Original research article

Correlation and path analysis in cowpea (*Vigna unguiculata* (L.) Walp.)

ABSTRACT

This study, conducted at Babasaheb Bhimrao Ambedkar University, Lucknow, India, over 2020-21 and 2021-22, aimed to examine genetic variability, heritability, and genetic advance among 30 diverse cowpea genotypes. The research employed a Randomized Block Design (R.B.D.) with three replications, assessing twenty-six quantitative traits. Genotypic correlations exceeded phenotypic correlations, underscoring genetic influence over environmental factors. Key findings included plant height's positive correlation with branches per plant and days to first flowering, while negatively correlating with nodes on main branches and pod diameter. Traits such as number of pods per plant and average pod weight showed strong positive correlations with pod yield, highlighting their importance in breeding programs. Path coefficient analysis revealed significant positive direct effects on pod yield per plant from traits including plant height, branches per plant, and average pod weight. Indirect effects through traits like days to first flowering and non-reducing sugars also contributed to pod yield. These insights into trait correlations and effects are crucial for developing superior cowpea genotypes with enhanced yield and agronomic traits. The findings emphasize the importance of genetic variability in breeding programs, enabling the selection of superior genotypes to improve cowpea productivity.

Keywords:*Cowpea, correlation coefficient, path coefficient, pod yield, yield attributes.*

1. INTRODUCTION

The cowpea (*Vigna unguiculata* (L.) Walp.) is the most widely recognized leguminous crop. It has 2n=22 chromosomes (Darlington and Wylie, 1955) and belongs to the Fabaceae subfamily of the Leguminosae family (Mackie and Smith, 1935). This plant grows in the semi-arid tropics, including parts of Asia, Africa, Southern Europe, the Southern United States, and Central and South America (Timko *et al.*, 2007).

Cowpea, grown in 37 countries, contributed 16% of the total area, whereas dry peas in 96 countries contributed 8%, tur in 24 countries contributed 7%, and lentil in 43 countries contributed 5% (Anonymous, 2022).

Cowpea grows mostly in tropical and subtropical climates around the world, functioning as a multipurpose vegetable, seed supply, and, to a lesser extent, fodder. Its smothering properties, drought resistance, soil rejuvenation powers, and numerous applications make it one of the most adaptable pulse crops. Its soft green pods are a rich source of calcium, phosphorus, and iron, with 84.9% moisture content, 4.3% protein, 8.0% carbs, and 2% fat (Aykrod, 1963). Cowpea cultivation is primarily concentrated in the Indian states of Uttar Pradesh, Punjab, Haryana, Rajasthan, Madhya Pradesh, and Maharashtra. It is one of the earliest legume kinds and is commonly known as "poor man's meat."

Indigenous and exotic germplasms provide the foundation for successful breeding initiatives targeted at increasing yield and yield-contributing characteristics. Yield is a multidimensional variable regulated by both polygene-controlled attributes and environmental influences; hence the success of any plant breeding program is dependent on population variation. Correlation and path coefficient analysis, developed by Dewey and Lu in 1959, allows breeders to determine direct and indirect effects, as well as the degree and direction of the relationship between yield and its component characteristics. This analytical

framework assists in developing an ideotype notion aimed at increasing productivity levels.

The current study was undertaken to determine the relationship between various metric traits and the direct and indirect effects of yield attributes on green pod yield in cowpea.

2. MATERIAL AND METHODS

The current study was conducted between 2020-21 and 2021-22 at the Horticultural Research Farm, Department of Horticulture, Babasaheb Bhimrao Ambedkar University (A Central University), Vidya Vihar Raebareli Road, Lucknow, Uttar Pradesh (India). The experiment field was located roughly 10 kilometers southeast of Lucknow Railway Station and 7 kilometers northeast of Chaudhary Charan Singh International Airport, (Amausi) Lucknow.

Lucknow is located at 26’55’ North latitude and 80’59’ Longitude, with an elevation of 123 meters above mean sea level (MSL) in central Uttar Pradesh's subtropical climate. The experimental region's climate is subtropical, with maximum temperatures ranging from 22 to 45°C in the summer and lowest temperatures ranging from 1.5 to 15°C in the winter, relative humidity ranging from 60 to 80% throughout the year, and an annual rainfall of 110 cm.

The experimental materials were consisted of 30 diverse genotypes including two checks.The genotypes were sown in Randomized Block Design (R.B.D.) with three replications during Kharif 2020-21 and 2021-22, with rows and plants spaced 60 cm and 30 cm apart, respectively. The method of seeding used was dibbling. Thinning 10 days after seeding helped to retain one plant per hill. The plot sizes for each genotype were 2.7 m × 1.20 m. The prescribed fertilizer doses for nitrogen, phosphorus, and potash were 55 kg, 80 kg, and 36 kg per hectare, respectively. Nitrogen was supplied in divided doses, half during planting and the other half during vegetative growth and pod formation of

cowpea genotypes.Throughout the experimentation study, all cultural operations were carried out as needed.

The data were noted on twenty-six quantitative traits as plant height (cm), number of branches per plant, number of nodes on main branches, days taken for first flowering, days to 50% flowering, number of cluster per plant, number of flower per cluster, number of green pods per cluster, number of peduncles per plant, number of pods per peduncle, days to physiological maturity, days to first picking, number of pods per plant, pod length (cm), pod diameter (cm), average pod weight (g), number of seeds per pod, weight of 100 seeds (g), pod yield/plant (g), pod yield/plot (kg), pod yield (q/ha), protein content (%), total sugars (mg/g fw), reducing sugar (mg/g fw), non-reducing sugars (mg/g fw) and T.S.S. (mg/g fw).Five plants were randomly tagged to collect data on yield, contributing attributes, and seed characteristics. The mean value for the treatment was calculated by averaging the results. Hedge and Hofrieter's (1962) approach was used to assess total sugar content.

The data on all twenty-six qualities were statistically analyzed, with correlation coefficients obtained using Searle's (1961) formula and path coefficients analyzed using Dewey and Lu's (1959) method.

3. RESULTS AND DISCUSSION

3.1 Correlation coefficient analysis

Correlation analysis provides information about yield components and thus helps in the selection of superior genotypes from diverse genetic population. The magnitude of genotypic correlation was higher than phenotypic correlation for all the traits that indicated inherent association between various characters. In most of the cases studied, the phenotypic correlation coefficient exhibited the close relatedness to their corresponding genotypic correlation showing that genetic factors are highly involved in governing these traits and little influence

by environment. For some traits it is high than genotypic correlation, showing the influence of environmental factors [Table 1(a) and 1(b)].

