



## Correlation and Path Analyses over Environments in Blackgram [*Vigna mungo* (L.) Hepper]

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### ABSTRACT

Correlation and path coefficient analysis were carried out using 12 genotypes of blackgram in six environments. Days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, pod length, number of seeds per pod, 1000 seed weight, yield kg/plot and protein content were positively correlated with seed yield per plant over environments. The positive correlation of plant height, pod length, 1000 seed weight and yield kg/plot with seed yield per plant and among themselves for these characters was observed suggesting that these are the major yield contributing traits in blackgram. Path coefficient analysis also showed direct positive contribution of yield kg/plot, number of primary branches per plant, 1000 seed weight and number of seeds per pod on seed yield. These traits deserve special emphasis in selection while selecting for improvement in seed yield of blackgram.

**Key words** : : Blackgram, Correlation, Path Analysis.

Blackgram [*Vigna mungo* (L.) Hepper] is an important pulse crop cultivated round the year in almost all parts of India. The magnitude of association between different characters may help plant breeder to know the improvement of one character will bring simultaneous improvement in other characters. Path analysis is an important tool for portioning the correlation coefficients into direct and indirect effects of independent variable on the dependent variable. Therefore, in the present study the association between yield and its component characters on yield through path analysis were estimated in six environments.

### MATERIAL AND METHODS

Twelve genotypes namely AKU-7, LBG-752, T-9, LBG-20, LBG-17, PBG-1, PBG-107, MBG-162, MBG-207, LBG-648, LBG-623 and LBG-645 were sown during *rabi*, 2006 (six environments) on three sowing dates *i.e* 15-09-2006, 30-09-2006 & 15-10-2006; with two fertility levels *i.e* 20kg N: 50kg P per ha (only basal) and 20kg N: 50kg P per ha (basal) + 20kg N per ha (top dressing) in each date of sowing) thus providing six environments for study in Agricultural Research Station (ARS) Madhira, Khammam (District) in Andhra Pradesh. Material was grown in randomized block design with three replications with 4m long plots of 4 rows per genotype per replication. An inter- and intra-row spacing of 30cm and 10 cm was practiced. Data was recorded on ten randomly selected plants from each genotype in each replication for eleven quantitative traits *viz.*, Days to 50% flowering, days

to maturity, plant height, number of primary branches per plant, number of pods per plant, pod length, number of seeds per pod, 1000 seed weight, seed yield per plant, yield kg/plot and protein content. The means of the data were utilized for statistical analysis of correlations (as per Falconer, 1964) and path analysis (as per Dewey and Lu, 1959).

### RESULTS AND DISCUSSION

The correlations among eleven quantitative characters are presented environment wise from Table 1 to Table 6. Correlation among yield and yield components indicated that seed yield per plant had a positive significant association both at genotypic as well as at phenotypic levels with plant height and pod length in all the six environments. Hence, simultaneous selection for these traits will be more reliable for deriving high yielding genotypes of blackgram irrespective of the environment. Similar results of strong positive association of seed yield per plant with plant height and pod length in blackgram were also observed by Parameswarappa and Kumar (2005), Venkatesan *et al.* (2004), Sunil kumar *et al.* (2003).

1000 seed weight and yield kg/plot exhibited significant positive association with seed yield per plant in all environments both at phenotypic and genotypic level except in environment 6 and 5 respectively, where it showed non-significant association at both levels. Similar results were earlier reported by Venkatesan *et al.* (2004), Mansingh and Singh (2003).

Table 1. Genotypic and phenotypic correlations among 11 quantitative traits in blackgram [*Vigna mungo* (L.) Hepper] during *rabi*, 2006 in environment 1

