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GENETIC ANALYSIS OF *GLYCINE MAX* (L) MERRILL IN SELECTED SOWING TIME

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Abstract

Glycine max (L) Merrill genotypes (Bossier, Hampton, Improved Pelican and Clark-63) were planted at 15 days interval (Ist June, 15th June, 1st July, 15th July, 1st August and 15th August) at Agricultural Research Institute, Tando Jam during summer, 1993. Seed yield and yield components varied significantly ($P<0.01$) due to change in sowing time and genotype. All genotypes yielded more when planted on 1st June, while decreased for each delay in planting beyond Ist June. Among genotypes Bossier yielded more over rest of the genotypes tested.

Genetic analysis depicted that plant height and seed yield/plant had greater genetic advance, whereas heritability was more in plant height, seed yield/plant, branches/plant, seed index, effective pod filling period and pods/plant. Correlation of yield was significant and positive with plant height, branches/plant, nodes/plant, pods/plant, seeds/pod, and seed index. Flowering days exhibited significant and positive association with effective pod filling period. Plant height had positive and significant relationship with nodes/plant and pods/plant. The correlation of branches/plant was positive and significant with nodes/plant, seeds/pod and seed index. Nodes/plant displayed positive and significant correlation with pods/plant, while pods/plant depicted positive and significant association with seeds /pod and seed index whereas seeds/pod had positive and significant association with seed index.

The path coefficient analysis reveals that pods/plant, plant height and seed index had high positive direct effect on yield, while maturity days displayed high negative direct effect on yield. The multiple regression analysis suggested that pods/plant and seed index contributed significantly towards yield and could be used for future plant breeding programme of soybean.

Introduction

One of the most important practices which influences the yield of soybean is the date of sowing (Carter & Hartwig, 1963; Egli *et al.*, 1987). In U.S.A. the yields are usually similar for mid-May to early June planting, which rapidly decreased as planting is delayed into late June and early July (Pendleton & Hartwig; 1973; Egli, 1976; Tanner & Hume, 1978). Similar relationships have been shown in Australia (Constable, 1977; Junes & Laing, 1978) and China (Xinqi & Shumin, 1984).

Genotypic and sowing date interactions have been reported (Carter & Boerma, 1979, Boquet *et al.*, 1982) suggesting that cultivars specially adapted to late planted environments could be developed. In Pakistan, environmental conditions vary from province to province and within province. It is possible that the development of cultivars for late planted environment (double cropping) would be facilitated by better understanding of the factors responsible for the yield reductions associated with delay plantings.

The knowledge of interrelationship of factors affecting yield is prerequisite for designing an effective plant breeding programme (Worley *et al.*, 1976). Although information regarding the simple correlation of agronomic and morphological characters with yield is helpful in the identification of the components of this trait, yet these do not provide precise information on the relative importance of direct and indirect effect of each of the componential characters. With increasing number of variable it becomes necessary to measure the contribution of these variables towards the observed correlation and therefore, partitioning of the correlation coefficients into components of direct and indirect influence provide insight in the materialization of such a complex character such as yield (Rajpur *et al.*, 1983, Pandey & Gitton, 1976). As such path coefficient analysis provides an effective means of partitioning correlation coefficient into unidirectional and alternate pathways. Thus, it permits a critical examination of specific factors that produce a given correlation and could successfully be employed in formulating an effective selection strategy. Path coefficient analysis has therefore been extensively used by conventional breeders (Bhatt, 1973, Lyrene & Shands, 1975 and Rajpur *et al.*, 1983). Experiments, therefore carried out to assess the genetic analysis of *Glycine max* (L) Merrill in selected sowing time.

