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Estimation of Genetic Parameters for Yield and its Component Traits in Urd Bean [*Vigna mungo* (L.) Hepper]

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ABSTRACT

The present investigation comprised of 30 urdbean genotypes was conducted during *kharif*, 2020 & 2021 and spring 2021 & 2022 crop seasons. The high estimates of heritability coupled with high genetic advance were obtained over all the crop seasons for the traits *viz*. plant height, primary branches per plant, clusters per plant, pods per cluster, pods per plant, 100 seed weight and seed yield per plant indicating that the heritability for these traits is most likely due to the additive gene effects. The traits viz. seed per pod and pods per plant not only exhibited high positive direct effect on seed yield per plant, but these components traits were also positively and significantly correlated with seed yield per plant indicating the true relationship with seed yield.

Key words : *Variability, Heritability, Genetic advance, Correlation, Path analysis.*

Introduction

Blackgram or urd bean [*Vigna mungo* (L.) Hepper] is India's one of the important pulse crop and occupy fourth position among pulses. In India, black gram is cultivated on 4.14 million hectare area with production of 2.29 million tons and 538 kg per hectare productivity in a year. In Uttarakhand state, blackgram is cultivated on about twelve-thousand hectare area and with a production of 12,830 tons and a productivity of 1069 kg per hectare (India stat, 2021). It is an important short duration crop grown in *Kharif* and spring season. Seed yield is a very complex character and is dependent upon the several yield components like number of pods per plant, 100 seed weight and number of seeds per pod, not only in urdbean, but also indifferent pulse crops and, therefore, direct improvement in seed yield is not possible (Choudhary *et al*., 2017; Meena *et al*., 2017and Pal *et al*., 2018). Studies regarding various variability parameterslike phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance provides the fair idea whether a particular trait can be improved upon by practicing selection or not. A sound knowledge of character association between seed yield and its component traits and also among component traits is essential to formulate selection criterion to bring desired improvements in seed yield and yield components. Association studies provides an idea regarding the contribution of different traits towards seed yield and also reveals the

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type, nature and magnitude of character association between yield and its component traits (Gaur *et al*, 2020). Furthermore, the grain yield is influenced by its various components directly and/or indirectly through other traits that create a complex situation for plant breeders for making desirable selection. Therefore, path coefficient analysis developed by Wright (1921) could provide a more realistic picture of the relationship, as it partitions the correlation coefficients into direct and indirect effects of the variables. Path coefficient analysis provides means to quantify the interrelationship of different yield components and indicate whether the influence is directly reflected in the yield or take some other pathways to produce an effect. Dewey and Lu (1959) employed path analysis for the first time in plants to identify direct and indirect influences of the component traits on grain yield. Thus, character association and path analysis provide the information on important yield contributing characters and a breeder can practice selection using this information for the isolation of superior yielding genotypes.

Materials and Methods

The experimental material consisted of 30 elite urdbean genotypes developed at different research institute in India and were evaluated in a randomized block design with three replications at Norman E. Borlaug Crop Research Centre (CRC) of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar during *kharif* season of 2020 & 2021 as well as spring season of 2021 & 2022 under normal sown conditions. Each genotype was raised in a two row plot of four meter length. A row to row spacing of 30 centimeters during both, *kharif* and spring season was maintained. A plant to plant spacing of 8 to 10 cm was maintained by thinning. Recommended agronomic practices were adopted to raise a normal and healthy crop during all the crop seasons. The observations on ten different metric traits *viz.* days to maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per cluster, pod length (cm), number of seeds per pod, number of pods per plant, 100 seed weight (g) and seed yield per plant (g) were recorded. Data on five randomly selected competitive plants from each replication were recorded for all the traits under study except for days to maturity, which were recorded on plot basis. The mean data was used for statistical analysis. The analysis of variance for randomized block design (RBD) was performed following Panse and Sukhatme (1985), genotypic and phenotype coefficients of variation (GCV and PCV) were calculated as per the formula suggested by Burton and De Vane (1953), heritability and genetic advance as per Allard (1960). Correlation and path coefficients were worked out as per the method suggested by Al-Jibouri *et al.* (1958) and Dewey and Lu (1959), respectively.