Character	Days to Maturity	Plant height	NO. of primary Branches plant <sup>-1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	Seed yield plant <sup>-1</sup>
Days to 50% flowering	0.5186** (0.4590)**	0.2688 (0.2003)	0.3963* (0.3917)*	0.5408** (0.4723)**	-0.0397 (-0.0390)	-0.0722 (-0.0591)	0.3841* (0.3550)*	0.3001 (0.2020)	0.2584 (0.2026)	0.3400* (0.2723)
Days to maturity		0.2334 (0.2026)	0.3283* (0.1877)	0.3599* (0.3087)	-0.6857** (-0.4974)**	-0.2927 (-0.1903)	0.6056** (0.4222)*	0.1772 (0.1221)	0.0338 (0.0370)	0.1334 (0.1506)
Plant height			0.6825** (0.3882)*	0.1772 (0.1504)	0.3972* (0.2902)	0.6898** (0.5331)**	0.6777** (0.4242)**	0.4465** (0.3432)*	-0.0455 (0.0256)	0.6352** (0.5364)**
No. of primary branches plant <sup>-1</sup>				0.3831* (0.3263)*	0.5536** (0.2320)	0.2661 (0.0999)	0.9379** (0.5381)**	1.0308** (0.5325)**	0.1478 (0.0929)	1.1564** (0.6579)**
No. of pods plant <sup>-1</sup>					-0.3271 (-0.2182)	0.0240 (-0.0506)	0.2632 (0.2155)	0.4703 (0.4749)**	0.6468** (0.4030)*	0.3475* (0.2239)
Pod length						0.6315** (0.5734)**	-0.0098 (0.0137)	0.3989* (0.3595)*	-0.0101 (-0.0686)	0.5832** (0.4718)**
No. of seeds pod <sup>-1</sup>							0.0466 (-0.0455)	0.4116* (0.2087)	0.1011 (0.1139)	0.3721* (0.4158)*
1000-seed weight								0.2244 (0.3307)**	-0.0496 (-0.0658)	0.6603** (0.4000)
Yield Kg Plot <sup>-1</sup>									0.4402** (0.1261)	1.0157** (0.7029)**
Protein %										0.0060 (-0.0178)

Table 2. Genotypic and phenotypic correlations among 11 quantitative traits in blackgram [*Vigna mungo* (L.) Hepper] during *rabi*, 2006 in environment 2

Character	Days to Maturity	Plant height	NO. of primary Branches plant <sup>-1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	Seed yield plant <sup>-1</sup>
Days to 50% flowering	0.5855** (0.4982)**	0.4294** (0.3978)*	0.2866 (0.2117)	0.2901 (0.2267)	-0.034 (0.066)	0.001 (-0.0273)	0.7759** (0.6579)**	0.1985 (0.1831)	0.2875 (0.3148)	0.4669** (0.3168)
Days to maturity		0.2405 (0.2310)	-0.2434 (-0.1984)	0.1590 (0.1684)	-0.5095 (-0.4664)	-0.0478 (0.0361)	0.1884 (0.1446)	0.3754* (0.3152)	0.0692 (0.0335)	0.2073 (0.1752)
Plant height			0.4644** (0.3240)*	0.2850 (0.2551)	0.4185* (0.4063)*	0.7701** (0.4925)**	0.8872** (0.7526)**	0.4157* (0.3679)*	0.2515 (0.2083)	0.7023** (0.5983)**
No. of primary branches plant <sup>-1</sup>				0.7575** (0.4978)**	0.5946** (0.3870)*	0.539** (0.3357)*	0.5131** (0.3545)*	0.6408** (0.4671)**	-0.1203 (-0.0531)	0.7967** (0.6380)**
No. of pods plant <sup>-1</sup>					-0.0455 (-0.0565)	0.1087 (0.0058)	0.2319 (0.22)	0.6959** (0.4734)**	0.2272 (0.1088)	0.5599** (0.4269)**
Pod length						0.6593** (0.4933)**	0.5266** (0.4382)**	0.3769* (0.2267)	-0.0262 (0.0007)	0.6416** (0.5137)**
No. of seeds pod <sup>-1</sup>							0.4909** (0.344)*	0.645** (0.2587)	-0.3949* (-0.3195)	0.7818** (0.4667)**
1000-seed weight								0.35* (0.1973)	0.3876* (0.2626)	0.7317** (0.5701)**
Yield Kg Plot <sup>-1</sup>									-0.0877 (-0.0106)	0.9568** (0.7061)**
Protein %										-0.019 (-0.0205)

