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GENETIC VARIABILITY AND CHARACTER ASSOCIATION ANALYSIS IN WINGED BEAN [*PSOPHOCORPUS TETRAGONOLOBUS* (L.) DC.] AT GREEN POD STAGE

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ABSTRACT
Fifteen genotypes of winged bean (including indigenous and exotic accessions with Maysoor local as check variety) were evaluated for genetic variability and character associations at Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the *kharif* season 2012-13. Highly significant differences among genotypes for all the traits studied were observed. Green seed yield per plant followed by number of green pods per plant and total leaf area were among the most variable traits. Traits like Green pod yield per plant (99.95% and 46.72%) followed by number of green pods per plant (94.46% and 42.88%) showed high heritability coupled with high genetic advance indicating their importance in selection programme for further improvement. Maximum positive phenotypic correlation with the green pod yield per plant was exhibited by number of green pods per plant (0.964) followed by total leaf area (0.731) and days to green pod stage(0.658). Path coefficient analysis indicated that number of green pods per plant (0.915) was the main character that contributed to the maximum extent directly and via other component characters towards the green pod yield per plant. It can be inferred that there is ample variability for further improvement for green pod yield per plant and number of green pods per plant should be applied as direct selection criterion.

INTRODUCTION

Legume vegetables have unique position in the world of food and agriculture because of their higher protein content, high capacity to fix atmospheric nitrogen and adaptability to wide range of agro-climatic region. In this context winged bean is a good source of protein for tropical region. Among legumes, winged bean [*Psophocorpus tetragonolobus* (L.) DC] has been assuming considerable importance at present as a protein rich legume crop for its incorporation in a variety of cuisine (Prasanth K. and Kumary I. S., 2014). All parts of the Winged bean are rich in protein and Masefield (1973) attributed this to the abundant nodulation and consequent high nitrogen fixation. The seed protein content and oil content have been reported to range from 30-37 and from 15-18 percent respectively (Masefield, 1973; Pospisil *et al*., 1971; Khan, 1976 and Claydon, 1975). The majority of people use the winged bean in their diet in the form of tender green pod. The young, tender pods may be eaten raw, sliced, or chopped. The immature pod provides bulk of comparatively low energy content, but it is a beneficial vegetable because of the minerals and vitamins it contains. For this highly nutritive underutilised legume vegetable to be a matter of choice of growers and consumers its genetic improvement must be carried out. The ultimate aim of any plant breeding programme is to improve the desirable trait of agronomic and economic importance. Availability and assessment of genetic variability is a prerequisite for any crop improvement programme. Once, the assessment of variability is taken the next step is to carry out character association studies so that the component traits can be determined for effective selection.

The major applicability of winged bean is at its green pod stage.Green pod yield is a complex trait dependent on several independent component traits. Thus, information on the extent of variation and the association of green pod yield attributes and their direct and indirect effects on green pod yield are of great significance for further improvement in this crop.

Keeping these facts in view, an investigation was undertaken to elucidate the variability and character associations in winged bean at green pod stage.

MATERIALS AND METHODS

The present experiment was conducted at the Vegetable Research Farm, Institute of Agricultural Sciences, Banaras Hindu University,Varanasi during the *kharif* season 2012-13. The university is situated at 25.18ÚN latitude and 83.03ÚE longitude. The site comes under the Indo-Gangetic alluvial belt of the semi-arid zone. The experiment was conducted in a Randomized block design with 15 genotypes (including indigenous and exotic accessions of winged bean with Maysoor local as check variety). These accessions were obtained from Birsa Agriculture University, Ranchi (Jharkhand) and NBPGR (sub centre) Akola (Maharashtra)and grown in three replications during *kharif* season 2012-13. The details of the genotypes are given in the table 1. Each genotype was sown in single row plots. Each plot consisted of one row of 4