The study estimated the correlation coefficients for 26 traits at the genotypic as well as phenotypic level over two years (2020-21 and 2021-22). At genotypic level, the key findings include plant height, which showed positive correlations with the number of branches per plant (0.589 and 0.552) and days to first flowering (0.515 and 0.471), and negative correlations with the number of nodes on main branches (-0.705 and -0.713), number of clusters per plant (-0.304 and -0.314), pod diameter (-0.252), weight of 100 seeds (-0.348), and total soluble solids (TSS) (-0.340). The number of branches per plant had positive correlations with days to first flowering (0.656 and 0.676), days to 50% flowering (0.466 and 0.523), days to physiological maturity (0.438 and 0.457), days to first picking (0.650 and 0.638), and pod length (0.463 and 0.431). The number of nodes on main branches was positively correlated with pod diameter (0.281 and 0.300), number of seeds per pod (0.228 and 0.250), weight of 100 seeds (0.456 and 0.428), protein content (0.216 and 0.219), and TSS (0.290 and 0.245).

Days to first flowering were positively correlated with days to 50% flowering (0.517 and 0.507), number of clusters per plant (0.209 and 0.249), days to physiological maturity (0.706 and 0.727), days to first picking (0.728 and 0.757), and pod length (0.291 and 0.304). Days to 50% flowering showed positive correlations with the number of flowers per cluster (0.327 and 0.320), number of pods per peduncle (0.536 and 0.552), days to physiological maturity (0.868 and 0.837), and days to first picking (0.657 and 0.617).

The number of clusters per plant was positively correlated with pod length (0.234 and 0.240). The number of flowers per cluster showed positive correlations with days to first picking (0.234) and, in the second year, with the number of pods per peduncle (0.225 and 0.369). The number of green pods per cluster showed positive correlations with several yield-related traits such as the

number of pods per plant (0.226), average pod weight (0.349 and 0.296), number of seeds per pod (0.267 and 0.259), TSS (0.243), pod yield per plant (0.304 and 0.261), pod yield per plot (0.287 and 0.241), and pod yield (q/ha) (0.297 and 0.241). The number of peduncles per plant had positive correlations with days to first picking (0.423 and 0.408), average pod weight (0.352 and 0.347), and pod yield per plant (0.209).

The number of pods per peduncle was positively correlated with days to physiological maturity (0.592 and 0.519) and days to first picking (0.364 and 0.350). Days to physiological maturity were positively correlated with days to first picking (0.716 and 0.500) and protein content (0.218). Days to first picking showed positive correlations with total sugars (0.317 and 0.289), reducing sugar (0.297 and 0.314), and non-reducing sugars (0.249 and 0.254). The number of pods per plant had significant positive correlations with pod diameter (0.417 and 0.424), average pod weight (0.658 and 0.640), number of seeds per pod (0.311 and 0.450), weight of 100 seeds (0.520 and 0.525), protein content (0.256), total sugars (0.523 and 0.532), reducing sugar (0.495 and 0.562), non-reducing sugars (0.547 and 0.493), pod yield per plant (0.922 and 0.918), pod yield per plot (0.924 and 0.915), and pod yield (q/ha) (0.928 and 0.920).

Pod diameter showed positive correlations with average pod weight (0.247 and 0.251), number of seeds per pod (0.504 and 0.533), weight of 100 seeds (0.794 and 0.797), protein content (0.662 and 0.624), total sugars (0.278 and 0.310), non-reducing sugars (0.236 and 0.301), pod yield per plant (0.370 and 0.367), pod yield per plot (0.404 and 0.404), and pod yield (q/ha) (0.403 and 0.411). Average pod weight was positively correlated with the number of seeds per pod (0.386 and 0.337), weight of 100 seeds (0.456 and 0.417), TSS (0.231), total sugars (0.639 and 0.646), reducing sugar (0.647 and 0.640), non-reducing sugars (0.556 and 0.611), pod yield per plant (0.863 and 0.858), pod yield per plot (0.842 and 0.845), and pod yield (q/ha) (0.843 and 0.841).

The number of seeds per pod had positive correlations with weight of 100 seeds (0.486 and 0.658), protein content (0.685 and 0.702), TSS (0.317 and 0.373), non-reducing sugars (0.220), pod yield per plant (0.326 and 0.405), pod yield per plot (0.336 and 0.441), and pod yield (q/ha) (0.339 and 0.438). Weight of 100 seeds showed positive correlations with protein content (0.499 and 0.468), total sugars (0.411 and 0.444), reducing sugar (0.333 and 0.390), non-reducing sugars (0.334 and 0.460), pod yield per plant (0.504 and 0.480), pod yield per plot (0.526 and 0.506), and pod yield (q/ha) (0.528 and 0.515).

Protein content was positively correlated with TSS (0.259 and 0.276), pod yield per plot (0.224), and pod yield (q/ha) (0.225). TSS in the second year showed positive correlations with reducing sugar (0.242), pod yield per plant (0.241), pod yield per plot (0.248), and pod yield (q/ha) (0.244). Total sugars, reducing sugar, and non-reducing sugars each showed strong positive correlations with pod yield per plant (0.638 and 0.638 for total sugars; 0.628 and 0.660 for reducing sugar; 0.619 and 0.579 for non-reducing sugars), pod yield per plot (0.638 and 0.638 for total sugars; 0.640 and 0.680 for reducing sugar; 0.620 and 0.583 for non-reducing sugars), and pod yield (q/ha) (0.635 and 0.635 for total sugars; 0.637 and 0.676 for reducing sugar; 0.617 and 0.581 for non-reducing sugars). Pod yield per plant had a very high positive correlation with pod yield per plot (0.996 and 0.997) and pod yield (q/ha) (0.994 and 0.995) in both years. These findings highlight significant correlations between various traits and yield attributes, suggesting potential markers for breeding programs.Sharma *et al.* (2016), Lokesh and Murthy (2017), Pushkar *et al.* (2018), Waghmare *et al.* (2018), Kamble *et al.* (2019), Das *et al.* (2020), Nagalakshmi *et al.* (2020) and Kavyashree *et al.* (2023) and Ajayi (2023) also worked on several cowpea genotypes and showed significant association of various yield attributed towards economic yield.

