Original Research Article

Direct and Indirect Effects of Yield Contributing Characters on Seed Yield in Green Gram(*vigna radiata.L.*)

Abstract

The present investigation was carried out to assess the genetic variability parameters, correlation and path analysis in 21 green gram genotypes for 13 quantitative traits at field experimentation center, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Uttar Pradesh in Randomized Block Design in three replications. Analysis of variance indicated high significant differences among thegenotypes for all the traits. Green gram (*Vigna radiata* L.) is one of the important pulse crops because of its short growth duration, adaptation to low water requirement and soil fertility. Variability is a greater need for initiating a breeding program for yield and yield contributing traits. High seed yield per plant was recorded by SM-2029, SPM-2040, PHULEMOONG-95418, CO-8, CO-7. All the traits showed significant variation among the lines. High GCV and PCV was recorded for Number of pods per plant, Number of clusters per plant, Number of primary branches and Plant height where GCV exhibited at moderate level and Number of pods per plant exhibited highest percentage of broad sense heritability and also high in genetic advance followed by Plant height and Number of primary branches and Number of clusters per plant. The studies on GCV and PCV indicated that the presence of high amount of variation and role of the environment on the expression of these traits. Seed index positively correlated to seed yield per plant at both phenotypic and genotypic levels.Seed index, Biological Yield and Number of Primary branches exhibited high positive direct effect to seed yield per plant at both phenotypic and genotypic path coefficient analysis. correlation coefficients in most cases were higher than their phenotypic correlation coefficients indicating the association was largely due to genetic reason. At both genotypic and phenotypic levels, significant positive correlations were observed for Seed Index, Days to maturity, Days to 50% pod setting, Plant height, Number of pods per plant and Number of clusters per plant.

Comment [K1]: Recommendation part is missed

Keywords: GCV, PCV, heritability, Correlation, Path analysis green gram

1.Introduction

Green gram (***Vigna radiata* L.**) 2n=22 is one of the most widely adapted; drought-tolerant, versatile, green manuring and nutritious grain legumes or pulse crop. It is used as dry seed or green pod as vegetable. It is originated and domesticated in Persia (Iran), where its progenitor (*Vigna radiate subspecies sublobata*) occurs wild archaeology has turned up carbonized green gram on many sites in India. Green gram belongs to family Leguminaceae, sub family Papilionaceae. Mungbean [*Vigna radiata* (L.) WILCZEK] is priced among pulse crops as its seeds are high in essential dietary protein. In India, it is third most important legume crop and is one of the important grain legumes of global economic importance. Mung bean also known as green gram are cultivated in different agro-climatic conditions and soil types in India and various other countries like China, Thailand, Philippines, Indonesia, Burma, and Bangladesh and in hot and dry regions of South Europe and Southern USA (**Singh *et al.* 2005**). Green gram is an herbaceous annual with erect semi erect stem usually 40 to 120 cm in height. Roots are strong with a tap root system. The leaves are trifoliate, entire ovate and occasionally lobed with long petiole. The inflorescence is terminal or axillary raceme withabout more than 10 flower per peduncle. Green gram is essentially a self-pollinated crop. The flower is a typical papilionaceous with 5 sepals, 5 petals, 10 stamens in diadelphous (9) +1 condition and monocarpellary ovary with hairy style. Pod containing 9 - 16 seeds, are 4-16 cm long. Greengram is an excellent source of high-quality protein (25%) having high digestibility. It is consumed as whole grains as well as "Dal" in a variety of ways in our food. Sprouted green gram is used in the preparation of curry or a savoury dish (South India). It is supposed to be easily digestible and hence the patients prefer it. It is also a good source of Riboflavin, Thiamine and Vitamin C (Ascorbic acid). When green gram is sprouted, seeds synthesized remarkable quantity of ascorbic acid (Vitamin C).According to Wright, 1921 path analysis is a partial regression analysis, which permits to separate coefficient of correlation to direct and indirect components effects of dependent and independent variables, which further permits the partitioning of correlation coefficient in to components of direct and indirect effects of independent variable on the dependent variable. Also, Path analysis is an effective technique in statistics which is made to quantify relationship of different components and their direct and indirect effect on crop yield. From this technique ranks can be given for yield attributing characters **.** Therefore, it is very much essential to improve its yield. For yield improvement, it is essential to have knowledge on variability of different characters.

