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# Genetic variability and heritability studies in cowpea (*Vigna unguiculata* (L.) Walp.)

Swathi S., Jiji Joseph*, Sindhumole P. and Deepu Mathew

*College of Agriculture, Kerala Agricultural University, Vellanikkara 680 656, Kerala, India*

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**Abstract**

Seven advanced lines along with two check varieties of cowpea were evaluated in a randomized block design with three replications during summer season of 2021 over three agro-ecological zones of Kerala. Assessment of genetic variability and heritability on twelve quantitative characters over three locations revealed significant difference between genotypes for all the characters studied. High GCV and PCV were observed for grain yield per plant at two environments. Number of pods per plant, length of pod, pod weight and test weight were controlled by additive gene action. The characters days to first flowering, days to first harvest, days to last harvest and protein content were under the influence of non additive gene action under two environments.

**Key words** : Cowpea, Gene action, Heritability, Variability

## Introduction

Cowpea (*Vigna unguiculata* (L.) Walp.), belonging to the family Fabaceae is one of the most important multipurpose grain legume crops grown extensively in the arid, semi-arid and subtropical regions of the world. India and Ethiopia are considered as the primary centres and China as the secondary centre of origin of cowpea (Vavilov, 1951). In India, cowpea is widely accepted as a kharif season crop, but it is also being cultivated as a rabi crop in the peninsular regions.

The crop can be cultivated throughout the year because of its photo insensitive nature. It is cultivated for both human as well as livestock consumption. Being of short duration nature, the crop harmonizes well with various multiple and intercropping systems and provides additional benefits as a green manure as well as a green fodder crop. Despite being a rich source of calcium and iron, cowpea grain contains 23.4 per cent protein, 1.8 per cent fat and 60.3 per cent carbohydrates on dry weight basis (Gupta, 1988).

In India cowpea is cultivated on 39 lakh hectares with national production and productivity accounting to about 19 lakhs tonnes and 567 kg ha$^{-1}$ respectively (Vir and Singh, 2013). The poor yield in cowpea is due to the unavailability of high yielding and stable genotypes (Ali et al., 2004). Cowpea being a self pollinated crop, the genetic variability existing within the crop is limited. Therefore, the effort of a breeder so as to develop better yielding genotypes relies primarily on exercising selection in segregating generations.

The effectiveness of selection process depends primarily on the amount of genetic variability present for each character and the extent to which these characters are inherited. In the present study, estimates of variability, heritability and genetic advance values with respect to twelve quantitative traits were estimated in five lines of cowpea at

* Author for Correspondences: Phone:9446153232 , Email: jiji.joseph@kau.in

Table 1. Details of cultures and check varieties used for the experiment

| S. No. | Cultures/ Lines | Details of cultures | Renamed cultures | Original cross combination |
|---|---|---|---|---|
| 1 | H-11-3-9-1-7-13-17 | (Table 2a and 2b) | $L_1$ | Anaswara x PKB 4 |
| 2 | H-11-49-7-1-8-10-15 | (Table 2a and 2b) | $L_2$ | Anaswara x PKB 4 |
| 3 | H-11-3-9-1-1-18-13 | (Table 2a and 2b) | $L_3$ | Anaswara x PKB 4 |
| 4 | H-11-2-20-3-14-16-12 | (Table 2a and 2b) | $L_4$ | Anaswara x PKB 4 |
| 5 | H-10-71-16-1-9-15-12 | (Table 2a and 2b) | $L_5$ | Anaswara x PKB 3 |
| 6 | Anaswara | - | $C_1$ | - |
| 7 | Kanakamony | - | $C_2$ | - |

stabilized $F_7$ generation along with two check varieties.

## Materials and Methods

The experimental material included five cowpea cultures in stabilized $F_7$ generation developed from pedigree selection of two crosses (Anaswara x PKB 3 and Anaswara x PKB 4) at the Department of Plant Breeding and Genetics, College of Agriculture, Vellanikkara along with two check varieties Anaswara and Kanakamony. Details regarding the cultures are presented in Table 1. The crops were raised over three locations, belonging to three different agro-ecological zones of Kerala viz., Regional Agricultural Research Station, Pattambi [Central midland zone, Environment 1], College of Agriculture, Vellanikkara [Malayoram zone, Environment 2] and Rice Research Station, Vyttila [Coastal sandy agro-ecological zone, Environment 3]. The crop was raised over three locations during the month of February 2021 to May 2021 adopting randomized block design (RBD) with three replications each. Field experiments were laid out in plots of 12.5 m x 5.2 m size and the plants were raised adopting spacing of 25 cm x 30 cm.

