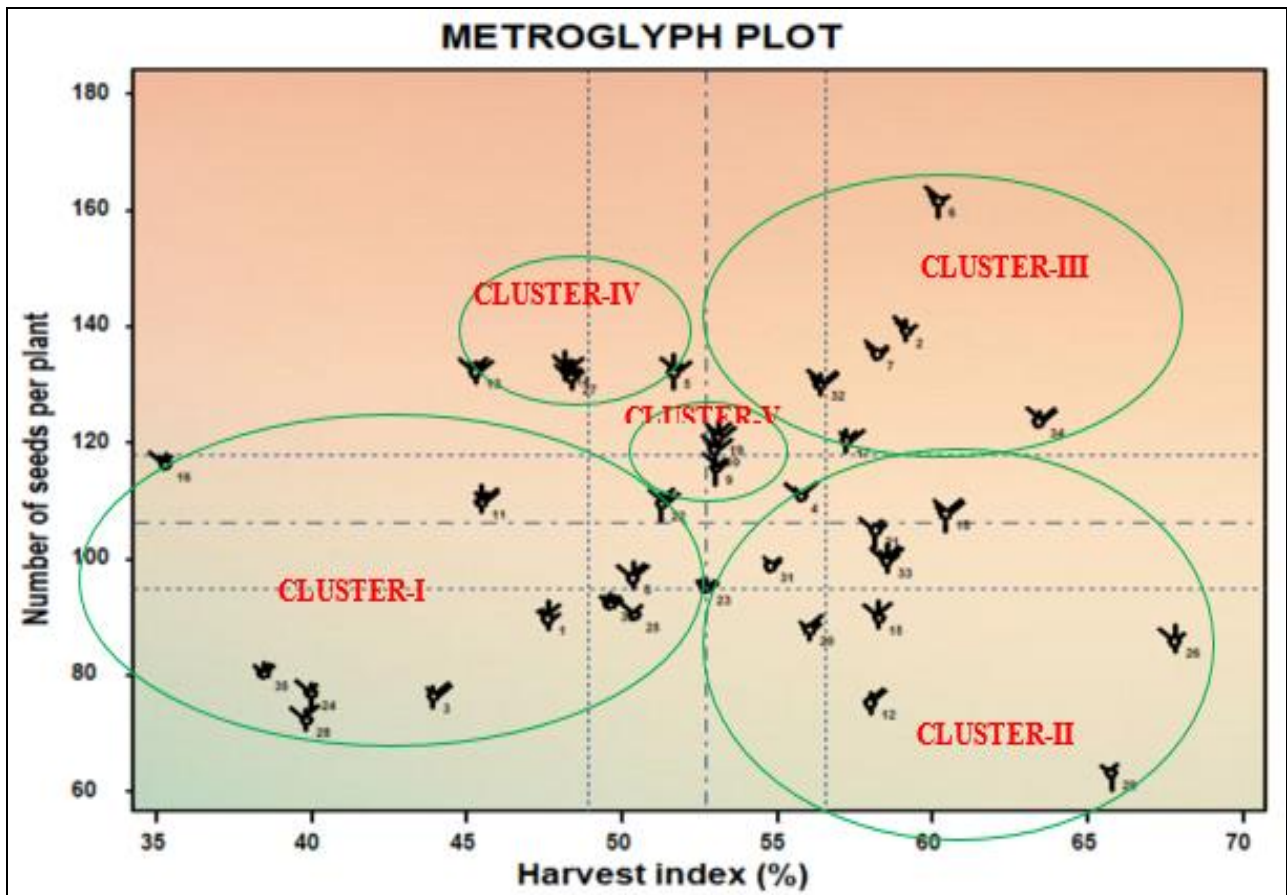


Fig 2: Scattered diagram of Metroglyph

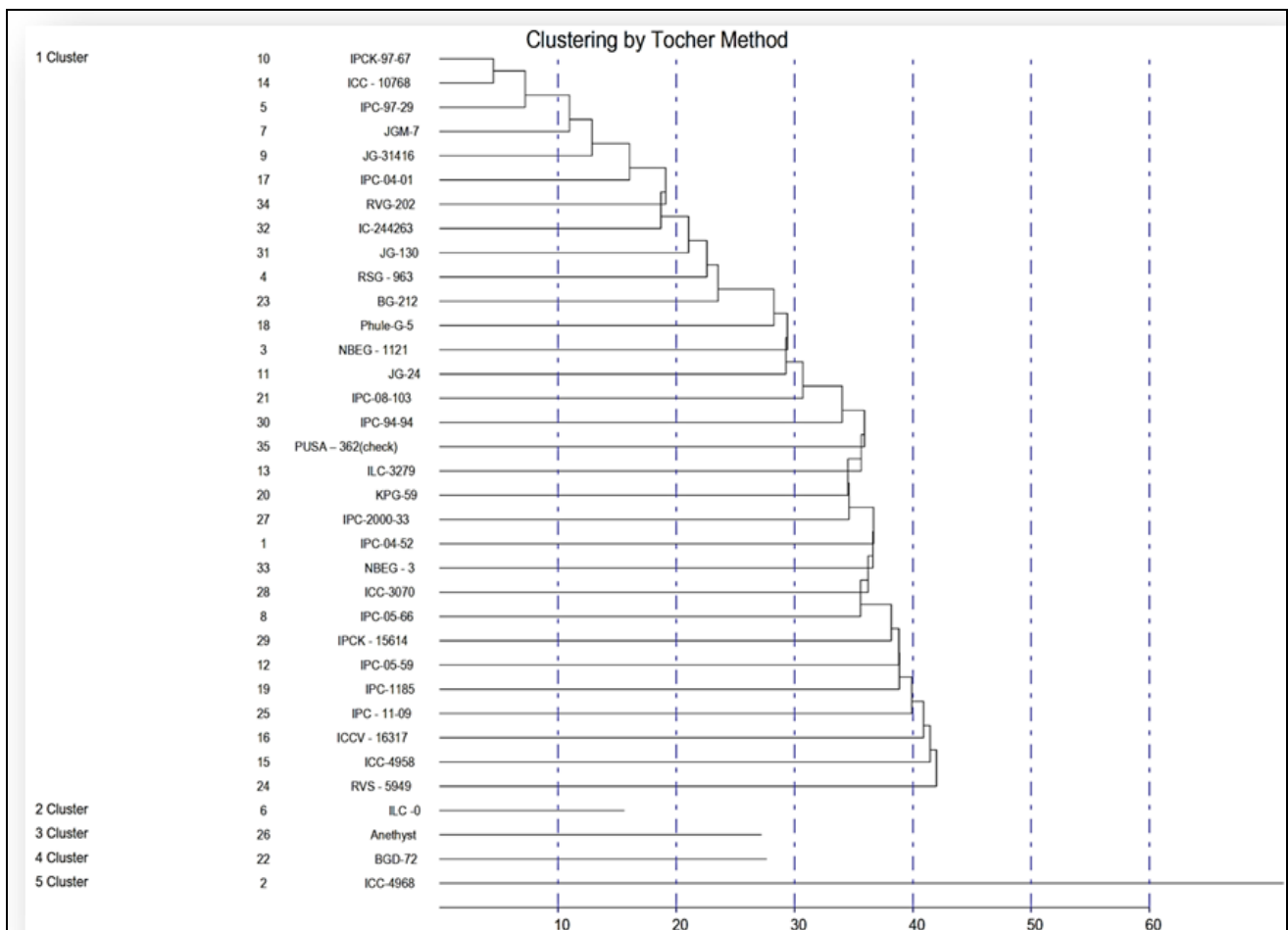


Fig 3: Clustering by Torcher's method

Conclusion

PCV, GCV, Heritability and Genetic Advance recorded highest for Seed yield per plant which implies effective selection in this studied population. On the basis of metroglyph analysis, the germplasm lines formed five complexes. From those complexes, the germplasm lines, IPC-97-29, ILC-0, ILC-3279, IPC-11-85, IC-244263 recorded highest index score and fell into different cluster, hence used as parents for getting good combinations. On the basis of D2 statistics, the germplasm lines, BGD-72, ICC-4968 were fell into two groups and having maximum inter cluster distance, hence consider as diverse parents for getting good combinations with maximum diversity. Group constellation between metroglyph and D2 statistics showed that there were no similarities for clustering pattern.

Aknowledgement

We are thankful to Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj for providing experimental material.

