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Genetic Variability of the Main Yield Related Characters in Soybean

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ABSTRACT

Information on yield correlations is derived from data on 16 yield-related traits in twenty-five genotypes of soybean. Analysis of variance, heritability, correlation coefficient and path analysis were carried out for the data recorded for various agronomic and yield traits and oil and protein content. Results revealed that there were highly significant differences among genotypes for all the characters. High heritability was recorded in 100-grain weight, days to maturity, days to flowering completion, days to pod initiation, leaf area, days to 50% flowering, oil contents, no. of shattered pods per plants, grain yield per plant, plant height and protein contents, respectively indicating the additive type of gene action. Correlation coefficient of yield was significant and positive with number of pods per plant. Increase in this trait will ultimately increase the grain yield. Path coefficient analysis revealed that days to pod initiation had maximum direct contribution to yield followed.

Key Words: *Glycine max* (L.); Genetic variation; Correlation; Agronomic traits

INTRODUCTION

In Pakistan, soybean is one of the non-conventional oilseed crops and can be successfully grown during both spring and autumn seasons. Nutritional value of soybean lies in its protein (40 - 42%) and oil contents (18 - 22%) and is free from cholesterol making it highly desirable in the human diet.

The profitable yields can be obtained through genetic improvement for high yield potential. The examination of genetic diversity is important for plant breeder in general and particularly in a newly introduced crop like soybean, which is not grown commercially in Pakistan. Introgression of diverse germplasm into the current soybean genetic base may increase genetic variability and lead to greater gains from selection (Thompson & Nelson, 1998). Annual wild soybeans (*Glycine soja*), the ancestors of cultivated soybeans (*G. max*), are important sources of major genes for resistance to pests, diseases and environmental stresses. The study of their genetic diversity is invaluable for efficient utilization, conservation and management of germplasm collections (Dong *et al.*, 2001). Genetic improvements could be accelerated if physiological attributes were used as selection criteria. Present work aims at studying the soybean germplasm for its genetic variability and to evaluate the performance of different genotypes. This information would ultimately lead to the determination of suitable plant types available for further studies in soybean.

MATERIALS AND METHODS

The research work was carried out during summer season (July-October, 2002) at experimental farm of Oilseed Programme, NARC, Islamabad. This center is situated at 33º42 latitude and 73º08 longitude at an altitude of 540 m above sea level (masl). Experimental material consisting of twenty-five soybean genotypes (Table I) was obtained from the Institute of Agro-Biotechnology and Genetic Resources (IABGR) of National Agricultural Research Center (NARC), Islamabad. The experimental design was randomized completely block design with 3 replications; each plot consisted of a single row of 5 m length with a row to row distance of 60 cm maintaining 20 - 24 plants m^{-1} in length. The crop was grown under normal conditions. Sowing was done with the help of hand drill. Five selected plants were used to take the data from each plot of each replication. Data were recorded for leaf area, chlorophyll content, 1st pod height, days to 50% flowering, days to flowering completion, days to pod initiation, days to 50% maturity, plant height, number of pods per plant, number of branches per plant, number of un-filled pods, number of shattered pods, 100-seed weight, grain yield, oil content and protein content. Data collected were analyzed statistically using least significant difference test at 5% probability level and was used to compare the difference among the genotype means (Steel & Torrie, 1984). Heritability estimates were obtained using the formula given by Allard (1960). Phenotypic, genotypic and environmental correlation coefficients were computed using the formulae as reported by Snedecor (1956). Path coefficients were worked out by the method used by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The mean squares of various traits (Table I) indicated that there were significant differences among genotypes for

Table I. Means of 16 characters studied in 25 lines of soybean grown during July-Oct. 2001

