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Study of genetic variability and character association for yield and yield related traits in f_3 generation of blackgram (*Vignamungo* (L.) Hepper)

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Abstract— *The present investigation was carried out with a view to study the magnitude of variability, correlation and path analysis excluding reciprocals involving 27 genotypes in blackgram during Kharif - 2018. The experimental material was planted in randomized block design with three replications at the Field Experimentation Centre, Department of Genetics and Plant Breeding, SHUATS, Prayagraj, U.P. The analysis of variance for all the characters revealed that parents were significant for all the characters, indicating presence of considerable amount of genetic variability in the germplasm tested. Harvest index, Number of primary branches, Number of pods per plant, Number of seeds per pod exhibited high GCV, PCV and genetic parameters revealed that heritability (broad sense) and genetic advance as % of mean values were high for Number of primary branches, Number of seeds per pod, biological yield, harvest index, seed yield per plant indicating that selection would be fruitful for improvement of these traitsAmong 27 genotypes studied MU-06 X KPU-13-192 showed high mean performance for seed yield per plant followed by MU-06 X NDUK-13-6, PU-31 and NDUK-13-6 Correlation coefficient analysis revealed that seed yield per plant exhibited positive and significant correlation associated with Plant height, Number of pods per plant, Biological yield and harvest index at both genotypic and phenotypic levels. Path coefficient analysis revealed that characters plant height, number of primary branches, days to maturity, biological yield, and harvest index have positive direct effect on seed yield per plant at genotypic and phenotypic levels.*

Keywords— ***Blackgram, GCV, PCV, Variability, Heritability, Correlation and Path analysis.***

I. INTRODUCTION

Blackgram (*Vigna mungo* [L]. Hepper) is commonly known as urad, mesh or kalai. India is primary center of origin of Blackgram and Central Asia is a secondary center of origin. It is one of the most important legumes of India which belongs to family leguminosae, sub order Papilionaceae and the tribe phaseoleae with chromosome number (2n=22)**.** It is India is the world's largest producer as well as consumer of Blackgram. It produces about 1.5 to 1.9 million tonnes of Blackgram annually from about 3.5 million hectares of area, with an average productivity of 500 kg per hectare. Black gram output accounts for about 10% of India's total pulse production. Urdbean crop is also gaining momentum since 2015-16 and there has been phenomenal increase in its coverage. During 2017-18 the crop was cultivated in an area of > 54 Lha. The success of this crop was released with a harvest of about 36 Lt at an ever-highest yield levels of 655 kg/ha. About 95 per cent of Urdbean production comes from 10 states of Madhya

Pradesh, Rajasthan, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Maharashtra, Jharkhand, Gujarat, Karnataka and West Bengal. In U.P. Blackgram is grown in about 6.14 lakh hectares with a total production of 3.15 lakh tones. Blackgram has a wide range of economic value. It is well known that 50 g pulses/person/day should be consumed in addition to other sources of protein such as cereals, milk, meat and egg which is very difficult task to achieve as the production and productivity of pulse crops including the

blackgram is very low. Hence, there is a strong need to improve the productivity of crop. This could be achieved by studying the genetic architecture of this crop for yield improvement. Therefore, the aim of present study is to identify suitable. Heritability is an important parameter which determines the extent of expressivity of a trait in a setup of environment or agro-climatic conditions. Therefore, heritability estimates are useful in predicting genetic advance under different intensities of selection. High heritable estimates together with high genetic advance are more valid for selection than heritability estimates alone **(Johnson *et al.*, 1955).** Estimation of genetic variability in conjunction with heritability and genetic advance gives an idea of the possible improvement of the character through selection.

II. MATERIALS AND METHODS

The present investigation was carried out at the field experimentation center, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. during *kharif*-2018. All types of facilities necessary for cultivation of successful crop including field preparation, inputs and irrigation facilities were provided from the Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. The recommended dose of fertilizer N:P:K @ 20:40:40 kg/ha was applied in the form of Urea and Di-Ammonium Phosphate as basal dose at the time of sowing

Five competitive plants from each genotype were randomly selected for recording observations on fifteen characters, viz. Days to 50 per cent flowering, Days to 50 per cent pod setting, Plant height (cm), Number of primary branches per plant,Number of days to maturity, Number of pods per plant, Number of seeds per pod, Number of seeds per plant, Biological yield per plant (g), Harvest index (%), 100 Seed weight (g), and Seed yield per plant (g).Correlation coefficient is the mutual association between variables without implying any cause and effect relationship. Single correlation coefficient were computed at genetopic and phenotypic levels between pair of characters adopting following formula given but (**Al-Jibouri *et al.*, 1958)**. Biometrical methods were followed to estimate genotypic and phenotypic coefficient of variation Heritability Broad Sense **(Burton and De Vane, 1953)**Genetic Advance **(Johnson *et al.* 1955)**Correlation coefficient analysis **(Al- Jibouri *et al.* 1958)** The test of significance for association between characters was done by comparing table 'r' values at (n-2) error degrees of freedom for phenotypic and genotypic correlations with estimated values, respectively Path coefficient analysis **(Dewey and Lu, 1959).**

III. RESULTS AND DISCUSSION

Analysis of variance showed highly significant differences for all the 13 characters used under study at 1% level of significance. This indicates that there is ample scope for selection of genotypes for yield and its components and also indicating the presence of considerable variability among the all traits (Table 1).