3.2 Path coefficient analysis

Correlation studies, while instructive, frequently fall short of providing a whole picture, especially when the causal threads are interlaced in elaborate tapestries. When the very strands of contributing variables share an action of interrelationships their direct dalliance with yield becomes enshrouded in uncertainty, thus casting aspersions upon the reliability of correlation coefficients as reliable barometric instruments of selection.

Moving beyond the boundaries of correlation, we discover the depths of path coefficient analysis, a torch illuminating the complex web that ties varied characters to produce. Within the cowpea realm, the narrative unfolds on a complicated stage, with seed yield acting as a marionette, its elaborate ballet controlled by a group of linked traits.

Both the phenotypic and genotypic terrains bear witness to this elucidation, etching their testimony upon the sacred tome of Tables 2(a)and 2(b).In few cases phenotypic values were higher than their corresponding genotypic coefficient showing influence of external factors for these traits, while rest characters exhibited high genotypic values representing less or no influence of environmental factors involved in both years.

During the years 2020-21 and 2021-22, at genotypic level the substantial positive direct effects on pod yield per plant were exerted by plant height(0.2798), number of branches per plant(0.2962), number of nodes on main branches(0.2987), number of cluster per plant(0.9951), number of flower per cluster(0.2857), number of pods per peduncle(0.1592), days to physiological maturity(0.3877), days to first picking(0.1662), number of pods per plant(0.4731), average pod weight (g)(0.2940), weight of 100 seeds (g)(0.7566), protein content (%)(0.7028), T.S.S. (0.4427), non-reducing sugars(0.3977), and pod yield (q/ha) (0.2687).Sharma *et al.* (2016) noted direct effect of number of pods per plant on yield followed by number of secondary branches per plant; Jogdhande*et al.* (2017) confirmed that number of nodes per plant, number of clusters per plant, number of green pods per cluster, number of pods per plant,

number of seeds per pod, 100 seed weight, pod diameter (cm), pod length (cm), number seeds per pod, % of fibres content and % of protein content had direct effect on yield; Association of days to maturity, primary branches per plant and pod length and negative direct effect at genotypic levels on grain yield was confirmed by the findings of Lokesh and Murthy (2017); Waghmare *et al.* (2018) revealed the direct effects of days to first flowering, days to fifty per cent flowering, plant height, number of pods per plant, number of seeds per pod, first 100 seed weight, pod diameter (cm) on economic yield in cowpea. Kavyashree *et al*. (2023) also observed the direct effects of number of pods per plant on yield per plant at Phenotypic and genotypic level.The negative direct effects on economic yield were also reported for the traits like days taken to first flowering (-0.9605), days to 50% flowering (-0.9801), number of green pods per cluster (-0.1517), number of peduncles per plant (-0.8961), pod length (-0.3904), pod diameter (-0.2844), number of seeds per pod (-0.8289) and rest of the traits exerted too low or negative direct effects on pod yield indicating that the if these traits will selected, gradually it will decrease the economic yield.

At both the genotypic and phenotypic levels in both years i.e., 2020-21 and 2021-22, number of nodes on main branches exhibited positive indirect effect on economic yield *via* days taken for first flowering, days to 50% flowering, number of cluster per plant, number of peduncles per plant, pod length (cm), protein content, T.S.S., non-reducing sugars and pod yield (q/ha); Days taken for first flowering exerted positive indirect effect on economic yield *via* plant height, number of branches per plant, number of cluster per plant, days to physiological maturity, days to first picking. Days to 50% flowering exhibited positive indirect effect on pod yield *via* plant height, number of branches per plant, days to physiological maturity and pod yield/plot, further number of cluster per plant *via* total sugars also showed positive indirect effect on pod yield. The trait number of flower per cluster *via* plant height, and number of green pods per cluster *via* plant height, average pod weight, reducing sugar,

non-reducing sugars and pod yield exerted positive indirect effects on pod yield; Number of peduncles per plant *via* plant height, reducing sugar, non-reducing sugars and pod yield exerted positive indirect effects on pod yield. Days to physiological maturity exhibited positive indirect effect on pod yield per plant *via* plant height, number of branches per plant, number of cluster per plant, days to first picking, reducing sugar, pod yield. Days to first picking exhibited positive indirect effect on pod yield per plant *via* plant height, number of branches per plant, days to physiological maturity, average pod weight, reducing sugars, non-reducing sugars and pod yield. These findings are in agreement with the earlier reports of Das *et al.* (2020), Nagalakshmi *et al.* (2020), Kavyashree *et al*. (2023) and Ajayi (2023).

At genotypic and phenotypic levels in both the years, the trait protein content exhibited positive indirect effects on pod yield per plant *via* days taken for first flowering, number of peduncles per plant, weight of 100 seeds, total sugar and pod yield (q/ha); Total soluble solids (T.S.S.) demonstrated positive indirect effects on pod yield per plant *via*average pod weight, weight of 100 seeds, reducing sugar, non-reducing sugar and pod yield (q/ha); whereas, total sugars *via* plant height, average pod weight, weight of 100 seeds, reducing sugar, non-reducing sugar and pod yield (q/ha); reducing sugar *via* plant height, average pod weight, weight of 100 seeds, T.S.S., non-reducing sugar and pod yield (q/ha); non-reducing sugars through plant height, average pod weight, weight of 100 seeds, T.S.S. and reducing sugars exerted positive direct effect on pod yield per plant; Pod yield/plot (kg) and pod yield (q/ha) *via*days taken for first flowering, protein content, T.S.S., reducing sugar, non-reducing sugars and pod yield per plotexhibited positive indirect effects on pod yield per plant. Similar results were also observed by earlier workers Jogdhande*et al.* (2017), Lokesh and Murthy (2017), Kamble *et al.* (2019) and Tambitkar*et al.* (2020).

However, the direct effects of rest of the characters were either negative or too low to be considered of any consequences indicating their negligible indirect

contribution towards grain yield per plants. The existence of negative as well as positive direct and indirect effects by same character on pod yield per plant *via* one or other character simultaneously, presents a complex situation where a compromise is needed to attain proper balance of different yield components in determining ideotype for high pod yield in cowpea.