Materials and Methods

Four exotic genotypes of *Glycine max* (L) Merrill viz., Bossier, Hampton, Improved Pelican and Clark - 63 were planted at 15 days interval (Ist June, 15th June, Ist July, 15th July, Ist August and 15th August) in a 4 replicated split plot design at the experimental field of Agricultural Research Institute, Tando Jam during summer, 1993. The seeds after inoculation with *Rhizobium japonicum* Strain were drilled in rows 60 cm apart, with 15 cm distance between plant to plant @ 75 kg/ha. A 3x5 metre plot size as sub-plot (Genotype) and 12 x 20 metre as main plot (Sowing date) respectively was used. A basal fertilizer dose of 50-90-25 kg NPK/ha was applied prior to sowing in the form of urea, SSP and SOP respectively. All the required cultural operations were adopted in all the plots according to the crop requirement.

Five plants from each sub-plot were selected randomly and tagged for recording agronomic observations i.e., days to flowering, days to maturity, plant height, # of branches per plant, # of nodes per plant, # of pods per plant, # of seeds per pod, seed index (100 seed weight) and seed yield per plant. At harvest seed yield per plot obtained was calculated as seed yield per hectare.

All the collected data were subjected to analysis of variance (ANOVA) through computer using `MSTATC' Software package. For genetic analysis, data from Ist June planted *Glycine max* (L) Merrill were used as the same displayed better results. The genetic selection parameters were analysed according to the method outlined by Singh (1990). Simple, multiple correlation and regression was tabulated according to Steel & Torrie (1960). Path coefficient analysis was done as suggested by Dewey & Lu (1959).

Results and Discussion

Sowing date: Differences in days to flowering, days to maturity, plant height, branch-

Table 1. Analysis of Variance corresponding to various sources of variation for growth, yield parameters and Seed Yield of *Glycine max* (L.) Merrill under Varying Sowing dates.

Source of Variation	Degrees of Freedom	MEAN SQUARE Days to flowering	Days to maturity	Plant height (cm)	# of branches/ plant	# of nodes/ plant	# of pods/ plant	# of seeds /pod	Effective pod filling period	Seed index (gm)	Seed weight plant (gm)	Seed yield ha. (M.t)
						N.S.						
Replications	3	0.148	2.560	1.938	0.069	0.042	4.560	0.010	0.667	4.380	0.062	0.006
Sowing dates (s)	5	85.310**	261.780**	100.820**	8.520**	24.520**	255.660**	0.292**	85.820**	493.400**	8.141**	0.476**
Main Plot Erro	15	0.654	1.660	1.415	0.091	0.222	1.540	0.023	0.192	3.690	0.039	0.001
Varieties (v)	3	181.670**	6042.290**	48971.130**	85.630**	161.610**	833.950**	4.060**	308.253**	2245.690**	132.197**	1.042**
SxV	15	3.800**	4.510^NS	3.642**	0.299**	0.703^NS	2.280^NS	0.018^NS	2.517**	6.890^NS	0.026^NS	0.004^NS
Sub Plot Error	54	0.691	4.800	0.302	0.070	0.355	1.770	0.026	0.623	3.620	0.090	0.003
Total:	95											

** Significant at $P < 0.01$ level of probability.

NS Non Significant.

es/plant, nodes/plant, pods/plant, seeds/pod, effective pod filling period, seed index, seed weight/plant and seed yield/ha over sowing dates and genotypes were significant ($P < 0.01$). However the interactions of sowing dates x genotypes (SxV) were also significant ($P < 0.01$) for days to flowering, plant height, branches/plant and effective pod filling period while non-significant for rest of the characters. This demonstrated that the effect of sowing date and genotypes was independent for characters displayed non-significant results while dependent for parameters which showed significant result (Table 1).

Early planted (Ist June) soybean produced significanty more seed yield in all 4 varieties studied when compared with delayed planted soybean which took more days to flowering resulting in delayed maturity. The significant interaction for characters studied showed that the effect of sowing date varied with genotypes to genotypes. Among genotypes Bossier was found to be high yielding followed by Hampton and Improved Pelican respectively. However Clark-63 proved low yielder and all the varieties showed reduction in seed yield as sowing was delayed beyond Ist June. Pendleton Hartwig (1973), Egli (1976) and Tanner & Hume (1978) have also reported that seed yield decreased rapidly as planting was delayed into late June or early July. Similar relationship have also been shown in Australia (Constable, 1977; Junes & Laing, 1978) and in China (Xinqi & Shumin, 1984).