Green gram is also used as green manure crop. It being a leguminous crop has capacityto fix the atmospheric nitrogen (30-40 kg N/ha). It also helps in preventing soil erosion. Being a short duration crop, it fits well in many intensive crop rotations. Green gram can be used as feed for cattle. After harvesting the pods, green plants are uprooted or cut from the ground level and chopped into small pieces and fed to the cattle. The husk of the seed can be soaked in water and used as cattle feed. It is self-pollinated crop. In North India, it is cultivated in both kharif and summer seasons and in South. India, it is cultivated in rabi season. India is the major producer of green gram in the world and grown in almost all the States. It is grown in about 4.5 million hectares with the total production of 2.5 million tonnes with a productivity of 548 kg/ha and contributing 10 % to the total pulse production. According to Government of India 3rd advance estimates, green gram production in **2020-21 is at 2.64million tonnes.** Mung bean is rich in essential amino acids particularly lysine, which is deficient in mostof thecereal grains. India is the major producer of green gram in the world and grown in almost all the States. It is grown in about 4.5 million hectares with the total production of 2.5 million tonnes with a productivity of 548 kg/ha and contributing 10 % to the total pulse production. According to Government of India 3rd advance estimates, green gram production in **2020-21 is at 2.64 million tonnes.**

Although the correlation coefficient indicates the nature of association among the different traits, path analysis splits the correlation coefficients into measure of direct and indirect effects, thus provides understanding of the direct and indirect contribution of each character towards yield .The pre-existence of variability and selection of genotypes with due selection pressure on yield attributes is of prime importance in any crop improvement programme. However, the assessment of genetic variability in the base population is the first step in any breeding programme. Thus, the knowledge of the magnitude of genetic variability and estimation of heritability for yield and its components in a population is very important in determining the influence of the environment for the expression of the characters, and the extent to which improvement is possible after selection. The yield is a complex character resulting from the interaction of various yield contributing characters, which have a positive or negative association with yield and among themselves. To assess the magnitude of correlations for various characters with yield is of great help while carrying out indirect selection for the improvement of yield. Path analysis is a standardized partial regression analysis, which further permits the partitioning of the correlation coefficient into components of direct and indirect effects of the independent variable on the dependent variable (Wright, 1921). Analysis of correlation coefficients between characters contributing directly or indirectly towards seed yield is amatter of considerable importance in exercising the selection for improvement in yield

2.OBJECTIVES

- To estimate genetic variability parameters for yield and its attributing characters in Green gram genotypes.
- To assess genotypic and phenotypic association among yield traits.
- To estimate direct and indirect effects of yield contributing characters on seed yield**.**

3.MATERIALS AND METHODS

The experiment was conducted during the Kharif season of 2022 at field experimentation centre of Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh. The experimentation site is situated 98m above sea level at 25.57^0N latitude and 81.56^0N longitude. This area's Subtropical Climate has extremely hot and cold seasons. Temperatures might drop as low as 1-2 degrees Celsius in December and January, especially during the rabi season. The temperature might reach 46 to 48 degrees Celsius during Zaid.

3.1 Experimental Material

The experimental material for present study is obtained from the Department of Genetics and Plant Breeding, SHUATS, Prayagraj (Allahabad). The details of experimental material the experimental material consisted of 21 diverse lines of greengram are as follows in Table 1. The observation was recorded on five randomly selected individual plant of each genotype for each replication for the following thirteen characters except days to 50% flowering, days to maturity which were recorded on plot basis. The characters included in the study were days to 50% flowering, days to 50% pod setting, plant height (cm), number of primary branches per plant, days to maturity, number of clusters per plant, number of pods per plant, pod length, number of seeds per pod, biological yield, seed index, harvest index, and seed yield per plant. The data recorded for these characters were subjected to biometrical and statistical analysis and the results were obtained on above mentioned characters

Comment [K2]: The experimental design, treatment units, plot size are not clearly indicated

Table 1. List of green gram genotypes used in present investigation.

