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ANALYSIS OF TRAIT ASSOCIATION IN COWPEA (*VIGNA UNGUICULATA* L. WALP) GENOTYPES UNDER SUMMER CONDITIONS

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ABSTRACT

The present investigation was conducted at the Dry Land Research Area, CCS Haryana Agricultural University, Hisar during the Summer, of 2021. Data were recorded on 12 quantitative traits to study for yield and its attributing traits among 48 cowpea genotypes. The amplitude of genotypic correlation coefficients among 12 traits was greater than their phenotypic correlation coefficients, indicating an innate relationship between various characters having far less impact on the environment. The seed yield per plant was found to have a positive and significant correlation with the number of branches per plant, pods per plant, clusters per plant, pods per cluster, and 100-seed weight. This suggests that selecting plants based on these traits would effectively enhance seed yield. To assess the real contribution of an individual character toward seed yield per plant correlation studies alone are not sufficient. Path analysis identified key traits contributing directly to seed yield, including days to 50% flowering, plant height, number of branches per plant, seeds per pod, pods per cluster and 100-seed weight. The strong direct effects of pods per cluster, branches per plant, and seeds per pod indicate their importance as yield components. The present study revealed that characters *viz*., number of pods per plant, number of branches, and plant height would be selected as important ones towards seed yield for the cowpea improvement program. Therefore, indirect selection using these traits would be a promising approach for improving seed yield per plant in a cowpea breeding program.

Key words : Cowpea, Grain-Yield, Path coefficient, Correlation.

Introduction

Cowpea (*Vigna unguiculata* L. Walp) is an economically significant legume predominantly cultivated in sub-Saharan Africa and parts of Asia, characterized by its impressive adaptability to diverse agroclimatic conditions, particularly in drought-prone regions. It is an adaptable, vascular, annual legume that thrives in warm seasons. It is classified within the Fabaceae family, specifically in the subtribe Phaeseolinae, genus Vigna, and section Catjang. All cultivated varieties of cowpeas fall under the *V. unguiculata* subspecies unguiculata. The cowpea thrives optimally in flatland environments, where temperatures fluctuate between 25 to 35°C and annual precipitation varies from 750 to 1100 mm (Drahansky *et al*., 2016). It exhibits greater resilience to sandy soils and drought conditions compared to soybeans. This legume can flourish in multiple soil types, provided that they possess good drainage. As a vital source of high-quality protein, cowpea seeds contain approximately 25% protein and 64% carbohydrates, making them an essential food source for millions in resource-limited settings (Abebe *et al*., 2022). In India, cowpea is grown as sole, inter-crop, mixed-crop and in agro-forestry combinations (Nguyen *et al*., 2019a). The crop's resilience to abiotic stresses, particularly drought, allows it to thrive during the *Kharif* season, where it occupies substantial acreage. Moreover, cowpea exhibits high biomass production, making it an important fodder crop contributing to animal husbandry. The plant holds multipurpose utility, with various edible parts—including dry seeds, immature pods and green leaves—being consumed. In addition to that, it also enhances soil fertility through nitrogen fixation and serves as a sustainable cover crop, supporting ecological balance and maintaining soil health in agricultural systems (Panchta *et al.*, 2020). Correlation studies play a vital role in the selection process when highly heritable traits are linked to a crucial character like yield. However, yield is a complex trait controlled by many factors such as polygene, environment, and genetic variability. By studying genotypic variability, heritability, and inter-trait correlations, breeders can prioritize traits that contribute significantly to crop performance under challenging conditions. This is particularly relevant for summer cultivation, where high temperatures and limited water availability can constrain growth and productivity. Since the correlation coefficient measures only the relationship between two characters and does not reveal the relative importance of each trait, this study was conducted to determine the nature of the relationship between grain yield and yield components. So to study the interrelationship and influential patterns of some important yield components on cowpea grain yield by adopting path coefficient analysis tools. The path-coefficient analysis measures one variable's direct and indirect influence on another. To evaluate each character's contribution to yield, it measures the interactions between various components, regardless of whether they directly affect yield or undergo indirect effects. The results will then be used as selection criteria for the improvement of grain yield in cowpeas under summer conditions.