Genetic Analysis *Genetic Selection Parameter*: Response to selection for quantitative traits is directly proportional to the function of its heritability, genetic advance and its genotypic variance. Heritability enables the plant breeder to recognize the genetic differences among traits and the genotypic variance reveals the potential for the improvement of a particular trait. The genetic characters showed a wide range of genotypic and phenotypic variance (Table 2). Plant height followed by yield/plant had high genotypic and phenotypic variance when compared with rest of the parameters. These characters were slightly affected by environment which reflect high heritability estimates. It has been suggested that heritability and genetic coefficient proved no indication for the amount of genetic progress that can be achieved through selection (Sivasubramanian & Memon, 1973). Soybean breeders should consider heritability estimates along with genetic advance values because heritability alone is not a good indicator of the amount of usable genetic variability (Masood *et al.*, 1986; Ashraf, *et al.*, 1994). High heritability coupled with high genetic advance was observed for plant height and yield/plant. These characters seem to be controlled by additive gene action and therefore improvement may be expected by directed selection. Khan (1990), Shandhau *et al.*, (1980), Larik & Hafiz (1981), Soomro & Larik (1981) and Larik *et al.*, (1987) have also reported high heritability for these characters indicating importance of additive genetic variation (Khan & Chowdhary, 1975). High heritability coupled with moderate low estimates of genetic advance is probably due to non additive gene (dominance and epistasis) effect (Singh & Choudhry, 1972). It would suggest that the selection based on plant height and yield/plant could be exploited for the improvement of yield in soybean genotypes and significant gain could be achieved through selection in early generation.

Simple Correlation and Regression: The data regarding association of seed yield with its qunatitative and qualitative characters (Table 3) showed that days to flowering had positive and highly significant correlation with effective pod filling period ($r = 0.790^{**}$).

Table 2. Estimates of genotypic variance (Vg), phenotypic variance (Vph), heritability (h.w), selection index (s) and genetic advance (GA) in *Glycine max* (L.) Merrill.

Traits	Genotypic Variance (Vg)	Phenotyic Variance (Vph)	Heritability broad sense (h.w)	Selection index (s)	Genetic advance (GA)
Days to flowering	6.990	7.194	0.972	14.820	14.405
Days to maturity	0.462	0.692	0.668	1.426	1.424
Plant height (cm)	2078.866	2079.267	0.999	2077.188	2075.111
# of branches per plant	2.754	2.769	0.995	5.704	5.675
# of nodes per plant.	2.993	3.057	0.979	6.297	6.165
# of pods per plant	40.677	41.013	0.992	84.487	83.811
# of seeds per pod	0.098	0.118	0.831	0.243	0.202
Effective pod filling period	15.609	15.715	0.993	32.373	32.146
Seed index (gm)	5.770	5.805	0.994	11.958	11.886
Seed weight per plant (gm)	86.910	87.213	0.997	179.659	179.120

Plant height displayed positive highly significant relationship with nodes/plant ($r=0.563^{**}$) and pods/plant ($r=0.579^{**}$). However, branches/plant had significant and positive association with nodes /plant ($r=0.563^{**}$), seeds/pod ($r=0.447^{*}$) and seed index ($r=0.615^{**}$). The association of number of nodes/plant was positive and significant with pods/plant ($r=0.639^{**}$) and seeds/pod ($r=0.540^{*}$). A significant and positive relationship was observed between pods/plant and seeds/pod ($r=0.626^{**}$) and seed index ($r=0.449^{**}$). Seeds/pod showed positive and significant association with seed index ($r=0.473^{*}$).