Estimation of genetic parameters: A wide range of Genotypic Coefficient of Variation (GCV) was observed for all the traits ranged from 3.71 (days to 50% pod setting) to 24.56 (harvest index). The magnitude of Genotypic Coefficient of Variation (GCV) were recorded high for 24.56 (harvest index) followed by number of primary branches per plant (23.68), number of seeds per pod (20.69) and number of pods per plant (20.68).Medium magnitude of Genotypic Coefficient of Variation (GCV) were recorded for number of clusters per plant (18.02), biological yield per plant (17.57), plant height (14.33), seed yield per plant (12.14) and pod length (10.35), whereas the magnitude of Genotypic Coefficient of Variation (GCV) were recorded low for days to maturity (9.95), seed index (7.29), days to 50% flowering (4.40) and days to 50% pod setting (3.71).

Heritability: The heritability estimates varied from 79.14 (number of pods per plant) to

95.11 (harvest index). All the characters *viz*,days to 50% flowering (91.27), days to 50% pod setting (88.94), plant height (81.57), number of primary branches per plant (92.35), number of clusters per plant (89.39), number of pods per plant (79.14), number of seeds per pod (84.58), pod length (83.38), seed index (81.89), biological yield (89.90), harvest index (95.11), seed yield per plant (84.75) and days to maturity (92.38) were identified with high heritability. High heritability of these traits indicates that there is a close correspondence between the genotype and phenotype and selection can be done for these characters

Genetic advance: Improvement in the mean genotypic value of selected plants over the parental population is known as genetic advance. It is the measure of gain under

selection. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection **(Johnson *et al.*, 1955).** The estimate of genetic advance ranged from

18.65 (harvest index) to seed index (0.42), whereas it is high for plant height (17.77). Moderate genetic advance was recorded number of pods per plant (5.99), biological yield per plant (5.62), number of seeds per pod (4.82), days to 50% pod setting (4.79), days to maturity (3.99), days to 50 % flowering (3.73), number of clusters per plant (1.92), number of primary branches per plant (1.63), pod length (1.42) and seed yield per plant (1.38) and low genetic advance was recorded for seed index (0.42).

IV. CONCLUSION

From the present investigation it is concluded that among 27 genotypes of Blackgram on the basis of mean performance MU-06 X KPU-13-192 showed high mean performance for seed yield per plant followed by MU-06 X NDUK-13-6, PU-31 and NDUK-13-6 were found to be superior and showed possessed maximum seed yield. Harvest index, Number of primary branches, Number of pods per plant, Number of seeds per pod exhibited high GCV, PCV and genetic parameters revealed heritability (broad sense) and genetic advance as % of mean values were high for Number of primary branches, Number of seeds per pod, biological yield, harvest index, seed yield per plant indicating that selection would be fruitful for improvement of these traits. Correlation coefficient analysis revealed that seed yield per plant exhibited positive and significant correlation associated with Plant height, Number of pods per plant, Biological yield and harvest index at both genotypic and phenotypic levels. Path coefficient analysis revealed that characters plant height, number of primary branches, days to maturity, biological yield, and harvest index have positive direct effect on seed yield per plant at genotypic and phenotypic levels.

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Table 1: Analysis of variance for 13 characters in 27 genotypes of blackgram

Characters	**Mean Sum of Squares**		
	Replications	Treatments	Error
	(df= 2)	(df= 26)	(df=52)
Days of 50 % flowering	8.346	4.642**	2.641
Days of 50% pod setting	12.605	3.354**	1.810
Days of maturity	6.90	6.69**	2.30
Plant height	9.072	151.955**	3.772
Number of clusters per plant	0.396	1.784**	0.170
Number of pods per plant	2.734	27.511**	1.306
Pod length	0.008	0.051**	0.016
Number of seeds per pod	0.413	0.350**	0.135
Number of primary branches plant	0.135	0.169**	0.077
Seed index	0.117	0.128**	0.066
Biological yield	1.305	17.553**	2.536
Harvest index	24.167	151.143**	16.230
Seed yield per plant	0.130	2.061**	0.152

Table 2: Estimation of components of variance and genetic parameters for 13 characters in black gram genotypes

S. No	**Character**	**Genotypic Coefficient of variation (%)**	**Phenotypic Coefficient of variation (%)**	**Heritability (h2)(%) (broad sense)**	**Genetic advance**	**Genetic advance as percent of mean (5%)**
1	Days to 50% flowering	4.40	4.61	91.27	3.73	8.66
2	Days to 50% Pod setting	3.71	3.93	88.94	4.79	7.21
3	Days to Maturity	14.33	15.87	81.57	17.77	26.66
4	Plant height	23.68	24.64	92.35	1.63	46.87
5	No.of primary branches	20.68	23.24	79.14	5.99	37.89
6	No.of clusters per plant	18.02	19.06	89.39	1.92	35.09
7	No.of pods per plant	10.35	11.34	83.38	1.42	19.48
8	No.of seeds per pod	20.69	22.49	84.58	4.82	39.19