Results and Discussion

The analysis of variance revealed highly significant differences among the mean square due to genotypes for all the characters studied during both the years, suggesting the presence of sufficient amount of variability in the experimental material. The data pertaining to genetic variability for all characters are given in Table 1 and 2.

The estimates of genotypic and phenotypic coefficient of variability indicated that phenotypic coefficients of variation were slightly higher than corresponding genotypic coefficients of variation for all the traits studied during both the years over all the seasons, indicating the effect of environment on the expression of characters studied. It is evident from the Table 1 that during both *kharif* 2020 & *kharif* 2021 season, the high estimates of PCV and GCV (>20%) were recorded for the characters like number of clusters per plant, pods per plant and seed yield/plant. For days to maturity and pod length, the estimates of PCV and GCV were low (<10%) during both the years. For rest of the characters the estimates were moderate (10—-20%). It is evident from the Table 2 that during spring 2021 & spring 2022 crop season, the high estimates of PCV & GCV were obtained for the characters *viz*. plant height, clusters per plant, pods per plant and seed yield per plant; the moderate estimates were obtained for pods per cluster, seeds per pod and 100 seed weight, whereas, low estimates of PCV and GCV were recorded for days to 50% maturity and pod length. A comparative study of Table 1 and Table 2 further showed that over all the four growing seasons, high estimates of PCV and GCV were recorded only for the traits *viz*. clusters per plant, number of pods per plant and seed yield per plant. Similar to the present findings, the high estimates of PCV and GCV for different traits in urd bean were earlier obtained by Kumar *et al.* (2014), Kumar *et al.* (2015), Hemalatha

Table 1. Phenotypicand genotypic coefficient of variations, heritability and genetic advance as % of mean for various traits during *kharif* 2020 and *kharif* 2021 season

Character	Year	Phenotypic range	Coefficient of variation	Mean ± S.E.	Phenotypic coefficient of variation (PCV)	Genotypic coefficient of variation (GCV)	Heritability in broad sense (%)	Genetic advance as % of mean
Days to Maturity	2020	85.00 - 102.00	9.09	92.87 ± 1.27	5.89	5.39	83.69	10.15
	2021	86.67 - 104.67	9.41	94.48 ± 1.01	5.23	4.90	87.51	9.44
Plant Height	2020	25.42 - 58.65	39.53	44.81 ± 0.95	18.20	17.82	95.89	35.95
	2021	30.42 - 90.56	49.71	49.51 ± 2.35	26.28	24.95	90.19	48.82
Primary Branches	2020	2.04 - 3.88	31.01	3.03 ± 0.08	19.25	18.74	94.72	37.57
per Plant	2021	1.97 - 5.34	46.17	3.25 ± 0.08	26.01	25.66	97.37	52.17
Cluster per plant	2020	10.10 - 24.10	40.95	16.05 ± 0.55	22.15	21.35	92.94	42.41
	2021	9.10 - 22.72	42.81	15.45 ± 0.56	28.14	27.42	94.96	55.05
Pods per Cluster	2020	1.86 - 2.80	20.12	2.19 ± 0.06	12.22	11.38	86.74	21.83
	2021	1.28 - 3.32	44.28	2.43 ± 0.04	20.26	20.02	97.62	40.74
Pod Length	2020	3.73 - 4.95	14.01	4.40 ± 0.08	6.39	5.47	73.22	9.64
	2021	3.70 - 4.83	13.24	4.34 ± 0.07	6.59	6.04	83.79	11.38
Seeds per Pod	2020	4.54 - 8.24	28.90	6.30 ± 0.28	14.89	12.80	73.82	22.65
	2021	4.34 - 8.13	30.36	6.25 ± 0.28	15.99	13.91	75.68	24.92
Pods per Plant	2020	17.77 - 49.21	46.94	32.09 ± 1.53	28.76	27.55	91.81	54.39
	2021	12.46 - 54.44	62.76	32.73 ± 1.28	29.83	29.05	94.84	58.28
100 Seed Weight	2020	2.73 - 4.53	24.83	3.48 ± 0.10	12.95	11.87	83.96	22.40
	2021	3.18 - 6.79	36.15	4.10 ± 0.06	17.19	17.02	98.04	34.72
Seed yield per Plant	2020	2.75 - 8.10	49.35	5.32 ± 0.47	32.95	29.21	78.56	53.33
	2021	3.09 - 7.88	43.66	4.79 ± 0.21	23.50	22.23	89.46	43.31