S.NO.	GENOTYPES
1	SPM 20-47
2	GM-3
3	SM-20-103
4	ML 337
5	TYPE-51
6	PHULE MOONG-9339
7	ML-331
8	BM-2002-1
9	T-44
10	SM-2029
11	SML 1638
12	PDM-139
13	SHWETA
14	SPM-2040
15	CO-7
16	JALAGAON-781
17	VBN-2
18	TS-16
19	CO-8
20	PHULE MOONG 95418
21	SAMRAT (Check)

Comment [K3]: All tables should be improved as to the standard for the scientific environment

3.2 Statistical analysis

The estimation of correlation coefficient was done using formula given by Searle [2] and test of significance was carried out by method described by Snedecor and Cochran [3]. The correlation coefficient was further partitioned into direct and indirect effect with the help of path coefficient analysis as suggested by Wright [4] and elaborated by Dewey and Lu [5]. Seed yield was regarded as a dependent variable since it was thought to be a factor that was influenced by the other features, also known as independent variables, as causes. The software called "RLanguage" and INDOSTAT was used to perform the analysis mentioned above.

4. RESULTS AND DISCUSSION

4.1 Correlation Analysis

4.2 Correlation Coefficient analysis

Genotypic Correlation

In present investigation, genotypic correlation coefficient of different characters with seed yield per plant and interrelationship among component characters are presented in table 4.

Correlation between seed yield and other component characters:

Seed yield exhibited positive significant correlation with seed index (0.852**) and number of primary branches (0.420**) and biological yield (0.394*) and positive non-significant association with days to maturity (0.038) and days to 50 percent flowering (0.1803) and negative significant correlation with pod length (-0.440**).

Table 2. Analysis of variance (mean sum of squares) for various characters studiedin Green gram.

Characters	Mean Sum of Squares		
	Replication d.f =2	**Treatments d.f =20**	**Error d.f=40**
Days to 50% Flowering	6.3840	60.777**	5.391
Days to 50% Pod Setting	17.348	13.432*	5.694
Days to Maturity	20.991	24.941**	10.528
Plant Height	50.559	436.045**	25.329
Number of PrimaryBranches	0.7890	5.744**	0.396
Number of Clusters perPlant	0.660	4.251**	0.33
Number of Pods per Plant	1.4740	18.682**	0.736
Pod Length	0.7170	0.886**	0.353
Number of Seeds per Pod	1.0690	1.377**	0.532
Biological Yield	16.992	24.444**	8.506
Harvest Index	2.2280	47.943**	3.978
Seed Index	0.0040	0.028**	0.006
Seed Yield Per Plant	0.0950	0.111*	0.047

Table 3 Genetic Parameters of 13 quantitative characters in green gram genotypes studied in kharif 2022

Traits	GCV	PCV	h^2 (Broad Sense)	Genetic Advancement 5%	Gen. Adv as 5% of Mean
Days to 50% flowering	11.291	12.834	77.398	7.787	20.463
Days to 50% pod setting	2.493	4.466	31.176	1.847	2.868
Days to maturity	3.493	6.241	31.333	2.527	4.028
Plant height (cm)	17.985	19.578	84.387	22.142	34.034
Number of primary branches	17.751	19.625	81.814	2.488	33.075
Number of clusters per plant	19.83	22.195	79.823	2.104	36.496
Number of pods per plant	29.315	31.066	89.045	4.754	56.985
Pod length (cm)	5.609	9.695	33.471	0.502	6.685
Number of seeds per pod	4.761	8.095	34.59	0.643	5.768
Biological yield (g)	7.093	11.439	38.445	2.944	9.059
Harvest Index (%)	17.448	19.674	78.651	6.994	31.876
Seed Index (%)	2.22	3.032	53.646	0.129	3.35
Seed yield per plant (g)	2.044	3.657	31.238	0.168	2.353

