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Trade-offs and Synergies: Understanding the relationship between Traits in Moth Bean *Vigna aconitifolia* (Jacq.)

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KEYWORDS

Moth bean genotypes, Correlation analysis, Path analysis, RBD

ABSTRACT:

An experiment was conducted at the agriculture farm of RNB Global University in Bikaner, Rajasthan, to assess the correlation and path coefficients among 30 different genotypes of moth bean. The study encompassed eight distinct traits: days to reach 50% flowering, days to maturity, plant height (cm), the number of branches per plant, pod length (cm), seed index (g), the number of seeds per pod and grain yield per plant (g). The research was carried out using a randomized block design, with rows spaced at 30 cm intervals and individual plants set 15 cm apart. The analysis of variance showed significant variations among all genotypes for all the traits under investigation. Correlation studies unveiled that grain yield exhibited positive and significant correlations at both phenotypic and genotypic levels with plant height (cm), number of branches per plant, and pod length (cm). Among these traits, the highest direct positive effects on grain yield were associated with the number of seeds per pod, days to 50% flowering, pod length (cm) and plant height (cm). These findings provide valuable insights into the relationships and influential factors contributing to grain yield in moth bean genotypes, facilitating future crop improvement efforts.

Introduction:

Moth bean, a member of the Vigna genus within the Papilionaceae subfamily of the Leguminaceae family, features a distinctive chromosome number of 2n=2×=22. Typically, this plant displays a bushy to semi-erect growth pattern, boasting numerous leaves and a compact stem. Its deep roots grant it remarkable drought tolerance. Historical accounts by De Candolle in 1884, Vavilov in 1926, and Jain and Mehta in 1980 trace the origins of moth bean to India, particularly the plateau of central India, regarded as its primary centre of origin. India takes the lead globally in moth bean cultivation, with significant plantings also found in Pakistan, Sri Lanka, Malaysia, Myanmar, South China, and the United States of America. Moth bean cultivation predominantly takes place in Rajasthan, primarily during the *kharif* season. Rajasthan boasts an impressive share, accounting for 75% of the nation's total cultivation area and 55% of its production, securing the top position in terms of both area (13.87 lakh hectares) and production (4.34 lakh tonnes). Furthermore, the state achieves a commendable productivity rate of 310 kilograms per hectare. In addition to Rajasthan, other states like Uttar Pradesh, Punjab, Haryana, and Madhya Pradesh also cultivate moth beans, primarily on marginal lands. Moth bean, scientifically known as *Vigna aconitifolia*, serves as a crucial pulse crop for the hot, arid regions of India, showcasing its adaptability to extreme ecological niches, especially enduring harsh drought and scorching climatic conditions.

Moth bean seeds stand out as a valuable protein source, containing approximately 22-24% protein content. What makes them particularly significant is their affordability compared to other pulses, making them a staple in the diets of low-income individuals and tribal communities in the rural regions where they are cultivated. Moth bean productivity is 4 quintals per hectare, primarily because it thrives in poor and marginal soils, often without receiving the necessary inputs. This robust legume thrives in hot, arid climates and demonstrates exceptional drought resistance, thanks to its well-developed deep root system. It can withstand high temperatures without compromising its flowering and fruit development. Additionally, It is an important source of hay at par in quality with alfa-alfa. In culinary applications, moth bean takes on various roles, being transformed into Dal (Mogar), sprouts, and green pods for vegetable consumption. Notably, it plays a central role in the creation of the famous spicy snack, *Bikaneri Bhujiya*. Furthermore, the expansive moth bean canopy serves as a natural moisture conservator and protector of soil against erosion. Beyond human consumption, moth bean doubles as green fodder for animals, amplifying its agricultural significance.

