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Correlation and Path Analysis Studies for Various Yield and Component Traits in the Segregating Generations of Blackgram [*Vigna mungo* (L). Hepper]

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ABSTRACT

Background: Blackgram despite of being a highly nutritious and short duration legume crop, it is not cultivated on large scales due to many constraints. Considering this, the research was aimed to develop blackgram genotypes with wider adaptability, genetic variability and high yielding potential by studying nature and magnitude of association among yield and related traits for effective production.

Methods: The present investigation was carried out at Experimental Farm of the Department of Genetics and Plant Breeding, College of Agriculture, CSK HPKV, Palampur (H.P.) to assess the character association and direct and indirect effects among yield and related traits in 14 crosses and ten parents for 11 quantitative characters during *Kharif* 2018 and 2019 in randomized complete block design with three replications.

Result: Correlation studies highlighted that seed yield per plant had significant and positive association with pods per plant, biological yield per plant, pod length, plant height and 100 seed-weight at genotypic and phenotypic levels in both generations. Study of path analysis revealed that biological yield per plant and pods per plant exhibited maximum positive direct and indirect effects to the total association between yield and other component traits in both the generations. These traits could be suggested as best selection indices on priority basis which would be commendable to improve the performance of genotypes during breeding programme.

Key words: Blackgram, Correlation, Genotypes, Path analysis, Seed yield, Traits.

INTRODUCTION

Blackgram [*Vigna mungo* (L.) Hepper], is a self-pollinated short-duration Kharif legume crop with 2n=22, belongs to the Fabaceae family. Its ancestor is believed to be as *V. mungo* var. *silverstris* with primary and secondary centre of origin in India and Central Asia respectively (Bhareti *et al.* 2011). It ranks fourth among pulses in terms of production and acerage and is a significant component of people's dietary requirements, containing seed protein (25-28%), carbohydrates (62-65%), fibre (3.5-4.5%), ash (4.5-5.5%), and oil (0.5-1.5%), as well as amino acids, vitamins and minerals. In India, it is grown in an area of about 4.49 million hectare with production and productivity of approx. 2.93 million tonnes and 500 kg per hectare annually (Anonymous 2019). Besides that, the crop's yield potential has been low and stable over time due to the crop's narrow genetic base, poor ideotype, non-availability of high yielding varieties, cultivation in harsh and marginal lands with poor management practices, and vulnerability to various biotic and abiotic stresses. The breeder's efforts are mostly focused on using selection in the segregating generation to generate better producing genotypes. In this case, selecting diverse parents with a wider genetic variability and high yielding potential will achieve the goal of improving quantitative characteristics such as yield. Since yield is a polygenically inherited trait with a complicated nature that is determined by several component features, direct selection is not possible to develop superior genotypes. As a result, significant biometrical tools like correlation coefficient, giving information about relationship between yield and its component traits is critical as it provides a measure of how much various characters are correlated and also aids in the elimination of traits that are of little or no use during the selection process. On the other hand, path coefficient analysis is simply a standardized partial regression coefficient that emphasizes the nature and magnitude of direct and indirect effects of one variable on another and allows the separation of correlation coefficient into unidirectional and alternate pathways for better interpretation of cause and effect relationship (Dewey and

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Lu, 1959) for choosing genotypes with favorable character combinations. With the foregoing in mind, the current study was done to determine the character association and direct and indirect effects in F_2 and F_3 generations of urdbean.

MATERIALS AND METHODS

The present experimental material used nine genotypes to create 14 distinct urdbean crosses using the line × tester design (Table 1). During *Kharif* 2018 and 2019, the 14 crosses, along with their parents, were grown at the Experimental Farm, Department of Genetics and Plant Breeding, College of Agriculture, CSK HPKV, Palampur, to produce F_2 and F_3 generations. The experiment was set up in three replications using randomized block design (RBD), with three rows of 2 m length in the F_2 generation and ten progeny rows in F_3 generation along with inter and intra-row spacing of 30 × 10cm respectively. 20 plants in F_2 whereas ten plants in F_3 generation were randomly selected from parents and crosses to record data for 11 morphological and yield traits including days to 50% flowering and days to 75% maturity (plot basis), plant height, branches per plant, pods per plant, pod length, seeds per pod, biological yield per plant, seed yield, harvest index, 100-seed weight (individual plant basis). Data observed for correlation coefficient values (r) were calculated at genotypic and phenotypic levels using the formula proposed by Al- Jibouri *et al.* (1958) and path analysis was performed following the procedure of Dewey and Lu (1959) using OP-STAT software.