Materials and Methods

The experiment was conducted at the Forage research area of the Department of Genetics & Plant Breeding, CCSHAU, Hisar during the summer season 2021. The experimental plant material for the present investigation was comprised of 48 genotypes of cowpea [*Vigna unguiculata* (L) Walp]. Each genotype was grown in a randomized complete block design (RCBD) with three replications. Each genotype was grown in paired rows of 2-meter length, following a row-to-row distance of 45 cm and plant-to-plant spacing of 15 cm. Observations were recorded for 12 traits *viz.*, days to 50% flowering, days to maturity, plant height (cm), number of pods per cluster, number of clusters per plant, number of pods per plant, number of seeds per pod, pod length (cm), number of branches per plant,100 seed weight (g), seed yield per plant (g), crude protein content (%). Five randomly selected plants from the middle of each row were taken for all traits under the study. The crude protein content was determined by multiplying the nitrogen content obtained by the Micro Kjeldhal method (Stuart, 1936) with a factor of 6.25 (Dubetz and Welis, 1968). The mean performance of individual genotypes was recorded and employed for statistical analysis. The phenotypic and genotypic correlation coefficients between possible pairs of all characters were calculated according to Al-Jibouri *et al.* (1958). The estimation of the direct and indirect effect of various independent characters on yield as dependent characters was determined according to the method suggested by Dewey and Lu (1959).

Results and Discussion

Correlation analysis defines the relationship between dependent traits and independent traits. We investigated the correlation coefficients between several quantitative features at the phenotypic and genotypic levels Table 1.2 presents these findings. The amplitude of genotypic correlation coefficients among 12 traits was greater than their phenotypic correlation coefficients, indicating an innate relationship between various characters having far less impact on the environment. According to Kumar *et al.* (2016), correlation analysis aids the breeder in efficiently devising the selection strategy for seed yield, which is related to numerous component traits and controlled by multiple genes and is therefore quite complex. The genotypic correlation of Seed yield per plant was positively and significantly associated with the number of branches per plant (0.589), number of pods per plant (0.593), number of clusters per plant (0.275), number of pods per cluster (0.575) and 100 seed weight (0.561). The genotypic correlation of seed yield per plant was negatively and significantly associated with pod length (-0.237). Seed yield per plant was positively and significantly associated with the pods per plant, seeds per pod, pods per cluster, number of branches per plant, cluster per plant and 100 seed weight, indicating simultaneous selection based on these characteristics would be effective for seed yield. Days to 50% flowering had a negative and significant correlation with the number of clusters per plant, the number of pods per cluster and had a positive correlation with crude protein. The results also supported by Walle *et al.* (2018), Bamji *et al.* (2020), Chaudhary *et al.* (2020), Snehal *et al.* (2021), Kumar *et al.* (2016) and Ugale *et al.* (2020). The number of branches per plant and the number of seeds per pod were positively and significantly correlated with days to maturity, while the number of clusters per plant and crude protein content were negatively correlated. Dinesh *et al.* (2017) and Walle *et al.* (2018) found a negative and substantial correlation between pod length and 100 seed weight, crude protein content and seed output per plant.

Table 1 : Genotypic (below) and phenotypic correlation (above the diagonal) correlation coefficient among genotypes of cowpea.

	Days to flowering	Day to maturity	Plant height	No of Branches /plant	No. of pod /plant	No. of cluster/ plant	No. of pod/ cluster	No. of seed/pod	Pod length	100 seed weight	Crude Protein content	Seed yield /plant
Days to flowering	**1.000**	-0.035	-0.019	0.021	-0.068	-0.162	-0.158	-0.018	-0.059	-0.118	0.100	-0.086
Day to maturity	-0.038	**1.000**	-0.001	**0.217****	0.047	-0.158	0.118	**0.180***	0.029	0.084	**-0.210***	0.078
Plant height	-0.050	-0.003	**1.000**	-0.136	0.029	-0.034	**-0.182***	0.134	0.058	-0.035	0.007	-0.042
No. of branches/plant	0.025	0.236**	-0.185*	**1.000**	**0.271****	0.160	**0.340****	0.008	**-0.272****	**0.411****	-0.037	**0.559****
No.of pod /plant	-0.071	0.056	0.048	0.284**	**1.000**	**0.399****	**0.308****	0.091	-0.157	**0.496****	-0.113	**0.579****
No.of cluster/plant	-0.180*	-0.170*	-0.034	0.185*	0.410**	**1.000**	0.042	0.048	-0.086	0.052	-0.089	**0.261****
No. of pod /cluster	-0.204*	0.110	-0.348**	0.427**	0.411**	0.000	**1.000**	0.057	-0.160	**0.548****	-0.100	**0.450****
No.of seed/pod	-0.062	0.249**	0.110	0.019	0.134	0.055	-0.097	**1.000**	0.089	0.115	0.136	0.087
Pod length	-0.038	0.025	0.055	-0.318**	-0.201*	-0.086	-0.263**	0.230**	**1.000**	-0.129	-0.123	**-0.198***
100 seed weight	-0.132	0.088	-0.030	0.430**	0.529**	0.054	0.718**	0.190*	-0.179*	**1.000**	-0.132	**0.522****
Crude Protein content	0.135	-0.383**	-0.032	-0.081	-0.193*	-0.098	-0.195*	0.251**	-0.322**	-0.229**	**1.000**	-0.089
Seed yield /Plant	-0.095	0.077	-0.067	**0.589****	**0.593****	**0.275****	**0.575****	0.135	**-0.237****	**0.561****	-0.147	**1.000**

Table 2 : Direct (diagonal) and indirect effects of various traits on seed yield per plant of Cowpea.