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Moth bean has long been considered a neglected crop, primarily from an evolutionary perspective, and consequently, it remains a secondary choice for many farmers. This neglect is further underscored by the scarcity of research efforts and the lack of a systematic literature base concerning this legume. To harness the full potential of moth bean, there is an urgent need for extensive research focusing on its adaptability to diverse environmental conditions, the development of innovative cultivation practices, responses to inputs, and the creation of high-yielding varieties. In any breeding program, the ultimate goal is to achieve high yield, a complex trait influenced by a polygenic system and environmental fluctuations. Direct selection based solely on yield may prove unreliable in many instances. Consequently, a study was undertaken to explore the degree and nature of the relationship between yield and its components. Correlation studies play a vital role in unravelling the associations among various traits and grain yield. This knowledge proves invaluable to breeders seeking to identify genotypes with the desired trait combinations. However, mere correlation coefficients may not suffice for selecting optimal yield components to enhance grain production. It is imperative to determine whether any specific yield component exerts a direct or indirect influence on grain yield, thus facilitating more effective selection studies. By exploring the intricate relationships within the crop's characteristics, researchers can pave the way for the improvement of moth bean yields and its overall agricultural significance.

Correlation analysis, while informative, can be incomplete in revealing the full nature of associations. In contrast, path coefficient analysis efficiently dissects correlation coefficients to measure the direct and indirect influences of independent variables on dependent ones, offering a comprehensive understanding of interrelationships. To gain a more profound insight into cause-and-effect relationships between character pairs, a combination of correlation and path analysis is essential.

Materials and Methods:

In *Kharif* 2022, the research study was conducted at the agricultural farm, the school of agriculture, RNB Global University, Bikaner. The experiment followed a randomized block design with replication. The study involved 30 different genotypes of moth bean. The rows were spaced at 30 cm intervals, and the individual plants were set 15 cm apart. Each experimental plot consisted of two rows, with each row measuring 4 meters in length. Data were collected for eight specific traits: days to reach 50% flowering, days to maturity, plant height (cm), the number of branches per plant, pod length (cm), seed index (g), the number of seeds per pod and grain yield per plant (g). Total rainfall and temperature (max. and min.) on weekly basis are shown in figure 3 and figure 4.Statistical analysis was conducted on the mean values of five plants for all traits except days to 50% flowering and days to maturity. The statistical significance of the data for various characteristics was assessed using the analysis of variance technique described by Panse and Sukhatme (1985). To test the significance of the mean sum of squares for each trait, the data were compared against the corresponding degrees of freedom for error using the F test, as outlined by Fisher and Yates in 1967. Furthermore, correlations between these eight traits were computed based on the method provided by Singh and Chaudhary (1979). Direct and indirect effects were estimated in accordance with the method described by Dewey and Lu (1959).

Results and Discussion:

By simultaneously using selection for yield-related characteristics, the effectiveness of selection may be improved. In the case of quantitative characteristics, the environment has an impact on the genotype, which in turn affects the expression of the phenotype as well as the association and, subsequently, the direction of association between the characters. The ability to measure the strength and direction of a correlation is utilized to determine if a change in one character will result in a change in the other characters at the same time. For indirect yield selection, a large positive correlation coefficient between component traits and grain yield at the genotypic level is crucial. Since there is no acceptable test for genotypic correlation coefficient significance, phenotypic correlation coefficients have received a lot of attention.

In general, the genotypic correlation coefficients were consistently higher than their corresponding phenotypic correlation coefficients (Table 1). This observation underscores the predominance of genetic factors in shaping the expression of traits, while also highlighting the influence of the environment in masking the full potential of genotypes. Sahoo (2022), Soni (2021), Chaudhari (2021), Sahoo (2018), Yadav (2018), Kohakade (2017) and Kumar (2016) reported the similar result. The results on correlation studies revealed that the grain yield per plant exhibited significant and positive association with plant height (0.199*, 0.198*) number of branches of plant (0.499*, 0.505**) and pod length (0.262*, 0.3779*) at both phenotypic and genotypic level. These findings suggested that selection for these characters is likely to be contributed towards high yield. Similar results were found by Sahoo (2022), Sahoo (2018), Yadav (2018) and Vir (2015). Significant and negative association of grain yield per plant was found with days to maturity (-0.511**, -0.523**). Similar findings were reported by Sahoo (2022), Soni (2021), Sahoo (2018), Yadav (2018) and Patil (2007). Therefore, enhancing these characteristics might have a negative impact on the others, potentially leading to an adverse overall gain. Among the inter relationships, significant and positive association were exhibited by days to 50% flowering with days to maturity (0.606**, 0.643**) and plant

