# GENETIC DIVERGENCE OF SOME COWPEA CULTIVARS

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## ABSTRACT

**Genetic divergence is an important consideration in the choice of parents used for hybridisation in cowpea (*Vigna unguiculata* L. Walp.) improvement. An experiment was conducted at the Regional Agricultural Research Centre, Maha Illuppallama with the objective of grouping 81 varieties of cowpea according to genetic distance using the Mahalanobis' $D^2$ statistic. Characters considered in this study were days to flowering, days to maturity, plant height, pod length and seed yield. It was found that the pod length contributed the most while the days to maturity contributed the least to divergence among cultivars. The varieties studied grouped into 14 clusters. Cultivars adapted to similar geographic regions did not appear to cluster together. Locally adapted varieties were placed in different clusters indicating that they may combine favourably with other adapted cultivars. Good correspondence between inter-cultivar and inter-cluster distances indicated that it is possible to select genetically diverse parents on the basis of inter-cluster distance alone.**

**KEY WORDS**: Cowpea, Genetic divergence, Multivariate analysis, Mahalanobis' $D^2$, Hybridisation

## INTRODUCTION

Hybridisation of inbred varieties followed by selection of desirable recombinants in the subsequent segregating generations has been a major method adopted in the improvement of cowpea (*Vigna unguiculata* L. Walp.) in Sri Lanka. The success of a breeding programme employing hybridisation and selection relies largely on the prudent selection of parents. The perils of choosing parents based on yielding ability alone are well known to plant breeders (Sharma, 1989). Hence, the importance of genetic diversity between breeding materials needs no emphasis. Conventionally, the parents are chosen so that they complement each other for traits of agronomic importance. It has been shown that the selection of parents based upon a multivariate analysis or eco-geographic diversity is more effective than the selection of parents at random or by the conventional method (Bhatt, 1973). The $D^2$ statistic is a multivariate measure of genetic diversity that can be used satisfactorily to classify potential parents (Mahalanobis, 1928; Bhatt, 1970).

The objective of this study is to group a collection of cowpea cultivars at Regional Agricultural Research Centre (RARC), Maha Illuppallama using information obtained from Mahalanobis $D^2$ analysis so that divergent genotypes would be utilized in hybridization.

## MATERIALS AND METHODS

Eighty one cultivars of cowpea from the germplasm collection of the RARC, Maha Illuppallama were included in this study. Among these were 40 cultivars received from International Institute of Tropical Agriculture, Nigeria and 18 received from Pakistan. Majority of the rest were genotypes found as off types or selections made from various varieties at Maha Illuppallama. The experiment was conducted at the RARC, Maha Illuppallama during the 1988 Yala season using a Randomised Complete Block Design with two replications. Each experimental plot consisted of two 2.1 m rows of cowpea spaced 30 cm apart and the distance between plants was 15 cm. The plots were irrigated five times during the experiment and managed in accordance with recommended cultural practices.

Observations were made on maturity and the number of days to maturity was computed. Other measurements included plant height, pod length and grain yield. Plant height was measured at maturity as the mean of five randomly selected plants from each plot. Pod length was measured as the mean of ten randomly selected pods. All other data were collected on a plot basis.

**Data analysis**

Analysis of variance and the analysis of covariance between all characters were carried out. Results from only 79 cultivars were used in the analysis as two varieties were discarded due to animal damage. Dispersion matrices of variance and covariance were prepared for Error and Error + Variety effects. The simultaneous tests of differences between mean values of the characters studied were done using the 'V' statistic which in turn utilizes Wilk's 'Λ' criterion (Rao, 1952). It was assumed that the 'V' statistic is distributed as the Chi-square with a p x q degree of freedom where p is the number of characters studied and q is the variety degrees of freedom.

Mahalanobis $D^2$ values were calculated according to the method outlined by Singh and Chaudhary (1979). The inverse of the variance and covariance matrix for varieties was computed by the pivotal condensation method. Original character means were transformed to an uncorrelated set of variables and the $D^2$ was estimated as the sum of squares of the differences in transformed values for the various characters. Original character means were transformed to an uncorrelated set of variables and the five characters were ranked on the basis of the difference between transformed values for each pair of varieties. The proportion of first ranks for each character was considered as its contribution towards divergence. The genotypes were grouped into different clusters following the Tocher's method (Rao, 1952). Mathematical computations were carried out using programmes written in GW BASIC.

## RESULTS AND DISCUSSION

The analysis of variance revealed highly significant differences among the cultivars in all characters studied (Table 1). The simultaneous differences between mean values were statistically significant as indicated by the 'V' statistic ($Chi^2$ = 1120.9, 390 d.f.).

The $D^2$ values between cultivars ranged from 0.000 to 88.515. Grouping the 79 cultivars of cowpea based on Mahalanobis $D^2$ statistic as per the method mentioned previously resulted in 14 clusters (Table 2). Average inter-cluster distances ranged from 0.270 to 80.858 (Table 3). The maximum intra-cluster distance of 0.122 was found in cluster III.