Genotype	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
95011	62	42.53	7.67	54	70	62	100	76.47	99	7	4	1	6.83	7.24	14.64	35.1
95013	33.33	40.6	7.87	53	69	61	100	58.2	97	7	6	1	4.47	9.55	15.78	37.4
95014	68.33	49.4	13.67	56	72	64	103	72.87	83	6	4	1	8.53	11.08	16.5	35.67
95015	28	41.57	9.53	54	70	62	102	62.27	181	11	13	5	4.27	16.17	15.79	37.3
95019	31.67	40.8	8.93	49	65	57	99	58.07	103	9	4	4	6.17	10.34	15.54	35
95020	50.67	47.4	8.13	56	72	64	109	62.8	89	6	4	1	6.13	6.69	15.4	36.5
95026	45.67	47.9	9.07	53	69	61	101	77.47	131	6	3	2	6.77	15.86	17.18	34.07
95027	62.33	43.93	9.8	55	71	63	100	56.93	92	7	6	1	5.03	7.31	15.62	36.1
95030-A	34.67	44.23	7.33	53	69	61	91	57.6	159	10	12	2	4.47	13.94	15.88	33.27
95030-B	36.33	43.5	11.4	49	65	57	94	90.27	174	8	5	9	4.93	17.67	15.26	37.07
95012-A	34	38.57	8.4	53	69	61	104	80.8	127	6	6	2	4.07	9.24	13.85	36.47
95012-B	57	45.2	10.27	55	71	63	91	74.53	125	6	7	2	5.73	10.71	15.56	35.97
95022-A	36.67	41.97	9.27	51	67	59	100	62.8	93	7	2	2	3.87	10.51	15.81	35.83
95022-B	34	39.83	7.13	50	66	58	99	63.8	104	7	4	3	5.37	10.92	16.09	36.5
95023-A	32.33	41.17	9.53	49	65	57	98	59.07	111	8	3	2	5.37	12.47	15.68	36.17
95023-B	38.67	46.03	12.07	52	68	60	97	54.07	168	11	8	5	4.47	9.53	14.7	38.33
95023-C	33	42.4	8.47	49	65	57	98	55.47	131	8	4	4	5.03	11.21	15.75	35.3
95024-A	40.33	39.3	8.53	51	67	59	98	47.67	163	8	5	4	5.17	12.41	15.49	37.23
95024-B	49.67	48.5	8.93	52	68	60	99	61.8	93	5	3	1	5.83	8.67	16.24	34.33
95024-C	42	45.47	7.33	49	65	57	97	57.47	152	8	4	2	5.07	17.11	15.27	38.13
95024-D	57.67	48.8	9.13	53	69	61	107	57	108	7	6	3	5.63	7.52	15.6	35.43
95025-A	30	40.13	7.4	53	69	61	98	59.2	144	6	4	3	4.27	11.19	15.94	37.3
95025-B	98.33	47.2	13.6	50	56	64	105	62.67	76	4	5	1	13.5	14.4	19.44	39
95029-A	33	39.2	7.2	53	69	61	100	62.67	176	7	8	1	4.77	12.44	15.51	32.03
95029-B	68.67	47.87	10.73	54	70	62	105	62.87	83	4	3	1	8.93	11.53	17.02	35.23
MS(VAR)	841.33	35.29	10.24	15.40	32.43	16.26	55.54	281.26	3366.06	8.97	21.60	9.21	12.49	28.29	3.11	7.60
MS(REP)	9.06	24.21	0.41	31.83	4.31	1.40	204.75	44.94	37.52	0.17	1.00	6.41	2.34	18.54	0.17	0.07
MS(ERROR)	23.05	9.70	2.38	0.41	0.38	0.39	0.32	34.11	481.51	1.35	2.92	1.30	0.00	4.34	0.39	0.63
F.RATIO(V)	36.5 **	3.64 **	4.3 **	37.90 **	86.29 **	42.02 **	175.76 **	8.25 **	6.99 **	6.63 **	7.41 **	7.07 **	3343.98 **	6.52 **	8.07 **	12.13 **
F.RATIO(R)	.393 ns	2.5 ns	.17 ns	78.35 **	11.47 **	3.63 *	648.002 **	1.32 ns	.08 ns	.13 ns	.34 ns	4.93 *	626.48 **	4.28 *	.43 ns	.10 ns
ST.ERROR	2.77	1.80	0.89	0.37	0.35	0.36	0.33	3.37	12.67	0.67	0.99	0.66	0.04	1.20	0.36	0.46
CD1	7.84	5.09	2.52	1.04	1.00	1.02	0.92	9.54	35.83	1.90	2.79	1.86	0.10	3.40	1.01	1.29
CD2	10.43	6.76	3.35	1.38	1.33	1.35	1.22	12.68	47.66	2.53	3.71	2.48	0.13	4.52	1.35	1.72
G.VAR.	272.76	8.53	2.62	5.00	10.68	5.29	18.41	82.38	961.52	2.54	6.23	2.64	4.16	7.99	0.91	2.32
P.VAR	295.81	18.23	5.00	5.40	11.06	5.68	18.72	116.49	1443.02	3.89	9.15	3.94	4.17	12.32	1.29	2.95
GCOV	36.27	6.68	17.48	4.28	4.82	3.80	4.29	14.23	25.31	22.34	45.88	63.09	35.26	24.72	6.03	4.23
PCOV	37.77	9.76	24.16	4.45	4.90	3.94	4.33	16.92	31.01	27.66	55.59	77.11	35.28	30.71	7.19	4.77
COH	0.92	0.47	0.52	0.93	0.97	0.93	0.98	0.71	0.67	0.65	0.68	0.67	1.00	0.65	0.70	0.79
GA	11.69	3.02	5.30	4.03	4.41	3.82	4.22	6.00	7.65	7.07	10.47	12.12	12.24	7.41	3.88	3.55