Observations were recorded on twelve quantitative traits. All the observations were recorded after harvest except for days to first flowering. Data recorded were tabulated and subjected to statistical analysis. Assessment and estimation of variability among genotypes were carried out using the statistical software R version 3.4.1. Components of variance (phenotypic and genotypic) were estimated according to the formula suggested by Snedecor and Cochran, 1994. Phenotypic, genotypic and environmental coefficients of variation were estimated using the formula suggested by Burton and De Vane (1953). PCV(phenotypic coefficient of variation) and GCV(genotypic coefficient of variation) are classified as low when less than 10 per cent, moderate when it is between 10 and 20 per cent and high if it is more than 20 per cent (Sivasubramanian and Madhavamenon, 1973).

Heritability in broad sense was computed for all the quantitative traits using the formula suggested by Lush in 1945. Heritability can be classified as low when less than 30 per cent, as moderate when between 30 and 60 per cent and as high when it is more than 60 per cent (Robinson et al., 1949). Genetic advance (GA) is a measure of genetic gain under selection. The expected genetic gain is estimated from the formula suggested by Johnson et al. (1955). Genetic advance was expressed as percentage of mean as suggested by Allard in 1960. Genetic advance expressed as percentage of mean can be classified as low (0-10%), as moderate (10.1-20%) and as high (>20%) as suggested by Johnson et al. (1955).

## Results and Discussion

*Performance of cowpea genotypes under environment 1 (RARS, Pattambi)*

Analysis of variance revealed significant difference between mean squares due to genotypes for all the characters studied (Table 2). The wide ranges in the observations among genotype (Table 3), indicated the presence of sufficient variability within each character for these traits to be further improved

Table 2. Analysis of variance (ANOVA) over three environments

| Source of variation | Degrees of freedom | Mean Sum of Squares | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PH(cm) | NB | DFF | DFH | DLH | NPP | LP(cm) | PW(g) | NSP | TW (g) | GYP(g) | PC (%) |
| Environment 1 | | | | | | | | | | | | | |
| Genotypes | 6 | 708.9* | 2.04* | 5.30* | 36.38* | 34.31* | 168.1* | 75.56* | 0.38* | 9.66* | 31.47* | 3375.6* | 1911.9* |
| Replication | 2 | 194.6 | 0.90 | 0.67 | 3.81 | 9.85 | 2.97 | 0.01 | 0.001 | 0.005 | 0.02 | 40.7 | 5.07 |
| Error | 12 | 397.1 | 0.68 | 0.67 | 1.8 | 3.13 | 2.88 | 0.02 | 0.002 | 0.006 | 0.25 | 41.7 | 5.07 |
| Environment 2 | | | | | | | | | | | | | |
| Genotypes | 6 | 1218.9 | 0.37* | 2.95* | 31.66* | 21.18* | 214.2* | 47.12* | 0.89* | 11.14* | 24.72* | 1538.2* | 9.557* |
| Replication | 2 | 2200.1 | 0.19 | 0.86 | 1.56 | 25.46 | 1.10 | 0.001 | 0.001 | 0.018 | 0.003 | 14.25 | 0.01 |
| Error | 12 | 1847.6 | 0.14 | 0.52 | 0.71 | 2.97 | 2.46 | 0.003 | 0.001 | 0.002 | 0.087 | 19.96 | 0.01 |
| Environment 3 | | | | | | | | | | | | | |
| Genotypes | 6 | 382.7 | 0.19 | 8.86* | 32.77* | 63.25* | 127.1* | 67.40* | 0.48* | 1.35* | 23.46* | 250.52* | 45.63* |
| Replication | 2 | 1048.1 | 2.36 | 1.61 | 3.69 | 38.51 | 3.42 | 0.012 | 0.008 | 0.005 | 0.053 | 32.71 | 0.001 |
| Error | 12 | 780.5 | 0.37 | 1.36 | 6.21 | 4.12 | 1.74 | 0.003 | 0.004 | 0.003 | 0.063 | 14.59 | 0.001 |