9	Pod length	17.57	18.53	89.90	5.62	34.31
10	seed index	7.29	8.05	81.89	0.42	13.58
11	Biological yield	24.56	25.19	95.11	18.65	49.35
12	Harvest Index	9.95	10.36	92.38	3.99	19.71
13	Seed yield	12.14	13.18	84.75	1.38	23.02

Vg = Genotypic variance; Vp = Phenotypic variance; GCV = Genotypic coefficient of variation; PCV = Phenotypic coefficient of variation; h^2(bs) = Heritability at broad sense;

GA = Genetic advance; GAM = Genetic advance as percent mean.

Table 3: List of genotypes used in present investigation

S. No	Genotypes	S. No	Genotypes
1.	KPU-13-189 X IU-02-1-3	16.	KPU-13-189
2.	KPU-63-189 X NDUK-13-4	17.	IU-02-1-3
3.	IU-02-1-3 X PU-31	18.	NDUK-13-4
4.	IU-02-1-3 X PU - 09-37	19.	PU-31
5.	IU-02-1-3 x PU-38	20.	PU-09-37
6.	IU-02-1-3 X AZAD-1	21.	PU-38
7.	IU-02-1-3 X MU-06	22.	MU-06
8.	MU-06 X PU-09-37	23.	KPU-13-192
9.	MU-06 X KPU-13-192	24.	KU-96-7
10.	MU-06 X PU-31	25.	NDUK-13-6
11.	MU-06 X KU-96-7	26.	KPU-63-189
12.	MU-06 x PU-28	27.	T9(CHECK)
13.	MU-06 X IU-02-1-3		
14.	PU-09-37 X MU-06		
15.	AZAD-1		

Table 4. Analysis of variance for 13 characters in Blackgram

S. No	Character	Mean sum of squares		
		Replication(d.f=2)	Treatment(d.f=26)	Error (d.f=52)
1	**Days of 50 % flowering**	8.346	4.642**	2.641
2	**Days of 50% pod setting**	12.605	3.354**	1.810
3	**Days of maturity**	6.90	6.69**	2.30
4	**Plant height**	9.072	151.955**	3.772
5	**Number of clusters per plant**	0.396	1.784**	0.170
6	**Number of pods per plant**	2.734	27.511**	1.306
7	**Pod length**	0.008	0.051**	0.016
8	**Number of seeds per pod**	0.413	0.350**	0.135

9	**Number of primary branches plant**	0.135	0.169**	0.077
10	**Seed index**	0.117	0.128**	0.066
11	**Biological yield**	1.305	17.553**	2.536
12	**Harvest index**	24.167	151.143**	16.230
13	**Seed yield per plant**	0.130	2.061**	0.152

Table 5 Mean performance of 27 genotypes of Blackgram for yield and component characters

S. No.	Genotypes	Days to 50% Flowering	Days to 50% Pod setting	Days to Maturity	Plant Height (cm)	No. of Primary Branches	No. of Clusters per Plant	No. of Pods per Plant	No. of Seeds per Pod	Pod Length (cm)	Seed index (g)	Biological Yield (g)	Harvest Index (%)	Seed yield per Plant (g)
1	**KPU-13-189 X IU-02-1-3**	44.33	54.67	67	63.4	6.33	18.8	4.39	6.58	3.4	3.96	14.42	30.36	5.23
2	**KPU-63-189 X NDUK-13-4**	43.67	52	70	58.1	6.17	24.33	4.51	7	3.13	4.21	16.4	36.58	4.9
3	**IU-02-1-3 X PU-31**	45.33	52	69.33	50.07	6.27	17.33	4.86	7.4	3.6	3.97	15.57	37.23	5.85
4	**IU-02-1-3 X PU - 09-37**	43	52.67	70.33	65.6	6.07	25.65	4.54	6.74	3.2	3.83	17.87	25.43	5.41
5	**IU-02-1-3 x PU-38**	46	53	69	57.47	6.87	23.33	4.48	6.71	3.4	3.85	16.6	35.25	6
6	**IU-02-1-3 X AZAD-1**	44	52.33	69	53.53	6.96	17.53	4.51	7.33	3.28	4.08	15.67	47.44	5.47
7	**IU-02-1-3 X MU-06**	44.33	52.33	68	45.17	7.6	16.73	4.48	6.44	3.47	3.78	20.33	31.58	5.15
8	**MU-06 X PU-09-37**	44	51.33	73	46.53	5.13	24.73	4.68	6.92	3.6	4.02	15.07	22.1	5.31
9	**MU-06 X KPU-13-192**	43	53.33	68	52.2	5.53	24.13	4.48	6.78	3.2	3.79	16.13	30.33	7.66
10	**MU-06 X PU-31**	45.33	56	67	45.4	5.53	18.93	4.29	6.41	3.6	3.78	17.27	47.33	5.44
11	**MU-06 X KU-96-7**	44.67	53	70.33	62.57	6.6	19.47	4.3	6.56	2.8	3.85	25.4	39.89	5.61
12	**MU-06 x PU-28**	46	54.33	69	51.9	7.27	20.6	4.54	7.04	3.4	3.73	18.4	24.56	5.56
13	**MU-06 X NDUK-13-6**	43	53.33	69	51.4	6.13	18.73	4.34	6.96	3.27	3.68	15.8	33.54	7.21
14	**MU-06 X IU-02-1-3**	43.67	51.67	69.67	67.6	6.2	20.07	4.53	7.11	3.33	4.02	13.67	32.54	5.44
15	**PU-09-37 X**	46	51.67	68.67	60.63	6	23.47	4.34	6.63	3	3.56	16.13	44.87	4.27