X1= Leaf Area (cm^2), X2= Chlorophyll Content, X3= 1st Pod Height (cm), X4= Days to 50% Flowering, X5= Days to Flowering Completion, X6= Days to Pod Initiation, X7= Days to Maturity, X8= Plant Height (cm), X9= No. of Pods/Plant, X10= No. of Branches/Plant, X11= No. of Unfilled Pods/Plant, X12= No. of Shattered Pods/Plant, X13= 100-Seed Weight (g),X14= Grain Yield/Plant (g), X15=Oil Content (%), X16= Protein Content (%).

all the characters under study. Maximum leaf area was found in genotype 95025-B (98.33 cm^2). First pod height ranged from 13.67 cm (95014) to 7.13 cm (95022-B). The results are in line with the findings of Joseph *et al.* (1983), who recorded a range of 17.3 - 6.4 cm for 1st pod height in different genotypes of soybean. The range of 49 - 56 days was recorded for days to 50% flowering. Results are contradictory to the findings of Dadson (1976), who evaluated different cultivars of soybean and revealed that most cultivars flowered at the optimum date, between 30 - 35 days after sowing. The difference in the results might be due to the difference in genetic constitution of breeding material and environmental condition. The range for days to 50% maturity was between 91 and 109 days. The results are well supported by the findings of Ghatge and Kadu (1993) and Whigham (1975).

Maximum plant height (90.27 cm) was observed in genotypes 95030-B, while minimum (47.67 cm) was recorded in genotypes 95024-A. These results are confirmed with the findings of Ghatge and Kadu (1993) and Rasaily *et al.* (1986), who reported high variability in plant height. Whigham (1975) recorded plant height in the range of 22 - 93 cm. Pods per plant showed highly significant differences among treatments. These results are in agreement with Rasaily *et al.* (1986), who obtained considerable genotypic variability for number of pods per plant.

The range of 4 - 11 was observed in genotypes for no. of branches per plant. Rasaily *et al.* (1986) reported similar results and obtained considerable genotypic variability for numbers of branches. Highly significant differences were observed among genotypes for number of un-filled pods per plant and number of shattered pods. Data regarding 100-grain weight showed a range of 3.87 g to 13.5 g among treatments. The results are somewhat contradictory to the findings of Maestri *et al.* (1998), who conducted trials to compare different genotypes of soybean and reported that seed size varied between 13.9 - 21.0 g 100^{-1} seeds. The results are different, because of the type of genotypes, which produced lighter seeds. These lines of low 100-seed weight may be used as fodder purpose or in breeding program to improve this character. Highest yield of 17.67 g $plant^{-1}$ was obtained in 95030-B. The results are supported with the findings of Rasaily *et al.* (1986), who performed experiments and obtained considerable genotypic variability for seed yield. Funnah and Mak (1978) also conducted field trials and found that some varieties yielded over 2000 kg ha^{-1}.