(significant at 0.05% level)

PH – plant height, NB – No. of branches, DFF – days to first flowering, DFH – days to first harvest, DLH - days to last harvest, NPP - No. of pods/ plant, LP - length of pod, PW – pod weight, NSP – No. of seeds / pod, TW - test weight, GYP - grain yield/plant, PC - protein content

Table 3. Mean performance of cowpea genotypes under environment 1

| Genotypes | PH | NB | DFF | DFH | DLH | NPP | LP | PW | NSP | TW | GYP | PC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_1$ | 179.56$^{ab}$ | 8.36$^{a}$ | 42.00$^{a}$ | 57.00$^{c}$ | 92.07$^{a}$ | 48.87$^{b}$ | 30.00$^{b}$ | 3.73$^{b}$ | 19.01$^{a}$ | 19.55$^{ab}$ | 181.45$^{a}$ | 23.55$^{c}$ |
| $L_2$ | 185.56$^{ab}$ | 8.44$^{a}$ | 40.29$^{b}$ | 57.68$^{bc}$ | 90.03$^{ab}$ | 46.84$^{b}$ | 30.61$^{a}$ | 3.94$^{a}$ | 19.05$^{a}$ | 18.68$^{b}$ | 166.26$^{b}$ | 24.26$^{b}$ |
| $L_3$ | 205.83$^{a}$ | 7.37$^{ab}$ | 42.33$^{a}$ | 60.00$^{b}$ | 84.01$^{cd}$ | 47.65$^{b}$ | 28.90$^{c}$ | 3.73$^{b}$ | 18.97$^{a}$ | 16.15$^{c}$ | 146.34$^{c}$ | 20.38$^{g}$ |
| $L_4$ | 169.39$^{b}$ | 6.23$^{b}$ | 40.33$^{b}$ | 56.01$^{c}$ | 85.03$^{cd}$ | 40.73$^{c}$ | 30.04$^{b}$ | 3.69$^{b}$ | 16.97$^{b}$ | 19.85$^{a}$ | 137.84$^{cd}$ | 24.62$^{a}$ |
| $L_5$ | 187.80$^{ab}$ | 7.43$^{ab}$ | 40.04$^{b}$ | 63.29$^{a}$ | 89.35$^{ab}$ | 40.89$^{c}$ | 28.49$^{d}$ | 3.71$^{b}$ | 16.97$^{b}$ | 19.36$^{ab}$ | 134.53$^{d}$ | 22.03$^{e}$ |
| $C_1$ | 175.60$^{ab}$ | 7.04$^{ab}$ | 40.33$^{b}$ | 57.01$^{c}$ | 83.03$^{d}$ | 32.56$^{d}$ | 26.56$^{e}$ | 3.31$^{c}$ | 15.09$^{c}$ | 19.31$^{ab}$ | 94.93$^{e}$ | 20.70$^{f}$ |
| $C_2$ | 210.87$^{a}$ | 8.32$^{a}$ | 38.33$^{c}$ | 52.00$^{d}$ | 87.00$^{bc}$ | 56.01$^{a}$ | 16.31$^{f}$ | 2.88$^{d}$ | 14.96$^{c}$ | 10.91$^{d}$ | 91.61$^{e}$ | 22.37$^{d}$ |

PH – plant height, NB – No of branches, DFF – days to first flowering, DFH – days to first harvest, DLH- days to last harvest , NPP - No. of pods/ plant, LP - length of pod, PW – pod weight, NSP – No. of seeds / pod, TW - test weight, GYP - grain yield/plant, PC - protein content