Figures in parenthesis indicates phenotypic correlation

\*\* Significant at 1% probability level

\*Significant at 5% probability level

Table 3. Genotypic and phenotypic correlations among 11 quantitative traits in blackgram [*Vigna mungo* (L.) Hepper] during *rabi*, 2006 in environment 3

Character	Days to Maturity	Plant height	NO. of primary Branches plant <sup>-1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	Seed yield plant <sup>-1</sup>
Days to 50% flowering	0.6056** (0.55)**	0.3377* (0.2664)	0.5114** (0.4647)**	0.3351* (0.2958)	-0.0168 (-0.0336)	-0.0274 (-0.0614)	0.6831** (0.5488)**	0.2452 (0.2067)	-0.1767 (-0.1424)	0.4202* (0.3314)*
Days to maturity		0.1874 (0.1752)	0.7119** (0.426)**	0.2382 (0.2395)	0.5442** (-0.043)	-0.4072* (-0.1452)	0.1477 (0.1312)	0.2237 (0.1652)	0.0281 (0.0642)	0.0897 (0.0583)
Plant height			0.6449** (0.2807)	0.3577* (0.2264)	0.4441** (0.2449)	0.6948** (0.5634)**	0.8204** (0.5449)**	0.4134* (0.2973)	-0.0553 (-0.0229)	0.6267** (0.5028)**
No. of primary branches plant <sup>-1</sup>				0.801** (0.5097)**	-0.1879 (-0.1127)	0.0653 (-0.2083)	0.4628** (0.2764)	0.8371** (0.5729)**	-0.2214 (-0.0832)	0.8598** (0.5704)**
No. of pods plant <sup>-1</sup>					-0.105 (0.0465)	-0.0728 (-0.0238)	0.2722 (0.2724)	0.8665** (0.6196)**	0.1441 (0.2378)	0.6362** (0.5081)**
Pod length						0.9446** (0.5060)**	0.4947** (0.4407)**	0.4367** (0.1744)	0.1092 (0.1714)	0.5086** (0.3903)*
No. of seeds pod <sup>-1</sup>							0.6732** (0.2748)	0.3362* (0.1681)	0.0991 (0.1697)	0.346* (0.3726)*
1000-seed weight								0.4166* (0.2598)	-0.0465 (-0.0166)	0.7142** (0.5098)**
Yield Kg Plot <sup>-1</sup>									0.1375 (0.0288)	0.946** (0.6966)**
Protein %										-0.342* (-0.1964)

Table 4. Genotypic and phenotypic correlations among 11 quantitative traits in blackgram [*Vigna mungo* (L.) Hepper] during *rabi*, 2006 in environment 4

Character	Days to Maturity	Plant height	NO. of primary Branches plant <sup>-1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	Seed yield plant <sup>-1</sup>
Days to 50% flowering	0.6358** (0.5874)**	0.4821** (0.4081)*	0.866** (0.6084)**	0.3150 (0.2229)	0.2952 (0.1995)	-0.2341 (-0.2661)	0.7760** (0.6212)**	0.4542** (0.4277)**	-0.018 (-0.0118)	0.3051 (0.2922)
Days to maturity		0.2277 (0.1564)	0.5807** (0.4524)**	0.2721 (0.2093)	-0.3328* (-0.2928)	-0.498** (-0.428)**	0.4541** (0.3519)*	0.1531 (0.1535)	0.3817* (0.2865)	0.0391 (0.0506)
Plant height			0.2245 (0.2214)	0.1975 (0.1427)	0.7779** (0.530)**	0.4317** (0.2950)	0.6554** (0.5304)**	0.7574** (0.6518)**	0.0017 (-0.0201)	0.6268** (0.4579)**
No. of primary branches plant <sup>-1</sup>				0.6052** (0.4475)**	0.0909 (0.1510)	-0.0118 (-0.0131)	0.9449** (0.4681)**	0.1909 (0.2406)	0.2252 (0.1257)	0.4669** (0.3174)
No. of pods plant <sup>-1</sup>					0.2043 (0.2652)	0.1245 (0.0850)	0.1801 (0.1689)	0.4246** (0.3759)*	0.2911 (0.2036)	0.6374** (0.4745)**
Pod length						0.6578** (0.5448)**	0.264 (0.1389)	0.8037** (0.6918)**	-0.1566 (-0.1052)	0.581** (0.4702)**
No. of seeds pod <sup>-1</sup>							0.2971 (0.0854)	0.4592** (0.3312)*	0.2401 (0.0861)	0.3567* (0.2417)
1000-seed weight								0.3672* (0.2844)	-0.0484 (0.0888)	0.455** (0.3312)*
Yield Kg Plot <sup>-1</sup>									-0.1716 (-0.0912)	0.7467** (0.6881)**
Protein %										-0.4427 (-0.233)