Table 2. Phenotypicand genotypic coefficient of variation, heritability and genetic advance as % of mean for various traits during spring 2021 &spring 2022 season

Character	Year	Phenotypic range	Coefficient of variation	Mean ± S.E.	Phenotypic coefficient of variation (PCV)	Genotypic coefficient of variation (GCV)	Heritability in broad sense (%)	Genetic advance as % of mean
Days to Maturity	2021	64.33 - 76.67	8.75	70.47 ± 0.75	5.53	5.22	89.00	10.14
	2022	64.00 - 78.00	9.86	71.74 ± 0.74	5.93	5.65	90.65	11.08
Plant Height	2021	15.89 - 53.09	53.93	28.04 ± 0.51	31.16	31.00	98.97	63.53
	2022	17.60 - 45.05	43.81	28.92 ± 0.81	26.31	25.86	96.62	52.37
Primary Branches	2021	2.03 - 4.00	32.56	2.95 ± 0.09	19.06	18.40	93.14	36.58
per Plant	2022	2.40 - 5.33	37.93	3.89 ± 0.16	21.38	20.12	88.51	38.99
Cluster per plant	2021	3.35 - 13.05	59.17	7.66 ± 0.28	29.09	28.40	95.29	57.11
	2022	4.52 - 16.67	56.36	9.65 ± 0.54	29.48	27.86	89.32	54.25
Pods per Cluster	2021	1.91 - 3.11	23.85	2.39 ± 0.08	14.50	13.38	85.21	25.45
	2022	1.96 - 3.67	33.22	2.42 ± 0.10	20.28	18.94	87.22	36.43
Pod Length	2021	3.60 - 4.46	10.63	4.05 ± 0.10	7.33	6.08	68.79	10.39
	2022	3.56 - 4.67	15.51	4.17 ± 0.08	7.99	7.22	81.68	13.45
Seeds per Pod	2021	4.00 - 6.33	22.59	5.46 ± 0.18	10.32	8.50	67.93	14.44
	2022	4.03 - 7.14	27.77	5.92 ± 0.18	12.12	10.93	81.35	20.31
Pods per Plant	2021	9.74 - 25.74	45.09	18.62 ± 1.49	25.60	21.53	70.74	37.30
	2022	10.15 - 31.67	51.15	21.36 ± 0.78	24.18	23.34	93.18	46.41
100 Seed Weight	2021	2.67 - 6.05	38.78	3.61 ± 0.07	18.23	17.93	96.77	36.34
	2022	2.79 - 6.67	38.34	3.63 ± 0.08	19.52	19.17	96.40	38.77
Yield per Plant	2021	1.57 - 3.80	41.61	2.38 ± 0.15	23.20	20.33	76.78	36.69
	2022	0.57 - 2.81	65.94	1.39 ± 0.11	38.16	35.64	87.22	68.57

Table 3. Genotypic and Phenotypic correlation coefficients among different characters in blackgram genotypes during *kharif* 2020 and *kharif* 2021