Table 4. Genetic parameters of cowpea genotypes under environment 1

| Genotypes | PH | NB | DFF | DFH | DLH | NPP | LP | PW | NSP | TW | GYP | PC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PCA | 11.92 | 14.01 | 3.67 | 6.34 | 4.22 | 16.99 | 18.41 | 10.04 | 10.39 | 18.46 | 24.94 | 7.38 |
| GCA | 5.43 | 8.87 | 3.07 | 5.89 | 3.69 | 16.57 | 18.40 | 9.96 | 10.37 | 18.24 | 24.49 | 7.38 |
| GA | 5.09 | 11.57 | 5.27 | 11.29 | 6.68 | 33.27 | 37.89 | 20.36 | 21.35 | 37.12 | 49.52 | 15.21 |
| Broad sense heritability | 0.21 | 0.40 | 0.69 | 0.86 | 0.77 | 0.95 | 0.99 | 0.98 | 0.99 | 0.98 | 0.96 | 1.00 |

PH – plant height, NB – No.ofbranches, DFF – days to first flowering, DFH – days to first harvest, DLH- days to last harvest , NPP - No. of pods/ plant, LP - length of pod, PW – pod weight, NSP – No. of seeds / pod, TW - test weight, GYP -grain yield/plant, PC - protein content

through breeding approaches.

Low PCV and GCV was observed for days to first flowering, days to first harvest, days to last harvest and protein content. Moderate PCV and GCV was exhibited by number of pods per plant, length of pod, number of seeds per pod and test weight. High PCV and GCV was observed for grain yield per plant (Table 4).

The magnitude of difference between PCV and GCV were high for the characters plant height and number of branches suggesting that these characters were under the control of environment with little role of genetic constitution on the phenotypic expression of these characters. Selection for such characters may not be rewarding.

High heritability with moderate or low genetic advance was observed for number of branches, days

Table 5. Mean performance of cowpea genotypes under environment 2

| Genotypes | PH | NB | DFF | DFH | DLH | NPP | LP | PW | NSP | TW | GYP | PC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_1$ | 229.52$^{a}$ | 4.04$^{ab}$ | 40.37$^{ab}$ | 59.40$^{a}$ | 89.04$^{a}$ | 43.28$^{b}$ | 27.91$^{b}$ | 3.18$^{e}$ | 18.00$^{b}$ | 17.88$^{b}$ | 139.25$^{a}$ | 23.01$^{c}$ |
| $L_2$ | 211.88$^{a}$ | 3.57$^{bc}$ | 39.25$^{bc}$ | 58.65$^{ab}$ | 87.05$^{ab}$ | 44.11$^{b}$ | 27.77$^{c}$ | 3.84$^{b}$ | 18.95$^{a}$ | 15.97$^{c}$ | 134.02$^{a}$ | 25.32$^{a}$ |
| $L_3$ | 180.96$^{a}$ | 4.35$^{a}$ | 41.24$^{a}$ | 58.95$^{a}$ | 82.13$^{c}$ | 43.01$^{b}$ | 26.53$^{d}$ | 3.11$^{f}$ | 18.99$^{a}$ | 14.96$^{d}$ | 122.24$^{b}$ | 20.64$^{g}$ |
| $L_4$ | 197.41$^{a}$ | 3.73$^{abc}$ | 40.33$^{ab}$ | 57.35$^{b}$ | 87.99$^{a}$ | 38.72$^{c}$ | 28.32$^{a}$ | 3.77$^{c}$ | 17.01$^{c}$ | 14.16$^{e}$ | 93.19$^{c}$ | 24.70$^{b}$ |
| $L_5$ | 238.96$^{a}$ | 3.91$^{abc}$ | 39.01$^{c}$ | 59.85$^{a}$ | 84.61$^{bc}$ | 38.35$^{c}$ | 27.79$^{c}$ | 3.98$^{a}$ | 16.05$^{d}$ | 15.08$^{d}$ | 92.50$^{c}$ | 21.42$^{e}$ |
| $C_1$ | 195.61$^{a}$ | 3.52$^{bc}$ | 39.33$^{bc}$ | 54.39$^{c}$ | 82.53$^{c}$ | 30.12$^{d}$ | 24.00$^{e}$ | 3.29$^{d}$ | 15.01$^{e}$ | 19.82$^{a}$ | 89.55$^{c}$ | 21.26$^{f}$ |
| $C_2$ | 212.65$^{a}$ | 3.31$^{c}$ | 38.33$^{c}$ | 51.00$^{d}$ | 86.19$^{ab}$ | 58.01$^{a}$ | 17.32$^{f}$ | 2.41$^{g}$ | 14.03$^{f}$ | 10.74$^{f}$ | 87.49$^{c}$ | 22.24$^{d}$ |