Figures in parenthesis indicates phenotypic correlation

\*\* Significant at 1% probability level

\*Significant at 5% probability level

Table 5. Genotypic and phenotypic correlations among 11 quantitative traits in blackgram [*Vigna mungo* (L.) Hepper] during *rabi*, 2006 in environment 5

Character	Days to Maturity	Plant height	NO. of primary Branches plant <sup>1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	Seed yield plant <sup>-1</sup>
Days to 50% flowering	0.6154** (0.5501)**	0.4630** (0.4141)*	0.7001** (0.532)**	0.4717** (0.3868)*	0.2454 (0.1059)	0.157 (0.0372)	0.7461** (0.5953)**	0.2252 (0.2614)	0.2458 (0.146)	0.5345** (0.4693)**
Days to maturity		-0.132 (-0.12)	0.3732* (0.3185)	0.2836 (0.2454)	-0.6457** (-0.476)**	-0.6165** (-0.4406)**	0.0476 (0.0166)	0.5119** (0.4043)*	0.2491 (0.1401)	0.1497 (0.1223)
Plant height			0.2336 (0.1971)	0.3585* (0.3229)	0.9231** (0.6164)**	0.8861** (0.5211)**	0.7358** (0.5392)**	-0.044 (0.0381)	0.193 (0.0295)	0.6751** (0.6221)**
No. of primary branches plant <sup>-1</sup>				0.7855** (0.4855)**	0.2513 (0.1337)	-0.0441 (0.041)	0.5974** (0.292)	0.6211** (0.4489)**	0.5786** (0.2783)	0.4081* (0.2839)
No. of pods plant <sup>-1</sup>					0.1159 (0.1226)	0.0727 (0.1089)	0.3013 (0.271)	0.8049** (0.5783)**	0.5318** (0.2583)	0.3468* (0.2448)
Pod length						1.0199** (0.7156)**	0.6799** (0.5697)**	-0.1866 (-0.1783)	-0.0249 (-0.0956)	0.6956** (0.4803)**
No. of seeds pod <sup>-1</sup>							0.7287** (0.4708)**	-0.3387* (-0.1744)	-0.1312 (-0.1609)	0.7635** (0.4731)**
1000-seed weight								-0.02 (-0.1484)	0.246 (0.0158)	0.7687** (0.6445)**
Yield Kg Plot <sup>-1</sup>									0.5925** (0.3844)**	0.1922 (0.1442)
Protein %										-0.0902 (-0.1276)

Table 6. Genotypic and phenotypic correlations among 11 quantitative traits in blackgram [*Vigna mungo* (L.) Hepper] during *rabi*, 2006 in environment 6