	MU-06													
16	**NDUK-13-6**	41.67	54	67.67	56.47	7	25.2	4.46	6.67	3.67	3.73	18.8	36.89	6.84
17	**AZAD-1**	45	52.67	69	46.17	5.93	20.47	4.55	6.89	3.67	4.27	16.87	28.84	5.48
18	**KPU-63-189**	45.33	53	69.33	50.53	5.8	21.07	4.39	5.93	3.6	4.05	14.53	49.72	6.51
19	**IU-02-1-3**	41.67	53.33	67.67	42.37	6.6	19.8	4.49	6.74	3.33	3.76	16.67	33.97	4.87
20	**NDUK-13-4**	45.33	52.67	68.33	51.83	4.47	18.1	4.57	6.96	3.47	3.46	16.07	35.27	4.61
21	**PU-31**	42.67	51.67	65	45.7	5.27	20.6	4.34	6.74	3.4	3.62	13.93	25.43	6.93
22	**PU-09-37**	43.67	52	66.33	42.6	6.2	18.13	4.4	6.48	3.07	3.58	16.67	36.79	5.65
23	**PU-38**	43.67	53	68.33	62.53	5.2	18.53	4.35	6.45	3.07	3.55	14.53	38.72	5.12
24	**MU-06**	43.33	52	69.67	53	6.2	21.07	4.31	6.15	3.27	3.88	19.67	34.36	4.74
25	**KPU-13-192**	42.33	52.33	68.67	54.17	6.27	16.4	4.28	6.33	3.07	3.69	15.67	41.41	5.7
26	**KU-96-7**	44.33	52.67	68	55.11	7.53	27.4	4.4	6.26	3.8	3.66	18.07	36.92	6.62
27	**T9(CHECK)**	44.33	51.67	69.33	47.33	7.39	23.27	4.5	6.7	3.33	3.59	18.87	29.44	6.41
	Mean	44.41	52.66	68.42	53.31	6.24	20.88	4.46	6.7	3.35	3.81	16.85	35.07	5.7
	SE	1.33	1.1	1.24	1.59	0.34	0.93	0.1	0.3	0.23	0.21	1.3	3.29	0.32
	CD5%	**2.66**	**2.2**	**2.48**	**3.18**	**0.68**	**1.87**	**0.21**	**0.6**	**0.45**	**0.42**	**2.61**	**6.6**	**0.64**
	CV	3.69	2.55	2.21	3.64	6.61	5.47	2.86	5.47	8.28	6.75	9.45	11.49	6.84
	Max	46	55	72.33	67.6	7.6	27.4	4.86	7.41	3.8	4.27	25.4	49.72	7.66
	Min	42	51.33	64	42.37	4.47	16.4	4.29	5.93	2.8	3.46	13.67	22.11	4.27

Table 6 Genetic parameters for 13 seed yield characters in Blackgram

Characters	Genotypic Coefficient Variation	Phenotypic Coefficient Variation	Heritability (%)	Genetic Advance	GA as % Mean
Days to 50% flowering	4.40	4.61	91.27	3.73	8.66
Days to 50% pod setting	3.71	3.93	88.94	4.79	7.21
Plant height (cm)	14.33	15.87	81.57	17.77	26.66
No. of primary branches / plant	23.68	24.64	92.35	1.63	46.87
No. of pods per plant	20.68	23.24	79.14	5.99	37.89
No. of clusters per Plant	18.02	19.06	89.39	1.92	35.09
Pod length (cm)	10.35	11.34	83.38	1.42	19.48
No. of seeds per pod	20.69	22.49	84.58	4.82	39.19
Biological yield per plant (g)	17.57	18.53	89.90	5.62	34.31
Seed index(g)	7.29	8.05	81.89	0.42	13.58
Harvest Index	24.56	25.19	95.11	18.65	49.35
Days to maturity	9.95	10.36	92.38	3.99	19.71
Seed yield per plant	12.14	13.18	84.75	1.38	23.02

