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Path coefficient analysis for important yield components in black gram [*Vigna mungo* (L.) Hepper]

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Abstract
An experiment was carried out during the *rabi* season of 2021-22 at Research and Education Farm, Department of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri with Twenty four genotypes of black gram raised in randomised block design with two replications for evaluating the direct and indirect effects for fifteen characters of black gram *viz*., days to initiation of flowering, days to 50 percent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of grains per pod, pod length (cm), hundred seed weight (g), grain yield per plant (g), dry matter per plant (g), harvest index (%) and protein content (%). The results of path analysis revealed that that positive direct effect on seed yield was exhibited by hundred seed weight, harvest index, dry matter per plant, days to fifty percent flowering, number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of grains per pod and pod length indicating importance of these characters and can be strategically used to improve the yield of black gram. While the characters *viz.*, days to initiation of flowering, days to maturity, plant height and protein content revealed negative direct effect of given magnitudes towards seed yield per plant.

Keywords: Black gram, path analysis, seed yield, phenotypic level, genotypic level

1. Introduction
Black gram [*Vigna mungo* (L.) Hepper] (2n = 2x= 22) belongs to family Leguminoceae; Sub-family Papillionaceae; Genus Vigna and species mungo with a genome size of 560 Mb (Arumunganathan and Earle, 1991) [1]. Black gram is also known by over 30 vernacular names such as Biri, Urd, mash, urad and others. It belongs to the Fabaceae family, which is the second largest after the Poaceae. It belongs to the Papilionaceae subfamily, which includes over 480 genera and 12,000 species. It is believed that black gram originated in India and central Asia. *Vigna mungo* var. mungo (L.) Hepper is believed to have been domesticated from its wild progenitor, *Vigna mungo* var. Silvestris Lukoki, Marchal, and otoul (Chandel *et al*. 1984) [4] based on archeological evidence found in India (Fuller and Harvey 2006) [6] domestication of black gram may have occurred about 4500 years ago.

The major portion of black gram is utilized in making dal, curries, soup, sweets and snacks. Black gram is an excellent source of protein (25-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids, and vitamins (Malik B. A., 1994) [9]. In terms of dietary protein content, it ranks second only to soybean. It contains vitamin A, B1, B3 and a trace of thiamine, riboflavin, niacin and vitamin C. It has the highest phosphoric acid content of any pulse.

India is the world's largest producer as well as consumer of black gram. Though, India is the world’s largest producer of black gram, it imports a large amount to meet the growing domestic needs. But the productivity in India is low as compared with world’s average. The breeding progress has been slow and uneven because several desirable traits need to be combined for developing appropriate plant type for a particular growing region and cropping system. Path analysis identifies the yield components which directly and indirectly influence the yield; hence help to combine the desirable traits in single variety. So this research effort is undertaken to ascertain the direct and indirect effects of different traits on seed yield calculated as suggested by Dewey and Lu (1959) [5] among twenty four different black gram genotypes for evolving the superior high yielding ones.

2. Material and Methods
The experiment was conducted during *rabi* 2021-22 raised in randomized block design at with two replications in the spacing of 30 cm x 20 cm at Research and Education Farm, Department

of Agril. Botany, College of Agriculture, Dapoli, Dist. Ratnagiri and the recommended cultural practices were followed. Each plot had 3 m x 1 m area. The observations were recorded on five randomly selected plants for fifteen characters *viz*., days to initiation of flowering, days to 50 percent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of grains per pod, pod length (cm), hundred seed weight (g), grain yield per plant (g), dry matter per plant (g), harvest index (%) and protein content (%).

3. Results & Discussion
Path analysis furnishes the cause and effect of different yield components which would provide better index for selection rather than mere correlation coefficients (Arya *et al.*, 2017) [2]. Correlation gives only the relation between two variables whereas path coefficient analysis allows separation of the direct effect and their indirect effects through other attributes by partitioning the correlation (Wright, 1921) [2].