References

- Anderson E. A semigraphical method for the analysis of complex problems. Proc. National Academy of Sciences, Washington, USA, 1957:43:923-927.
- Astereki H, Pouresmael M, Sharifi P, Rasht I. Genetic variability of yield, and yield components in chickpea (*Cicer arietinum* L.). Thai Journal of Agricultural Science, 2015:48(3):115-124.
- Avinalappa H, Raghunath S. Analysis of genetic variability parameters for seed yield and its attributing traits of desi chickpea (*Cicer arietinum* L.) under different environments in West Bengal. Journal of Agri research, 2018:5(2):105-109.
- Arora RN, Kumar K. Genetic variability studies for yield contributing traits in Kabuli chickpea (*Cicer arietinum* L.). Journal of Pharmacognosy and Phytochemistry, 2018:7(2):2675-2677.
- Babbar A, Prakash V, Tiwari P, Iquebal MA. Genetic variability for chickpea (*Cicer arietinum* L.) under late sown season. *Legume Res*, 2012:35(1):1-7.
- Babbar A, Pandey S, Singh R. Genetic studies on chickpea genotypes grown in late sown under rice fall conditions of Madhya Pradesh. Electronic Journal of Plant Breed, 2015:6(3):738-748.
- Babbar A, Pandey S, Singh R. Research Article Genetic studies on chickpea genotypes grown in late sown under rice fallow conditions of Madhya Pradesh. Electronic Journal of Plant Breeding, 2015:6(3):738-748.
- Barad SH, Javia RM, Solanki HV, Panera A. Estimation of genetic variability for Kabuli chickpea (*Cicer arietinum* L.) under timely and late sowing condition. Journal of Pharmacognosy and Phytochemistry, 2018:7(4):421-423.
- Chandra R, Desai AR, Govind S, Gupta PN. Metroglyph analysis in turmeric (*Curcuma longa* L.) germplasm in India. *Scientia Horticulturae*, 1997:70:211-222.
- Datta D, Mukherjee BK, Barua NS, Das SP. Metroglyph analysis of maize (*Zea mays* L.) inbreds for preliminary classification and group constellation. African. Journal of Agriculture Research, 2013:8(45):5659-5663.
- Desai K, Tank CJ, Gami RA, Patel AM, Chauhan RM. Genetic variability in indigenous collection of chickpea (*Cicer arietinum* L.) genotypes for seed yield and quality traits. Journal Programme Agri, 2015:6(1):10-13.
- Dev A, Verma P, Kumhar BL. Genetic Character Variability Studies in Desi Chickpea (*Cicer arietinum* L.) Genotypes. International Journal Curr. Microbiol. App. Sci, 2017:6(4):20-25.
- Gaikwad AR, Desai NC, Pawar GH, Langhi AM. Genetic divergence in chickpea. International Journal Agril. Sci, 2014:10(2):812-815.
- Giridhar K, Surya Kumari S, Naram Naidu L. Pattern of Morphological Variation and group ordination in Coriander (*Coriandrum sativum* L.). J Res ANGRAU, 2014:42(3-4):117-122.
- Gediya LN, Patel DA, Kumar S, Kumar D, Parmar DJ, Patel SS *et al*. Phenotypic variability, path analysis and molecular diversity analysis in chickpea (*Cicer arietinum* L.). *Vegetos*, 2019, 1-14.
- Hasan MT, Deb AC. Assessment of genetic variability, heritability, character association and selection indexes in chickpea (*Cicer arietinum* L.). International Journal Biosciences, 2017:10(2):111-129.
- Jadhav RS, Mohrir MN, Ghodke MK. Genetic Divergence studies in Chickpea (*Cicer arietinum* L.). *Bioinfolet*, 2011:8(1):38-43.
- Jakhar DS, Singh R, Kamble MS. Genetic diversity studies in chickpea (*Cicer arietinum* L.) in Kolhapur region of Maharashtra. Bangladesh J Bot, 2016:45(3):459-464.
- Jivani JV, Mehta DR, Pithia MS, Madariya RB, Mandavia CK. Variability Analysis and Multivariate Analysis in Chickpea (*Cicer arietinum* L.). Electronic Journal of Plant Breeding, 2013:4(4):1284-1291.
- Jha UC, Basu PS, Singh DK. Genetic variation and diversity analysis of chickpea genotypes based on quantitative traits under high temperature stress. International Journal Bioresources Stress Management, 2015:6:700-706.
- Joshi P, Yasin M, Sundaram P. Genetic Variability, Heritability and Genetic Advance Study for Seed Yield and Yield Component Traits in a Chickpea Recombinant Inbred Line (RIL) Population. International Journal Pure Application Biosciences, 2018:6(2):136-141.
- Khan FA, Younas M, Mustafa G. Metroglyph Analysis for the Yield and Quality Related Characters of (*Brassica juncea* L.) International. Journal of Agric. & Biology, 2005:07(2):260-262.
- Kuldeep R, Pandey S, Babbar A, Prakash V. Genetic diversity analysis in Chickpea grown under heat stress conditions of Madhya Pradesh. Elec J of Plant Breed, 2015:6(4):962-971.
- Kuldeep R, Pandey S, Babbar A, Mishra DK. Research Note Genetic variability, character association and path coefficient analysis in chickpea grown under heat stress conditions. Electronic Journal of Plant Breeding, 2014:5(4):812-819.
- Kumar A, Nath S, Yadav AK, Kumar B, Kumar A, Yadav PK *et al*. Estimation of Genetic variability in