	Days to flowering	Day to maturity	Plant height	No. of Branches/ plant	No. of pod /plant	No. of cluster/ plant	No. of pod/cluster	No. of seed/pod	Pod length	100 seed weight	Crude Protein content
Days to flowering	**0.019**	-0.001	-0.001	0.001	-0.001	-0.004	-0.004	-0.001	-0.001	-0.003	0.003
Day to maturity	0.007	**-0.186**	0.001	-0.044	-0.010	0.032	-0.021	-0.046	-0.005	-0.016	0.071
Plant height	-0.005	0.000	**0.109**	-0.020	0.005	-0.004	-0.038	0.012	0.006	-0.003	-0.004
No. of Branches/plant	0.010	0.096	-0.075	**0.407**	0.116	0.075	0.174	0.008	-0.130	0.175	-0.033
No. of pod /plant	-0.021	0.017	0.015	0.086	**0.303**	0.124	0.125	0.041	-0.061	0.161	-0.058
No. of cluster/plant	-0.004	-0.004	-0.001	0.004	0.010	**0.023**	0.000	0.001	-0.002	0.001	-0.002
No. of pod /cluster	-0.087	0.047	-0.147	0.181	0.174	0.000	**0.423**	-0.041	-0.111	0.304	-0.083
No. of seed/pod	-0.015	0.062	0.027	0.005	0.033	0.014	-0.024	**0.248**	0.057	0.047	0.062
Pod length	0.003	-0.002	-0.004	0.022	0.014	0.006	0.018	-0.016	**-0.070**	0.013	0.023
100 Seed weight	0.020	-0.014	0.005	-0.066	-0.082	-0.008	-0.111	-0.029	0.028	**-0.154**	0.035
Crude protein content	-0.022	0.062	0.005	0.013	0.031	0.016	0.032	-0.041	0.052	0.037	**-0.100**
Seed yield /Plant	-0.095	0.077	-0.067	0.589	0.593	0.275	0.575	0.135	-0.237	0.561	-0.147
Partial R^2	-0.002	-0.014	-0.007	0.240	0.180	0.006	0.243	0.033	0.017	-0.087	0.024

R Square = 0.6326, Residual effect = 0.6061

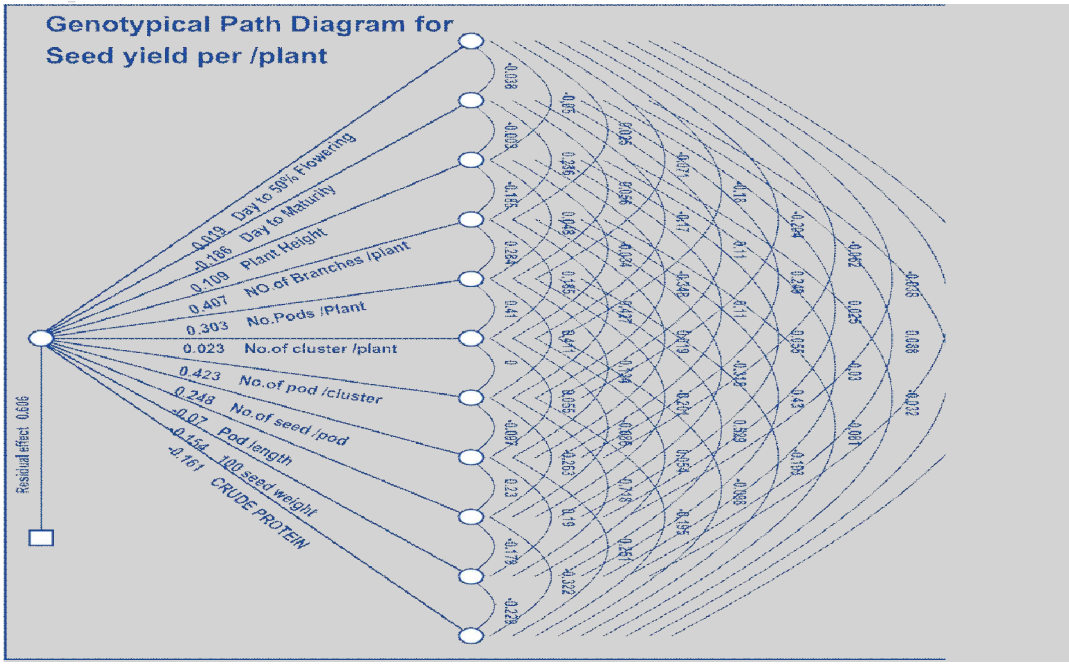

Fig. 1 : Genotypical Path diagram for Seed yield/plant.