4. Conclusion

The pod yield per plant had positive and highly significant correlation with number of green pods perm plant, number of pods per plant, pod diameter (cm), average pod weight (g), number of seeds per pod, weight of 100 seeds (g), T.S.S., total sugars (mg/g fw), reducing sugar ((mg/g fw) and non-reducing sugars (mg/g fw) both at genotypic and phenotypic levels in both the years (first year and second year). This showed that most of the contributing traits had significant positive traits on economic trait.At both the genotypic and phenotypic levels in both years *i.e*., 2020-21 and 2021-22, the direct and indirect effects of the traits Number of nodes on main branches, days taken for first flowering, days to 50% flowering, number of cluster per plant, number of peduncles per plant, pod length (cm), protein content, T.S.S., non-reducing sugars and pod yield (q/ha)revealed most of the metric traits were associated with economic yield. Selection will be rewarding for a breeding program including these traits.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

REFERENCES

Darlington, C.D. and Wylie, A.P. (1955). Chromosome atlas of flowering plants. London: George Allen and Unwin.

Mackie, W. W., and Smith, F. L. (1935). Evidence of field hybridization in beans. Agron. J., 27: 903909.

Timko, M.P., Ehlers, J.D. and Roberts, P.A. (2007). Cowpea. In: Kole C (ed) Genome Mapping and Molecular Breeding in Plants, Volume 3, Pulses, Sugar and Tuber Crops, Springer Verlag, Berlin Heidelberg. pp. 49–67.

Anonymous (2022). Annual Progress Report 2021-22, DPD, Bhopal.

Aykroyd, U.R. (1963). Indian Council of Medical Research, Special Report. Vegetable, National Book Trust India, New Delhi, 42: 188-191.

Hedge, J.E. and Hofrieter, B.I. (1962). In: Methods in carbohydrate chemistry. Vol. 17, R.L. Whistler and IN. Bc Miller, eds. Academic Press, New York.

Searle, S.R. (1961). Phenotypic, genotypic and environmental correlations. Biometrics, 17: 474-480.

Dewey, D. R. and Lu. K. H. (1959). Correlation and path coefficient analysis of components of Crested wheat grass. Agronomy Journal, 51 (1): 515-518.

Sharma, M., Sharma, P. P., Upadhyay, B. and Bairwa, H. L. (2016). Study of correlation coefficient and path analysis in cowpea [Vigna unguiculata (L.)Walp] germplasm line. International Journal of Development Research,6(8): 9011-9016.

Lokesh, G. Y. and Murthy, N. (2017). Correlation and path analysis studies in F2population of cowpea. (Vigna unguiculata (L.) Walp.) Int. J. Pure App. Biosci., 6 (1): 279-283.

Pushkar, P. S., Kumar, S., Meena, R., Kumar, P. and Tribhuvan, R. (2018). Correlation and path analysis in cowpea [Vigna unguiculata (L.) Walp.].Int. J. Pure App. Bio. sci., 6 (5): 142-146.

Waghmare, P. D., Pethe. U. B. and Sabale, G. R. (2018). Study on correlationand path analysis for yield and yield components in cowpea

[Vigna unguiculata (L.) Walp]. Int.J.Curr.Microbiol.App.Sci., 8 (12): 296-303.

Kamble, A. S. Wankhade, M. P., Deshmukh, J. D., Chavan, B. R. and Shinde, A.V. (2019). Correlation studies in cowpea (Vigna unguiculata L.). Journalof Pharmacognosy and Phytochemistry, 8 (3): 321-323.

Das, S., Karak, C. and Roy, (2020). Genetic Variability, Correlation and PathAnalysis Studies in cowpea [Vigna unguiculata (L.) Walp.]. InternationalJournal of Economic Plants, 7 (3): 123-128.

Nagalakshmi, R. M., Usha, K. and Anand, K. (2020). Correlation and pathanalysis in cowpea (Vigna unguiculata (L.) Walp). The InternationalQuaternary Journal on Life Science, 15 (3): 397-401.

Kavyashree, N.M., Sanjeev, K.D., Patil, B.R., Hegde, M.G., Shamarao, J. (2023).Genetic Variability and Character Association Studies on Yield and YieldAttributing Traits in Grain Type Cowpea (Vigna unguiculata (L.) Walp.).International Journal of Bio-resource and Stress Management, 14(1): 012-018.

Ajayi, A.T. (2023). Genetic Variability of Quantitative Traits in F2 Hybrids of Cowpea and Parent Lines. J Genet Resour., 9(1): 1-10.

Jogdhande, S., Vijay, S., Kale and Nagrev, P. K. (2017). Correlation and pathanalysis study in cowpea [Vigna unguiculata (L.) Walp.] genotypes. International Journal of Current Microbiology and Applied Sciences, 6(6): 3305-3313.

Table 1 (a): Genotypic correlation coefficient among 26 traits of cowpea genotypes during 2020-21 (FIRST YEAR)

Characters	Plant Height (cm)	Number of branches per plant	Number of nodes on main branches	Days taken for first flowering	Days to 50% flowering	Number of cluster per plant	Number of flower per cluster	Number of green pods per cluster	Number of peduncles per plant	Number of pods per peduncle	Days to physiological maturity	Days to first picking	Number of pods per plant
	1	2	3	4	5	6	7	8	9	10	11	12	13
Plant Height (cm)	1.000	0.589**	-0.705**	0.515**	0.399**	-0.304**	0.073	0.168	0.515**	0.031	0.412**	0.615**	-0.029
Numberof branches per plant		1.000	-0.502**	0.656**	0.466**	0.005	0.155	0.172	0.238*	0.080	0.538**	0.650**	-0.318**
Numberof nodes on main branches			1.000	-0.365**	-0.194	0.149	-0.136	-0.250*	-0.240*	-0.002	-0.205	-0.380**	0.119
Days taken for first flowering				1.000	0.517**	0.209*	0.159	0.196	0.063	0.185	0.706**	0.728**	-0.213*
Days to 50% flowering					1.000	0.084	0.327**	0.070	0.002	0.536**	0.868**	0.657**	-0.096
Number of cluster per plant						1.000	-0.017	-0.201	0.022	0.013	0.140	0.005	0.098
Number of flower per cluster							1.000	0.021	0.072	0.204	-0.034	0.370**	-0.293**
Number of green pods per cluster								1.000	-0.114	-0.037	0.116	0.010	0.226*
Number of peduncles per plant									1.000	-0.013	0.161	0.423**	0.064
Number of pods per peduncle										1.000	0.592**	0.364**	-0.091
Days to physiological maturity											1.000	0.716**	-0.044
Days to first picking												1.000	0.018
Number of pods per plant													1.000
Pod length (cm)													
Pod diameter (cm)													
Average pod weight (g)													
Number of seeds per pod													
Weight of 100 seeds (g)													
Protein content (%)													
T.S.S													
Total sugars (mg/g fw)													
Reducing sugar ((mg/g fw)													
Non-reducing sugars (mg/g fw)													
Pod yield/plant (g)													
Pod yield/plot (kg)													

Pod yield (q/ha)													

Table 1 (a) continued....