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height (0.170*, 0.176*); plant height with number of branches per plant (0.628**, 0.636**), seed index (0.266**), number of seeds per pod (0.357**, 0.359**); number of branches per plant with pod length (0.304**, 0.445**) and seed index (0.0.267**); seed index with number of seeds per pod (0.355**). These results exhibited that simultaneous selection is possible for all these traits. Similar result was observed by Sahoo (2018), Yadav (2018) and Kohakade (2017).

Table-1 : Estimation of Phenotypic (P) and genotypic (G) correlation coefficient for eight traits in moth bean

		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Pod length (cm)	Seed index (g)	Number of seeds per pod	Grain yield per plant (g)
Days to 50% flowering	**P**	1.000	0.606**	0.170*	0.140	-0.062	-0.157	-0.260*	-0.147
	G	1.000	0.643**	0.176*	0.164*	-0.099	0.135	-0.271**	-0.153
Days to maturity	**P**		1.000	-0.132	-0.248*	0.069	-0.158	-0.276**	-0.511**
	G		1.000	-0.135	-0.255	0.108	-0.108	-0.287	-0.523**
Plant height (cm)	**P**			1.000	0.628**	0.061	0.266**	0.357**	0.199*
	G			1.000	0.636**	0.083	0.024	0.359**	0.198*
Number of branches per plant	**P**				1.000	0.304**	0.114	0.077	0.499**
	G				1.000	0.445**	0.267**	0.077	0.505**
Pod length (cm)	**P**					1.000	0.155	-0.061	0.262*
	G					1.000	0.172	-0.079	0.379*
Seed index (g)	**P**						1.000	0.355**	0.135
	G						1.000	0.105	0.035
Number of seeds per pod	**P**							1.000	-0.088
	G							1.000	-0.089
Grain yield per plant (g)	**P**								1.000
	G								1.000

*,** Significant at 5 % and 1 % level of significance, respectively.

Table-2 : Direct (diagonal) and indirect effects (non-diagonal) of different traits on grain yield per plant in moth bean.

		Days to 50% flowering	Days to maturity	Plant height (cm)	Number of branches per plant	Pod length (cm)	Seed index (g)	Number of seeds per pod	Grain yield per plant (g)
Days to 50% flowering	**P**	**0.178**	-0.027	0.008	-0.014	-0.021	0.013	-0.021	-0.147
	G	**0.265**	-0.051	0.008	-0.023	-0.030	-0.014	-0.029	-0.153
Days to maturity	**P**	0.112	**-0.043**	0.011	-0.006	-0.024	0.011	-0.025	-0.511**
	G	0.196	**-0.069**	0.010	-0.010	-0.029	-0.012	-0.022	-0.523**
Plant height (cm)	**P**	0.027	-0.009	**0.053**	-0.008	-0.006	-0.004	-0.059	0.199*
	G	0.047	-0.016	**0.043**	-0.010	-0.006	0.003	-0.068	0.198*
Number of branches per plant	**P**	0.039	-0.004	0.007	**-0.062**	0.023	-0.004	0.006	0.499**
	G	0.075	-0.008	0.006	**-0.080**	0.026	0.004	0.005	0.505**
Pod length (cm)	**P**	-0.038	0.010	-0.003	-0.014	**0.098**	-0.008	0.036	0.262*
	G	-0.083	0.021	-0.003	-0.022	**0.095**	0.010	0.082	0.379*
Seed index (g)	**P**	0.073	-0.015	-0.007	0.009	-0.026	**0.031**	0.020	0.135
	G	0.126	-0.029	-0.005	0.012	-0.034	**-0.029**	0.003	0.035
Number of seeds per pod	**P**	-0.012	0.003	-0.010	-0.001	0.011	0.002	**0.309**	-0.088
	G	-0.030	0.006	-0.011	-0.002	0.030	0.000	**0.261**	-0.089