The data (Table 4) further revealed that plant height had positive and significant association with seed yield ($r=0.514^{*}$). The coefficient of determination ($r^2=0.264$) showed that 26.4% variation in yield was accounted for by the variation in plant height. The regression coefficient ($b=0.319$) depicted that for a unit increase in plant height, the corresponding increase in seed yield was 0.32 gm/plant (Fig.1).

Number of branches/ plant exhibited positive and significant association with yield ($r=0.627^{**}$). The coefficient of determination ($r^2=0.393$) indicated that 39.3% variation in yield was accounted for by the variation in branches/ plant. The regression coefficient ($b=1.547$) revealed that for an increase of single branch, the corresponding increase in yield was 1.55 gm/plant (Fig. 1).

Table 3. Matrix of Coefficient of Correlation (r) between seed yield per plant and its quantitative and qualitative characters in *Glycine max* (L.) Merrill.

ASSOCIATION	PARAMETERS									
	Days to flower-ing	Days maturity	Plant height (cm)	# of branches plant	# of seeds/ nodes plant	# of pods/ plant	# of pod	Effective pod period	Seed index (gm)	Seed yield plant (gm)
x1 = Days to flowering.	1.000									
x2 = Days to maturity.	0.394^{NS}	1.000								
x3 = Plant height (cm).	0.352^{NS}	-0.062^{NS}	1.000							
x4 = # branches/ plant.	0.158^{NS}	-0.218^{NS}	-0.354^{NS}	1.000						
x5 = # of nodes/ plant.	0.220^{NS}	-0.146^{NS}	0.563^{**}	0.562^{**}	1.000					
x6 = # of pods/ plant.	0.090^{NS}	-0.383^{NS}	0.579^{**}	0.415^{NS}	0.669^{**}	1.000				
x7 = # of seeds/ pod.	-0.110^{NS}	-0.133^{NS}	-0.350^{NS}	0.447^{*}	0.540^{*}	0.622^{**}	1.000			
x8 = Effective pod filling period.	0.790^{**}	0.397^{NS}	-0.208^{NS}	0.385^{NS}	0.250^{NS}	-0.082^{NS}	-0.102^{NS}	1.000		
x9 = Seed index (gm).	0.336^{NS}	-0.139^{NS}	-0.399^{NS}	0.615^{**}	0.370^{NS}	0.449^{*}	0.473^{*}	0.337^{NS}	1.000	
x10 = Seed yield/ plant (gm).	0.191^{NS}	-0.401^{NS}	-0.514^{*}	0.627^{**}	0.620^{**}	0.841^{**}	0.606^{**}	0.106^{NS}	0.811^{**}	1.000

*Significant at $P < 0.05$ level of probability. **Significant at $P < 0.01$ level of probability. NS Non Significant.