Character	Year		Days to maturity	Plant height	Primary branches	Cluster per plant	Pods per cluster	Pod length	Seeds per	Pods per	100 Seed weight	Yield Plant
Days to Maturity	2020	r_g	1	-0.029	-0.218*	-0.164	-0.016	0.115	-0.016	-0.213*	-0.234*	-0.157
		r_p	1	-0.023	-0.184	-0.15	-0.038	0.08	0.011	-0.19	-0.187	-0.162
	2021	r_g	1	0.447**	0.073	0.084	-0.044	-0.02	0.07	0.19	0.139	-0.175
		r_p	1	0.372**	0.060	0.094	-0.034	-0.028	0.076	0.182	0.129	-0.164
Plant Height	2020	r_g		1	-0.382**	0.224*	-0.202	0.212*	0.338**	0.056	-0.055	0.132
		r_p		1	-0.364**	0.203	-0.184	0.164	0.304**	0.043	-0.072	0.114
	2021	r_g		1	0.078	0.276**	0.265*	0.052	0.216*	0.414**	-0.016	0.163
		r_p		1	0.070	0.247*	0.243*	0.043	0.198	0.372**	-0.017	0.145
Primary Branches per Plant	2020	r_g			1	0.359**	0.459**	-0.165	0.018	0.444**	0.197	0.378**
		r_p			1	0.345**	0.421**	-0.157	0.026	0.428**	0.195	0.325**
	2021	r_g			1	0.614**	0.356**	0.2	0.409**	0.560**	0.234*	0.481**
		r_p			1	0.585**	0.346**	0.167	0.359**	0.535**	0.227*	0.445**
Cluster per plant	2020	r_g				1	0.135	-0.305**	0.049	0.899**	0.138	0.152
		r_p				1	0.128	-0.255*	0.023	0.844**	0.13	0.126
	2021	r_g				1	0.126	0.370**	0.061	0.816**	0.258*	0.381**
		r_p				1	0.124	0.335**	0.044	0.785**	0.249*	0.330**
Pods per Cluster	2020	r_g					1	-0.192	-0.081	0.322**	-0.278**	0.244*
		r_p					1	-0.146	-0.031	0.294**	-0.251*	0.225*
	2021	r_g					1	0.323**	0.311**	0.532**	-0.068	0.293**
		r_p					1	0.288**	0.259*	0.503**	-0.07	0.267*
Pod Length	2020	r_g						1	0.111	-0.282**	0.074	-0.205
		r_p						1	0.052	-0.249*	0.072	-0.177
	2021	r_g						1	0.384**	0.376**	-0.127	-0.094
		r_p						1	0.293**	0.348**	-0.119	-0.045
Seeds per Pod	2020	r_g							1	0.054	-0.136	0.528**
		r_p							1	0.046	-0.085	0.374**
	2021	r_g							1	0.063	-0.149	0.335**
		r_p							1	0.06	-0.122	0.260*
Pods per Plant	2020	r_g								1	0.068	0.244*
		r_p								1	0.076	0.222*
	2021	r_g								1	0.279**	0.430**
		r_p								1	0.267*	0.398**
100 Seed Weight	2020	r_g									1	-0.233*
		r_p									1	-0.16
	2021	r_g									1	0.366**
		r_p									1	0.352**
Yield per Plant	2020	r_g										1
		r_p										1
	2021	r_g										1
		r_p										1

Table 4. Genotypic and Phenotypic correlation coefficients among different characters in blackgram genotypes during spring 2021 and spring 2022