RESULTS AND DISCUSSION

In the present study, days to 50% flowering showed significant and positive correlation with days to 75% maturity both at phenotypic and genotypic levels, while it had significant negative association with 100-seed weight in F_2 generation and in F_3 generation (Table 2) it reported non-significant correlation with all the traits, thus having no effect on seed yield.

Days to 75% maturity in F_2 population showed significant positive correlation with branches per plant, seeds per pod and negative association with plant height, pods per plant, pod length and biological yield per plant whereas this trait showed significant positive association with branches per plant, pods per plant, seeds per pod, biological yield per plant and 100- seed weight whereas significant negative relation with plant height in F_3 population.

For F_2 generation, plant height revealed significant and positive correlation with pods per plant, pod length and biological yield per plant while showed negative association with branches per plant (genotypically:G) and seeds per pod whereas for F_3 generation showed significant and positive association with branches per plant, pods per plant, pod length, seeds per pod, biological yield per plant and 100-seed weight while showed significant negative association with harvest index.

Branches per plant were found to have positive and significant association in F_2 generation with seeds per pod. It's negatively correlated with pods per plant, pod length and biological yield per plant. For F_3 generation, branches per plant was found positively and significantly associated with pods per plant, pod length, seeds per pod, biological yield per plant, 100 seed weight (G) and harvest index (G).

There was significant and positive association of pods per plant with pod length and biological yield per plant and was negatively correlated with seeds per pod in F_2 population, while pods per plant had significant and positive correlation with pod length, seeds per pod, biological yield

Table 1: Source of genotypes and parents used in the study**.**

Genotypes	Source
(Lines)	
IC-281980, IC-281982, IC-281993, IC-436852, IC-398973, IC-413306, IC-413304	Indigenous collection from IIPR, Kanpur
(Testers)	
HPBU-111*	Pure line selection from local material of Himachal Pradesh by CSK HPKV, Palampur
Him Mash-1*	Advanced line selection from DPU-91-5 × Mash-338
(Check)	
Palampur-93	Pure line selection from local material of Himachal Pradesh by CSK HPKV, Palampur
Crosses evaluated in present study	
IC-281980 x HPBU-111	IC-281980 x Him Mash-1
IC-281982 x HPBU-111	IC-281982 x Him Mash-1
IC-281993 x HPBU-111	IC-281993 x Him Mash-1
IC-436852 x HPBU-111	IC-436852 x Him Mash-1
IC-398973 x HPBU-111	IC-398973 x Him Mash-1
IC-413306 x HPBU-111	IC-413306 x Him Mash-1
IC-413304 x HPBU-111	IC-413304 x Him Mash-1

(* Parents also used as checks).

Table 2: Estimates of correlation coefficients at phenotypic and genotypic level for various traits in both generations in blackgram (P≤0.05;**P≤0.01).