**Table 1. Analysis of variance for days to flowering, days to maturity, plant height, pod length and grain yield of 79 cowpea cultivars.**

| Source of variation | Degrees of freedom | Mean squares | | | | |
|---|---|---|---|---|---|---|
| | | Flowering | Maturity | Yield | Height | Pod length |
| Blocks | 1 | 12.25 | 2.78 | 882912 | 10.30 | 11.65 |
| Cultivars | 78 | 47.77** | 39.47** | 440990** | 22.56** | 15.81** |
| Error | 78 | 5.98 | 7.95 | 63985 | 6.92 | 1.68 |
| Total | 157 | 26.78 | 23.57 | 256503 | 14.72 | 8.76 |

** - Denotes significance at 1% level of probability.

**Table 2. Clustering pattern of 79 cowpea cultivars based upon the Mahalanobis' $D^2$ statistic**

| Cluster | Cultivars | | | |
|---|---|---|---|---|
| I | PAK 27051 | IT 82D-812 | IT 83S-818 | MI 35 |
| | TVu 1890 | CP 26 | PAK 27002 | PAK 27001 |
| | PAK 27054 | | | |
| II | EG No. 3 | CV-V38 | MICP 330 | IT 82D-789 |
| | IT 83S-689-4 | MICP 357 | MICP 211 | CES 41-6 |
| III | CP 456 | Tvu 90 | Sel. 230-2 | Ife Brown |
| | Pak 27006 | | | |
| IV | PAK 27052 | IT 85-D 3244-L | | |
| V | Tvu 1641 | PAK 27023 | PAK 27056 | MICP 27 |
| | MICP 99 | PAK 27005 | Tvu 82 | C-152 |
| | IT 84S-2213-2 | TVx 1850-01E | TVx 3671-14C-01D | Tvu 78 |
| VI | IT 83D-326-2 | IT83D-235 | IT 82E-18 | |
| VII | MICP 355 | IT 82D 889 | PAK 27053 | TVx 4654-44E |
| | PAK 27055 | IT 85D 3097 | IT 85D 3047 | IT 84E-1-108 |
| | MICP 399 | IT 82E-3 | IT 83D-666 | PAK 27027 |
| VIII | MICP 245 | IT 82D 513-1 | IT 85D-3144-R | PAK 27059 |
| | IT 82E-27 | VITA-7 | MICP 349 | PAK 27004 |
| | MICP 179 | | | |
| IX | PAK 27003 | PAK 27058 | CV-V-16 | IT 85D-3135 |
| | MICP 353 | | | |
| X | MICP 194 | PAK 27057 | | |
| XI | IT 85D 2946 | IT 85D 3132 | IT 82E-16 | Arlington |
| XII | IT 84S-3346-4 | IT 85D-3234 | TVu 2397 | MICP 217 |
| XIII | IT 85D-3282 | IT 84S-2049 | MICP 348 | |
| XIV | TVx 4678-03E | | | |

**Table 3. Average inter-cluster and intra-cluster $D^2$ values among 14 clusters of cowpea.**

| Cluster | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | XIII | XIV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I | **0.113** | 23.114 | 44.556 | 65.239 | 16.901 | 29.347 | 11.272 | 1.890 | 0.932 | 38.456 | 6.343 | 0.533 | 3.823 | 55.649 |
| II | . | **0.015** | 3.591 | 10.785 | 0.551 | 0.441 | 2.179 | 11.985 | 32.733 | 2.005 | 5.324 | 16.945 | 8.200 | 7.115 |
| III | . | . | **0.122** | 2.034 | 6.651 | 1.647 | 11.106 | 28.391 | 57.600 | 0.270 | 17.400 | 35.813 | 22.379 | 0.671 |
| IV | . | . | . | **0.035** | 15.800 | 7.116 | 22.381 | 45.288 | 80.858 | 3.529 | 31.041 | 54.562 | 37.601 | 0.389 |
| V | . | . | . | . | **0.047** | 1.753 | 0.619 | 7.644 | 25.247 | 4.410 | 2.594 | 11.689 | 4.688 | 11.271 |
| VI | . | . | . | . | . | **0.056** | 4.308 | 16.566 | 40.089 | 0.637 | 8.486 | 22.334 | 12.051 | 4.203 |
| VII | . | . | . | . | . | . | **0.056** | 4.052 | 18.233 | 8.154 | 0.754 | 7.101 | 1.997 | 16.920 |
| VIII | . | . | . | . | . | . | . | **0.062** | 5.189 | 23.558 | 1.389 | 0.471 | 0.383 | 37.360 |
| IX | . | . | . | . | . | . | . | . | **0.019** | 50.638 | 11.762 | 2.626 | 8.213 | 70.137 |
| X | . | . | . | . | . | . | . | . | . | **0.001** | 13.656 | 30.361 | 18.106 | 1.586 |
| XI | . | . | . | . | . | . | . | . | . | . | **0.053** | 3.329 | 0.337 | 24.541 |
| XII | . | . | . | . | . | . | . | . | . | . | . | **0.026** | 1.584 | 45.821 |
| XIII | . | . | . | . | . | . | . | . | . | . | . | . | **0.002** | 30.407 |
| XIV | . | . | . | . | . | . | . | . | . | . | . | . | . | - |

Pod length was found to be the greatest contributor to divergence (Table 4). Number of days to maturity, contributing only 7.4%, was the smallest contributor to divergence.