Character	Year		Days to maturity	Plant height	Primary branches per plant	Cluster per plant	Pods per cluster	Pod length	Seeds per Pod	Pods per plant	100 seed Weight	Yield per Plant
Days to maturity	2021	r_g	1	0.056	-0.118	-0.245*	-0.299**	-0.157	0.304**	0.05	0.047	-0.144
		r_p	1	0.045	-0.102	-0.229*	-0.236*	-0.184	0.263*	0.004	0.047	-0.12
	2022	r_g	1	-0.054	-0.136	-0.216*	-0.078	-0.529**	0.242*	0.152	0.012	-0.049
		r_p	1	-0.046	-0.11	-0.191	-0.084	-0.482**	0.191	0.143	0.01	-0.032
Plant height	2021	r_g		1	0.394**	0.206	-0.189	0.019	0.147	-0.016	0.036	-0.196
		r_p		1	0.380**	0.205	-0.173	0.029	0.121	-0.015	0.035	-0.173
	2022	r_g		1	0.455**	0.079	-0.132	0.14	0.005	0.03	0.078	-0.211*
		r_p		1	0.424**	0.083	-0.109	0.13	0.015	0.031	0.076	-0.179
Primary branches per plant	2021	r_g			1	0.213*	0.099	0.046	-0.048	-0.193	-0.151	-0.317**
		r_p			1	0.212*	0.108	0.023	-0.045	-0.192	-0.142	-0.286**
	2022	r_g			1	0.206	-0.076	0.143	-0.066	-0.193	-0.16	-0.421**
		r_p			1	0.199	-0.078	0.116	-0.04	-0.142	-0.155	-0.362**
Cluster per plant	2021	r_g				1	-0.177	0.166	-0.296**	0.422**	0.019	0.008
		r_p				1	-0.164	0.15	-0.226*	0.336**	0.016	-0.015
	2022	r_g				1	-0.410**	-0.004	-0.230*	0.288**	-0.021	-0.014
		r_p				1	-0.345**	0.012	-0.18	0.271**	-0.016	0.006
Pods per Cluster	2021	r_g					1	0.223*	-0.216*	0.145	0.304**	-0.145
		r_p					1	0.141	-0.117	0.066	0.275**	-0.161
	2022	r_g					1	0.054	0.235*	0.218*	0.263*	0.112
		r_p					1	0.058	0.212*	0.184	0.235*	0.109
Pod Length	2021	r_g						1	0.196	-0.213*	-0.036	-0.006
		r_p						1	0.117	-0.131	-0.036	-0.01
	2022	r_g						1	0.199	-0.520**	-0.157	0.006
		r_p						1	0.18	-0.432**	-0.142	-0.004
Seeds per Pod	2021	r_g							1	-0.471**	-0.007	0.101
		r_p							1	-0.300**	-0.034	-0.049
	2022	r_g							1	-0.132	0.1	-0.276**
		r_p							1	-0.121	0.087	-0.218*
Pods per Plant	2021	r_g								1	0.366**	0.081
		r_p								1	0.305**	0.106
	2022	r_g								1	0.268*	0.016
		r_p								1	0.259*	0.031
100 Seed Weight	2021	r_g									1	-0.125
		r_p									1	-0.097
	2022	r_g									1	-0.145
		r_p									1	-0.128
Yield per Plant	2021	r_g										1
		r_p										1
	2022	r_g										1
		r_p										1

et al. (2017) and Gomathi *et al.* (2020).

The estimates of heritability were high (>75%) for all the traits except pod length during both the year indicating that these traits were least influenced by the environment. Selection for improvement of these traits may not be very useful, as the estimates of broad sense heritability are based on total genetic variance which include both fixable (additive) as well as non-fixable (dominance and epistatic) variances (Bohra *et al*., 2015; Pal *et al*., 2018; Verma *et al*., 2018 and Gaur *et al*., 2020).

It is further evident from the Table 1 that the estimates of genetic advance as percent of mean were high (>20%) for the traits viz. plant height, primary branches per plant, clusters per plant, pods per cluster, seeds per pod, pods per plant, 100 seed weight and seed yield per plant during *kharif* 2020 and 2021 crop season. The high estimates of genetic advance as percent of mean were obtained for the traits *viz.* plant height, primary branches per plant, clusters per plant, pods per cluster, pods per plant, 100 seed weight and seed yield per plant during spring 2021 and 2022 crop season (Table 2). High estimates of heritability alone did not assure that the selection may bring the desirable change in the character and therefore, heritability accompanied withgenetic advance gives better idea regarding the effectiveness of selection (Verma *et al*., 2018 and Gautam *et al*., 2021). In the present investigation, high estimates of heritability coupled with high genetic advance were obtained over all the crop seasons for thetraits *viz.* plant height, primary branches per plant, clusters per plant, pods per cluster, pods per plant, 100 seed weight and seed yield per plant indicating that the heritability for these traits is most likely due to the additive gene effects and the selection may be effective (Gowsalya *et al.,* 2016; Hemalatha *et al.,* 2017 and Gomathi *et al.,* 2020).