Traits	Generations		Days to 75% maturity	Plant height (cm)	Branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	Biological yield per plant (g)	Harvest index (%)	100-seed weight (g)	Seed yield per plant (g)
Days to 50% flowering	F2	P	0.287*	0.122	0.118	0.105	0.066	-0.14	0.117	-0.175	-0.26*	-0.041
		G	0.288*	0.129	0.149	0.113	0.068	-0.226	0.122	-0.179	-0.350**	-0.036
	F3	P	-0.091	0.126	-0.013	0.049	0.06	-0.196	0.105	-0.12	0.082	-0.058
		G	-0.101	0.124	-0.021	0.049	0.065	-0.223	0.108	-0.124	0.096	-0.06
Days to 75% maturity	F2	P		-0.698**	0.263*	-0.478**	-0.663**	0.336**	-0.341**	0.057	-0.101	-0.248*
		G		-0.716**	0.318**	-0.498**	-0.761**	0.556**	-0.343**	0.056	-0.138	-0.255*
	F3	P		-0.300*	0.396**	0.275*	-0.049	0.348**	0.241*	0.13	0.245*	0.282*
		G		-0.312**	0.439**	0.278*	-0.05	0.368**	0.242*	0.133	0.263*	0.283*
Plant height (cm)	F2	P			-0.22	0.591**	0.611**	-0.488**	0.340**	-0.08	-0.008	0.344**
		G			-0.264*	0.608**	0.694**	-0.774**	0.341**	-0.09	-0.06	0.344**
	F3	P			0.287*	0.485**	0.696**	0.338**	0.541**	-0.259*	0.304**	0.499**
		G			0.312**	0.503**	0.721**	0.357**	0.551**	-0.276*	0.335**	0.508**
Branches per plant	F2	P				-0.533**	-0.297*	0.472**	-0.653**	0.072	-0.097	-0.515**
		G				-0.645**	-0.369**	0.788**	-0.771**	0.061	-0.177	-0.664**
	F3	P				0.657**	0.484**	0.505**	0.401**	0.231	0.13	0.632**
		G				0.730**	0.530**	0.605**	0.450**	0.257*	0.235*	0.718**
Pods per plant	F2	P					0.524**	-0.477**	0.741**	0.171	0.126	0.845**
		G					0.649**	-0.896**	0.759**	0.168	0.112	0.867**
	F3	P					0.529**	0.474**	0.600**	0.252*	0.285*	0.925**
		G					0.546**	0.502**	0.608**	0.257*	0.314**	0.936**
Pod length (cm)	F2	P						-0.339**	0.327**	0.139	0.009	0.335**
		G						-0.550**	0.374**	0.172	-0.063	0.400**
	F3	P						0.671**	0.747**	-0.283*	0.340**	0.632**
		G						0.731**	0.765**	-0.291*	0.392**	0.655**
Seeds per pod	F2	P							-0.527**	0.065	0.077	-0.451**
		G							-0.833**	0.101	-0.149	-0.729**
	F3	P							0.572**	-0.054	0.341**	0.578**
		G							0.616**	-0.065	0.334**	0.615**
Biological yield per plant (g)	F2	P								-0.291*	0.037	0.725**
		G								-0.297*	0.052	0.729**
	F3	P								-0.469**	0.414**	0.671**
		G								-0.474**	0.444**	0.675**
Harvest index (%)	F2	P									0.259*	0.393**
		G									0.313**	0.389**
	F3	P									-0.246*	0.258*
	F	G									-0.284*	0.254*
100-seed weight (g)	F2	P										0.250*
		G										0.309**
	F3	P										0.368**
		G										0.380**

per plant, 100- seed weight and harvest index in F_3 population.

In F_2 generation, positive and significant correlation was observed in pod length with biological yield per plant and negatively associated with seeds per pod. In F_3 generation, pod length showed positive and significant correlation with seeds per pod, biological yield and 100-seed weight. It showed negative association with harvest index.

Seeds per pod was negatively associated with biological yield per plant in F_2 generation, but this trait in F_3 generation revealed significant and positive association with biological yield per plant and 100- seed weight.