Residual effect: genotypic= 0.8994, phenotypic= 0.87

The correlation analysis gives information, but it's incomplete since it doesn't explain the underlying factors driving the numerous interrelationships. The interaction of a variety of constituent qualities determines how a complicated trait, like green fodder yield, is expressed. Through the examination of causal networks, a clearer understanding of how each element contributes to the overall genetic architecture of a complex character may be achieved.

As a result, in this circumstance, Wright's (1921) path coefficient analysis was helpful in separating direct and indirect causes of association, allowing a detailed examination of the specific forces acting to produce a given correlation and measuring the relative importance of each causal character. Such a research offers a reasonable basis for assigning weight to each trait when choosing an appropriate genetic improvement criterion. In order to ascertain the genuine nature of character association, the analysis in the current study compared the findings of simple correlation.

The results of path analysis indicated that days to 50% flowering (0.178, 0.265), plant height (0.053, 0.043), pod length (0.098, 0.095) and number of seed per pod (0.309, 0.261) had direct positive influence on grain yield per plant (Table 2).

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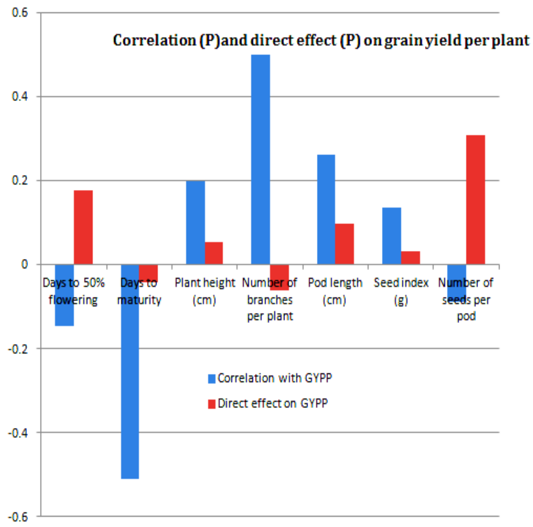