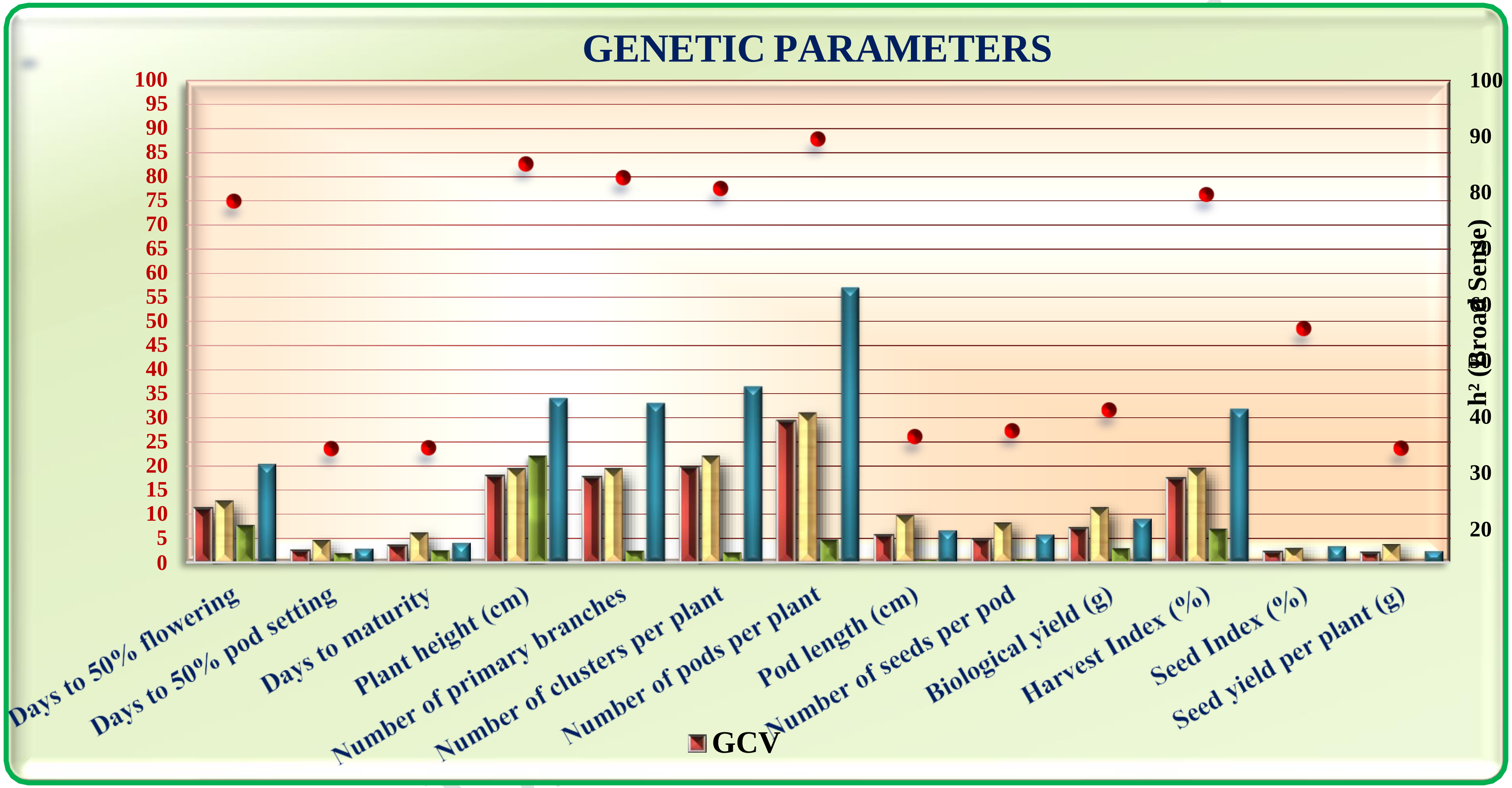


Fig: .1 Histogram representing estimates of variance and genetic parameters

Table 4 Genotypic correlation coefficient between yield and its component traits in greengram genotypes grown during *kharif 2022* at SHUATS, Prayagraj