PH – plant height, NB – No. of branches, DFF – days to first flowering, DFH – days to first harvest, DLH - days to last harvest, NPP - No. of pods/ plant, LP- length of pod, PW – pod weight, NSP – No. of seeds / pod, TW - test weight, GYP -grain yield/plant, PC - protein content

Table 6. Genetic parameters of cowpea genotypes under environment 2

| Genotypes | PH | NB | DFF | DFH | DLH | NPP | LP | PW | NSP | TW | GYP | PC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PCA | 19.31 | 12.28 | 2.90 | 5.82 | 3.51 | 20.24 | 15.44 | 16.17 | 11.43 | 18.57 | 21.17 | 7.88 |
| GCA | 6.91 | 7.39 | 2.27 | 5.63 | 2.88 | 19.89 | 15.44 | 16.17 | 11.43 | 18.47 | 20.77 | 7.88 |
| GA | 5.09 | 9.17 | 3.65 | 11.21 | 4.85 | 40.28 | 31.81 | 33.30 | 23.54 | 37.85 | 41.96 | 16.23 |
| Broad sense heritability | 0.13 | 0.36 | 0.61 | 0.94 | 0.67 | 0.97 | 0.99 | 0.99 | 0.99 | 0.98 | 0.96 | 1.00 |

PH – plant height, NB – No. of branches, DFF – days to first flowering, DFH – days to first harvest, DLH- days to last harvest, NPP - No. of pods/ plant, LP- length of pod, PW – pod weight, NSP – No. of seeds / pod, TW - test weight, GYP - grain yield/plant, PC - protein content

Table 7. Mean performance of cowpea genotypes under environment 3

| Genotypes | PH | NB | DFF | DFH | DLH | NPP | LP | PW | NSP | TW | GYP | PC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $L_1$ | 92.32$^{a}$ | 4.03$^{a}$ | 35.67$^{bc}$ | 56.36$^{bc}$ | 84.00$^{a}$ | 38.09$^{bc}$ | 26.21$^{d}$ | 3.59$^{d}$ | 16.03$^{b}$ | 16.53$^{b}$ | 100.79$^{a}$ | 26.47$^{a}$ |
| $L_2$ | 81.07$^{a}$ | 4.25$^{a}$ | 37.71$^{ab}$ | 60.04$^{ab}$ | 81.04$^{abc}$ | 38.27$^{bc}$ | 28.24$^{a}$ | 3.88$^{b}$ | 16.99$^{a}$ | 15.27$^{c}$ | 99.36$^{a}$ | 24.74$^{b}$ |
| $L_3$ | 107.00$^{a}$ | 4.37$^{a}$ | 35.01$^{c}$ | 55.04$^{cd}$ | 71.01$^{d}$ | 40.11$^{b}$ | 27.17$^{b}$ | 3.44$^{e}$ | 16.08$^{b}$ | 14.95$^{c}$ | 95.90$^{ab}$ | 20.96$^{c}$ |
| $L_4$ | 109.85$^{a}$ | 3.83$^{a}$ | 39.08$^{a}$ | 57.33$^{abc}$ | 80.03$^{bc}$ | 35.45$^{d}$ | 22.74$^{e}$ | 3.64$^{c}$ | 16.01$^{b}$ | 15.03$^{c}$ | 85.29$^{c}$ | 20.10$^{d}$ |
| $L_5$ | 101.35$^{a}$ | 4.05$^{a}$ | 37.44$^{ab}$ | 61.00$^{a}$ | 83.04$^{ab}$ | 37.01$^{cd}$ | 26.50$^{c}$ | 3.91$^{a}$ | 15.05$^{c}$ | 16.13$^{b}$ | 89.56$^{bc}$ | 15.31$^{g}$ |
| $C_1$ | 113.88$^{a}$ | 4.55$^{a}$ | 39.05$^{a}$ | 56.03$^{bc}$ | 78.12$^{c}$ | 29.39$^{e}$ | 28.39$^{a}$ | 3.27$^{f}$ | 16.08$^{b}$ | 18.97$^{a}$ | 89.44$^{bc}$ | 18.03$^{f}$ |
| $C_2$ | 104.71$^{a}$ | 3.92$^{a}$ | 39.32$^{a}$ | 51.03$^{d}$ | 84.01$^{a}$ | 51.03$^{a}$ | 15.03$^{f}$ | 2.75$^{g}$ | 15.05$^{c}$ | 9.72$^{d}$ | 74.42$^{d}$ | 18.43$^{e}$ |