Characters	Pod length (cm)	Pod diameter (cm)	Average pod weight (g)	Number of seeds per pod	Weight of 100 seeds (g)	Protein content (%)	T.S.S	Total sugars (mg/g fw)	Reducing sugar ((mg/g fw)	Non-redu. sugars (mg/g fw)	Pod yield/plant (g)	Pod yield/plot (kg)	Pod yield (q/ha)
	14	15	16	17	18	19	20	21	22	23	24	25	26
Plant Height (cm)	0.223*	-0.252*	0.110	-0.150	-0.348**	-0.170	-0.340**	0.190	0.115	0.120	0.081	0.056	0.054
Numberof branches per plant	0.463**	-0.201	-0.143	-0.211*	-0.242*	-0.389**	-0.126	-0.049	-0.042	-0.111	-0.227*	-0.235*	-0.239*
Numberof nodes on main branches	-0.354**	0.281**	-0.036	0.228*	0.456**	0.216*	0.290**	-0.010	-0.037	0.084	0.011	0.054	0.059
Days taken for first flowering	0.291**	-0.127	-0.091	0.008	-0.236*	-0.172	-0.071	0.072	0.156	-0.008	-0.136	-0.130	-0.133
Dyas to 50% flowering	0.148	-0.308**	-0.143	-0.096	-0.301**	-0.013	-0.090	-0.049	0.016	-0.072	-0.107	-0.070	-0.067
Number of cluster per plant	0.234*	0.141	-0.052	-0.002	0.033	-0.222*	-0.154	-0.178	-0.057	-0.294**	0.010	0.052	0.052
Number of flower per cluster	-0.121	-0.323**	-0.202	-0.087	-0.044	-0.112	-0.018	-0.252*	-0.280**	-0.326**	-0.310**	-0.327**	-0.324**
Number of green pods per cluster	0.076	-0.110	0.349**	0.267*	0.028	0.136	0.243*	0.132	0.192	0.192	0.304**	0.287**	0.297**
Number of peduncles per plant	-0.174	-0.075	0.352**	0.023	-0.126	-0.256*	-0.072	0.231*	0.150	0.130	0.200	0.171	0.163
Number of pods per peduncle	-0.051	0.035	-0.012	0.063	-0.019	0.160	-0.115	-0.034	0.004	0.006	-0.026	0.001	0.000
Days to physiological maturity	0.155	-0.085	-0.008	0.141	-0.307**	0.218*	-0.052	0.013	0.179	0.006	0.002	0.046	0.058
Days to first picking	0.136	-0.114	0.138	-0.041	-0.109	-0.173	0.033	0.317**	0.297**	0.249*	0.110	0.112	0.104
Number of pods per plant	-0.050	0.417**	0.658**	0.311**	0.520**	0.256*	0.193	0.523**	0.495**	0.547**	0.922**	0.924**	0.928**
Pod length (cm)	1.000	0.048	-0.065	-0.178	0.095	-0.204	-0.332**	0.071	0.135	0.009	-0.001	0.025	0.016
Pod diameter (cm)		1.000	0.247*	0.504**	0.794**	0.662**	0.084	0.278**	0.202	0.236*	0.370**	0.404**	0.403**
Average pod weight (g)			1.000	0.386**	0.456**	0.053	0.231*	0.639**	0.647**	0.556**	0.863**	0.842**	0.843**
Number of seeds per pod				1.000	0.486**	0.685**	0.317**	0.154	0.190	0.220*	0.326**	0.336**	0.339**
Weight of 100 seeds (g)					1.000	0.499**	0.186	0.411**	0.333**	0.344**	0.504**	0.526**	0.528**
Protein content (%)						1.000	0.259*	-0.109	-0.115	-0.052	0.163	0.224*	0.225*
T.S.S							1.000	0.239*	0.257*	0.325**	0.238*	0.252*	0.245*
Total sugars (mg/g fw)								1.000	0.949**	0.928**	0.638**	0.638**	0.635**
Reducing sugar ((mg/g fw)									1.000	0.853**	0.628**	0.640**	0.637**
Non-reducing sugars (mg/g fw)										1.000	0.619**	0.620**	0.617**
Pod yield/plant (g)											1.000	0.996**	0.994**

Pod yield/plot (kg)												1.000	0.995**
Pod yield (q/ha)													1.000

*, ** significant at 5% and 1% level, respectively.

Table 1 (b): Phenotypic correlation coefficient among 26 traits of cowpea genotypes during 2020-21 (FIRST YEAR)

Characters	Plant Height (cm)	Number of branches per plant	Number of nodes on main branches	Days taken for first flowering	Dyas to 50% flowering	Number of cluster per plant	Number of flower per cluster	Number of green pods per cluster	Number of peduncles per plant	Number of pods per peduncle	Days to physiological maturity	Days to first picking	Number of pods per plant
	1	2	3	4	5	6	7	8	9	10	11	12	13
Plant Height (cm)	1.000	0.579**	-0.696**	0.489**	0.349**	-0.292**	0.061	0.162	0.510**	0.030	0.261*	0.553**	-0.024
Numberof branches per plant		1.000	-0.495**	0.610**	0.426**	0.000	0.158	0.168	0.230*	0.080	0.361**	0.577**	-0.315**
Numberof nodes on main branches			1.000	-0.352**	-0.192	0.150	-0.144	-0.235*	-0.237*	-0.001	-0.131	-0.349**	0.114
Days taken for first flowering				1.000	0.414**	0.175	0.140	0.172	0.080	0.173	0.438**	0.636**	-0.202
Dyas to 50% flowering					1.000	0.063	0.257*	0.072	-0.020	0.487**	0.555**	0.545**	-0.087
Number of cluster per plant						1.000	-0.032	-0.200	0.023	0.009	0.128	-0.003	0.095
Number of flower per cluster							1.000	0.007	0.051	0.202	-0.074	0.337**	-0.279**
Number of green pods per cluster								1.000	-0.116	-0.046	0.108	0.001	0.222*
Number of peduncles per plant									1.000	-0.018	0.075	0.403**	0.060
Number of pods per peduncle										1.000	0.379**	0.314**	-0.086
Days to physiological maturity											1.000	0.371**	-0.052
Days to first picking												1.000	0.007
Number of pods per plant													1.000
Pod length (cm)													
Pod diameter (cm)													
Average pod weight (g)													
Number of seeds per pod													
Weight of 100 seeds (g)													
Protein content (%)													
T.S.S													
Total sugars (mg/g fw)													
Reducing sugar ((mg/g fw)													