Table 1: Path analysis for different characters at phenotypic level in Black gram

Characters	DIF	DFF	DTM	PH (cm)	NBPP	NCPP	NPPC	NPPP	NGPP	PL (cm)	HSW	PC (%)	DMPP (g)	HI (%)	GYPP (g)
DIF	-0.0118	-0.0092	-0.0094	-0.0047	-0.0031	-0.0014	0.0021	-0.0009	-0.0024	-0.0024	0.001	-0.002	0.0022	-0.004	0.0544
DFF	0.1167	0.1491	0.14	0.0233	0.0185	-0.0032	0.0051	-0.0016	0.0394	0.0033	-0.0251	0.0328	-0.047	0.0482	-0.004
DTM	-0.0817	-0.0968	-0.1031	-0.0313	-0.0281	-0.0123	0.0039	-0.0088	-0.0211	-0.0113	0.0142	-0.0309	0.0179	-0.0369	0.0751
PH (cm)	-0.007	-0.0028	-0.0054	-0.0177	-0.0105	-0.0124	0.006	-0.0091	0.0048	-0.0053	-0.0021	-0.0008	-0.0043	-0.0116	0.483**
NBPP	0.0074	0.0035	0.0077	0.0167	0.0282	0.0224	-0.0017	0.0201	-0.001	0.0108	-0.0011	0.0058	0.0098	0.0159	0.586**
NCPP	0.0224	-0.004	0.0221	0.1301	0.1472	0.185	0.0105	0.1744	-0.0226	0.0731	0.0022	0.0307	0.1225	0.1113	0.827**
NPPC	-0.0395	0.0076	-0.0084	-0.0745	-0.0136	0.0126	0.2215	0.0593	0.0671	0	-0.0417	0.0456	0.0237	0.0136	0.314*
NPPP	0.0145	-0.0022	0.0169	0.1018	0.1408	0.1861	0.0529	0.1975	-0.0092	0.0686	-0.0142	0.0357	0.1343	0.1126	0.856**
NGPP	0.0168	0.0221	0.0171	-0.0228	-0.003	-0.0102	0.0253	-0.0039	0.0836	0.0061	-0.025	-0.004	-0.0077	0.0098	0.0658
PL (cm)	0.006	0.0007	0.0033	0.009	0.0113	0.0117	0	0.0103	0.0022	0.0297	0.0019	0.0047	0.0107	0.0061	0.384*
HSW (g)	-0.0237	-0.0487	-0.0398	0.035	-0.0116	0.0034	-0.0545	-0.0208	-0.0866	0.0185	0.2895	0.0559	0.0452	-0.0241	0.2104
PC (%)	-0.0154	-0.0203	-0.0278	-0.0041	-0.0189	-0.0153	-0.019	-0.0167	0.0045	-0.0148	-0.0179	-0.0925	-0.0055	-0.012	0.1491
DMPP(g)	-0.0696	-0.1179	-0.065	0.0898	0.1291	0.2473	0.04	0.2541	-0.0344	0.1347	0.0583	0.0222	0.3735	0.0118	0.687**
HI (%)	0.1192	0.1149	0.127	0.2326	0.1996	0.2136	0.0218	0.2024	0.0415	0.0733	-0.0295	0.046	0.0112	0.3551	0.596**

*Significant at 5% level **Significant at 1% level

Note: Bold figures indicate direct effects

Note: DIF- Days to initiation of flowering, DFF- Days to 50% flowering, DTM- Days to maturity, NBPP- Number of branches per plant, NCPP- Number of clusters per plant, NPPC- Number of pods per cluster, NPPP- Number of pods per plant, NGPP-Number of grains per pod, PL- Pod length, HSW- Hundred seed weight, PH- Plant height, GYPP- Grain yield per plant, DMPP- Dry matter per plant, HI- Harvest index, PC- Protein content