Character	Days to Maturity	Plant height	NO. of primary Branches plant <sup>1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	Seed yield plant <sup>-1</sup>
Days to 50% flowering	0.533** (0.4715)**	0.4155* (0.393)*	0.888** (0.6672)**	0.2457 (0.1982)	0.2683 (0.2039)	0.105 (0.0669)	0.7089** (0.529)**	0.3506* (0.2782)	0.1874 (0.1886)	0.4837** (0.4397)**
Days to maturity		0.0546 (0.0451)	0.4874** (0.2966)	0.06 (0.04)	-0.5818** (-0.4084)**	-0.5081** (-0.3071)	0.5682** (0.473)**	0.2126 (0.1829)	-0.187 (-0.179)	0.0847 (0.103)
Plant height			0.6905** (0.4656)**	-0.037 (0.028)	0.772** (0.5569)**	0.3896* (0.1757)	-0.13 (-0.128)	0.5037** (0.416)*	0.447** (0.348)*	0.599** (0.511)**
No. of primary branches plant <sup>-1</sup>				0.7115** (0.4249)**	0.4709** (0.3253)	0.333 (0.0634)	0.381 (0.188)	0.9639** (0.474)**	0.4224* (0.2114)	1.0229** (0.617)**
No. of pods plant <sup>-1</sup>					0.3176 (0.1949)	0.2971 (0.0885)	-0.0716 (-0.1551)	0.7833** (0.509)**	0.359* (0.3154)	0.6548** (0.493)**
Pod length						0.7496** (0.4166)*	-0.3853* (-0.1703)	0.5386** (0.3656)*	0.8316** (0.369)*	0.6164** (0.502)**
No. of seeds pod <sup>-1</sup>							0.18 (0.2154)	0.4732** (0.1777)	0.9266** (0.378)*	0.5749** (0.273)
1000-seed weight								-0.1092 (-0.013)	-0.0271 (0.067)	-0.0268 (0.084)
Yield Kg Plot <sup>-1</sup>									0.682** (0.46)**	0.9823** (0.84)**
Protein %										0.6791** (0.44)**

Figures in parenthesis indicates phenotypic correlation

\*\* Significant at 1% probability level

\*Significant at 5% probability level

Table 7. Direct and indirect effects of morphological traits on seed yield per plant in blackgram [*Vigna mungo* (L.) Hepper] in enviroment 1

Character	Days to 50% flowering	Days to Maturity	Plant height	NO. of primary Branches plant <sup>1</sup>	No. of pods plant <sup>1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>1</sup>	Protein %	rp
Days to 50% flowering	<b>0.0571</b>	0.0262	0.0114	0.0224	0.0270	-0.0022	-0.0034	0.0203	0.0115	0.0116	0.2733
Days to maturity	0.0636	<b>0.1385</b>	0.0281	0.0260	0.0428	-0.0689	-0.0264	0.0585	0.0169	0.0051	0.1506
Plant height	0.0202	0.0205	<b>0.1011</b>	0.0392	0.0152	0.0293	0.0539	0.0429	0.0347	0.0026	0.5364**
No. of primary branches plant <sup>1</sup>	0.1343	0.0643	0.1331	<b>0.3428</b>	0.1118	0.0795	0.0342	0.1844	0.1825	0.0318	0.6579**
No. of pods plant <sup>1</sup>	-0.0421	-0.0276	-0.0134	-0.0291	<b>-0.0892</b>	0.0195	0.0045	-0.0192	-0.0424	-0.0360	0.2239
Pod length	-0.0056	-0.0716	0.0418	0.0334	-0.0314	<b>0.1440</b>	0.0826	0.0020	0.0518	-0.0099	0.4718**
No. of seeds pod <sup>-1</sup>	-0.0113	-0.0363	0.1016	0.0191	-0.0096	0.1093	<b>0.1907</b>	-0.0087	0.0398	0.0217	0.4158*
1000-seed weight	-0.0103	-0.0123	-0.0123	-0.0156	-0.0063	-0.0004	0.0013	<b>-0.0290</b>	-0.0096	0.0019	0.400*
Yield Kg Plot <sup>1</sup>	0.0869	0.0526	0.1477	0.2292	0.2044	0.1547	0.0898	0.1423	<b>0.4304</b>	0.0543	0.7029**
Protein %	-0.0205	-0.0037	-0.0026	-0.0094	-0.0407	0.0069	-0.0115	0.0067	-0.0127	<b>-0.1011</b>	-0.0178

Residual = 0.5137

Table 8. Direct and indirect effects of morphological traits on seed yield per plant in blackgram [*Vigna mungo* (L.) Hepper] in enviroment 2