	DF50	**DP50**	**DM**	**PH**	**NPB**	**NCPP**	**NPPP**	**PL**	**NSPP**	**BY**	**HI**	**SI**	**SYPP**
DF50	1	0.679**	0.708**	0.592**	0.1450	0.2187	0.1128	0.749**	0.681**	0.0678	0.0421	0.0979	0.1803
DP50		1	0.858**	0.384*	0.521**	0.887**	0.689**	0.484**	0.916**	-0.0129	0.261*	0.1877	-0.0861
DM			1	0.289*	0.321*	0.364*	0.559**	-0.1293	0.533**	0.310*	-0.1550	0.1928	0.0380
PH				1	-0.0116	0.259*	0.0915	0.1149	0.596**	0.255*	0.283*	-0.1827	-0.0729
NPB					1	0.822**	0.594**	-0.0543	0.1624	0.1258	0.1964	0.0807	0.420**
NCPP						1	0.558**	-0.0745	0.495**	0.385*	0.321*	0.0426	0.375*
NPPP							1	-0.1834	0.293*	0.0949	0.0824	-0.1748	-0.1139
PL								1	0.327*	-0.467**	-0.0040	-0.403*	-0.440**
NSPP									1	0.261*	0.0723	-0.0043	-0.1290
BY										1	-0.436**	0.1219	0.394*
HI											1	0.1614	-0.0130
SI												1	0.852**

Table 5. Phenotypic correlation coefficient between yield and its component traits in greengram genotypes grown during *kharif 2021* at SHUATS, Prayagraj

Sr. No.	Characters	DF50	DP50	DM	PH	NPB	NCPP	NPPP	PL	NSPP	BY	HI	SI	SYPP
1.	DF50	1	0.334*	0.370*	0.488**	0.1243	0.1850	0.1278	0.291*	0.293*	-0.0084	0.0278	0.0695	0.0992
2.	DP50		1	0.364*	0.1758	0.2424	0.432**	0.375*	0.0277	0.1874	0.0758	0.0422	-0.0153	-0.1291
3.	DM			1	0.1296	0.1254	0.2273	0.303*	0.0493	0.1290	0.0845	-0.0788	0.0419	0.0028
4.	PH				1	-0.0073	0.2297	0.0831	0.0317	0.318*	0.0264	0.2067	-0.1089	-0.0588
5.	NPB					1	0.725**	0.549**	-0.1437	0.0573	0.0397	0.1752	0.0672	0.2022
6.	NCPP						1	0.513**	-0.0646	0.2349	0.1766	0.263*	0.1460	0.1732
7.	NPPP							1	-0.1359	0.1173	0.0534	0.1091	-0.0723	-0.1126
8.	PL								1	0.427**	-0.1142	0.1031	-0.1601	-0.0906
9.	NSPP									1	0.0633	0.1395	-0.0772	-0.0534
10.	BY										1	-0.298*	-0.0270	0.1576
11.	HI											1	0.0820	-0.0530
12.	SI												1	0.2151

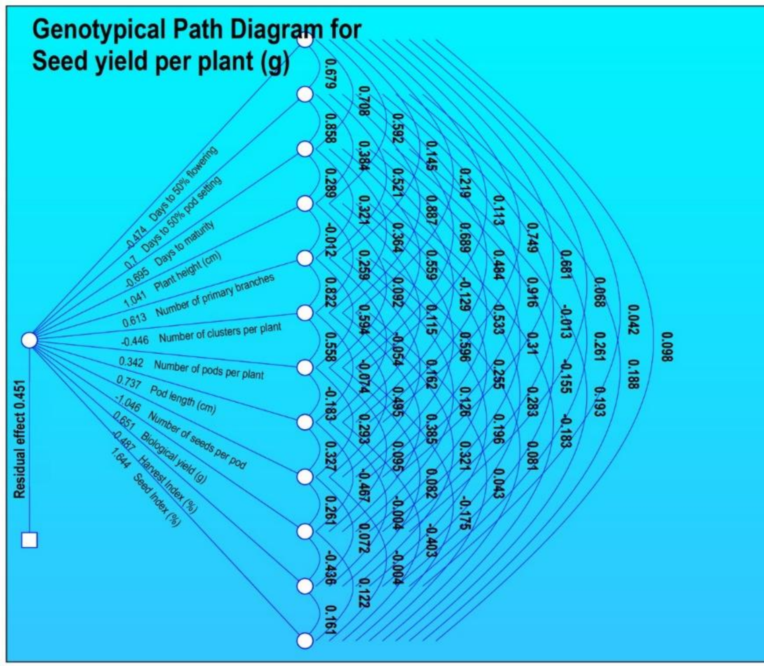
Table 6 Genotypical path matrix for Seed yield per plant showing direct (in bold) and indirect effects of various characters.