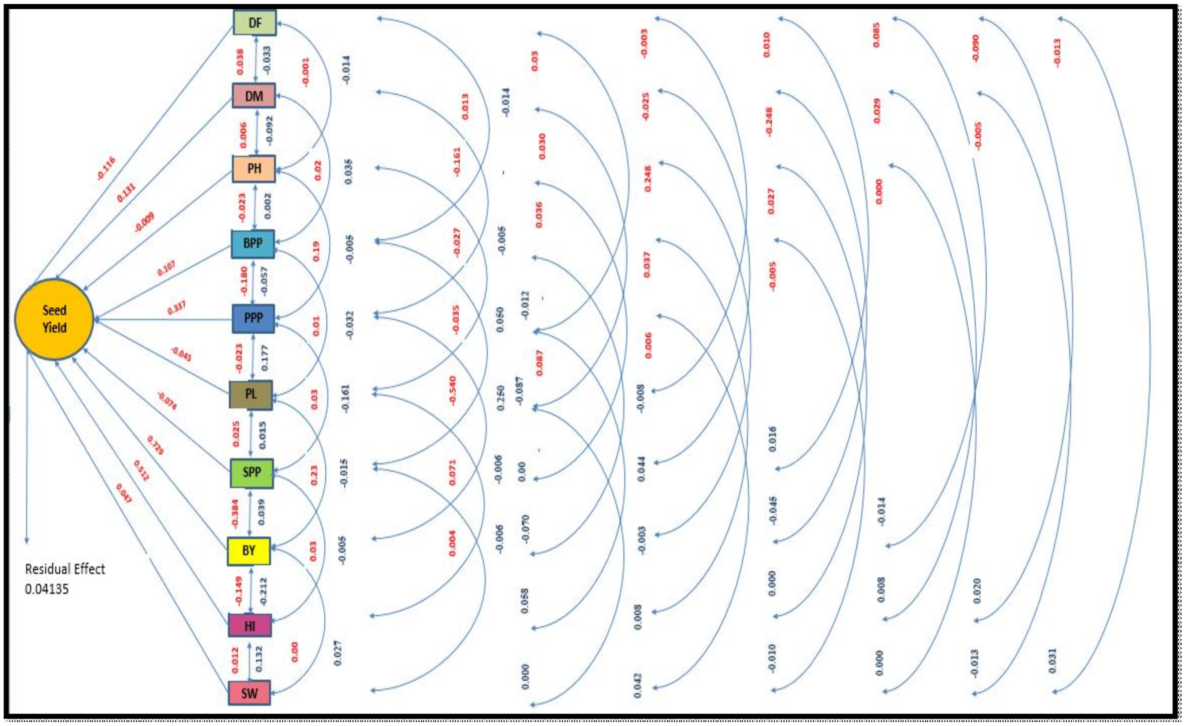

Fig 1: Stimates of direct and indirect effects at phenotypic levels for different traits in blackgram (F_2 generation)

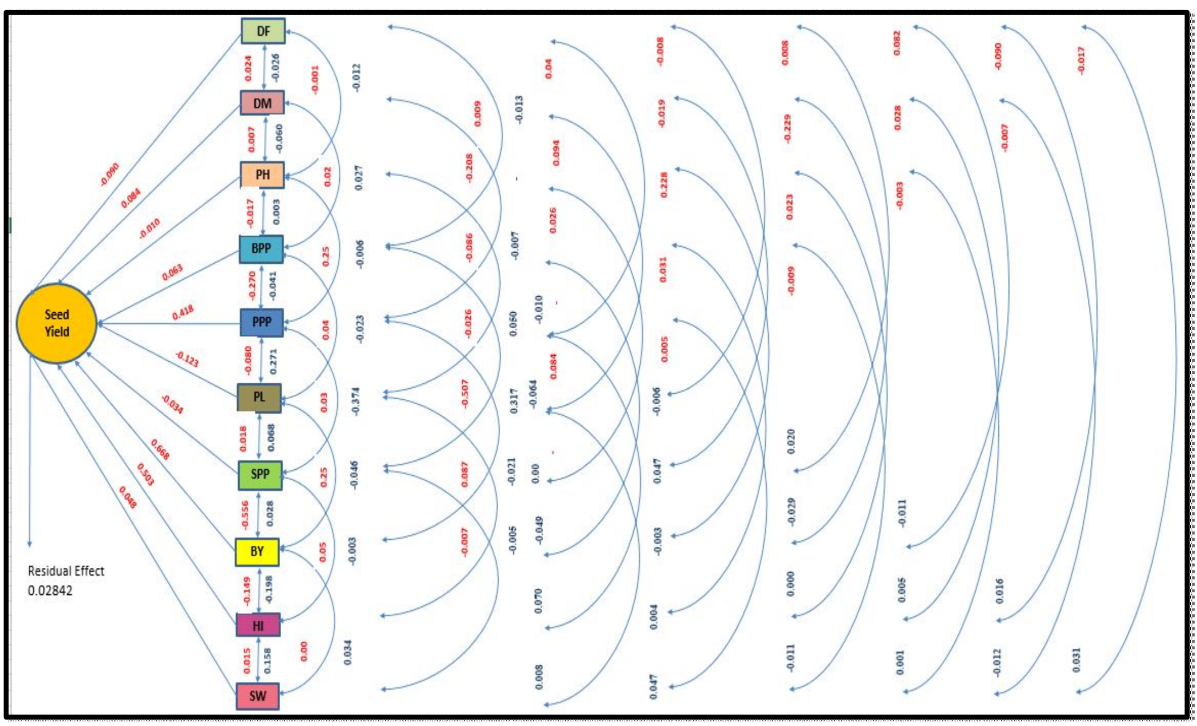

Fig 2: stimates of direct and indirect effects at genotypic levels for different traits in blackgram (F_2 generation).