m length with row to row and plant to plant distance being 75 X 60 cm, respectively. Recommended agronomic practices were followed to raise a good crop stand.Morphological observations on various traits viz. Days to flower initiation, Days to pod initiation,Days to green pod stage,Pod length (cm),Pod width (cm),Number of green pods per plant,Total leaf area (cm^2), Number of green seeds per pod,Green pod yield per plant (g),Green seed yield per plant (g), and Weight of 100-green seed (g)were recorded from five randomly selected plants of each genotype and the average value was used for statistical analysis. The analysis of variance was carried out following the Panse and Sukhatme (1967) procedure. Correlation coefficient analysis was done according to Robinson *et al*. (1951) and the methodology proposed by Dewey & Lu (1959) was followed to carry out the path coefficient analysis for green pod yield and its components, keeping pod yield as dependent variable and other variables as independent ones.

RESULTS

The analysis of variance as presented in table 2 has shown highly significant variation for all the eleven traits studied. The estimates of different variability parameters viz. mean, range, GCV, PCV, heritability and genetic advance as percent of means are shown in table 3.In the present investigation higher magnitude of GCV was observed for the traits like green pod yield per plant (22.69%), green seed yield per pod (21.88%) and number of green pods per plant (21.42%). However, the phenotypic coefficient of variation was observed maximum for green seed yield per pod (23.41%) followed shortly by green pod yield per plant (22.69%) and the number of green pods per plant (22.04%). Relatively higher magnitude of heritability was calculated for the traits like green pod yield per plant (99.95%), weight of 100 green seeds (gm.) (97.10%) and total leaf area (96.54%). Genetic advance as percent of mean was calculated for all the characters under study and green pod yield per plant (46.72%) had shown the maximum value for this. Other characters showing higher magnitude of genetic advance as percent of means were number of green pods per plant (42.88%), green seed yield per pod (42.15%) and total leaf area (cm^2) (40.38%).

Table 1: Details of the genotypes used in this study

S.No.	Accession No.
1.	IC-15018
2.	IC-17005
3.	IC-26949
4.	IC-31981
5.	IC-34865-1
6.	IC-95222
7.	IC-95227
8.	IC-95229
9.	IC-95233
10.	EC-27886
11.	EC-38955
12.	EC-142654-4
13.	EC-142662
14.	TMV Local
15.	Maysoor Local (Check)

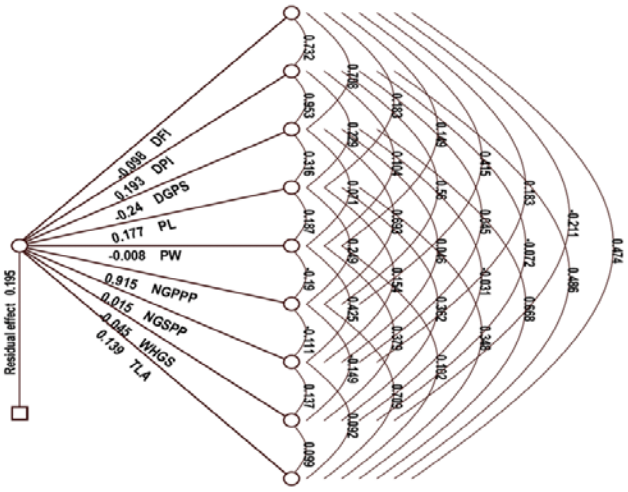

Figure1: Phenotypic Path Diagram for Green pod yield per plant (g).
Abbreviations: Same as in Table 2

The nature and magnitude of association among different characters was studied with the help of genotypic and phenotypic correlation (Galton, 1889). The genotypic and phenotypic correlation coefficients between green pod yield per plant and its component, characters in fifteen winged bean genotypes are presented in Table 4. Among the traits studied,the number of green pod per plant (0.964) was found to exhibit highly significant positive correlation with green pod yield per plant. Other traits showing highly significant positive correlation with green pod yield per plant were total leaf area (0.731), days to green pod stage (0.658) and days to pod initiation (0.515) at phenotypic level. The estimates of genotypic correlation coefficient also had shown the similar trend of association.