Figure 1. Relation between Phenotypic correlation and direct effect

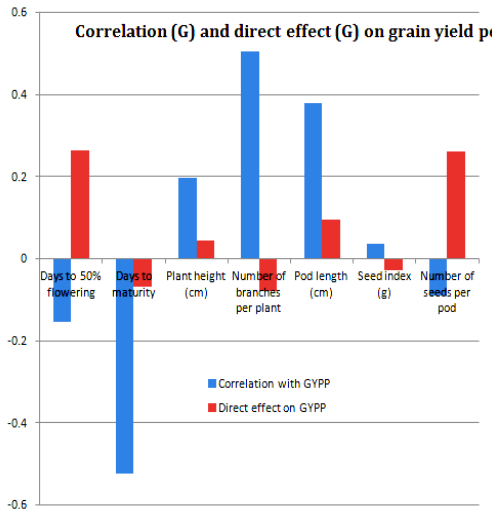

Figure 2. Relation between Genotypic correlation and direct effect

This implies that even a small improvement in any of these traits could directly enhance grain yield. Similar findings have been observed by Sahoo (2022), Soni (2021), Sahoo (2018) and Kumar (2016). Days to 50% flowering and number of seeds per pod had negative association but positive direct effect with seed yield per plant. This may be due to negative indirect influence through other traits which had negative values. (10) reported same result for days to maturity in mothbean. The characters namely number of branches per plant and seed index had positive association with seed yield but their direct effects were negative. As a result, the association appears to be caused by the indirect positive effects. Positive indirect effect for days to 50% flowering via plant height (0.265); Days to maturity via days to 50% flowering (0.196) and plant height (0.010); Plant height via days to 50% flowering (0.047) and seed index (0.003); Number of branches per plant via days to 50% flowering (0.075), plant height (0.006), pod length (0.026), seed index (0.004), number of seeds per pod (0.005); Pod length via days to maturity (0.021), seed index (0.010) and number of seeds per pod (0.003); Seed index via days to 50% flowering (0.126) number of branches per plant (0.012) and number of seeds per pod (0.003); Number of seeds per pod via days to maturity (0.006), pod length (0.030) and number of seeds per pod (0.261) were recorded in the present study. The relatively low residual effects (0.8994 for genotypic effects and 0.8775 for phenotypic effects) showed that the attributes chosen for the study were able to account for the majority of the impacts on seed yield in the moth bean germplasm.

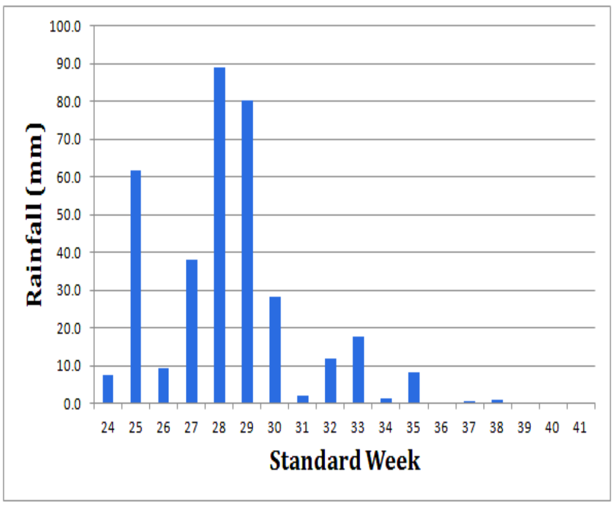

Figure 3. total rainfall (weekly basis)

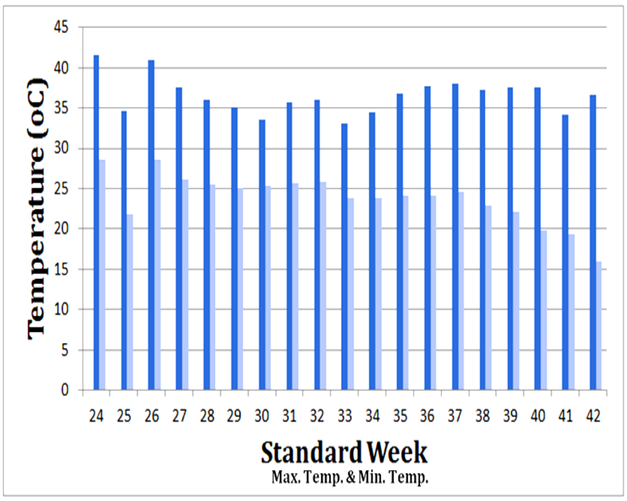

Figure 4. Maximum and minimum temperature (weekly basis)

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Conclusions:

The information obtained from the moth bean correlation and path coefficient study will be useful in identifying the structural yield components that can be efficiently incorporated into a better plant type. Because it is cultivated in inadequate environments, a modification in the plant type is necessary for greater adaptation. In light of the results mentioned above, it is evident that direct selection based on plant height, days to 50% flowering, pod length, and number of seeds per pod can assist to increase seed output in moth bean. The number of branches per plant and the seed index had a substantial positive connection but had a negative direct effect on seed yield, therefore they were taken into consideration during simultaneous selection.

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