Sr. No.	Characters	DF50	DP50	DM	PH	NPB	NCPP	NPPP	PL	NSPP	BY	HI	SI	SYPP
1.	DF50	**-0.4736**	-0.3216	-0.3353	-0.2804	-0.0687	-0.1036	-0.0534	-0.3547	-0.3224	-0.0321	-0.0199	-0.0464	0.1803
2.	DP50	0.4757	**0.7005**	0.6011	0.2691	0.3651	0.6210	0.4824	0.3389	0.6416	-0.0091	0.1825	0.1315	-0.0861
3.	DM	-0.4924	-0.5968	**-0.6954**	-0.2006	-0.2233	-0.2532	-0.3884	0.0899	-0.3708	-0.2158	0.1078	-0.1341	0.0380
4.	PH	0.6161	0.3998	0.3002	**1.0406**	-0.0121	0.2692	0.0953	0.1195	0.6202	0.2657	0.2948	-0.1901	-0.0729
5.	NPB	0.0889	0.3197	0.1970	-0.0071	**0.6134**	0.5039	0.3642	-0.0333	0.0996	0.0772	0.1205	0.0495	0.420**
6.	NCPP	-0.0975	-0.3953	-0.1624	-0.1154	-0.3663	**-0.4459**	-0.2488	0.0332	-0.2206	-0.1718	-0.1433	-0.0190	0.375*
7.	NPPP	0.0386	0.2356	0.1911	0.0313	0.2031	0.1909	**0.3421**	-0.0627	0.1003	0.0325	0.0282	-0.0598	-0.1139
8.	PL	0.5517	0.3564	-0.0953	0.0846	-0.0400	-0.0549	-0.1350	**0.7366**	0.2410	-0.3442	-0.0030	-0.2967	-0.440**
9.	NSPP	-0.7119	-0.9578	-0.5576	-0.6233	-0.1699	-0.5173	-0.3065	-0.3422	**-1.0457**	-0.2728	-0.0756	0.0045	-0.1290
10.	BY	0.0442	-0.0084	0.2022	0.1663	0.0820	0.2510	0.0618	-0.3044	0.1699	**0.6515**	-0.2838	0.0794	0.394*
11.	HI	-0.0205	-0.1268	0.0754	-0.1378	-0.0956	-0.1564	-0.0401	0.0020	-0.0352	0.2119	**-0.4865**	-0.0785	-0.0130
12.	SI	0.1610	0.3087	0.3170	-0.3003	0.1326	0.0700	-0.2873	-0.6622	-0.0070	0.2004	0.2653	**0.8320**	0.852**

Table 7 Phenotypical path matrix for Seed yield per plant showing direct (in bold) and indirect effects of various characters.