With a view to study the direct (diagonal) and indirect effects of components of green pod yield per plant,the path coefficient analysis was undertaken both at phenotypic and genotypic levels and is given in the table 5 and is also shown diagrammatically in the fig.1. The table 5 reveals that the number of green pod per plant (0.915) and pod length (cm) (0.177) are the only characters having the positive and direct effects on the green pod yield per plant both at phenotypic and the genotypic level. Other characters showing direct positive effects on green pod yield at phenotypic level are days to pod initiation, total leaf area (cm^2) and number of green seed per pod. Also, the days to pod initiation and total leaf area (cm^2) have shown to have high magnitude of direct negative effect on green pod yield at the genotypic level. The significant positive correlation (0.731) observed between green pod yield per plant and total leaf area (cm^2) was mainly due to the effect of total leaf area (cm^2) on the green pod yield per plant via other traits like number of green pod per plant and pod length. The same is the case with days to green pod stage. The pod length has shown the indirect association with green pod yield per plant via characters like number of green pod per plant.Some traits like days to green pod stage and days to flower initiation have shown direct negative effect on the green pod yield at phenotypic level. A lower value of residual effect (0.195) was estimated in the phenotypic path coefficient

Table 2: Analysis of variance for fifteen characters in winged bean

Source of variation	d.f.	DFI	DPI	DGPS	PL	PW	NGPPP	NGSPP	GPYPP	GSYPP	WHGS	TLA
Replications	2	9.38	15.35	21.88	0.24	0.004	0.221	1.082	7.8	76.77	1.833	11663.97
Treatment	14	22.36**	29.67**	66.58**	1.73**	0.033**	59.46**	2.14**	14224.95**	634.23**	46.877**	533246.40**
Error	28	3.01	5.36	7.02	0.42	0.005	1.14	0.54	2.34	29.025	0.56	6303.8
S.E. m ±		1.42	1.89	2.16	0.53	0.06	0.87	0.59	1.25	4.39	0.64	64.83
C.V (%)		2.08	2.52	2.24	4.5	4.23	5.19	7.47	0.5	8.3	2.16	3.78
C.D (5%)		2.9	3.87	4.39	1.08	1.12	1.78	1.23	2.56	9.01	1.23	132.79

Abbreviations: DFI = days to flower initiation, DPI = days to pod initiation, DGPS = days to green pod stage , PL = pod length(cm.), PW = pod width(cm.), NGPPP = No. of green pod per plant, NGSPP = No. of green seed per pod, GPYPP = green pod yield per plant (gm.), GSYPP = green seed yield per plant (gm.), WHGS = wt. of 100 green seeds (gm.), TLA = total leaf areas(cm^2); *Significant at 5 per cent level: **Significant at 1 percent level.

Table 3: Components of variability of green pod yield and green seed yield and its yield contributing traits in winged bean

Sr. No.	Traits	Mean	Range Min	Max	GCV (%)	PCV (%)	Heritability (%)	GA as % of mean
1	DFI	83.20 ± 1.42	79.34	85.04	3.05	3.7	68.18	5.19
2	DPI	91.89 ± 1.89	87.73	99.56	3.1	3.99	60.2	4.95
3	DGPS	115.65 ± 2.16	107.42	125.04	3.85	4.48	73.86	6.82
4	PL	14.48 ± 0.53	13.33	15.7	4.55	6.4	50.56	6.66
5	PW	1.78 ± 0.06	1.58	1.96	5.37	6.83	61.69	8.68
6	NGPPP	20.58 ± 0.87	13	26.23	21.42	22.04	94.46	42.88
7	NGSPP	9.82 ± 0.59	8.8	11.01	4.56	8.75	27.13	4.88
8	GPYPP	303.50 ± 1.25	187.24	406.98	22.69	22.69	99.95	46.72
9	GSYPP	64.90 ± 4.39	37.14	87.79	21.88	23.41	87.42	42.15
10	WHGS	32.39 ± 0.64	28.77	39.43	12.04	12.22	97.1	24.44
11	TLA	2100.39 ±64.83	1215.63	2690.45	19.95	20.31	96.54	40.38

Abbreviations: Same as in Table 2.