In general, genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic correlation coefficients during all the four growing seasons (Table 3 & 4), indicating that there is a strong association between the traits genetically, but the phenotypic values were lessened by the significant interaction of environment. Similar findings regarding genotypic and phenotypic correlation coefficients were earlier reported by Kumar *et al.* (2015), Hemalatha *et al.* (2017) and Gomathi *et al.* (2020) in urdbean. A critical insight of Table 3 revealed that during both the *kharif* seasons, seed yield per plant exhibited positive and significant correlation with primary branches per plant, seeds per pod and pods per plant only, however, during both spring seasons seed yield per plant exhibited positive and significant correlation with primary branches per plant only (Table 4) at both genotypic

Table 5. Path coefficient analysis at phenotypic level during *kharif* 2020 and *kharif* 2021

Character	Year	Phenotypic correlation with yield per plant	Days to maturity	Plant height	Primary branches per plant	Cluster per plant	Pods per cluster	Pod length	Seeds per pod	Pods per plant	100 seed weight
Days to maturity	2020	-0.162	**-0.109**	-0.005	-0.072	0.043	0.000	-0.013	0.003	-0.043	0.034
	2021	-0.164	**-0.329**	0.031	0.009	-0.001	-0.001	0.007	0.023	0.061	0.037
Plant height	2020	0.114	0.003	**0.233**	-0.143	-0.059	-0.002	-0.027	0.086	0.010	0.013
	2021	0.145	-0.122	**0.082**	0.010	-0.002	0.009	-0.011	0.059	0.125	-0.005
Primary branches	2020	0.325**	0.020	-0.085	**0.392**	-0.100	0.003	0.026	0.008	0.097	-0.035
per plant	2021	0.445**	-0.020	0.006	**0.143**	-0.005	0.012	-0.044	0.108	0.180	0.064
Cluster per plant	2020	0.126	0.016	0.047	0.135	**-0.290**	0.001	0.042	0.007	0.190	-0.024
	2021	0.330**	-0.031	0.020	0.084	**-0.009**	0.004	-0.087	0.013	0.265	0.071
Pods per cluster	2020	0.225*	0.004	-0.043	0.165	-0.037	**0.008**	0.024	-0.009	0.066	0.046
	2021	0.267**	0.011	0.020	0.050	-0.001	**0.035**	-0.075	0.078	0.169	-0.020
Pod length	2020	-0.177	-0.009	0.038	-0.061	0.074	-0.001	**-0.164**	0.015	-0.056	-0.013
	2021	-0.045	0.009	0.004	0.024	-0.003	0.010	**-0.261**	0.088	0.117	-0.034
Seeds per pod	2020	0.374**	-0.001	0.071	0.010	-0.007	0.000	-0.009	**0.283**	0.010	0.015
	2021	0.260*	-0.025	0.016	0.051	0.000	0.009	-0.076	**0.300**	0.020	-0.035
Pods per plant	2020	0.222*	0.021	0.010	0.168	-0.244	0.002	0.041	0.013	**0.226**	-0.014
	2021	0.398**	-0.060	0.031	0.077	-0.007	0.018	-0.091	0.018	**0.337**	0.075
100 seed weight	2020	-0.160	0.020	-0.017	0.077	-0.038	-0.002	-0.012	-0.024	0.017	**-0.181**
	2021	0.352**	-0.042	-0.001	0.033	-0.002	-0.002	0.031	-0.037	0.090	**0.283**

Diagonal bold values represent direct contribution of traits on seedyield per plant

as well as phenotypic level. The present finding indicated that an improvement in these component traits may bring desirable improvements in the seed yield per plant. It was further observed that 100 – seed weight exhibited significant and positive correlation at genotypic as well as phenotypic level with pods per plant during both the spring seasons (Table 4). Present results indicated that during both the *kharif* seasons, pods per plant was positively and significantly associated with primary branches per plant, clusters per plant and pods per cluster, whereas, during both the spring seasons the trait pods per plant was positively and significantly associated with number of cluster per plant at both genotypic as well as phenotypic level. The present finding of correlation between different traits were in perfect conformity of the earlier findings of Kumar *et al*. (2014), Kumar *et al*. (2015), Hemalatha *et al*. (2017) and Gomathi *et al*. (2020) in urd bean.