Character	Days to 50% flowering	Days to Maturity	Plant height	NO. of primary Branches plant <sup>1</sup>	No. of pods plant <sup>1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>1</sup>	Protein %	rp
Days to 50% flowering	<b>-0.2989</b>	-0.1489	-0.1189	-0.0633	-0.0678	-0.0199	0.0082	-0.1966	-0.0547	-0.0941	0.3168
Days to maturity	0.2213	<b>0.4443</b>	0.1026	-0.0881	0.0748	-0.2072	-0.0160	0.0642	0.1400	0.0149	0.1752
Plant height	-0.0232	-0.0134	<b>-0.0582</b>	-0.0189	-0.0148	-0.0236	-0.0287	-0.0438	-0.0214	-0.0121	0.5983**
No. of primary branches plant <sup>1</sup>	0.0756	-0.0708	0.1156	<b>0.3569</b>	0.1777	0.1382	0.1198	0.1265	0.1667	-0.0190	0.6380**
No. of pods plant <sup>1</sup>	0.0144	0.0107	0.0162	0.0316	<b>0.0635</b>	-0.0036	0.0004	0.0140	0.0301	0.0069	0.4269**
Pod length	0.0276	-0.1929	0.1680	0.1601	-0.0234	<b>0.4136</b>	0.2040	0.1812	0.0937	0.0003	0.5137**
No. of seeds pod <sup>-1</sup>	0.0010	0.0013	-0.0184	-0.0126	-0.0002	-0.0185	<b>-0.0374</b>	-0.0129	-0.0097	0.0120	0.4667**
1000-seed weight	0.2558	0.0562	0.2926	0.1378	0.0856	0.1704	0.1337	<b>0.3888</b>	0.0767	0.1021	0.5701**
Yield Kg Plot <sup>1</sup>	0.0521	0.0896	0.1046	0.1328	0.1346	0.0645	0.0736	0.0561	<b>0.2844</b>	-0.0030	0.7061**
Protein %	-0.0089	-0.0010	-0.0059	0.0015	-0.0031	0.0000	0.0091	0.0003	0.0003	<b>-0.0284</b>	-0.0205

Residual = 0.4228

Note: Bold figures indicates direct effects  
 \*\* Significant at 1% probability level  
 \* Significant at 5% probability level  
 rp = phenotypic correlation with seed yield

Table 9. Direct and indirect effects of morphological traits on seed yield per plant in blackgram [*Vigna mungo* (L.) Hepper] in environment 3

Character	Days to 50% flowering	Days to Maturity	Plant height	NO. of primary Branches plant <sup>-1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	rp
Days to 50% flowering	<b>-0.0151</b>	-0.0083	-0.0040	-0.0070	-0.0044	0.0005	0.0009	-0.0083	-0.0031	0.0021	0.3314*
Days to maturity	-0.0288	<b>-0.0524</b>	-0.0092	-0.0223	-0.0126	0.0226	0.0076	-0.0069	-0.0087	-0.0034	0.0583
Plant height	-0.0113	-0.0074	<b>-0.0424</b>	-0.0119	-0.0096	-0.0104	-0.0239	-0.0231	-0.0126	0.0010	0.5028**
No. of primary branches plant <sup>-1</sup>	0.1829	0.1677	0.1105	<b>0.3936</b>	0.2006	-0.0444	-0.082	0.1088	0.2255	-0.0328	0.5704**
No. of pods plant <sup>-1</sup>	0.0663	0.0540	0.0511	0.1150	<b>0.2256</b>	0.0105	-0.0054	0.0614	0.1398	0.0536	0.5081**
Pod length	-0.0062	-0.0793	0.0452	-0.0208	0.0086	<b>0.1844</b>	0.0933	0.0812	0.0322	0.0316	0.3903*
No. of seeds pod <sup>-1</sup>	-0.0220	-0.0522	0.2025	-0.0749	-0.0086	0.1818	<b>0.3594</b>	0.0987	0.0604	0.0610	0.3726*
1000-seed weight	0.0717	0.0171	0.0712	0.0361	0.0356	0.0576	0.0359	<b>0.1307</b>	0.0340	-0.0022	0.5098**
Yield Kg Plot <sup>-1</sup>	0.0493	0.0394	0.0708	0.1365	0.1477	0.0401	0.0401	0.0619	<b>0.2383</b>	0.069	0.6966**
Protein %	0.0447	-0.0202	0.0072	0.0262	-0.0747	-0.0533	-0.0533	0.0052	-0.0090	<b>-0.3143</b>	-0.1964