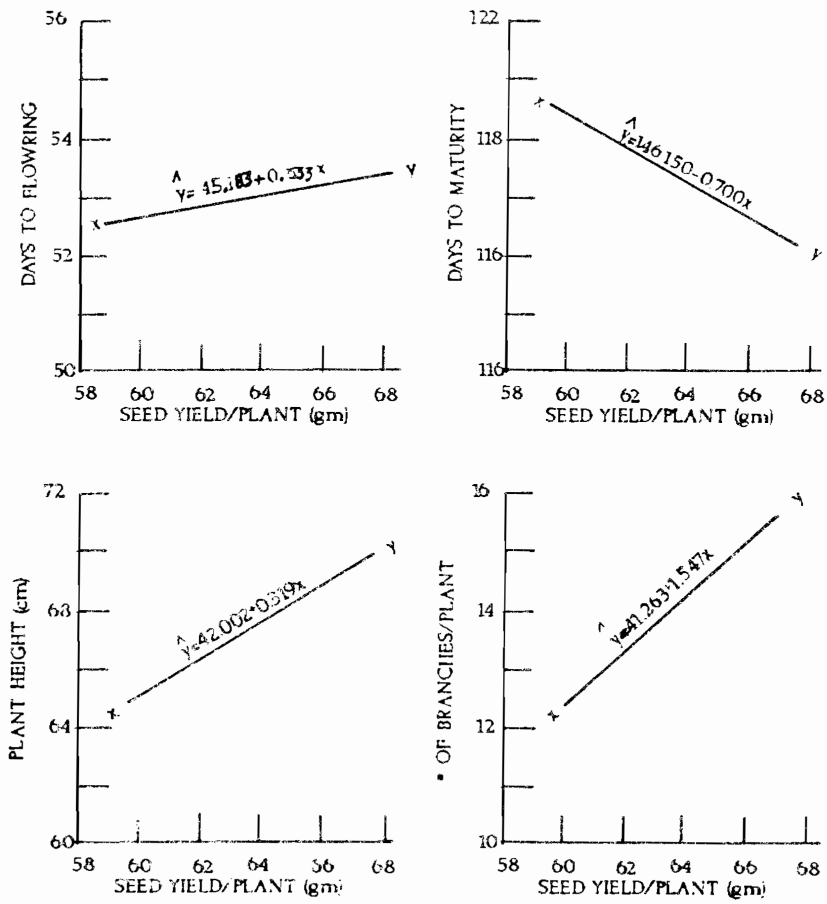

Fig.1. Relationship of seed yield/plant (gm) with days to flowering, days to maturity, plant height (cm) and number of branches/plant in *Glycine max* (L.) Merrill.

It was found that nodes/plant showed positive and highly significant relation with yield ($r=0.620^{**}$).The coefficient of determination ($r^2=0.384$) indicated that 38.4% variation in yield was accounted due to the variation in nodes/plant. For every increase in node/plant, the increase in yield was 0.78 gm/plant (Fig.2).

The correlation of pods/plant with yield was frequent and positive ($r=0.841^{**}$). The coefficient of determination ($r^2=0.708$) indicated that there was 70.8% change in yield due to variation in pod/plant. The regression coefficient ($b=0.595$) displayed that for increase of one pod/plant, corresponding increase in yield was 0.60 gm/plant (Fig.2). Seeds/pod showed positive and highly significant association with yield ($r=0.606^{**}$). The coefficient of determination ($r^2=0.367$) reveals that 36.7% of variation in yield was estimated for by the variation in seeds/pod. The regression coefficient ($b=2.099$) depicted that for an increase of single seed/pod, the increased in seed yield was 2.1 gm/plant (Fig- 2).

Table 4. Estimates of Simple Correlation (r), Coefficient of Determination (r^2), Regression Coefficient (byx), Multiple Correlation (R), Coefficient of Determination (R^2), and Partial Regression (B) for Yield and its Quantitative and Qualitative Characters in *Glycine max* (L.) Merrill.

Characters	Mean X	Correlation Coefficient (r)	Coefficient of determination (r^2)	Regression Coefficient (byx)	Partial Regression Coefficient (B)	't' test	Remarks
x1 = Days to flowering.	53.00	0.191^{NS}	0.037	0.333	0.0002 +0.0020	0.127	NS
x2 = Days to maturity.	119.00	-0.401^{NS}	0.168	-0.700	-0.0020 0.0021	-1.006	NS
x3 = Plant height (cm).	65.45	0.514^{*}	0.264	0.319	-0.0003 0.0004	-0.879	NS
x4 = # branches plant.	13.95	0.627^{**}	0.393	1.547	-0.0015 +0.0024	-0.617	NS
x5 = # of nodes plant.	21.80	0.620^{**}	0.384	0.782	0.0009 +0.0012	0.734	NS
x6 = # of pods/ plant.	53.95	0.841^{**}	0.708	0.595	-0.0020 +0.0035	4.845	**
x7 = # of seeds pod.	2.85	0.606^{**}	0.367	2.099	-0.0003 +0.0028	-0.586	NS
x8 = Effective pod filling period	34.45	0.106^{NS}	0.011	0.263	0.0040 +0.0082	-0.367	NS
x9 = Seed index (gm)	12.75	0.811^{**}	0.658	1.423	0.0096 +0.0017	5.736	*
x10 = Seed yield plant (gm).	62.85	-	-	-	-	-	-