Table 9: Path analysis for different characters at genotypic level in black gram

Characters	DIF	DFF	DTM	PH (cm)	NBPP	NCPP	NPPC	NPPP	NGPP	PL (cm)	HSW	PC (%)	DMPP (g)	HI (%)	GYPP (g)
DIF	-0.0445	-0.0388	-0.0407	-0.0216	-0.0133	-0.0068	0.0135	-0.0032	-0.0102	-0.0100	0.0052	-0.0104	0.0094	-0.0195	0.0412
DFF	0.1767	0.2032	0.1896	0.0360	0.0248	-0.0062	0.0181	-0.0093	0.0564	0.0105	-0.0433	0.0553	-0.0702	0.0800	-0.0156
DTM	-0.1311	-0.1339	-0.1435	-0.0484	-0.0409	-0.0182	0.0006	-0.0107	-0.0283	-0.0257	0.0248	-0.0507	0.0262	-0.0599	0.0778
PH (cm)	0.0668	0.0244	0.0465	0.1377	0.0822	0.0987	-0.0490	0.0728	-0.0390	0.0591	0.0177	0.0088	0.0335	0.0921	0.515**
NBPP	0.0278	0.0114	0.0266	0.0557	0.0933	0.0753	-0.0073	0.0684	-0.0039	0.0489	-0.0052	0.0198	0.0332	0.0540	0.609**
NCPP	0.0221	-0.0044	0.0184	0.1040	0.1172	0.1451	0.0099	0.1402	-0.0215	0.0840	0.0009	0.0262	0.0985	0.0898	0.865**
NPPC	-0.0796	0.0233	-0.0012	-0.0932	-0.0205	0.0178	0.2617	0.0816	0.0961	0.0061	-0.0491	0.0532	0.0263	0.0204	0.347*
NPPP	0.0142	-0.0090	0.0146	0.1034	0.1433	0.1888	0.0610	0.1955	-0.0071	0.0959	-0.0150	0.0440	0.1401	0.1166	0.909**
NGPP	0.0323	0.0393	0.0279	-0.0401	-0.0059	-0.0210	0.0520	-0.0051	0.1416	0.0217	-0.0550	-0.0132	-0.0128	0.0204	0.0633
PL (cm)	-0.0161	-0.0037	-0.0128	-0.0306	-0.0374	-0.0413	-0.0017	-0.0350	-0.0109	-0.0714	-0.0085	-0.0125	-0.0401	-0.0179	0.541**
HSW (g)	-0.0357	-0.0649	-0.0526	0.0391	-0.0170	0.0019	-0.0571	-0.0233	-0.1183	0.0361	0.3045	0.0659	0.0506	-0.0205	0.2104
PC (%)	-0.0196	-0.0228	-0.0296	-0.0053	-0.0178	-0.0151	-0.0170	-0.0188	0.0078	-0.0146	-0.0181	-0.0837	-0.0078	-0.0116	0.1783
DMPP(g)	-0.0879	-0.1438	-0.0758	0.1013	0.1480	0.2824	0.0418	0.2982	-0.0375	0.2335	0.0691	0.0388	0.4161	0.0186	0.715**
HI (%)	0.1159	0.1042	0.1104	0.1770	0.1530	0.1637	0.0207	0.1578	0.0380	0.0665	-0.0178	0.0368	0.0118	0.2646	0.627**

*Significant at 5% level **Significant at 1% level

Note: Bold figures indicate direct effects.

Note: DIF- Days to initiation of flowering, DFF- Days to 50% flowering, DTM- Days to maturity, NBPP- Number of branches per plant, NCPP- Number of clusters per plant, NPPC- Number of pods per cluster, NPPP- Number of pods per plant, NGPP-Number of grains per pod, PL- Pod length, HSW- Hundred seed weight, PH- Plant height, GYPP- Grain yield per plant, DMPP- Dry matter per plant, HI- Harvest index, PC- Protein content