Residual = 0.4359

Table 10. Direct and indirect effects of morphological traits on seed yield per plant in blackgram [*Vigna mungo* (L.) Hepper] in environment 4

Character	Days to 50% flowering	Days to Maturity	Plant height	NO. of primary Branches plant <sup>-1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	rp
Days to 50% flowering	<b>-0.2324</b>	-0.1365	-0.0948	-0.1414	-0.0518	-0.0464	0.0619	-0.1444	-0.0994	0.0027	0.2922
Days to maturity	-0.0632	<b>-0.1076</b>	-0.0168	-0.0487	-0.0225	0.0315	0.0461	-0.0378	-0.0165	-0.0308	0.0506
Plant height	-0.0009	-0.0003	<b>-0.0022</b>	-0.0005	-0.0003	-0.0011	-0.0006	-0.0011	-0.0014	0.000	0.4579**
No. of primary branches plant <sup>-1</sup>	0.0961	0.0714	0.0349	<b>0.1579</b>	0.0706	0.0238	-0.0021	0.0739	0.0380	0.0198	0.3174
No. of pods plant <sup>-1</sup>	0.0602	0.0566	0.0386	0.1209	<b>0.2702</b>	0.0717	0.0230	0.0456	0.1016	0.0550	0.4745**
Pod length	-0.0190	0.0279	-0.0505	-0.01444	-0.0252	<b>-0.0952</b>	-0.0519	-0.0132	-0.0658	0.0100	0.4702**
No. of seeds pod <sup>-1</sup>	0.0138	0.0222	-0.0153	0.0007	-0.0044	-0.0282	<b>-0.0517</b>	-0.0044	-0.0171	-0.0045	0.2417
1000-seed weight	0.1543	0.0874	0.1317	0.1163	0.0419	0.0345	0.0212	<b>0.2484</b>	0.0706	0.0221	0.3313*
Yield Kg Plot <sup>-1</sup>	0.2804	0.1006	0.4274	0.1577	0.2464	0.4536	0.2172	0.1864	<b>0.6556</b>	-0.0598	0.6881**
Protein %	0.0029	-0.0710	0.0050	-0.0311	-0.0504	0.0261	-0.0213	-0.0220	0.0226	<b>-0.2477</b>	-0.2330

Residual = 0.6018

Note: Bold figures indicates direct effects  
 \*\* Significant at 1% probability level  
 \* Significant at 5% probability level  
 rp = phenotypic correlation with seed yield

Table 11. Direct and indirect effects of morphological traits on seed yield per plant in blackgram [*Vigna mungo* (L.) Hepper] in enviroment 5

Character	Days to 50% flowering	Days to Maturity	Plant height	NO. of primary Branches plant <sup>-1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	rp
Days to 50% flowering	<b>-0.1742</b>	-0.0959	-0.0721	-0.0927	-0.0674	-0.0184	-0.0065	-0.1034	-0.0456	-0.0255	0.4693**
Days to maturity	0.1380	<b>0.2508</b>	-0.0303	0.0799	0.0616	-0.1196	-0.1105	0.0042	0.1014	0.0351	0.1223
Plant height	0.1597	-0.0466	<b>0.3856</b>	0.0760	0.1245	0.2377	0.2010	0.2080	0.0147	0.0114	0.6221**
No. of primary branches plant <sup>-1</sup>	0.0285	0.0171	0.0106	<b>0.0535</b>	0.0260	0.0072	0.0022	0.0156	0.0240	0.0149	0.2839
No. of pods plant <sup>-1</sup>	-0.0921	-0.0584	-0.0769	-0.1156	<b>-0.2381</b>	-0.0292	-0.0259	-0.0645	-0.1377	-0.0615	0.2448
Pod length	0.0004	-0.0020	0.0025	0.0005	0.0005	<b>0.0041</b>	0.0029	0.0032	-0.0007	-0.0004	0.4803**
No. of seeds pod <sup>-1</sup>	0.0066	-0.0777	0.0920	0.0072	0.0192	0.1263	<b>0.1765</b>	0.0831	0.0308	-0.0284	0.4731**
1000-seed weight	0.3342	0.0093	0.3027	0.1639	0.1521	0.3198	0.2643	<b>0.5613</b>	-0.08333	0.0089	0.6445**
Yield Kg Plot <sup>-1</sup>	0.1024	0.1583	0.0149	0.1758	0.2264	-0.0698	-0.0683	-0.0581	<b>0.3915</b>	0.1505	0.1442
Protein %	-0.0341	-0.0326	-0.0069	-0.0647	-0.0601	0.0222	0.0374	-0.0037	-0.0894	<b>-0.2326</b>	-0.1276