Sr. No.	Characters	DF50	DP50	DM	PH	NPB	NCPP	NPPP	PL	NSPP	BY	HI	SI	SYPP
1.	DF50	**0.2394**	0.0800	0.0885	0.1167	0.0297	0.0443	0.0306	0.0697	0.0702	-0.0020	0.0067	0.0166	0.0992
2.	DP50	-0.0775	**-0.2321**	-0.0845	-0.0408	-0.0562	-0.1001	-0.0869	-0.0064	-0.0435	-0.0176	-0.0098	0.0036	-0.1291
3.	DM	0.0052	0.0051	**0.0140**	0.0018	0.0017	0.0032	0.0042	0.0007	0.0018	0.0012	-0.0011	0.0006	0.0028
4.	PH	-0.0681	-0.0245	-0.0181	**-0.1396**	0.0010	-0.0321	-0.0116	-0.0044	-0.0445	-0.0037	-0.0289	0.0152	-0.0588
5.	NPB	0.0237	0.0463	0.0239	-0.0014	**0.1910**	0.1384	0.1048	-0.0274	0.0109	0.0076	0.0335	0.0128	0.2022
6.	NCPP	0.0438	0.1022	0.0538	0.0544	0.1717	**0.2369**	0.1216	-0.0153	0.0557	0.0418	0.0622	0.0346	0.1732
7.	NPPP	-0.0360	-0.1054	-0.0851	-0.0234	-0.1543	-0.1443	**-0.2813**	0.0382	-0.0330	-0.0150	-0.0307	0.0203	-0.1126
8.	PL	-0.0296	-0.0028	-0.0050	-0.0032	0.0146	0.0066	0.0138	**-0.1016**	-0.0433	0.0116	-0.0105	0.0163	-0.0906
9.	NSPP	-0.0064	-0.0041	-0.0028	-0.0070	-0.0013	-0.0052	-0.0026	-0.0094	**-0.0220**	-0.0014	-0.0031	0.0017	-0.0534
10.	BY	-0.0011	0.0095	0.0106	0.0033	0.0050	0.0221	0.0067	-0.0143	0.0079	**0.1252**	-0.0373	-0.0034	0.1576
11.	HI	-0.0012	-0.0018	0.0033	-0.0087	-0.0074	-0.0111	-0.0046	-0.0044	-0.0059	0.0126	**-0.0423**	-0.0035	-0.0530
12.	SI	0.0070	-0.0015	0.0042	-0.0109	0.0067	0.0146	-0.0073	-0.0161	-0.0077	-0.0027	0.0082	**0.1003**	0.2151
13.	SYPP	0.0992	-0.1291	0.0028	-0.0588	0.2022	0.1732	-0.1126	-0.0906	-0.0534	0.1576	-0.0530	0.2151	**1.0000**