Table 4: Phenotypic (P) and Genotypic (G) correlation coefficients among green pod yield and its yield attributes in fifteen genotypes of winged bean

Characters		DFI	DPI	DGPS	PL	PW	NGPPP	NGSPP	WHGS	TLA	GPYPP
DFI	P	1	0.732**	0.708**	0.183	0.149	0.415	0.183	-0.211	0.474	0.362
	G	1	0.941**	0.881**	0.275	0.157	0.481	0.242	-0.229	0.681**	0.439
DPI	P		1	0.953**	0.229	0.104	0.560*	0.045	-0.072	0.486	0.515*
	G		1	0.972**	0.414	0.156	0.671**	0.302	-0.091	0.665**	0.659**
DGPS	P			1	0.316	0.071	0.693**	0.046	-0.031	0.668**	0.658**
	G			1	0.501	0.135	0.763**	0.181	-0.047	0.812**	0.762**
PL	P				1	0.187	0.249	0.154	0.362	0.348	0.387
	G				1	0.235	0.386	-0.134	0.595*	0.514*	0.549*
PW	P					1	-0.19	0.425	0.379	0.102	-0.157
	G					1	-0.229	0.582	0.520*	0.148	-0.198
NGPPP	P						1	-0.111	-0.149	0.709**	0.964**
	G						1	-0.096	-0.185	0.746**	0.991**
NGSPP	P							1	0.137	0.092	-0.077
	G							1	0.379	0.185	-0.135
WHGS	P								1	0.099	-0.091
	G								1	0.101	-0.093
TLA	P									1	0.731**
	G									1	0.743**

**Significance at p = 1%; * Significance at p = 5%,Abbreviations: Same as in Table 1.

analysis as indicated in the fig.1.

DISCUSSION

The most basic requirement of any crop improvement programme is the presence of variation for the traits. Here, high magnitude of variability for all the characters studied suggests the opportunity for further improvement of this underutilised crop. Relatively higher value of PCV as compared to GCV for almost all the traits indicates the interference of environment in the expression of these traits. A higher value of GCV for traits like number of green pods per plant, green pod yield per plant and green seed yield per pod reveal that direct selection for these traits will be rewarding since variation for these traits have little environmental influence. Similar results were found by Mohamadali&Madalgeri (2005) and Suganthi and Murugan (2008) in cowpea. In any selection

Table 5: Direct (diagonal) and indirect effects of green pod yield components on green pod yield per plant at phenotypic (P) and genotypic (G) level

Characters		DFI	DPI	DGPS	PL	PW	NGPPP	NGSPP	WHGS	TLA	GPYPP
DFI	P	-0.098	0.141	-0.17	0.032	-0.001	0.379	0.003	0.01	0.066	0.362
	G	0.466	-1.045	0.688	0.019	0.042	0.63	-0.04	-0.028	-0.292	0.439
DPI	P	-0.071	0.193	-0.229	0.041	-0.001	0.512	0.001	0.003	0.067	0.515*
	G	0.438	-1.111	0.759	0.029	0.041	0.877	-0.05	-0.011	-0.314	0.659**
DGPS	P	-0.069	0.184	-0.24	0.056	-0.001	0.634	0.001	0.001	0.093	0.658**
	G	0.41	-1.079	0.781	0.035	0.036	0.999	-0.03	-0.006	-0.384	0.762**
PL	P	-0.018	0.044	-0.076	0.177	-0.002	0.227	0.002	-0.016	0.048	0.387
	G	0.128	-0.46	0.391	0.07	0.062	0.505	0.022	0.073	-0.243	0.549*
PW	P	-0.015	0.02	-0.017	0.033	-0.008	-0.174	0.006	-0.017	0.014	-0.157
	G	0.073	-0.173	0.106	0.016	0.265	-0.3	-0.179	0.064	-0.07	-0.198
NGPPP	P	-0.041	0.108	-0.166	0.044	0.002	0.915	-0.002	0.007	0.098	0.964**
	G	0.224	-0.745	0.596	0.027	-0.061	1.308	0.016	-0.023	-0.352	0.991**
NGSPP	P	-0.018	0.009	-0.011	0.027	-0.003	-0.102	0.015	-0.006	0.013	-0.077
	G	0.113	-0.335	0.141	-0.009	0.287	-0.126	-0.165	0.046	-0.088	-0.135
WHGS	P	0.021	-0.014	0.008	0.064	-0.003	-0.137	0.002	-0.045	0.014	-0.091
	G	-0.107	0.101	-0.037	0.042	0.138	-0.242	-0.063	0.122	-0.048	-0.093
TLA	P	-0.046	0.094	-0.16	0.062	-0.001	0.648	0.001	-0.005	0.139	0.731**
	G	0.288	-0.739	0.634	0.036	0.039	0.976	-0.031	0.012	-0.472	0.743**