PH – plant height, NB – No. of branches, DFF – days to first flowering, DFH – days to first harvest, DLH- days to last harvest, NPP - No. of pods/ plant, LP - length of pod, PW – pod weight, NSP – No.of seeds / pod, TW - test weight, GYP - grain yield/plant, PC - protein content

to first flowering, days to first harvest, days to last harvest [DLH] and protein content [PC]. Low heritability coupled with low genetic advance was observed for plant height [PH]. The results were in accordance with those of Khanpara et al. (2015) and Meena et al. (2015), where high heritability with high genetic advance was observed for number of pods per plant, length of pod, number of seeds per pod and test weight.

High heritability with high genetic advance observed for number of pods per plant, length of pod, pod weight, number of seeds per pod, test weight and grain yield per plant indicated that the characters are controlled by additive gene action and selection for such traits will be effective. The study confirmed for the presence of non-additive gene action for number of branches, days to first flowering, days to first harvest, days to last harvest and protein content as indicated by high heritability with moderate or low genetic advance and selection for such traits can turn ineffective. Low heritability coupled with low genetic advance observed in plant height indicated the dominance of environmental effects over the trait.

*Performance of cowpea genotypes under environment 2 (COA, Vellanikkara)*

Analysis of variance revealed significant difference between the genotypes for all the characters under study except for plant height (Table 2). There existed wide range between the genotypes for the twelve

Table 8. Genetic parameters of cowpea genotypes under environment 3

| Genotypes | PH | NB | DFF | DFH | DLH | NPP | LP | PW | NSP | TW | GYP | PC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PCA | 25.09 | 13.45 | 5.23 | 6.85 | 6.09 | 17.15 | 19.04 | 11.47 | 4.24 | 18.41 | 10.65 | 18.95 |
| GCA | 11.35 | 5.69 | 4.20 | 5.25 | 5.54 | 16.80 | 19.03 | 11.47 | 4.22 | 18.34 | 9.78 | 18.95 |
| GA% | 10.58 | -4.95 | 6.96 | 8.29 | 10.37 | 33.91 | 39.20 | 23.62 | 8.65 | 37.63 | 18.50 | 39.04 |
| Broad sense heritability | 0.20 | 0.18 | 0.65 | 0.59 | 0.83 | 0.96 | 0.99 | 1.00 | 0.99 | 0.99 | 0.84 | 1.00 |

PH – plant height, NB – No. of branches, DFF – days to first flowering, DFH – days to first harvest, DLH - days to last harvest, NPP - No. of pods/ plant, LP - length of pod, PW – pod weight, NSP – No. of seeds / pod, TW - test weight, GYP - grain yield/plant, PC - protein content

characters studied (Table 5). Low PCV and GCV was observed for days to first flowering, days to first harvest, days to last harvest and protein content. Similar results were observed by Sabale et al. (2018) wherein, low GCV and PCV was reported for days to flowering and days to maturity. Moderate PCV and GCV was observed for length of pod, pod weight, number of seeds per pod and test weight whereas high PCV and GCV was observed for the trait grain yield per plant (Table 6).

The magnitude of difference between PCV and GCV was high for plant height and number of branches indicating these characters are governed by environment than the genotype. The magnitude of difference was low for the traits length of pod, pod weight, number of seeds per pod, test weightand protein content. Since the expression of these traits are largely controlled by the genetic constitution with little or no effects from the environment, further improvement can be achieved through selection.