Non-reducing sugars (mg/g fw)													
Pod yield/plant (g)													
Pod yield/plot (kg)													
Pod yield (q/ha)													

Table 1 (b) continued....

Characters	Pod length (cm)	Pod diameter (cm)	Average pod weight (g)	Number of seeds per pod	Weight of 100 seeds (g)	Protein content (%)	T.S.S	Total sugars (mg/g fw)	Reducing sugar ((mg/g fw)	Non-redu. sugars (mg/g fw)	Pod yield/plant (g)	Pod yield/plot (kg)	Pod yield (q/ha)
	14	15	16	17	18	19	20	21	22	23	24	25	26
Plant Height (cm)	0.219*	-0.250*	0.107	-0.146	-0.338**	-0.169	-0.333**	0.189	0.113	0.119	0.080	0.055	0.053
Numberof branches per plant	0.466**	-0.198	-0.144	-0.208*	-0.240*	-0.265*	-0.128	-0.051	-0.041	-0.110	-0.223*	-0.232*	-0.238*
Numberof nodes on main branches	-0.348**	0.299**	-0.036	0.214*	0.447**	0.151	0.305**	-0.014	-0.038	0.083	0.013	0.057	0.060
Days taken for first flowering	0.254*	-0.135	-0.060	0.003	-0.229*	-0.160	-0.077	0.092	0.134	-0.013	-0.132	-0.122	-0.121
Dyas to 50% flowering	0.143	-0.315**	-0.138	-0.028	-0.288**	-0.019	-0.091	-0.056	0.049	-0.073	-0.105	-0.060	-0.057
Number of cluster per plant	0.222*	0.146	-0.062	-0.009	0.048	-0.207*	-0.147	-0.177	-0.058	-0.279**	0.007	0.050	0.051
Number of flower per cluster	-0.115	-0.300**	-0.188	-0.096	-0.053	0.074	-0.047	-0.243*	-0.267*	-0.313**	-0.284**	-0.317**	-0.310**
Number of green pods per cluster	0.075	-0.103	0.344**	0.264*	0.024	0.085	0.253*	0.125	0.187	0.189	0.296**	0.290**	0.289**
Number of peduncles per plant	-0.165	-0.073	0.348**	0.020	-0.121	-0.232*	-0.075	0.240*	0.137	0.128	0.194	0.168	0.163
Number of pods per peduncle	-0.054	0.035	-0.014	0.063	-0.020	0.146	-0.113	-0.037	0.014	0.003	-0.022	-0.002	0.001
Days to physiological maturity	0.117	-0.056	-0.012	0.085	-0.189	0.061	-0.013	0.007	0.109	0.040	-0.019	0.042	0.024
Days to first picking	0.086	-0.090	0.129	-0.031	-0.112	-0.097	0.011	0.301**	0.265*	0.220*	0.104	0.092	0.096
Number of pods per plant	-0.052	0.399**	0.652**	0.305**	0.515**	0.190	0.192	0.514**	0.494**	0.541**	0.916**	0.917**	0.920**
Pod length (cm)	1.000	0.034	-0.073	-0.164	0.091	-0.149	-0.325**	0.070	0.125	0.013	-0.002	0.025	0.019
Pod diameter (cm)		1.000	0.234*	0.465**	0.774**	0.508**	0.102	0.266*	0.192	0.230*	0.365**	0.393**	0.392**
Average pod weight (g)			1.000	0.373**	0.446**	0.046	0.224*	0.637**	0.632**	0.549**	0.852**	0.837**	0.834**
Number of seeds per pod				1.000	0.464**	0.491**	0.305**	0.152	0.194	0.212*	0.313**	0.330**	0.335**
Weight of 100 seeds (g)					1.000	0.365**	0.182	0.404**	0.327**	0.345**	0.499**	0.519**	0.522**
Protein content (%)						1.000	0.144	-0.102	-0.091	-0.043	0.148	0.163	0.171
T.S.S							1.000	0.227*	0.252*	0.317**	0.233*	0.252*	0.238*
Total sugars (mg/g fw)								1.000	0.926**	0.920**	0.628**	0.633**	0.631**

Reducing sugar ((mg/g fw)									1.000	0.837**	0.624**	0.630**	0.630**
Non-reducing sugars (mg/g fw)										1.000	0.612**	0.617**	0.612**
Pod yield/plant (g)											1.000	0.985**	0.990**
Pod yield/plot (kg)												1.000	0.994**
Pod yield (q/ha)													1.000

*, ** significant at 5% and 1% level, respectively.