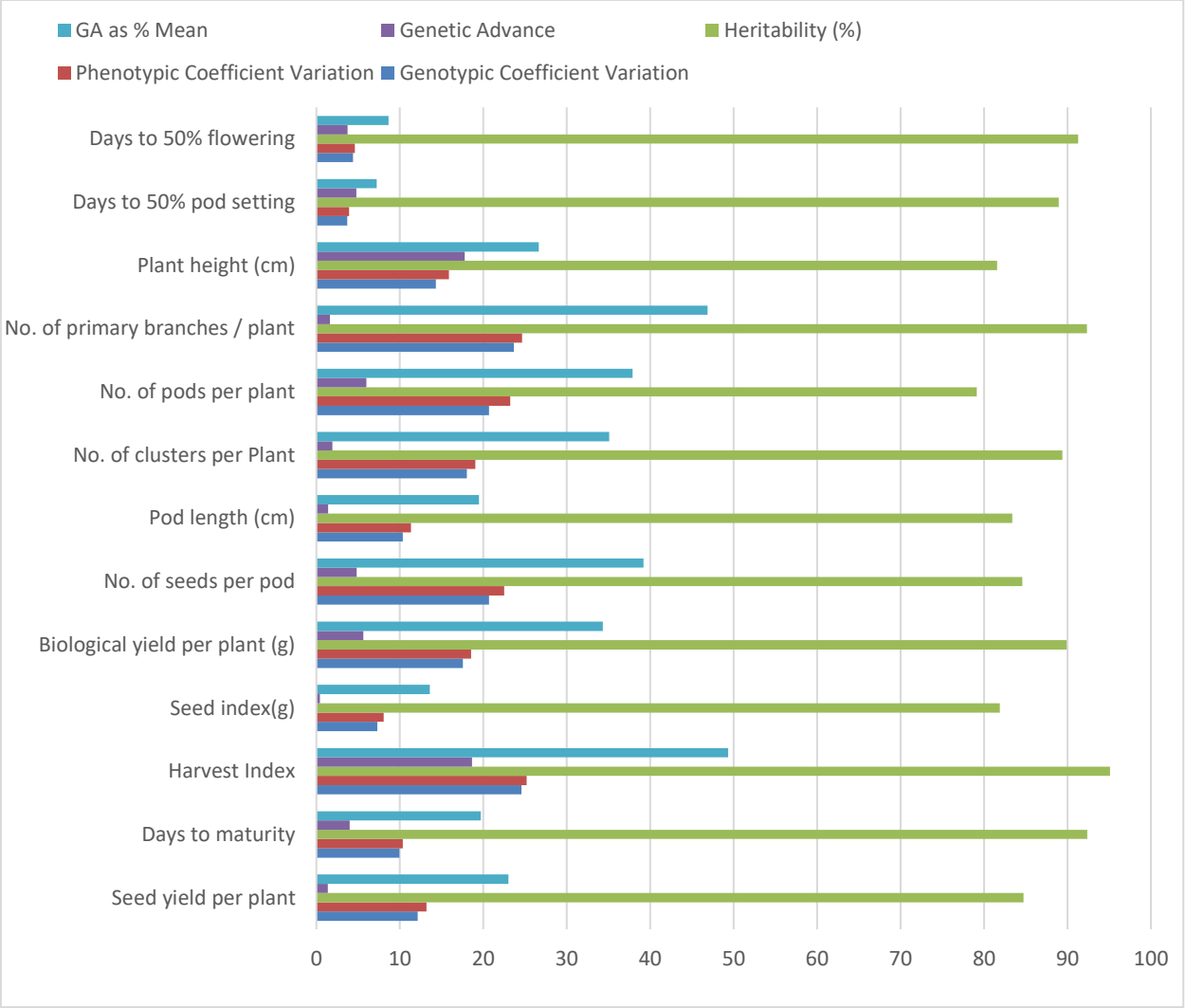

Fig. 1.Bar chart representing the relationship among the GCV, PCV, heritability and genetic advance as percent of mean in blackgram

Table 7 Genotypic correlation coefficient of seed yield and its component traits in Blackgram

Characters	Days to 50% flowering	Days to 50% pod setting	Plant height	No. of primary branches	No. of pods per plant	No. of clusters per Plant	Pod length	No. of seeds per pod	Biological yield	Seed index	Harvest Index	Days to maturity	Seed yield per plant
Days to 50 % flowering	1.000	0.242*	0.297**	0.126	-0.434**	-0.113	-0.035	-0.029	-0.047	-0.055	-0.023	-0.027	-0.04
Days to 50% pod setting		1.000	0.025	0.305**	-0.541**	0.037	-0.086	0.217	-0.085	0.008	0.02	0.202	-0.142
Plant height			1.000	-0.031	-0.015	-0.275*	0.091	0.18	-0.223	-0.243*	0.391**	0.027	0.471**
No. of primary branches				1.000	0.135	0.118	0.17	0.146	0.308**	0.318**	-0.246*	-0.011	0.027
No. of pods per plant					1.000	0.355**	0.381**	-0.046	0.128	-0.106	0.035	-0.053	0.291*
No. of clusters						1.000	-0.284*	0.14	0.054	0.272*	0.059	0.243*	0.151

per Plant													
Pod length							1.000	-0.032	0.251*	-0.616**	-0.320**	-0.072	-0.264*
No. of seeds per pod								1.000	0.500**	0.16	-0.337**	0.435**	-0.007
Biological yield									1.000.00	0.166	-0.878**	0.308**	0.177**
Seed index										1.000	0.017	-0.212	0.189
Harvest Index											1.000	-0.391**	0.702**
Days to maturity												1.000	-0.22