Multiple R = 0.980^{**} Multiple R^2 = 0.961 Estimated Error = 0.459

Y = 55.799 + 0.0002 x1 - 0.0020 x2 - 0.0003 x3 + 0.0015 x4 + 0.0009 x5 - 0.0020 x6 - 0.0003 x7 + 0.0040 x8 + 0.0096 x9

* & ** Significant at $P < 0.05$ and $P < 0.01$ levels of probability respectively. NS: Non significant.

Highly significant and positive association ($r = 0.811^{**}$) was found between seed index and yield. The coefficient of determination ($r^2 = 0.658$) explains that 65.8% variation in yield was estimated for by the variation in seed index. The regression line plotted (Fig.3) illustrated that for a unit increase in seed index it would improve seed yield by 1.423 gm/plant.

The present results of simple correlation are in line with the findings of Ansari *et al.*, (1992), Gautam & Singh (1977);Shetter *et al.*, (1978), Rajpur *et al.*, (1983) Hussain *et al.*, (1991) and Din *et al.*, (1992). The low phenotypic correlation could result

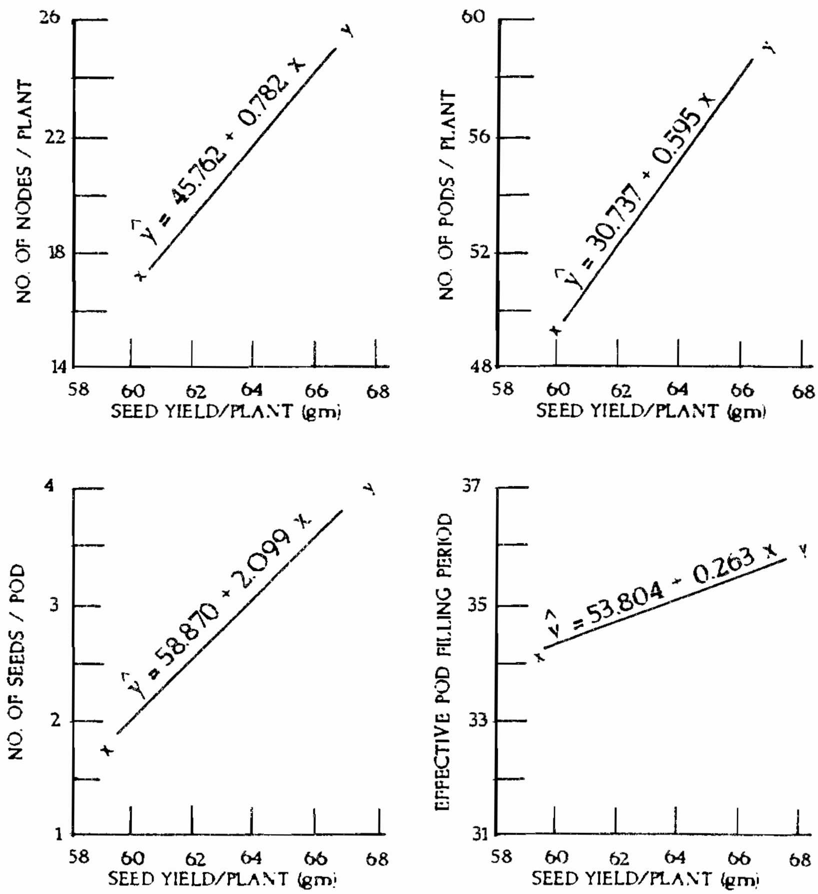

Fig.2. Relationship of seed yield/plant (gm) with Number of nodes/plant, Number of pods/plant and Number of seeds/pod in *Glycine max* (L.) Merrill.

from the masking and modifying influence of environment on the association of character at the genic level.