Table 3: Estimates of direct and indirect effects at phenotypic and genotypic level for various traits in both generations in blackgram (*P≤0.05;**P≤0.01).

Traits	Generations		Days to 50% flowering	Days to 75% maturity	Plant height (cm)	Branches per plant	Pods per plant	Pod length (cm)	Seeds per pod	Biological yield per plant (g)	Harvest index (%)	100-seed weight (g)	Seed yield per plant (g)
Days to 50% flowering	F2	P	-0.116	0.038	-0.001	0.013	0.036	-0.003	0.01	0.085	-0.09	-0.013	-0.041
		G	-0.090	0.024	-0.001	0.009	0.047	-0.008	0.008	0.082	-0.09	-0.017	-0.036
	F3	P	-0.108	0.002	0.004	0.000	0.021	0.008	0.007	0.054	-0.055	0.01	-0.058
		G	-0.118	0.001	0.001	0.001	0.022	0.012	0.013	0.053	-0.056	0.011	-0.06
Days to 75% maturity	F2	P	-0.033	0.131	0.006	0.028	-0.161	0.03	-0.025	-0.248	0.029	-0.005	-0.248*
		G	-0.026	0.084	0.007	0.020	-0.208	0.094	-0.019	-0.229	0.028	-0.007	-0.255*
	F3	P	0.010	-0.02	-0.01	-0.009	0.117	-0.006	-0.012	0.122	0.06	0.03	0.282*
		G	0.012	-0.014	-0.003	-0.013	0.122	-0.009	-0.022	0.118	0.06	0.031	0.283*
Plant height (cm)	F2	P	-0.014	-0.092	-0.009	-0.023	0.199	-0.027	0.036	0.248	0.027	0	0.344**
		G	-0.012	-0.06	-0.01	-0.017	0.254	-0.086	0.026	0.228	0.023	-0.003	0.344**
	F3	P	-0.014	0.006	0.032	-0.007	0.207	0.092	-0.011	0.275	-0.119	0.037	0.499**
		G	-0.015	0.004	0.009	-0.009	0.221	0.134	-0.021	0.27	-0.126	0.04	0.508**
Branches per plant	F2	P	-0.014	0.035	0.002	0.107	-0.18	0.013	-0.035	-0.476	0.037	-0.005	-0.515**
		G	-0.013	0.027	0.003	0.063	-0.27	0.046	-0.026	-0.515	0.031	-0.009	-0.664**
	F3	P	0.001	-0.008	0.009	-0.024	0.281	0.064	-0.017	0.204	0.106	0.016	0.632**
		G	0.003	-0.006	0.003	-0.030	0.321	0.099	-0.036	0.221	0.117	0.028	0.718**
Pods per plant	F2	P	-0.012	-0.063	-0.005	-0.057	0.337	-0.023	0.035	0.54	0.087	0.006	0.845**
		G	-0.010	-0.042	-0.006	-0.041	0.418	-0.08	0.03	0.507	0.084	0.005	0.867**
	F3	P	-0.005	-0.006	0.016	-0.016	0.427	0.069	-0.016	0.305	0.115	0.035	0.925**
		G	-0.006	-0.004	0.005	-0.022	0.44	0.102	-0.03	0.298	0.117	0.037	0.936**
Pod length (cm)	F2	P	-0.008	-0.087	-0.005	-0.032	0.177	-0.045	0.025	0.238	0.071	0.000	0.335**
		G	-0.006	-0.064	-0.007	-0.023	0.271	-0.123	0.018	0.250	0.087	-0.003	0.400**
	F3	P	-0.006	0.001	0.023	-0.012	0.226	0.131	-0.022	0.380	-0.13	0.042	0.632**
		G	-0.008	0.001	0.007	-0.016	0.24	0.186	-0.044	0.375	-0.132	0.047	0.655**
Seeds per pod	F2	P	0.016	0.044	0.004	0.05	-0.161	0.015	-0.074	-0.384	0.033	0.004	-0.451**
		G	0.020	0.047	0.007	0.05	-0.374	0.068	-0.034	-0.556	0.051	-0.007	-0.729**
	F3	P	0.021	-0.007	0.011	-0.012	0.202	0.088	-0.033	0.291	-0.025	0.042	0.578**
		G	0.026	-0.005	0.003	-0.018	0.221	0.136	-0.060	0.302	-0.03	0.04	0.615**
Biological yield per plant (g)	F2	P	-0.014	-0.045	-0.003	-0.07	0.25	-0.015	0.039	0.729	-0.149	0.002	0.725**
		G	-0.011	-0.029	-0.003	-0.049	0.317	-0.046	0.028	0.668	-0.149	0.002	0.729**
	F3	P	-0.011	-0.005	0.017	-0.01	0.256	0.098	-0.019	0.509	-0.215	0.051	0.671**
		G	-0.013	-0.003	0.005	-0.014	0.268	0.143	-0.037	0.490	-0.216	0.053	0.675**
Harvest index (%)	F2	P	0.020	0.008	0.000	0.008	0.058	-0.006	-0.005	-0.212	0.512	0.012	0.393**
		G	0.016	0.005	0.000	0.004	0.07	-0.021	-0.003	-0.198	0.503	0.015	0.389**
	F3	P	0.013	-0.003	-0.008	-0.005	0.107	-0.037	0.002	-0.239	0.458	-0.03	0.258*
		G	0.015	-0.002	-0.003	-0.008	0.113	-0.054	0.004	-0.232	0.455	-0.034	0.254*
100-seed weight (g)	F2	P	0.031	-0.013	0.000	-0.01	0.042	0.000	-0.006	0.027	0.132	0.047	0.250*
		G	0.031	-0.012	0.001	-0.011	0.047	0.008	0.005	0.034	0.158	0.048	0.309**
	F3	P	-0.009	-0.005	0.01	-0.003	0.122	0.045	-0.011	0.211	-0.113	0.122	0.368**
		G	-0.011	-0.004	0.003	-0.007	0.138	0.073	-0.02	0.218	-0.129	0.119	0.380**