*significant at 5% level of significance ** significant at 1% level of significance

Table 8. Phenotypic correlation coefficient of seed yield and its component traits in Blackgram

Characters	Days to 50% flowering	Days to 50% pod setting	Plant height	No. of primary branches	No. of pods per plant	No. of clusters per Plant	Pod length	No. of seeds per pod	Biological yield	Seed index	Harvest Index	Days to maturity	Seed yield per plant
Days to 50% flowering	1.000	0.12	0.235*	0.113	-0.276*	-0.168	-0.004	-0.037	-0.009	-0.002	-0.005	0.039	-0.02
Days to 50% pod setting		1.000	0.062	0.155	-0.428**	0.015	-0.102	0.156	-0.001	-0.032	-0.037	0.11	-0.133
Plant height			1.000	0.087	-0.012	-0.171	0.086	0.166	-0.181	-0.12	0.341**	0.007	0.411**
No. of primary branches				1.000	0.16	0.091	0.102	0.163	0.205	0.189	-0.141	-0.029	0.06
No. of pods per plant					1.000	0.182	0.287*	-0.075	0.118	-0.149	0.032	-0.045	0.245*
No. of clusters per Plant						1.000	-0.253*	0.105	0.058	0.098	0.056	0.168	0.162
Pod length							1.000	0.001	0.222	-0.328**	-0.271*	-0.029	-0.187
No. of seeds per pod								1.000	0.441**	0.09	-0.309**	0.369**	0.012
Biological yield									1.000	0.053	0.853**	0.260*	0.194*
Seed index										1.000	0.026	-0.139	0.055
Harvest Index											1.000	-0.345**	0.670**
Days to maturity												1.000	-0.177

*significant at 5% level of significance ** significant at 1% level of significance

Table 9. Direct and indirect effects of yield and its component traits in Blackgram at genotypic level

Characters	Days to 50% flowering	Days to 50% pod setting	Plant height	No. of primary branches	No. of pods per plant	No. of clusters per Plant	Pod length	No. of seeds per pod	Biological yield	Seed index	Harvest Index	Days to maturity	Seed yield per plant
Days to 50% flowering	**0.141**	-0.041	-0.051	0.029	-0.024	0.020	0.005	0.001	-0.074	0.010	-0.051	-0.006	-0.04
Days to 50% pod setting	0.034	**-0.169**	-0.004	0.071	-0.030	-0.007	0.012	-0.009	-0.133	-0.001	0.045	0.049	-0.142
Plant height	0.042	-0.004	**-0.171**	-0.007	-0.001	0.050	-0.013	-0.008	-0.349	0.045	0.881	0.007	0.471
No. of primary branches	0.018	-0.051	0.005	**0.233**	0.007	-0.021	-0.024	-0.006	0.482	-0.060	-0.554	-0.003	0.027
No. of pods per plant	-0.061	0.091	0.003	0.031	**0.055**	-0.064	-0.053	0.002	0.200	0.020	0.080	-0.013	0.291
No. of clusters per Plant	-0.016	-0.006	0.047	0.028	0.019	**-0.180**	0.039	-0.006	0.085	-0.051	0.134	0.059	0.151
Pod length	-0.005	0.015	-0.016	0.040	0.021	0.051	**-0.139**	0.001	0.392	0.115	-0.722	-0.017	-0.264
No. of seeds per pod	-0.004	-0.037	-0.031	0.034	-0.003	-0.025	0.004	**-0.044**	0.782	-0.030	-0.760	0.105	-0.007
Biological yield	-0.007	0.014	0.038	0.072	0.007	-0.010	-0.035	-0.022	**1.564**	-0.031	-1.977	0.074	0.177
Seed index	-0.008	-0.001	0.042	0.074	-0.006	-0.049	0.085	-0.007	0.259	**-0.187**	0.038	-0.051	0.189
Harvest Index	-0.0032	-0.0033	-0.0670	-0.0574	0.0019	-0.0107	0.0444	0.0147	-1.3723	-0.0032	**2.2525**	-0.0944	0.702
Days to maturity	-0.0037	-0.0340	-0.0046	-0.0025	-0.0029	-0.0438	0.0103	-0.019	0.4808	0.0397	-0.881	**0.2414**	-0.22