Multiple Correlation and Partial Regression: Detailed information on the effectiveness of various quantitative traits and their contribution towards yield was worked out by multiple correlation and partial regression (Table 4-5). This was accomplished by assessing the cumulative effect of yield components on yield, taking seed yield as dependent character and other parameters as independent variables. The multiple correlation of all yield parameters tested with yield was positive and highly significant (R=0.980). Ansari *et al.*, (1992), Rajpur *et al.*, (1983), Juneja & Sharma (1971) and Malhotra *et al.*, (1972) also reported positive and highly significant multiple correlation of yield with pods/plant and seed index.

The significance of partial regression coefficients was tested using F value (Table 5) which depicted that only pods/plant and seed index contributed significantly towards yield/plant, thus reflecting the importance of these variables in yield evalua-

Table 5. Test of Significance for Multiple Regression

Source of Variation	Degrees of Freedom	S. S.	M. S.	Observed F Ratio	Remarks
Regression	9	52.441	5.827	27.63	**
Residual	10	2.109	0.211	-	-
Total:	19	54.550	-	-	-

** Significant at $P < 0.01$ level of probability

tion, while the other 7 traits did not contribute significantly towards yield (Table 4). The regression analysis yielded an ultimate regression equation which accounted for 96.1% of the variation in the yield if selection index was based on pods/plant and seed index, respectively.

Path Coefficient Analysis: The data pertaining to direct and indirect influence of various qauntitative traits on seed yield (Table 6) depicted that days to flowering had positive direct effect on yield (0.0183). There was positive indirect effect via plant height (0.0139), nodes/plant (0.0051), number of pods/plant (0.0800), seeds/pod (0.0006) and seed index (0.0263). Days to maturity displayed negative direct effect on yield (-0.2900). There was negative indirect effect via branches/plant (-0.0108) and effective pod filling period (-0.6040). Plant height exhibited positive direct effect on yield (0.1946) The positive indirect effect was via days to flowering (0.1320), branches/plant (0.0252), nodes/plant (0.0072), pods/plant (0.1240) and seeds/pod (0.0051). It was noted that branches/plant had negative direct effect on yield (-0.0309). The negative indirect influence via days to maturity (-0.0200) and effective pod filling period (-0.0500). However, nodes/plant displayed positive direct impact on yield (0.0051). There was positive indirect effect via plant height (0.300), branches/plant (0.3229), pods/plant (0.0001), effective pod filling period (0.0102) and seed index (0.0111). It was observed that pods/plant depicted positive direct effect on yield (0.3603). The positive indirect effect was via days to flowering (0.0230), plant height (0.0201), branches/plant (0.1631), nodes /plant (0.1011), effective pod filling period (0.2752), and seed index (0.1120). Number of seed/pod showed positive direct effect on yield (0.0006) and positive indirect effect via days to maturity (0.0011), plant height (0.0041), branches/plant (0.0010), node/plant (0.2039), pods/plant (0.2020), effective pod filling period (0.0024) and seed index (0.2011). It was further found that effective pod filling period had negative direct influence on yield (-0.1040). The negative indirect effect was via days to flowering (0.1032), and days to maturity (-0.1021), respectively. Seed index had positive direct effect on yield (0.1767). The positive indirect effect was via days to flowering (0.0048), plant height (0.2150), branches/plant (0.1218), pods/plant (0.1249), seeds /pod (0.3211), and effective pod filling period (0.1142),

Table 6. Direct and indirect effect of quantitative and qualitative traits on yield in *Glycine max* (L.) Merrill.