High heritability coupled with high genetic advance was observed for characters number of pods per plant, length of pod, pod weight, number of seeds per pod , test weight and grain yield per plant. Selection for such characters are effective since they are controlled by additive gene action. High heritability with moderate or low GA was observed for number of branches, days to first flowering, days to first harvest, days to last harvest and protein content. Since these traits were under the control of non- additive genes, selection will not be effective. Low heritability along with low genetic advance was observed for plant height indicating the predominant effect of environment over these traits.

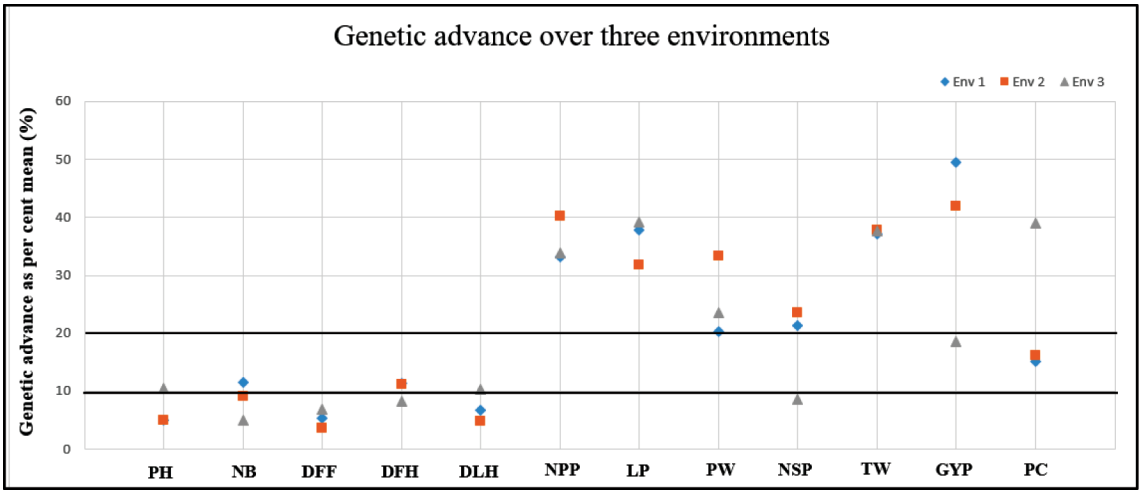
*Performance of cowpea genotypes under environment 3 (RRS, Vyttila)*

Analysis of variance revealed significant difference between genotypes for all the characters studied except for plant height and number of branches (Table 2). Wide range in observation existed between genotypes for the twelve characters studied (Table 7).

Low PCV and GCV was observed for days to first flowering , days to first harvest, days to last harvest and number of seeds per pod. Moderate PCV and GCV was observed for number of pods per plant, length of pod, pod weight, test weight and protein content (Table 8).

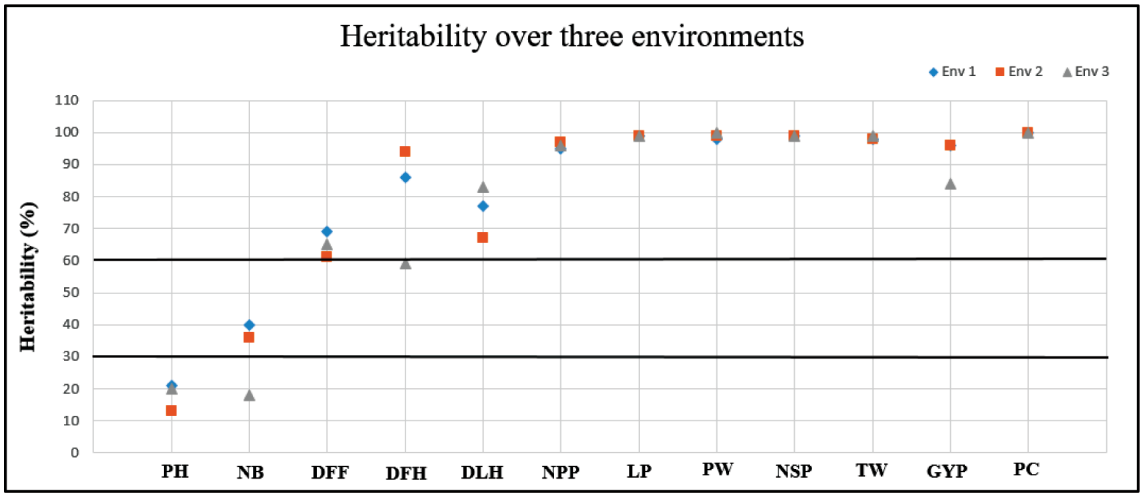
The magnitude of difference between PCV and GCV was high for the characters plant height and number of branches. This explained the predominance of environmental effects in the expression of these characters. The difference in magnitude was considerably less for length of pod, pod weight, number of seeds per pod and protein content. Since these characters are little manipulated by environmental effects further improvement in these characters can be achieved through selection.