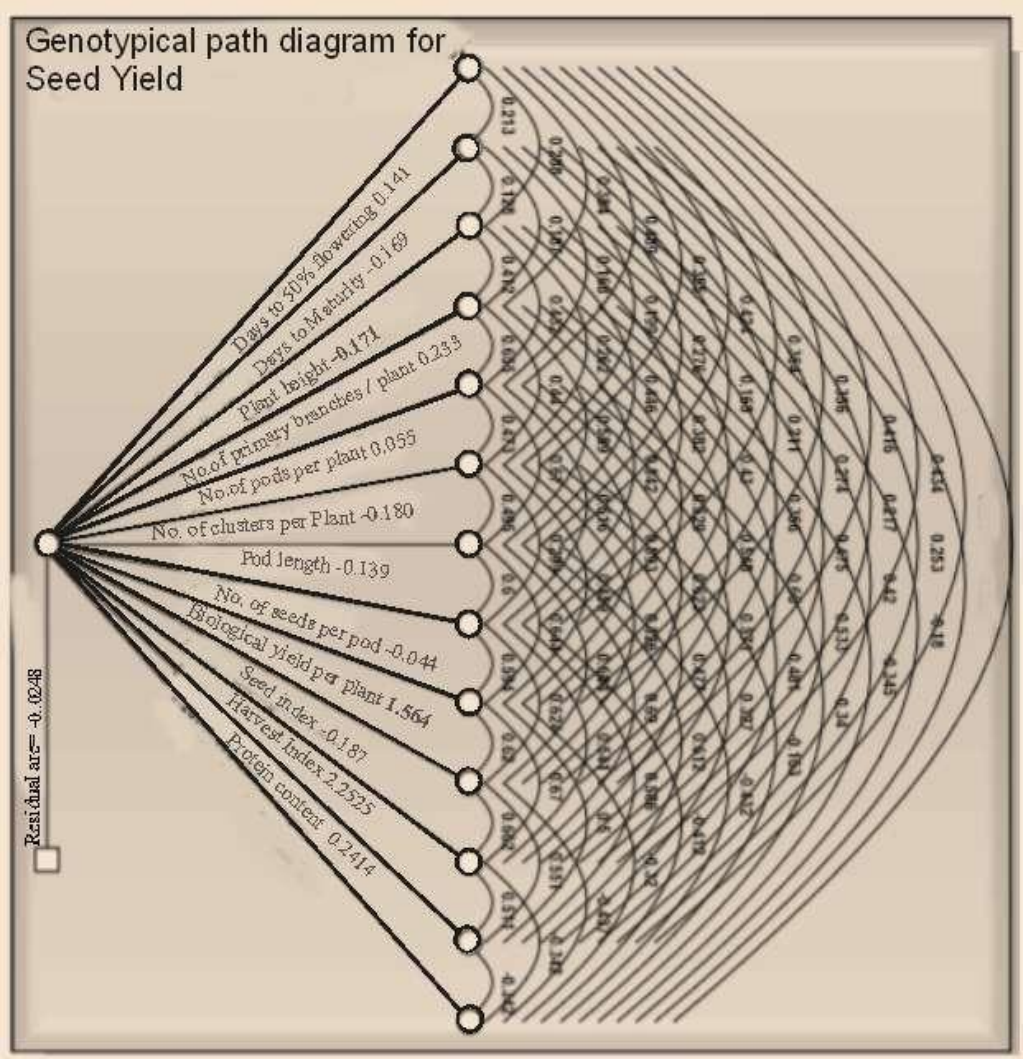

Fig 2: Genotypical path diagram for seed yield.

Table 10 Direct and indirect effects of yield and its component traits in Blackgram at Phenotypic level

Characters	Days to 50% flowering	Days to 50% pod setting	Plant height	No. of primary branches	No. of pods per plant	No. of clusters per Plant	Pod length	No. of seeds per pod	Biological yield	Seed index	Harvest Index	Days to maturity	Seed yield per plant
Days to 50% flowering	**-0.025**	-0.012	0.009	0.011	0.004	0.005	0.000	0.001	-0.011	0.000	-0.008	0.005	-0.02
Days to 50% pod setting	-0.003	**-0.100**	0.002	0.015	0.006	0.000	0.003	-0.006	-0.001	0.002	-0.064	0.014	-0.133
Plant height	-0.006	-0.006	**0.040**	0.008	0.000	0.005	-0.003	-0.007	-0.224	0.007	0.595	0.001	0.411
No. of primary branches	-0.003	-0.016	0.003	**0.097**	-0.002	-0.003	-0.003	-0.007	0.253	-0.011	-0.246	-0.004	0.06
No. of pods per plant	0.007	0.043	-0.001	0.015	**-0.014**	-0.005	-0.009	0.003	0.146	0.009	0.056	-0.006	0.245
No. of clusters per Plant	0.004	-0.001	-0.007	0.009	-0.002	**-0.030**	0.008	-0.004	0.072	-0.006	0.099	0.022	0.162