Traits	Days to flowering	Days to maturity	Plant height (cm)	# of branches/ plant	# of nodes/ plant	# of pods/ plant	# of seeds/ pod	Effective filling period	index (gm)	Seed Coefficient (r)	Correlation
x1 = Days to flowering	0.0183	-0.0199	0.0139	-0.0808	0.0051	0.0800	0.0006	-0.0120	0.0263	0.191^{NS}
x2 = Days to maturity.	0.0793	-0.2900	0.0945	-0.0108	0.0091	0.1600	0.0046	-0.6040	0.1562	-0.401^{**}
x3 = Plant height (cm)	0.1320	-0.2100	0.1946	0.0252	0.0072	0.1240	0.0051	-0.0200	-0.2560	0.514^{**}
x4 = # branches/ plant.	0.0660	-0.0200	0.2180	-0.0309	0.3021	0.0053	0.0150	-0.0500	0.1220	0.627^{**}
x5 = # of nodes/ plant	-0.0030	-0.0230	0.3000	0.3229	0.0051	0.0001	-0.0023	0.0102	0.0111	0.620^{**}
x6 = # of pods/ plant.	0.0230	-0.2140	0.0201	0.1631	0.1011	0.3603	-0.0011	0.2752	0.1120	0.841^{**}
x7 = # of seeds/ pod.	-0.0102	0.0011	0.0041	0.0010	0.2039	0.2020	0.0006	0.0024	0.2011	0.606^{**}
x8 = Effective pod filling period	-0.1032	-0.1021	0.0250	0.1401	0.1356	0.0012	0.1131	-0.1040	0.0010	0.106^{NS}
x9 = Seed index (gm)	0.0048	-0.2361	0.2150	0.1218	0.1249	0.3211	-0.0310	0.1142	0.1767	0.811^{**}

Residual effect (P x Y) = 0.4320

*Values are in bold letter indicating direct effect.

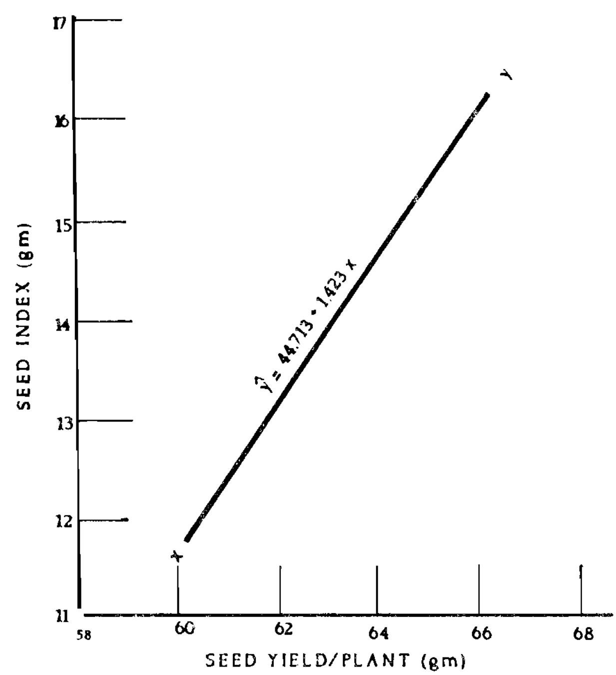

Fig.3. Relationship of seed yield/plant (gm) with seed index (gm) in *Gycine max* (L.) Merrill.

respectively. These results demonstrated that pods /plant, plant height and seed index had high positive direct effect on yield, while days to maturity showed high negative direct effect on yield. Patel & Pokle (1976), Srivastava, *et al.*, (1976) and Ansari *et al.*, (1992) also found that number of pods/plant, plant height and seed index have high positive direct effect on yield while maturity days had high negative direct effect on yield in soybean. Gautam & Singh (1978); Rajpur *et al.*, (1982) & Patirana et al., (1979) have also supported these findings.

On the basis of present investigation, it may be argued that number of pods/plant and seed index are the important yield components. These characters may therefore be used in future selection programme of soybean crop.

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