Path coefficient analysis

To assess the real contribution of an individual character toward seed yield per plant correlation studies alone are not sufficient. Path coefficient provides a clear and more realistic picture of a complex situation that exists at the correlation level. It measures the direct as well as indirect effect of one variable on the dependent variable through the other traits. The path coefficient analysis was done on genotypic correlations and results have been presented in Table 2.

A perusal data of path coefficient analysis observed that number of pod per cluster (0.423) had highest direct and positive effect on seed yield per plant followed by number of branches per plant (0.4072) number of pod per cluster (0.3031), number of seed per pod (0.247), and days to flowering (0.0190), plant height (0.1085). However, days to maturity (-0.185), pod length (-0.070), 100-seed weight (-0.154) and crude protein content (-0.100) showed high direct and negative effect on seed yield per plant.

Path analysis is a powerful measure to estimate the contribution of direct and indirect effects of various independent characters on a dependent character *i.e.*, seed yield per plant. In the present investigation, direct and indirect effects of various quantitative characters on seed yield per plant are presented. The high direct effect of number of pods per cluster (0.423), number of branches per plant (0.407), pods per plant (0.303), seed per pod (0.247) on seed yield per plant indicated that these are important components of seed yield. Thus, indirect selection for high seed yield per plant based on these characters would be effective. The result of these traits is in agreement with the previous reports by Tsegaye *et al*. (2018) and Bamji *et al*. (2020). Similar findings were earlier supported by Manggoel *et al*. (2012) for number of seeds per pod; by Lal *et al*. (2017); Gupta *et al*. (2019), Panchta *et al*. (2020), Paghadar *et al*. (2019), Das *et al*. (2020) and Snehal *et al*. (2021) for number of pods per plant; by Kumar *et al*. (2016), Srinivas *et al*. (2017), Nguyen *et al*. (2019) and Chaudhary *et al*. (2020) for number of pods per cluster and number of seeds per pod, Dinesh *et al*. (2017) and Patel *et al*. (2016) for number of branches per plant.

Number of seeds per pod and number of branches per plant, number of pods per cluster, and number of clusters per plant and pod length was showed high positive indirect effect on seed yield per plant through number of pods per plant, showing indirect selection through pod per cluster would be effective based on these traits. This result was in accordance with the previous report of Nguyen *et al*. (2019) for seed yield. The similar findings were also supported by Walle *et al*. (2018) and Bamji *et al*. (2020) for number of clusters per plant and pod length by Lal *et al*. (2018), Paghadar *et al*. (2019), Waghmare *et al*. (2019) and Chaudhary *et al*. (2020) for number of seeds per pod and pod length; by Gupta *et al*. (2019) for number of pods per cluster and number of clusters per plant.

The negative indirect effect was shown by days to maturity (-0.0025), plant height (-0.0032) and days to 50%

flowering (-0.0163) via 100-seed weight. The results were confirmed as earlier reported by Patel *et al*. (2016) for plant height; by Bamji *et al*. (2020) for days to maturity. The present study revealed that characters *viz*., number of pods per plant, number of branches, and plant height would be selected as important ones towards seed yield for the cowpea improvement program.

Conclusion

The seed yield per plant was found to have a positive and significant correlation with the number of branches per plant, pods per plant, clusters per plant, pods per cluster and 100-seed weight. This suggests that selecting plants based on these traits would effectively enhance seed yield. Path analysis identified key traits contributing directly to seed yield, including days to 50% flowering, plant height, number of branches per plant, seeds per pod, pods per cluster, and 100-seed weight. The strong direct effects of pods per cluster, branches per plant, and seeds per pod indicate their importance as yield components. Therefore, indirect selection using these traits would be a promising approach for improving seed yield per plant in a cowpea breeding program.

In conclusion, cultivating cowpea in summer conditions highlights the crop's importance as a climate-resilient, nutrient-dense food source. Its adaptability to hot and dry environments, coupled with its multiple uses, makes it a valuable crop for smallholder farmers aiming to enhance food security, soil health, and income. As climate change continues to affect agricultural productivity, cowpea's role in summer cropping systems is likely to become even more significant, offering a reliable solution to the challenges of farming under increasingly unpredictable weather conditions.

Authors contribution

Conceptualization (AD, RP, SR); Preparation of the manuscript (AD, RP, SR); Review and editing (AD, RP, SR, NK, AJ, AD); Editing and final approval (AD, RP, SR). All authors read and approved the manuscript.

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Competing interests

The authors confirm that there are no conflicts of interest associated with this publication.

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