Pod length	0.000	0.010	0.003	0.010	-0.004	0.007	**-0.030**	0.000	0.273	0.020	-0.474	-0.004	-0.187
No. of seeds per pod	0.001	-0.016	0.007	0.016	0.001	-0.003	0.000	**-0.041**	0.544	-0.005	-0.539	0.048	0.012
Biological yield	0.000	0.000	-0.007	0.020	-0.002	-0.002	-0.007	0.018	**1.233**	-0.003	-1.090	0.034	0.194
Seed index	0.000	0.003	-0.005	0.018	0.002	-0.003	0.010	-0.004	0.065	**-0.061**	0.046	-0.018	0.055
Harvest Index	0.00012	0.0037	0.01351	-0.01364	-0.00044	-0.00167	0.00816	0.01251	-1.05246	-0.00161	**1.74624**	-0.04457	0.670
Days to maturity	-0.00097	-0.01107	0.00028	-0.00278	0.00062	-0.00496	0.00087	-0.01495	0.32048	0.00845	-0.60259	**0.12917**	-0.177

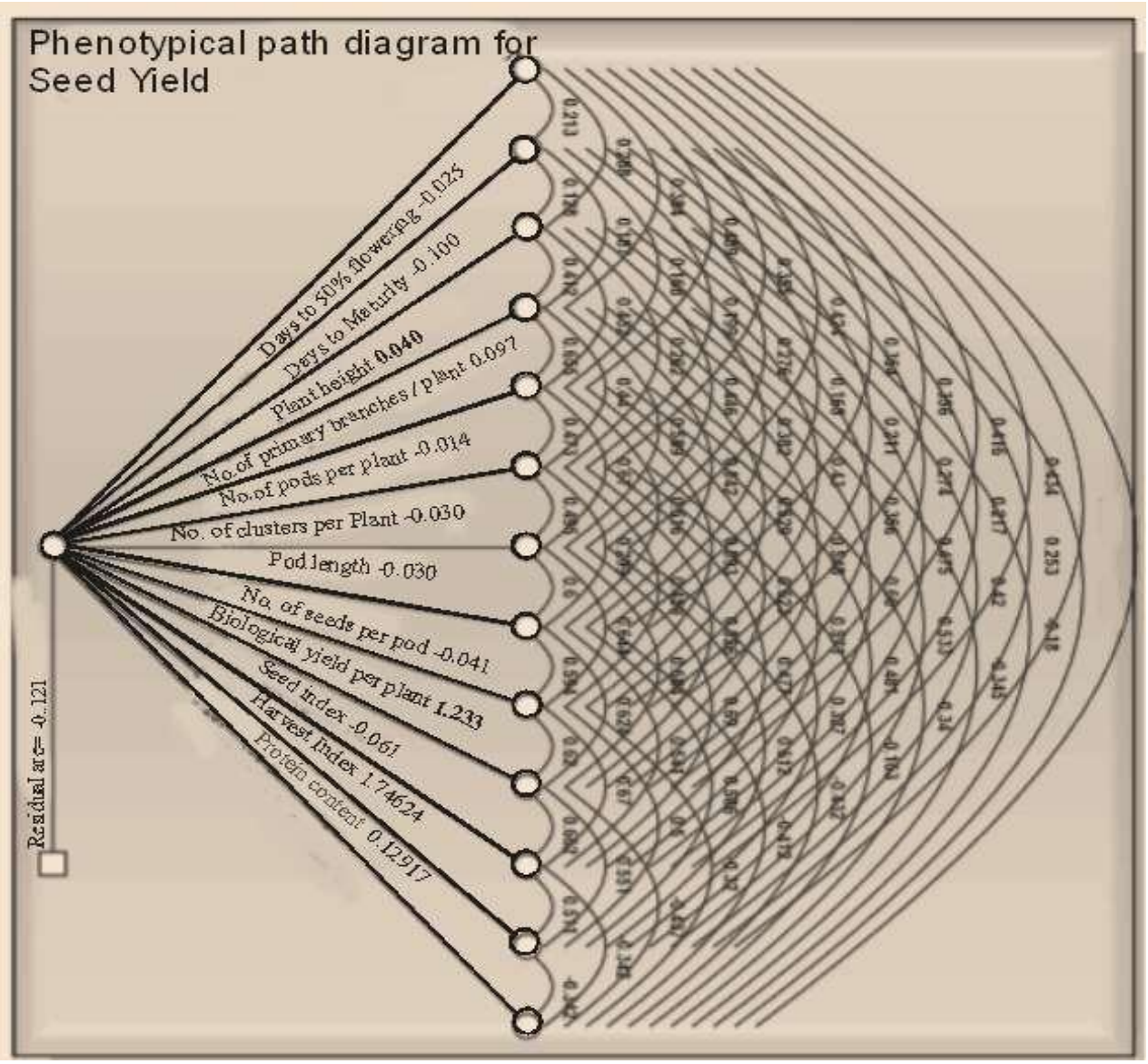

Fig 3: Phenotypical path diagram for seed yield