Phenotypic Residual effect = 0.195; Genotypic Residual effect = -0.0102; Diagonal values indicate direct effects Abbreviations: Same as in Table 2

programme the heritability of the traits under study determines the effectiveness of the selection as well as the breeder's efficiency. In the present experiment, very high estimate of heritability for the traits like green pod yield per plant (gm) followed shortly by weight of 100 green seeds (gm) and total leaf areas (cm^2) shows higher proportion of genetic variance for these traits. However, estimate of heritability alone does not prove to be sufficient for being the true representative of exploitable variation. The breeder should be cautious in making selections based on heritability as it includes both additive and non-additive genetic variances. It is the estimate of heritability coupled with genetic advance which the breeders are more concerned with (Johnson *et al.,* 1955). Here, higher magnitudes of heritability coupled with high estimates of genetic advance for the traits like green pod yield per plant (gm) followed by number of green seed per pod envisages their importance in the selection programme in making the selection more rewarding.

The study of correlation was taken up to gather information on the inter-relationship among all eleven characters. Highly significant positive estimates of both genotypic and phenotypic correlation coefficient by number of green pod per plant, total leaf area (cm^2) and days to green pod stage for green pod yield per plant are the indicative of potential applicability of these traits in indirect selection programmes for improving green pod yield per plant. In winged bean these findings are also supported by earlier workers like Mohamadali and Madalgeri (2004) who have reported positive correlation of number of pods per plant, number of seeds per pod and pod yield per plant. Significant genotypic correlation for green pod yield per plant by days to pod initiation and pod length (cm) coupled with non significant estimates of their respective phenotypic correlation coefficients indicate the interference of environmental factors in their association.Malaghan *et al*. (2014) have also found the positive correlation between pod yield per plant and plant length in *Cyamopsistet ragonaloba*L. The estimates of correlation coefficients indicate only the extent and direction of association between yield and its attributes, but does not show the direct and indirect effects of different yield components on green pod yield *per se*. For this reason path coefficient analysis was done to understand the way by which a change in any one component is likely to disturb the whole network of cause and effect. Thus, each component has two paths of action *viz*., the direct influence on green pod yield per plant and its indirect effect through components which are not directly visible from the correlation studies. The higher estimates of direct and positive effects by number of green pod per plant and pod length (cm) on the green pod yield per plant both at phenotypic and the genotypic level signifies the effectiveness of direct selection for higher number of green pod per plant to improve thegreen pod yield. Similar results were reported earlier by Mohamadali and Madalgeri (2004) also observed a high direct effect of number of pods per plant. Similarly, Rai and Dharmatti (2014) had also reported the high direct effect of pod yield per plant on the pod yield per hectare. Some traits like days to green pod stage and days to flower initiation have shown direct negative effect on the green pod yield at phenotypic level although their direct negative effects were cancelled by indirect positive effects via other traits. The direct negative effect on the green pod yield by days to green pod stage and days to flower initiation at phenotypic level were cancelled by indirect positive effects via other traits.

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