High heritability coupled with high genetic advance as observed for characters number of pods per plant, length of pod, test weight and protein content. This indicated the predominance of additive gene action over the traits that selection for such characters are effective. High heritability with moderate or low genetic advance was observed for days to first flowering, days to first harvest, days to last harvest, number of seeds per pod and grain yield per plant.




PH – plant height, NB – No. of branches, DFF – days to first flowering, DFH – days to first harvest, DLH- days to last harvest , NPP-no of pods/ plant, LP- length of pod, PW – pod weight, NSP – no of seeds / pod, TW- test weight, GYP-grain yield/plant, PC- protein content

Figure 1. Comparison of genetic advance over three environments




PH – plant height, NB – No.of branches, DFF – days to first flowering, DFH – days to first harvest, DLH- days to last harvest , NPP-no of pods/ plant, LP- length of pod, PW – pod weight, NSP – No. of seeds / pod, TW- test weight, GYP-grain yield/plant, PC- protein content

Figure 2. Comparison of heritability over three environments

Selection for such traits can be misleading since they are under the control of non- additive gene action. Low heritability with low genetic advance was observed for plant height and number of branches, indicating the prominent effect of environment over the expression of these traits.

*Comparison of genetic components over three environments*

A comparison of genetic advance and heritability over three locations are presented in Fig. 1 and 2.

Additive gene action reflected through high heritability and high genetic advance was observed

for number of pods per plant, length of pod, pod weight, number of seeds per pod, test weight and grain yield per plant in environment 1 whereas number of pods per plant, length of pod, pod weight, number of seeds per pod, test weight and grain yield per plant recorded high heritability coupled with high genetic advance in the second environment. In the third environment, number of pods per plant, length of pod, pod weight, test weight and protein content had high heritability and genetic advance. Based on the observation from all the three environments, it can be inferred that number of pods per plant, length of pod, pod weight and test weight were found to be controlled by additive gene action suggesting further possible improvement of these traits through selection.

Non additive gene action was found to be influencing the traits days to first flowering, days to first harvest, days to last harvest and protein content in environment 1 since they had high heritability with moderate or low genetic advance. Similarly in environment 2, days to first flowering, days to first harvest and protein content had high heritability with moderate or low genetic advance. It was found that days to last harvest and grain yield per plant were controlled by non additive gene action in the third environment. The characters days to first flowering, days to first harvest, days to last harvest and protein content were under the influence of non additive gene action under two environments indicating the inefficiency of these traits towards selection.

The traits, plant height and number of branches were greatly under the influence of environment at RRS, Vyttila as indicated by the low heritability. The large magnitude of difference between PCV and GCV for these characters over three locations also confirmed the influence of environment over these characters. The hinderance contributed by environment 3 (RRS, Vyttila) towards yield and yield contributing characters can be attributed to the stressful condition offered by the coastal sandy zone over the growth of plant.

## Conclusion

Evaluation of cowpea genotypes over three environments revealed significant variability within each character and the possibilities for further improvement through suitable breeding interventions. When characters like plant height and number of branches were more under the influence of environment over three locations, characters like length of pod, pod weight, test weight and protein content were less under the influence of environment over two locations. The dominance of genetic control over environmental effects for the characters of length of pod, pod weight, number of seeds per pod and protein content indicates that selection for such characters can be rewarding. Traits like number of pods per plant, length of pod and test weight had high heritability with high genetic advance in all the environments indicating that the characters are under the control of additive gene action and hence for the suitability in further selection.

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