Path coefficient analysis showed that during both the *kharif* seasons and both the spring seasons maximum contribution towards the seed yield per plant was exhibited by the traits seeds per pod and pods per plant (Table 5 & 6). It is further evident that the traits seeds per pod and pods per plant not only contributed maximum towards seed yield per plant but these components traits were also positively and significantly correlated with seed yield per plant during both the *kharif* seasons. It indicated the true relationship between seed yield per plant and the component traits *viz*. seeds per pod and pods per plant. Direct selection for these traits will be rewarding for yield improvement. Present findings regarding the contribution of different component traits towards the seed yield per plant were well supported by the earlier finding obtained by Tank and Sharma (2019) and Sagar *et al*.(2021) in blackgram.

Conclusion

On the basis of present findings, it can be concluded that the traits like seeds per pod and pods per plant not only exhibited moderate to high estimates of heritability and genetic advance, they contributed maximum towards the dependent variable seed yield per plant besides showing high positive correlation with seed yield per plant. This indicated that these two component traits are governed by additive gene action and direct selection for these component traits may bring desirable improvement in seed yield per plant.

Conflict of interest

The authors declare no conflict of interest.

Table 6. Path coefficient analysis at phenotypic level during spring 2021 and spring 2022

Character	Year	Phenotypic correlation with yield per plant	Days to maturity	Plant height	Primary branches per plant	Cluster per plant	Pods per cluster	Pod length	Seeds per pod	Pods per plant	100 seed weight
Days to maturity	2021	-0.120	**-0.193**	-0.004	0.023	0.016	0.046	-0.003	-0.001	0.001	-0.005
	2022	-0.032	**0.058**	-0.002	0.050	-0.033	-0.022	-0.013	-0.052	-0.015	-0.002
Plant height	2021	-0.173	-0.009	**-0.093**	-0.085	-0.014	0.034	0.000	0.000	-0.002	-0.004
	2022	-0.179	-0.003	**0.050**	-0.192	0.014	-0.029	0.003	-0.004	-0.003	-0.016
Primary branches per plant	2021	-0.286**	0.020	-0.035	**-0.224**	-0.015	-0.021	0.000	0.000	-0.025	0.015
	2022	-0.362**	-0.006	0.021	**-0.452**	0.034	-0.021	0.003	0.011	0.015	0.032
Cluster per plant	2021	-0.015	0.044	-0.019	-0.047	**-0.069**	0.032	0.002	0.000	0.044	-0.002
	2022	0.006	-0.011	0.004	-0.090	**0.171**	-0.092	0.0003	0.049	-0.029	0.003
Pods per cluster	2021	-0.161	0.046	0.016	-0.024	0.011	**-0.193**	0.002	0.000	0.009	-0.028
	2022	0.109	-0.005	-0.005	0.035	-0.059	**0.268**	0.002	-0.058	-0.020	-0.049
Pod length	2021	-0.010	0.036	-0.003	-0.005	-0.010	-0.027	**0.014**	0.0002	-0.017	0.004
	2022	-0.004	-0.028	0.006	-0.052	0.002	0.016	**0.026**	-0.049	0.046	0.029
Seeds per pod	2021	0.267*	-0.060	-0.021	0.010	0.016	0.023	-0.091	**0.211**	-0.139	0.004
	2022	0.273**	0.011	-0.102	0.018	-0.201	0.007	0.005	**0.238**	0.013	-0.207
Pods per plant	2021	0.214*	-0.001	0.001	0.043	-0.023	-0.013	-0.002	0.001	**0.131**	-0.031
	2022	0.213*	-0.159	0.002	-0.064	0.046	0.049	-0.011	0.033	**0.189**	-0.054
100 seed weight	2021	-0.097	-0.009	-0.003	0.032	-0.001	-0.053	-0.001	0.000	0.040	**-0.102**
	2022	-0.128	0.001	0.004	0.070	-0.003	0.063	-0.004	-0.024	-0.028	**-0.207**

Diagonal bold values represent direct contribution of traits on seed yield per plant

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