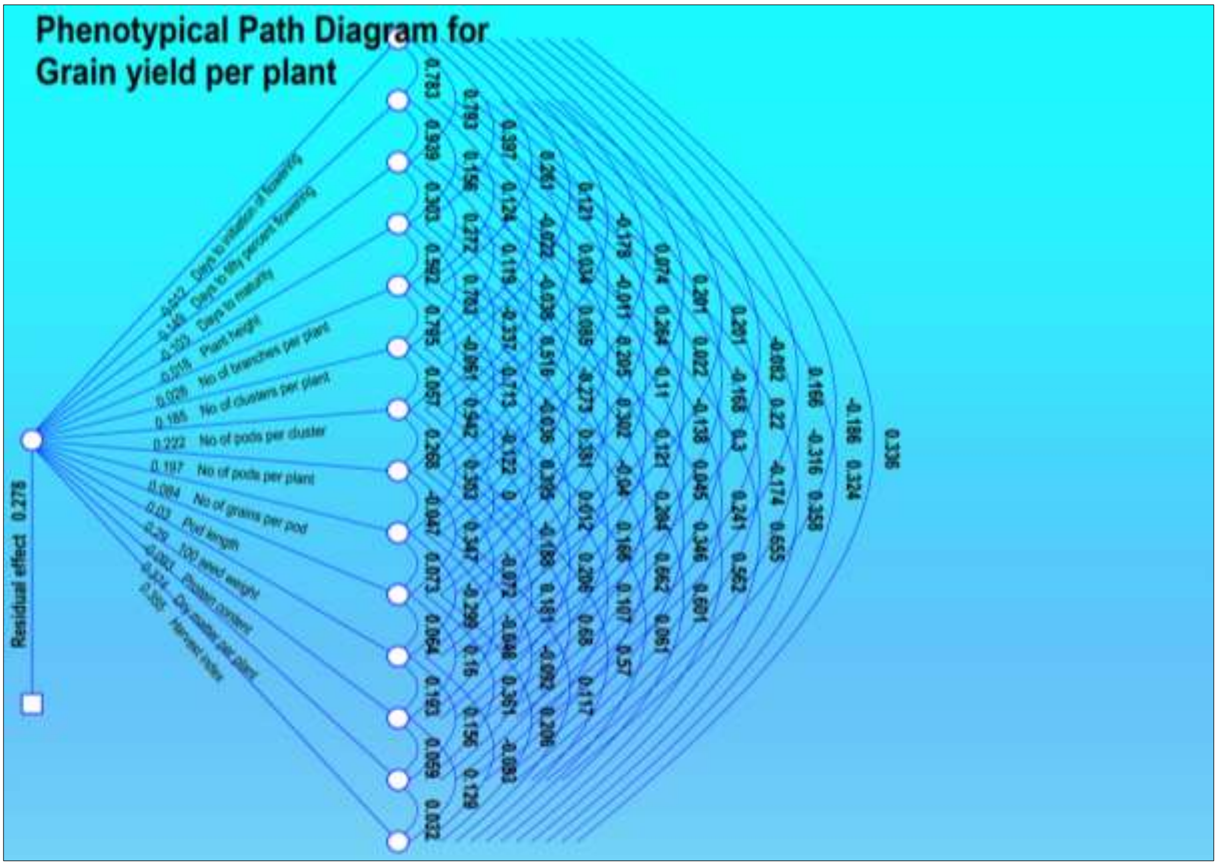

Fig 1: Phenotypical path diagram for grain yield per plant

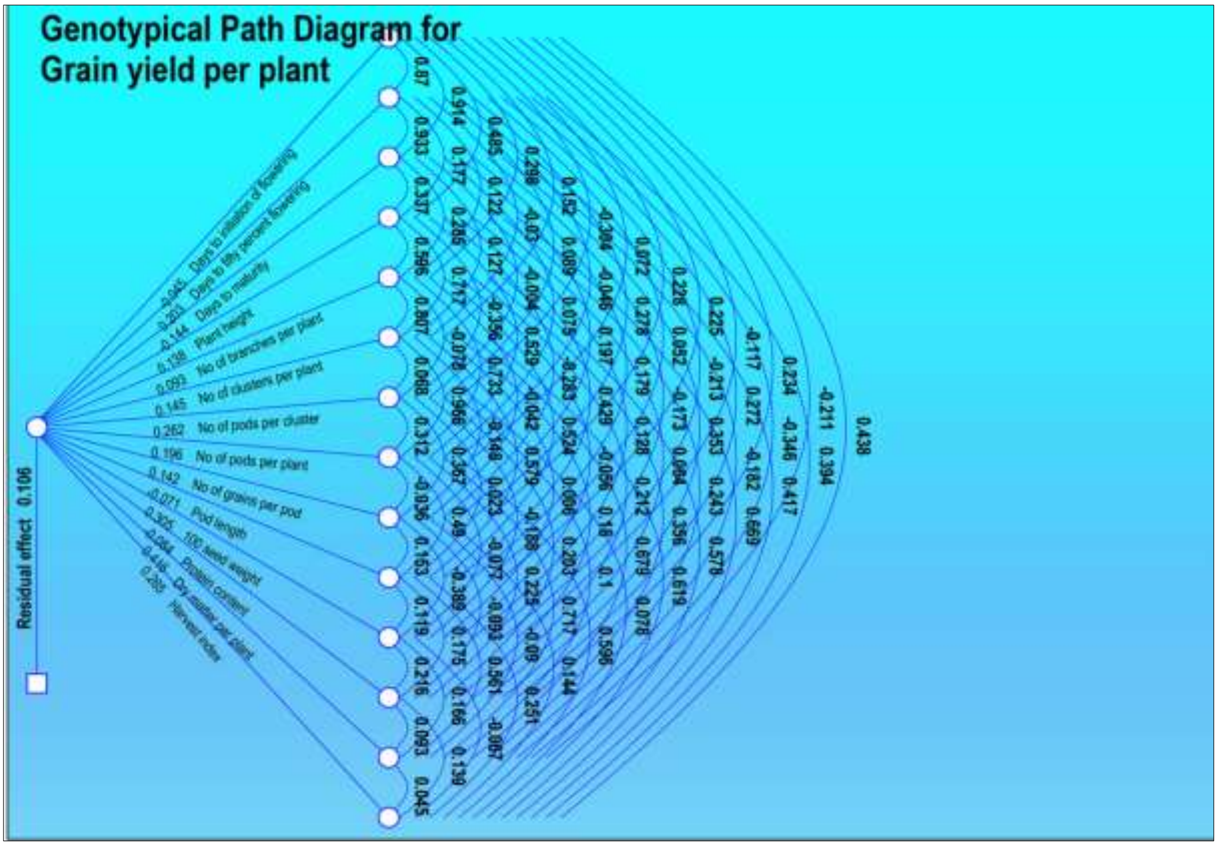

Fig 2: Genotypical path diagram for grain yield per plant

Path coefficient analysis (Table 1 and 2) results showed that positive direct effect on seed yield was exhibited by hundred seed weight, harvest index, dry matter per plant, days to fifty percent flowering, number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of grains per pod and pod length. These characters have also been identified as major direct contributors towards seed yield in blackgram by earlier workers Veeramani *et al*. (2005) [16], Singh *et al*., (2007) [13], Shivade *et al*. (2011) [12], Panigrahi *et al.* (2014) [10], Kanimoli *et al.* (2015) [8], Gowsalya *et al.* (2016) [7], Reena *et al.*, (2016) [11], Yashoda *et al.* (2016) [18], Sohel *et al*., (2016) [14], Arya *et al*., (2017) [2] and Bhanu *et al*., (2019) [3] The observation showed the extent of reliability of these traits as a good selection index for grain yield. Hence, selection based on these traits would be effective in increasing the seed yield. Conversely, the other characters *viz.* days to initiation of flowering, days to maturity, plant height and protein content revealed negative direct effect of given magnitudes towards seed yield per plant. These are in accordance with findings of Gowsalya *et al.* (2016) [7] for days to maturity, Panigrahi *et al.* (2014) [10] for plant height and Tank and sharma (2019) [15] for protein content.

The negative direct effect of days to initiation of flowering, days to maturity and plant height were nullified by positive indirect effects through dry matter per plant, hundred seed weight and number of pods per cluster. Gowsalya *et al*. (2016) [7] reported similar results for days to maturity.

Number of clusters per plant, number of pods per cluster and number of pods per plant had moderate to high positive direct effect on seed yield per plant and positive indirect effect through pod length, dry matter per plant and harvest index resulted in very strong positive association with seed yield per plant. Gowsalya *et al.* (2016) [7] reported positive direct effect of number of pods per cluster and number of pods per plant on seed yield per plant.