Dadson (1976) also evaluated different cultivars of soybean and revealed highest seed yields of 2.0 - 2.46, 1.18 - 1.88, 1.29 - 1.59 and 1.21 - 1.24 t ha^{-1} were given by cultivars Davis, Hardee, Improved Pelican and Williams, respectively. Ghatge and Kadu (1993) found the similar results and observed high variability for seed yield.

A range of 19.44% (95025-B) to 13.85% (95012) was recorded for oil content. Similar results were reported by Dadson (1976) and Maestri *et al.* (1998). Analysis of variance for protein content revealed that treatments were statistically highly significant. Rao *et al.* (1998) evaluated the performance of twelve soybean genotypes and determined their seed protein composition. Similar results were also found by Dadson (1976) and Maestri *et al.* (1998).

The partitioning of variance (Table I) revealed that high heritability was recorded in 100-grain weight, days to maturity, days to flowering completion, days to pod initiation, leaf area, days to 50% flowering, oil contents, plant height and protein contents, respectively indicating the additive type of gene action. Moderate heritability (0.67, 0.65, 0.68, 0.67 & 0.65) was noted for pods per plant, branches per plant, un-filled pods per plant, shattered pods per plant and grain yield per plant. On the basis of heritability, selection for 100-grain weight, grain yield per plant, days to maturity, days to flowering completion, days to pod initiation, leaf area, days to 50% flowering, oil contents, plant height and protein contents will provide the greatest improvement in soybean.

These results are comparable to the results reported by various scientists including Jain and Ramgiry (2000), Jagtap and Mehetre (1994), Ghatge and Kadu (1993), Rasaily *et al.* (1986), Zhu (1992) and Rao *et al.* (1998).

The results regarding genotypic, phenotypic and environmental coefficients of correlation given in Table II showed that the grain yield was positively and significantly correlated with number of pods per plant. Positive association of yield with this character illustrated that selecting for an increased number of pods per plant can

Table II. Genotypic, phenotypic and environmental correlation coefficients among 16 characters studied in 25 genotypes of soybean grown