**Table 4. Percent contribution of individual characters towards divergence.**

| Character | % Contribution |
|---|---|
| Days to flowering | 20.6 |
| Days to maturity | 7.4 |
| Grain yield | 23.8 |
| Plant height | 12.0 |
| Pod length | 36.1 |

The genetic diversity available in cowpea is of great magnitude that no serious attempts have been made to create it through wide crossing and mutation breeding (Rachie and Roberts, 1974). However, this valuable resource would not be properly utilized if due consideration is not given to genetic diversity of parents selected for hybridisation. Analysis of eco-geographic diversity and Coefficient of Parentage are alternatives to multivariate analysis of characteristics on which divergent parents can be identified for hybridization. Information on the origin or the region of adaptation of each variety is required to group them based on eco-geographic diversity whereas information on the pedigree is required to estimate the coefficient of parentage. Information on neither the region of adaptation nor the pedigree was available for most of the cultivars studied in the present experiment. On the other hand, the clustering pattern observed does not coincide with the geographic origin or parentage for the cultivars with known origins. For example, cultivar MI 35 is in cluster I while 'Arlington', which is one of its parents, is in cluster XI. Similarly, 'Selection 230-2' which was derived from the cross MI 35 x Arlington was grouped separately from its parents. It should be noted that all three varieties are known to be adapted to similar environments despite belonging to different clusters. This is in agreement with several workers who reported that the similarities in phenotypes do not necessarily correspond with eco-geographic origin or parentage (Lee and Kaltsikes, 1973; Singh and Gill, 1984; Raut et al., 1985; Thakur and Zarger, 1989).

Successful choice of parents in a breeding program should produce an abundance of transgressive segregants without narrowing the genetic base of the resultant progeny. Selection of parents based on their yielding ability alone may result in a narrow genetic base since co-adapted gene blocks responsible for high yield of both parents are not likely to be different as pointed out by Sharma (1989). Hence, the chances of obtaining higher yielding transgressive segregants may also be reduced. This implies that the best results are obtained by crossing adapted varieties with unadapted varieties or by ensuring that the parents are genetically diverse for yielding ability. Grain yield has contributed substantially towards divergence among the cultivars in the present experiment. Therefore, the chances are high for parents selected from distant clusters to be genetically diverse for yielding ability. Accordingly, selecting parents from distant clusters as a means of obtaining transgressive segregants may be more effective for pod length, grain yield and days to flowering than for days to maturity and plant height.

Among the cultivars tested in this experiment, MI 35, Arlington, Selection 230-2, IT 82D-789 and IT 82D-889 are the cultivars that can be regarded as adapted to local conditions. But they were found in different clusters indicating that sufficient diversity exists among the adapted varieties. Although our objective is to select parents based on the Mahalanobis $D^2$ statistic between individual cultivars, the results show that there is an excellent correspondence between inter-cultivar distances and the relevant inter-cluster distances implying that it can be accomplished solely on the basis of inter-cluster distances (Table 5).

**Table 5. Mahalanobis' distance between some 'adapted' varieties of cowpea and the average inter-cluster distance between corresponding clusters**

| Cultivar | | IT 82D-789 | Sel. 230-2 | IT 82D-889 | Arlington |
|---|---|---|---|---|---|
| | Cluster | I | II | VII | XI |
| MI 35 | | 26.503 | 44.158 | 11.560 | 7.509 |
| | I | **23.114** | **44.556** | **11.272** | **6.343** |
| IT 82D-789 | | . | 2.241 | 3.056 | 5.798 |
| | II | . | **3.591** | **2.179** | **5.324** |
| Sel 230-2 | | . | . | 10.531 | 15.248 |
| | III | . | . | **11.106** | **17.400** |
| IT 82D-889 | | . | . | . | 0.435 |
| | VII | . | . | . | **0.754** |

* - bold figures indicate inter-cluster distances.

Accordingly, favourable results can be expected by crossing 'MI 35' with 'Sel. 230-2', 'IT 82D-789' and 'IT 82D-889' but not with 'Arlington'. On the other hand MI 35 and 'Sel. 230-2' are the best combiners among the adapted cultivars for 'IT 82D-789' and 'Arlington' respectively. As mentioned earlier, it may be a better strategy to cross these adapted cultivars with unadapted cultivars from distant clusters than with other adapted cultivars. However, there may be a critical limit to genetic divergence between parents, beyond which the probability of obtaining transgressive segregants decline as pointed out by Arunachalam and Bandyopadhyay (1984) in relation to the exploitation of heterosis in several crops. Therefore, it may be advisable to avoid selecting two varieties from extremely distant clusters as parents.

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