Residual =0.5665

Table 12. Direct and indirect effects of morphological traits on seed yield per plant in blackgram [*Vigna mungo* (L.) Hepper] in enviroment 6

Character	Days to 50% flowering	Days to Maturity	Plant height	NO. of primary Branches plant <sup>-1</sup>	No. of pods plant <sup>-1</sup>	Pod length	No. of seeds pod <sup>-1</sup>	1000seed wt.	Yield Kg plot <sup>-1</sup>	Protein %	rp
Days to 50% flowering	<b>0.0700</b>	0.0330	0.0275	0.0467	0.0139	0.0143	0.0047	0.0371	0.0195	0.0132	0.4397**
Days to maturity	-0.0586	<b>-0.1244</b>	-0.0056	-0.0364	-0.0050	0.0508	0.0382	-0.0589	-0.0227	0.0223	0.1030
Plant height	0.0445	0.0051	<b>0.1131</b>	0.0527	0.0032	0.0630	0.0199	-0.0145	0.0471	0.0394	0.5110**
No. of primary branches plant <sup>-1</sup>	0.1068	0.0468	0.0745	<b>0.1601</b>	0.0680	0.0521	0.0101	0.0302	0.0759	0.0338	0.6175**
No. of pods plant <sup>-1</sup>	0.0177	0.0036	0.0025	0.0380	<b>0.0894</b>	0.0174	0.0079	-0.0139	0.0455	0.0282	0.4932**
Pod length	0.0178	-0.0356	0.0485	0.0283	0.0170	<b>0.0871</b>	0.0363	-0.0148	0.0318	0.0321	0.5025**
No. of seeds pod <sup>-1</sup>	0.0017	-0.0079	0.0045	0.0016	0.0023	0.0106	<b>0.0256</b>	0.0055	0.0045	0.0097	0.2730
1000-seed weight	0.0637	0.0569	-0.0154	0.0227	-0.0186	-0.0205	0.0259	<b>0.1202</b>	-0.0017	-0.0081	0.0840
Yield Kg Plot <sup>-1</sup>	0.1821	0.1197	0.2733	0.3105	0.3331	0.2393	0.1163	-0.0090	<b>0.6545</b>	0.3012	0.8401**
Protein %	-0.0059	0.0056	-0.0109	-0.0066	-0.0099	-0.0115	-0.0118	0.0021	-0.0144	<b>-0.0313</b>	0.4407**

Residual = 0.4295

Note: Bold figures indicates direct effects  
 \*\* Significant at 1% probability level  
 \* Significant at 5% probability level  
 rp = phenotypic correlation with seed yield

Seed yield per plant had a significant positive association with number of pods per plant in all environments except in environment 1 and 5 and number of primary branches per plant in all six environments except in environments 4 and 5 at genotypic level. This is accordance with earlier reports by Venkatesan *et al.* (2004) and Parameswarappa and Kumar (2005). Number of pods per plant recorded high significant positive correlation with number of primary branches per plant and yield kg/plot. This type of association is highly desirable because of significant association between number of pods per plant and seed yield per plant.

The results suggested that selection of any of the above characters in combination with plant height and pod length would bring about improvement in seed yield per plant. However, protein content showed negative association with yield in all environments except in environment 6. There should be a balance between protein and yield during the selection programme. Path analysis study (Table 7 to 12) revealed that the yield improvement could be achieved through component characters like number of primary branches per plant, 1000 seed weight and number of seeds per pod in many environments, which exhibited positive direct effect on seed yield per plant in many environments. Parameswarappa and Kumar (2005), Mansingh and Singh (2003), reported the similar results on seed yield per plant.

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