Variables		X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
X2	rG	.711 **														
	rP	.6101 **														
	rE	.7025 **														
X3	rG	.7051 **	.6714 **													
	rP	.496 *	.3984 *													
	rE	0.032	0.131													
X4	rG	0.278	0.367	0.086												
	rP	0.263	0.249	0.079												
	rE	0.075	0.038	0.103												
X5	rG	-0.198	0.109	-0.269	.8251 **											
	rP	-0.184	0.074	-0.175	.8285 **											
	rE	0.047	0.009	0.132	.9628 **											
X6	rG	.6454 **	.4958 *	.3971 *	.8382 **	0.382										
	rP	.6026 **	0.333	0.298	.8484 **	.4095 *										
	rE	0.060	0.028	0.113	.9815 **	.984 **										
X7	rG	.4175 *	0.338	0.186	0.281	0.039	.4211 *									
	rP	.3985 *	0.232	0.134	0.276	0.044	.4103 *									
	rE	0.028	0.031	0.003	0.214	0.254	0.212									
X8	rG	0.131	0.167	0.225	0.220	0.165	0.199	-0.036								
	rP	0.114	0.018	0.227	0.199	0.153	0.184	-0.042								
	rE	0.055	-0.199	0.240	0.141	0.173	0.159	-0.173								
X9	rG	-.6605 **	-.4809 *	-0.265	-0.165	0.073	-0.335	-.5395 **	-0.043							
	rP	-.513 **	-0.255	-0.203	-0.128	0.055	-0.267	-.452 *	0.039							
	rE	0.029	0.033	-0.116	0.009	-0.032	-0.020	-0.204	0.219							
X10	rG	-.7315 **	-.4801 *	-0.242	-0.234	0.106	-.4803 *	-.4733 *	-0.309	.6941 **						
	rP	-.5581 **	-0.229	-0.154	-0.178	0.084	-0.374	-0.392	-0.196	.5869 **						
	rE	0.056	0.085	-0.030	0.022	0.003	0.001	-0.163	0.042	0.380						
X11	rG	-0.254	-0.206	0.002	0.311	0.234	0.280	-0.253	-0.185	.6652 **	.6771 **					
	rP	-0.204	-0.113	-0.110	0.278	0.213	0.257	-0.208	-0.104	.5179 **	.547 **					
	rE	-0.018	0.009	-0.284	0.205	0.223	0.226	-0.017	0.078	0.214	0.287					
X12	rG	-.4402 *	-0.222	0.223	-.4297 *	-0.176	-.5319 **	-.4131 *	0.211	.6765 **	.6222 **	0.251				
	rP	-0.354	-0.115	0.127	-0.331	-0.137	-.4116 *	-0.340	0.106	.5029 *	.4505 *	0.160				
	rE	-0.050	0.021	-0.012	0.042	0.050	0.056	-0.069	-0.127	0.154	0.116	-0.029				
X13	rG	.8838 **	.6235 **	.7003 **	0.026	-.4419 *	.4678 *	.4236 *	0.124	-.5859 **	-.6627 **	-0.305	-0.339			
	rP	.8473 **	.4244 *	.505 **	0.025	-.4338 *	.4516 *	.4217 *	0.102	-.4804 *	-.5357 **	-0.255	-0.278			
	rE	-0.113	-0.090	-0.071	0.016	0.071	0.025	.4784 *	-0.098	-0.139	-0.042	-0.202	-0.022			
X14	rG	-0.173	-0.011	0.177	-.4233 *	-.4147 *	-0.285	-0.388	0.192	.5433 **	0.199	0.225	.4483 *	0.096		
	rP	-0.148	-0.083	0.092	-0.321	-0.330	-0.222	-0.321	0.217	.5728 **	0.240	0.202	0.332	0.073		
	rE	-0.089	-0.177	-0.028	0.041	-0.014	0.000	-0.148	0.272	.6298 **	0.317	0.156	0.109	-0.212		
X15	rG	.6643 **	.5735 **	.5562 **	-0.091	-.5207 **	0.359	0.257	-0.117	-.4863 *	-.6284 **	-0.196	-0.297	.8517 **	0.321	
	rP	.5351 **	0.295	0.339	-0.062	-.4281 *	0.294	0.208	-0.058	-0.270	-0.374	-0.171	-0.246	.7126 **	0.304	
	rE	0.004	-0.084	0.004	0.073	0.007	0.028	-0.084	0.085	0.198	0.158	-0.114	-0.136	-0.040	0.270	
X16	rG	0.162	-0.040	.4255 *	-0.291	-.4393 *	-0.057	0.098	-0.144	0.002	0.052	-0.076	0.341	0.160	0.196	0.170
	rP	0.140	-0.006	0.268	-0.264	-0.385	-0.058	0.093	-0.064	-0.028	0.012	-0.032	0.255	0.146	0.060	-0.046
	rE	0.011	0.055	-0.018	-0.118	-0.024	-0.080	0.106	0.176	-0.112	-0.092	0.091	0.029	0.273	-0.296	-.685 **

Table III. Direct (Bold) and Indirect Effects of 15 characters (Independent variables) on Grain Yield (Dependent Variable) in 25 lines of soybean