Table 2 (a): Genotypic correlation coefficient among 26 traits of cowpea genotypes during 2021-22 (SECOND YEAR)

Characters	Plant Height (cm)	Number of branches per plant	Number of nodes on main branches	Days taken for first flowering	Dyas to 50% flowering	Number of cluster per plant	Number of flower per cluster	Number of green pods per cluster	Number of peduncles per plant	Number of pods per peduncle	Days to physiological maturity	Days to first picking	Number of pods per plant
	1	2	3	4	5	6	7	8	9	10	11	12	13
Plant Height (cm)	1.000	0.552**	-0.713**	0.471**	0.392**	-0.314**	0.055	0.137	0.520**	0.012	0.354**	0.603**	0.002
Numberof branches per plant		1.000	-0.451**	0.676**	0.523**	0.004	0.248*	0.130	0.170	0.129	0.457**	0.638**	-0.324**
Numberof nodes on main branches			1.000	-0.287**	-0.141	0.190	-0.099	-0.239*	-0.241*	0.016	-0.133	-0.382**	0.087
Days taken for first flowering				1.000	0.507**	0.249*	0.112	0.021	0.068	0.232*	0.727**	0.757**	-0.190
Dyas to 50% flowering					1.000	0.058	0.320**	0.016	-0.013	0.552**	0.837**	0.617**	-0.043
Number of cluster per plant						1.000	0.008	-0.186	0.015	0.039	0.121	-0.007	0.067
Number of flower per cluster							1.000	0.121	0.100	0.225*	0.045	0.369**	-0.308**
Number of green pods per cluster								1.000	-0.058	-0.076	-0.057	0.008	0.206
Number of peduncles per plant									1.000	-0.036	0.001	0.408**	0.046
Number of pods per peduncle										1.000	0.519**	0.350**	-0.075
Days to physiological maturity											1.000	0.500**	-0.235*
Days to first picking												1.000	0.049
Number of pods per plant													1.000
Pod length (cm)													
Pod diameter (cm)													
Average pod weight (g)													
Number of seeds per pod													
Weight of 100 seeds (g)													

Protein content (%)													
T.S.S													
Total sugars (mg/g fw)													
Reducing sugar ((mg/g fw)													
Non-reducing sugars (mg/g fw)													
Pod yield/plant (g)													
Pod yield/plot (kg)													
Pod yield (q/ha)													

Table 2 (a) continued....

Characters	Pod length (cm)	Pod diameter (cm)	Average pod weight (g)	Number of seeds per pod	Weight of 100 seeds (g)	Protein content (%)	T.S.S	Total sugars (mg/g fw)	Reducing sugar ((mg/g fw)	Non-redu. sugars (mg/g fw)	Pod yield/plant (g)	Pod yield/plot (kg)	Pod yield (q/ha)
	14	15	16	17	18	19	20	21	22	23	24	25	26
Plant Height (cm)	0.210*	-0.234*	0.107	-0.310**	-0.315**	-0.291**	-0.314**	0.167	0.140	0.136	0.100	0.077	0.069
Numberof branches per plant	0.431**	-0.282**	-0.198	-0.322**	-0.251*	-0.493**	-0.117	-0.086	-0.015	-0.115	-0.275**	-0.279**	-0.275**
Numberof nodes on main branches	-0.324**	0.300**	-0.024	0.250*	0.428**	0.219*	0.245*	0.040	-0.085	0.093	-0.007	0.039	0.048
Days taken for first flowering	0.304**	-0.098	-0.099	-0.254*	-0.207*	-0.182	-0.019	0.084	0.184	0.017	-0.149	-0.138	-0.140
Dyas to 50% flowering	0.171	-0.279**	-0.122	-0.267*	-0.258*	0.013	-0.062	-0.059	0.010	-0.111	-0.051	-0.007	-0.015
Number of cluster per plant	0.240*	0.154	-0.049	-0.074	0.030	-0.191	-0.153	-0.177	-0.079	-0.203	-0.019	0.016	0.026
Number of flower per cluster	-0.102	-0.322**	-0.179	-0.189	-0.043	-0.156	-0.062	-0.258*	-0.343**	-0.209*	-0.294**	-0.313**	-0.316**
Number of green pods per cluster	0.122	-0.148	0.296**	0.259*	0.002	0.050	0.170	0.079	0.132	0.075	0.261*	0.241*	0.241*
Number of peduncles per plant	-0.127	-0.007	0.347**	-0.247*	-0.085	-0.422**	-0.136	0.196	0.098	0.197	0.209*	0.182	0.170
Number of pods per peduncle	0.040	0.049	-0.026	-0.181	-0.037	0.100	-0.079	-0.020	0.005	-0.075	-0.030	-0.008	-0.006
Days to physiological maturity	0.062	-0.334**	-0.202	-0.302**	-0.505**	-0.095	-0.159	-0.132	0.030	-0.276**	-0.206	-0.160	-0.162
Days to first picking	0.132	-0.101	0.150	-0.283**	-0.100	-0.244*	0.056	0.289**	0.314**	0.254*	0.115	0.132	0.112
Number of pods per plant	-0.023	0.424**	0.640**	0.450**	0.525**	0.159	0.202	0.532**	0.562**	0.493**	0.918**	0.915**	0.920**
Pod length (cm)	1.000	0.035	-0.011	0.001	0.124	-0.178	-0.331**	0.076	0.219*	0.045	0.016	0.035	0.036
Pod diameter (cm)		1.000	0.251*	0.533**	0.797**	0.624**	0.077	0.310**	0.262*	0.301**	0.367**	0.404**	0.411**
Average pod weight (g)			1.000	0.337**	0.417**	-0.055	0.188	0.646**	0.640**	0.611**	0.858**	0.845**	0.841**
Number of seeds per pod				1.000	0.658**	0.702**	0.373**	0.126	0.204	0.109	0.405**	0.441**	0.438**

Weight of 100 seeds (g)					1.000	0.468**	0.149	0.444**	0.390**	0.460**	0.480**	0.506**	0.515**
Protein content (%)						1.000	0.276**	-0.105	-0.105	-0.125	0.077	0.128	0.123
T.S.S							1.000	0.204	0.242*	0.187	0.241*	0.248*	0.244*
Total sugars (mg/g fw)								1.000	0.910**	0.991**	0.628**	0.634**	0.631**
Reducing sugar ((mg/g fw)									1.000	0.845**	0.660**	0.680**	0.676**
Non-reducing sugars (mg/g fw)										1.000	0.579**	0.583**	0.581**
Pod yield/plant (g)											1.000	0.997**	0.995**
Pod yield/plot (kg)												1.000	0.998**
Pod yield (q/ha)													1.000

*, ** significant at 5% and 1% level, respectively.