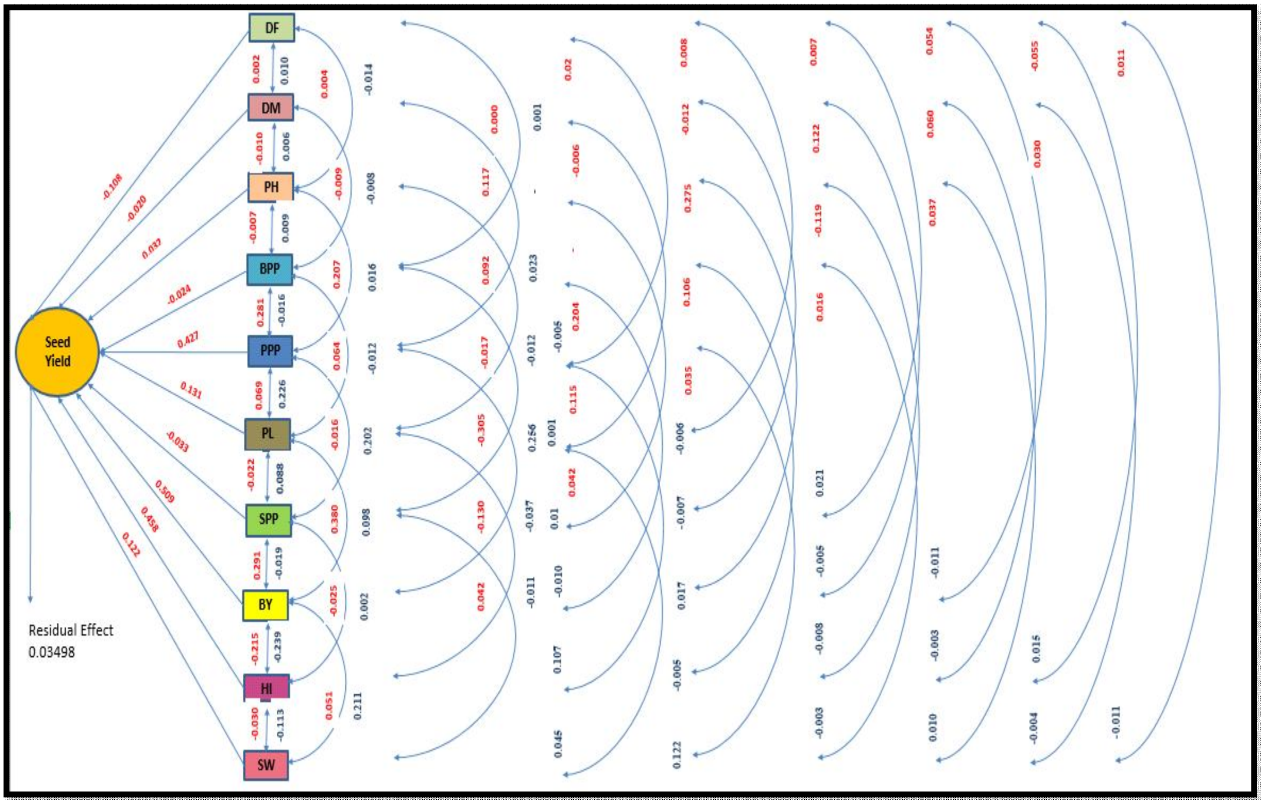

Fig 3: Estimates of direct and indirect effects at phenotypic for different traits in blackgram (F_3 generation).