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15
X1	**-1.905**	0.961	-1.369	-0.841	0.092	4.064	-0.376	-0.116	-0.042	-0.657	0.540	-1.060	1.306	-0.694	-0.076
X2	-1.355	**1.352**	-1.303	-1.108	-0.051	3.123	-0.304	-0.148	-0.031	-0.431	0.439	-0.535	0.921	-0.600	0.019
X3	-1.343	0.908	**-1.941**	-0.259	0.126	2.501	-0.167	-0.199	-0.017	-0.218	-0.004	0.537	1.035	-0.581	-0.199
X4	-0.530	0.496	-0.166	**-3.022**	-0.385	5.279	-0.253	-0.195	-0.011	-0.210	-0.661	-1.035	0.038	0.095	0.137
X5	0.377	0.147	0.523	-2.493	**-0.466**	2.404	-0.035	-0.145	0.005	0.095	-0.497	-0.425	-0.653	0.544	0.206
X6	-1.230	0.670	-0.771	-2.533	-0.178	**6.297**	-0.379	-0.175	-0.021	-0.431	-0.596	-1.281	0.691	-0.375	0.027
X7	-0.796	0.457	-0.361	-0.850	-0.018	2.652	**-0.900**	0.032	-0.034	-0.425	0.538	-0.995	0.626	-0.269	-0.046
X8	-0.250	0.226	-0.437	-0.666	-0.077	1.251	0.032	**-0.883**	-0.003	-0.277	0.393	0.509	0.183	0.123	0.067
X9	1.258	-0.650	0.515	0.497	-0.034	-2.109	0.485	0.038	**0.064**	0.623	-1.415	1.629	-0.866	0.508	-0.001
X10	1.394	-0.649	0.471	0.706	-0.049	-3.025	0.426	0.273	0.044	**0.898**	-1.440	1.498	-0.979	0.657	-0.025
X11	0.484	-0.279	-0.003	-0.939	-0.109	1.765	0.228	0.163	0.042	0.608	**-2.127**	0.603	-0.451	0.205	0.036
X12	0.839	-0.301	-0.433	1.299	0.082	-3.349	0.372	-0.187	0.043	0.559	-0.533	**2.408**	-0.501	0.310	-0.160
X13	-1.684	0.843	-1.360	-0.078	0.206	2.946	-0.381	-0.109	-0.037	-0.595	0.649	-0.817	**1.478**	-0.890	-0.075
X14	-1.266	0.775	-1.080	0.275	0.243	2.261	-0.232	0.104	-0.031	-0.564	0.417	-0.714	1.258	**-1.045**	-0.080
X15	-0.309	-0.054	-0.826	0.880	0.205	-0.356	-0.088	0.127	0.000	0.047	0.162	0.820	0.236	-0.178	**-0.468**

X1= Leaf Area (cm^2), X2= Chlorophyll Content, X3= 1st Pod Height (cm), X4= Days to 50% Flowering, X5= Days to Flowering Completion, X6= Days to Pod Initiation, X7= Days to Maturity, X8= Plant Height (cm), X9= No. of Pods/Plant, X10= No. of Branches/Plant, X11= No. of Unfilled Pods/Plant, X12= No. of Shattered Pods/Plant, X13= 100-Seed Weight (g), X14= Oil Content (%), X15= Protein Content (%).

increase the yield. The results are in line with those of Manzoor and Kaleri (1971), Khurana and Sandhu (1972), Amaranath *et al.* (1990), Khanghah and Sohani (1999), Chand (1999) and Rajanna *et al.* (2000). It was negatively associated with days to 50% flowering and days to flowering completion. The results are also supported by Jagtap and Choudhary (1993). The results presented in Table III revealed that leaf area, first pod height, days to 50% flowering, days to flowering completion, days to maturity, plant height, oil content and protein content had negative direct effects on yield. This suggested that selection on the basis of these traits might lead to the loss in terms of bean yield. Similar findings were reported by Srinives *et al.* (1986) that direct effect of leaflet index on yield was small and negative. Whereas these are in contradiction to the results of Sharma *et al.* (1983), who reported that days to maturity and days to flowering are contributed most to seed yield. The contradiction in results might be due to the influence of environmental factors. However, chlorophyll content, days to pod initiation, number of branches per plant, number of pods per plant and 100-seed weight exerted positive direct effects. The maximum direct effect was observed for Days to pod initiation (6.297). Days to pod initiation suggested important selection criteria. Harer and Deshmukh (1992), Das *et al.* (1989) and Lin and Nelson (1988) also reported similar type of results.

It was concluded that the germplasm exhibited a wide range of variability for most of the traits. Some genotypes possessed desirable genes for more than one character and hence could be utilized directly or included in hybridization programme for variety development. The accessions 95015, 95019, 95026, 95030-A, 95030-B, 95023-A, 95025-B, 95024-A and 95029-A proved better for yield and yield contributing traits. It is suggested that these lines could be utilized to develop physiologically efficient cultivars with high yield potential.

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