Hundred seed weight showed non- significant association with seed yield even though it had positive direct effects on seed yield. It may be due to their high negative effects through other characters like number of branches per plant, number of pods per plant, days to initiation of flowering, harvest index, days to maturity, days to 50 percent of flowering, number of pods per cluster and number of grains per pod at both phenotypic as well as genotypic level. Panigrahi *et al*. (2014) [10], Kanimoli *et al*. (2015) [8], Gowsalya *et al*. (2016) [7], Reena *et al*., (2016) [7] and Yashoda *et al*. (2016) [18] reported similar findings.

Pod length had negligible positive direct effect on grain yield per plant phenotypic level and negligible negative direct effect at genotypic level. Veeramani *et al*. (2005) [16] and Shivade *et al*. (2011) [12] and sohel *et al.*, (2016) [14] reported positive direct effect of pod length on grain yield per plant at phenotypic level while Panigrahi *et al.*, (2014) [10] and Yashoda *et al.*, (2016) [18] recorded negative direct effect at genotypic level.

Conclusion

Black gram is grown in varying agro-ecological conditions and cropping systems with diverse cultural practices, so it needs appropriate plant type for each growing situation. The present study revealed that selection based on hundred seed weight, harvest index, dry matter per plant, days to fifty percent flowering, number of primary branches per plant, number of clusters per plant, number of pods per cluster, number of pods per plant, number of grains per pod, protein content and pod length could help in genetic improvement of seed yield per plant in black gram population under study. So direct selection for these traits can help to improve black gram seed yield per unit area.

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