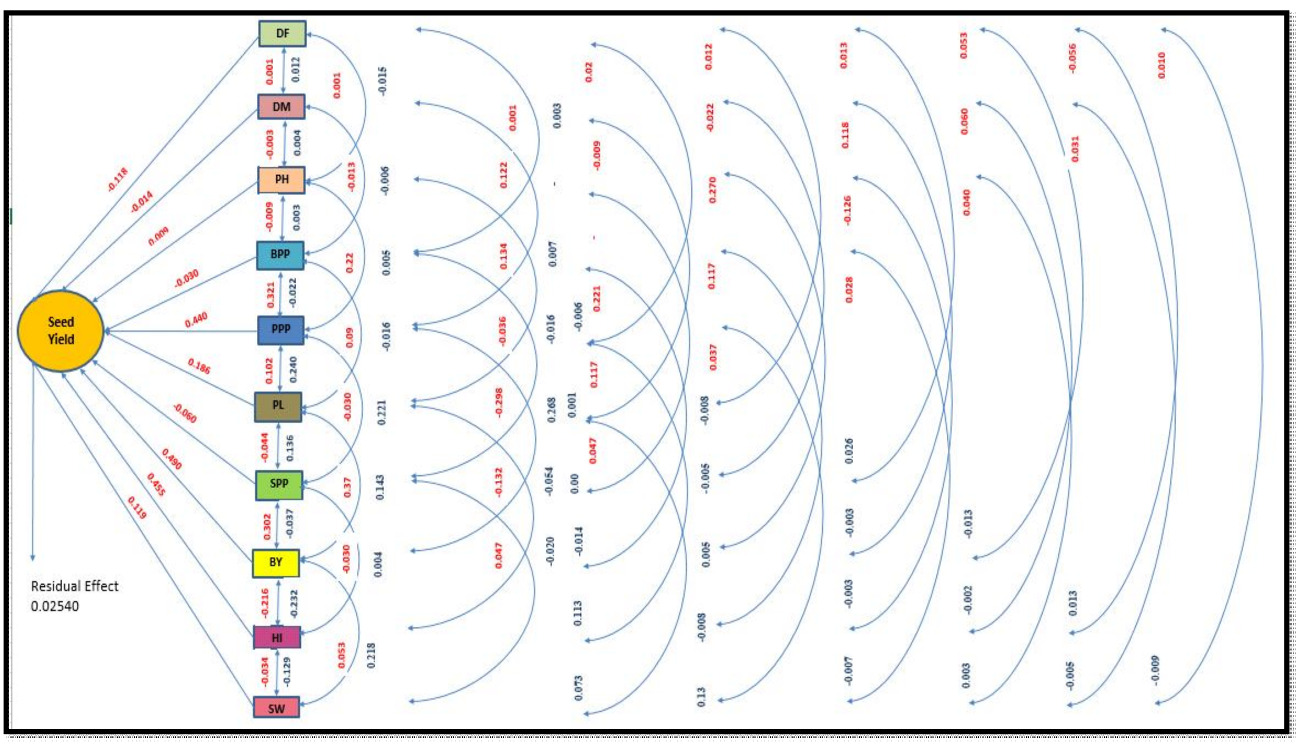

Fig 4: Estimates of direct and indirect effects at genotypic levels for different traits in blackgram (F_3 generation).