Figure 2



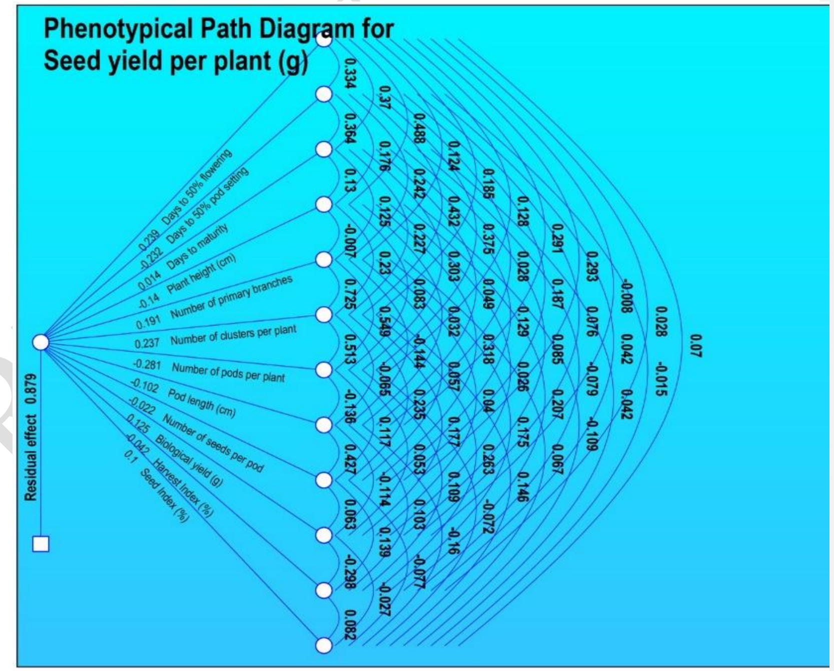


Figure 3

Figure 2: Genotypical path Diagram for seed yield per plant

Figure 3: Phenotypical Path Diagram for Seed yield per plant

In plant breeding programs, several characters are generally to be handled together by a breeder as most of the characters are interrelated. Thus, the different components of yield very often exhibit considerable amount of association among themselves and with yield. Hence, for rational improvement of seed yield and its components the understanding of correlations has been proved to be very useful. It was imperative to obtain information regarding the interrelationships of different plant characters with yield since it helps in the the quicker assessment of high yielding genotypes in breeding programs. An estimate of total correlation was not sufficient to fully analyze the correlation between two variables, as it was the result of interaction between genotypes and environment. The true association can be known only through genotypic correlation, which eliminates the environmental effects. For most of the characters, the values of genotypic correlations were higher than their phenotypic correlations in the present investigation.

This suggest that though there was high degree of association between two variables at genotypic level, its phenotypic expression was diluted by the influence of environment. It also suggests that there was an inherent relationship between the characters studied. The study of genotypic correlation gives an idea of the degree of relationship between different variables. This relationship among yield contributing characters as well as their association with yield provides information for exercising selection pressure for aiming for genetic improvement in seed yield. Similar results were obtained for **Tabasum *et al.* (2010), Kumar *et al*. (2013) and Reddy *et al.* (2011)**

Path Analysis

Path Coefficient analysis

Seed yield, a polygenic trait, was influenced by its various components directly as well as indirectly via other traits, which create a complex situation before a breeder for making selection. Therefore, path coefficient analysis could provide a more realistic picture of the interrelationship, as it considers direct as well as indirect effects of the variables by partitioning the correlation coefficient.

In the present study ,13 quantitative characters viz., Days to 50% flowering, Days to 50% pod setting, Days to maturity, Plant height (cm), Number of clusters per plant, Number of pods per plant, Pod length, Number of primary branches, Number of seeds per pod, Seed index (g), Harvest index (%), Biological yield (g), Seed yield per plant (g) were selected for partitioning their genotypic and phenotypic correlation coefficients with seed yield into direct and indirect effects. The seed yield was considered as the dependent variable while the above mentioned thirteen components' characters as the independent variables. The genotypic and phenotypic correlation coefficients worked out between seed yield per plant and each of these twelve causal variables and among themselves are given in Table-4 &5. The direct and indirect effects of these causal variables on seed yield are given in Table 6, Table.7, Fig 2 and Fig .3

Genotypic Path Coefficient analysis

The genotypic path coefficient analysis matrix for all the characters was given in table.6 and Fig .2

Among all the characters under study, Plant height exhibited highest effect on seed yield per plant followed by plant height, Seed Index, Pod length and days to 50 percent pod setting while the highest negative effect was shown by Number of clusters per plant followedby Days to 50 percent flowering and Harvest Index.

5. CONCLUSION

Considerable variability existed in the genotypes for all the characters studied. These were the genotypes with high mean values in desirable direction i.e., From the present investigation it is concluded that among 21 genotypes of green gram, Swetha showed early flowering (33 days), PDM-139 had characters like early maturity (61 days), PDM-139 showed early Days to 50 percent pod setting (61 days), Jalgaon-781 showed high Plant Height (42.96), High seed yield per plant was recorded by SM- 2029, SPM-2040, PHULEMOONG-95418, CO-8, CO-7 (7.2). All the traits showed significant variation among the lines. High GCV and PCV was recorded for Number of pods per plant, Number of clusters per plant, Number of primary branches and Plant height, highest percentage of broad sense heritability and also high in genetic advance followed by Plant height and Number of primary branches and Number of clusters per plant. Seed index, Biological Yield and Number of Primary branches exhibited high positive direct effect to seed yield per plant at both phenotypic and genotypic path coefficient analysis. These characters should be given due consideration during selection for crop improvement. Correlation analysis among the yield and its contributing characters revealed that the genotypic correlation coefficients in most cases were higher than their phenotypic correlation coefficients indicating the association was largely due to genetic reason. At both genotypic and phenotypic levels, significant positive correlations were observed for Seed Index, Days to maturity, Days to 50% pod setting, Plant height, Number of pods per plant and Number of clusters per plant.

Comment [K7]: based on your findings there should be a recommendation

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