- chickpea (*Cicer arietinum* L.) germplasm. Research Environment Life Science,2016:9:362-364.
26. Kumar A, Kumar A, Yadav AK, Nath S, Kumar JK. Correlation and path coefficient analysis for various quantitative traits in chickpea (*Cicer arietinum* L.). *SP1*, 2018, 2695-2699.
 27. Kishor L, Swarup I, Nehra A, Kirar G, Jeeterwal RC. Genetic Variability, Heritability and Genetic Advance Analysis in Chickpea (*Cicer arietinum* L.), International Journal Pure Application Biosciences,2018:6(4):141-144.
 28. Laiju N, Islam MJ, Hasanuzzaman M, Mandol MAS, Kabir G. Metroglyph Analysis in Two Species of *Hordeum*. Pakistan J of Bio Sci,2002:5(11):1217-1219.
 29. Mohammed A, Tesso B, Ojiewo C, Ahmed S. Assessment of Genetic Variability and Heritability of Agronomic Traits in Ethiopian Chickpea (*Cicer arietinum* L.) Landraces. Black Sea Journal of Agriculture,2019:2(1):10-15.
 30. Nimbalkar RD, Katre YY, Phad DS. Genetic diversity in Chickpea (*Cicer arietinum* L.). *Bioinfolet*,2017:14(1):60-63.
 31. Olayiwola MO, Dabo OA, Ariyo OJ. Assessment of morphological variation among Okra [*Abelmoschus esculentus* L. (moench)] accessions to aid selection of ideal parents. Elec J of Plant Breed,2015:6(3):663-667.
 32. Punitha D, Ganesamurthy K, Rajarathinam S. Metroglyph analysis of morphological variations in Sorghum germplasm. Electronic J of Plant Breed,2010:1(4):536-541.
 33. Pandey A, Gupta S, Kumar A, Thongbam PD, Pattanayak A. Genetic divergence, path coefficient and cluster analysis of chickpea (*Cicer arietinum* L.) cultivars, in the mid-altitudes of Meghalaya. Indian J. Agril. Sci,2013:83(12):1300-1304.
 34. Parhe SD, Harer PN, Nagawade DN. Investigation of genetic divergence in chickpea (*Cicer arietinum* L.) genotypes. *The Bioscan*,2014:9(2):879-882.
 35. Peerzada OH, Chaurasia AK, Anzer UI. Evaluation of Chickpea Germplasm (*Cicer kabulium* L.) for Yield and Yield Attributing Traits. Annuals of Biology,2015:31(1):64-67.
 36. Rashid M, Cheema AA, Ashraf M. Clustering of Basmati Rice Mutants by Metroglyph Analysis. Pak J Bot,2007:39(6):2043-2049.
 37. Reddy AT, Gowda J, Jayalakshmi V, Ahammed K, Kamakshi N, Vijayabharathi A *et al.* Variability Studies for Morphological Traits in the F2 Population of chickpea (*Cicer arietinum* L.). Trends in Biosciences,2017:10(48):9583-9586.
 38. Singh RP, Singh I, Singh S, Sandhu JS. Assessment of genetic diversity among interspecific derivatives in chickpea. J of Food Legumes,2012:25(2):150-152.
 39. Shaikh JA, Bagade AB, Kalpande HV, More AW. Metroglyph analysis of Sorghum germplasms. *Bioinfolet*,2017:14(1):88-92.
 40. Sreelakshmi C, Shivani D, Kumar CS. Genetic divergence, variability and character association studies in bengalgram (*Cicer arietinum* L.). Electronic Journal of Plant Breeding,2010:1(5):1339-1343.
 41. Singh V, Singh P, Kumar A, Nath S. Estimation of genetic variability parameters in chickpea (*Cicer arietinum* L.) germplasm. Journal of Pharmacognosy and Phytochemistry,2018:7(2):1204-1206.