Biological yield per plant was significantly and negatively correlated with harvest index in F_2 population. Similarly, this trait was negatively correlated with harvest index but significantly and positively associated with 100-seed weight in F_3 population.

Harvest index was significantly and positively associated in F_2 population with 100- seed weight whereas significantly negatively correlated with 100-seedweight in F_3 generation.

The significant and positive association of seed yield per plant in F_2 generation was reported with pods per plant following biological yield per plant, pod length, harvest index, plant height and100-seed weight. On the other hand, seed yield per plant was found to be significantly and positively associated with all traits, except days to 50% flowering (Gomathi *et al.,* 2021). Sathees *et al*. (2019) and Vadivel *et al*. (2019) noticed significant correlation with pods per plant, 100-seed weight and pod length, and Mathivathana *et al.* (2015); Singh *et al.* (2016) and Chowdhury *et al.* (2020) with plant height, branches per plant, pods per plant, seeds per pod and 100- seed weight; Saran *et al.* (2020) reported for number of pods per plant, pod length, biological yield per plant and harvest index; Joshna *et al.* (2021) for branches per plant, pods per plant, seeds per pod and harvest index in urdbean.

However, in F_2 generation, yield was negatively correlated with seeds per pod, branches per plant and days to 75% maturity. But in F_3 generation, there was no negative association observed for seed yield with other related traits.

Direct effects of different traits on seed yield

In path analysis, the direct positive effects were recorded highest for biological yield per plant following harvest index, pods per plant, days to 75% maturity, number of branches per plant and 100- seed weight at both phenotypic and genotypic levels for F_2 generation, whereas in F_3 generation (Table 3 and Fig 1,2,3 and 4), the highest direct positive values were revealed for biological yield per plant followed by harvest index, pods per plant, pod length, 100-seed weight and plant height. Results are in conformity with Tambe *et al.* (2018) for harvest index, biological yield, plant height, days to 50% flowering and pods per plant and Chowdhury *et al.* (2020) for pods per plant, 100-seed weight, branches per plant and plant height in blackgram.

The highest direct negative effects at phenotypic level were revealed by seeds per pod and days to 50% flowering in both generations implying low association among these characters and selection based upon these traits would be ineffective.

Indirect effects of different traits on seed yield

The positive indirect effect *via* biological yield was the main contributor to the correlation between plant height and seed yield, pod length and seed yield and pods per plant and seed yield, at both the levels followed by pods per plant in both generations, except for correlation between seeds per pod and seed yield and days to 75% maturity and seed yield in F_3 generation only.

The positive indirect effect *via* pods per plant was main contributor to correlation between biological yield &seed yield and harvest index and seed yield at both the levels in F_2 and F_3 generations, except for correlation among branches per plant and seed yield in F_3 generation only.

The positive indirect effect via harvest index in F_2 and biological yield in F_3 were the main contributors to the correlation between 100-seed weight and seed yield per plant at both the levels followed by pods per plant.

Thus, the low magnitude of unexplained variation (residual effect) at phenotypic and genotypic levels in F_2 (P: 0.04135; G: 0.02842) and F_3 generation (P: 0.03498; G: 0.02540) for seed yield indicated that the 11 traits included in the present investigation accounted for the greater part of the variation present in the dependent variable.

CONCLUSION

Generally, the genotypic correlations were found higher than the phenotypic correlations revealing strong inherent association among the various traits. Seed yield per plant showed positive and significant association with pods per plant, biological yield, pod length, plant height and 100-seed weight in both generations, reflecting that the effective selection on the basis of these traits can lead to higher yield. Furthermore, the most favorable associations appeared in the advanced segregating generation rather than the early segregating generation.

Path analysis determined that biological yield per plant and pods per plant had the greatest positive direct and indirect effects on the total association between yield and other component traits in both generations, implying that they are the best selection indices for achieving improved genotype performance. Also harvest index, seeds per pod, pod length and 100-seed weight had contributed to some extent and can be helpful in improvement through selection in urdbean.

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