Table 2 (b): Phenotypic correlation coefficient among 26 traits of cowpea genotypes during 2021-22 (SECOND YEAR)

Characters	Plant Height (cm)	Number of branches per plant	Number of nodes on main branches	Days taken for first flowering	Dyas to 50% flowering	Number of cluster per plant	Number of flower per cluster	Number of green pods per cluster	Number of peduncles per plant	Number of pods per peduncle	Days to physiological maturity	Days to first picking	Number of pods per plant
	1	2	3	4	5	6	7	8	9	10	11	12	13
Plant Height (cm)	1.000	0.539**	-0.697**	0.436**	0.368**	-0.310**	0.064	0.130	0.508**	0.014	0.239*	0.559**	0.004
Numberof branches per plant		1.000	-0.448**	0.646**	0.458**	0.006	0.236*	0.132	0.164	0.127	0.326**	0.560**	-0.318**
Numberof nodes on main branches			1.000	-0.293**	-0.131	0.179	-0.087	-0.235*	-0.233*	0.009	-0.098	-0.329**	0.078
Days taken for first flowering				1.000	0.399**	0.234*	0.097	0.025	0.066	0.228*	0.411**	0.639**	-0.172
Dyas to 50% flowering					1.000	0.031	0.234*	0.011	-0.011	0.498**	0.573**	0.468**	-0.041
Number of cluster per plant						1.000	-0.003	-0.189	0.016	0.038	0.090	0.003	0.061
Number of flower per cluster							1.000	0.105	0.075	0.223*	0.017	0.335**	-0.290**
Number of green pods per cluster								1.000	-0.061	-0.082	-0.023	-0.002	0.204
Number of peduncles per plant									1.000	-0.040	-0.042	0.374**	0.045
Number of pods per peduncle										1.000	0.335**	0.302**	-0.071
Days to physiological maturity											1.000	0.243*	-0.181
Days to first picking												1.000	0.034
Number of pods per plant													1.000
Pod length (cm)													

Pod diameter (cm)													
Average pod weight (g)													
Number of seeds per pod													
Weight of 100 seeds (g)													
Protein content (%)													
T.S.S													
Total sugars (mg/g fw)													
Reducing sugar ((mg/g fw)													
Non-reducing sugars (mg/g fw)													
Pod yield/plant (g)													
Pod yield/plot (kg)													
Pod yield (q/ha)													

Table 2 (b) continued....

Characters	Pod length (cm)	Pod diameter (cm)	Average pod weight (g)	Number of seeds per pod	Weight of 100 seeds (g)	Protein content (%)	T.S.S	Total sugars (mg/g fw)	Reducing sugar ((mg/g fw)	Non-redu. sugars (mg/g fw)	Pod yield/plant (g)	Pod yield/plot (kg)	Pod yield (q/ha)
	14	15	16	17	18	19	20	21	22	23	24	25	26
Plant Height (cm)	0.200	-0.233*	0.109	-0.301**	-0.312**	-0.216*	-0.312**	0.165	0.140	0.136	0.101	0.073	0.068
Numberof branches per plant	0.429**	-0.277**	-0.198	-0.314**	-0.247*	-0.372**	-0.111	-0.088	-0.018	-0.113	-0.273**	-0.274**	-0.274**
Numberof nodes on main branches	-0.306**	0.304**	-0.026	0.229*	0.420**	0.180	0.235*	0.040	-0.089	0.092	-0.005	0.039	0.049
Days taken for first flowering	0.272**	-0.093	-0.082	-0.237*	-0.206	-0.119	-0.015	0.081	0.176	0.012	-0.146	-0.127	-0.135
Dyas to 50% flowering	0.172	-0.277**	-0.099	-0.185	-0.248*	-0.089	-0.060	-0.047	0.024	-0.100	-0.052	-0.016	0.002
Number of cluster per plant	0.226*	0.163	-0.054	-0.066	0.045	-0.172	-0.157	-0.175	-0.078	-0.196	-0.018	0.016	0.021
Number of flower per cluster	-0.107	-0.306**	-0.161	-0.205	-0.042	0.039	-0.077	-0.255*	-0.322**	-0.197	-0.274**	-0.302**	-0.307**
Number of green pods per cluster	0.119	-0.149	0.289**	0.257*	-0.006	0.034	0.191	0.074	0.121	0.074	0.257*	0.242*	0.235*
Number of peduncles per plant	-0.121	-0.007	0.340**	-0.240*	-0.079	-0.369**	-0.134	0.206	0.091	0.190	0.205	0.181	0.172
Number of pods per peduncle	0.038	0.046	-0.025	-0.176	-0.037	0.107	-0.090	-0.023	0.018	-0.078	-0.032	-0.010	-0.006
Days to physiological maturity	0.054	-0.244*	-0.127	-0.209*	-0.352**	-0.083	-0.067	-0.127	0.002	-0.136	-0.154	-0.116	-0.114
Days to first picking	0.075	-0.065	0.125	-0.235*	-0.089	-0.206	0.045	0.268*	0.267*	0.222*	0.131	0.102	0.098
Number of pods per plant	-0.025	0.403**	0.636**	0.434**	0.518**	0.125	0.196	0.528**	0.558**	0.486**	0.908**	0.911**	0.910**

Pod length (cm)	1.000	0.021	-0.016	0.003	0.118	-0.117	-0.321**	0.076	0.209*	0.047	0.012	0.031	0.044
Pod diameter (cm)		1.000	0.237*	0.505**	0.783**	0.452**	0.071	0.298**	0.256*	0.293**	0.360**	0.396**	0.396**
Average pod weight (g)			1.000	0.325**	0.407**	-0.032	0.181	0.638**	0.629**	0.608**	0.848**	0.837**	0.835**
Number of seeds per pod				1.000	0.635**	0.478**	0.364**	0.123	0.200	0.102	0.400**	0.423**	0.431**
Weight of 100 seeds (g)					1.000	0.348**	0.137	0.440**	0.382**	0.455**	0.474**	0.504**	0.507**
Protein content (%)						1.000	0.176	-0.111	-0.062	-0.096	0.066	0.088	0.093
T.S.S							1.000	0.195	0.223*	0.186	0.236*	0.249*	0.235*
Total sugars (mg/g fw)								1.000	0.892**	0.977**	0.622**	0.629**	0.630**
Reducing sugar ((mg/g fw)									1.000	0.827**	0.648**	0.669**	0.666**
Non-reducing sugars (mg/g fw)										1.000	0.573**	0.578**	0.576**
Pod yield/plant (g)											1.000	0.986**	0.987**
Pod yield/plot (kg)												1.000	0.992**
Pod yield (q/ha)													1.000

*, ** significant at 5% and 1% level, respectively.