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ASSESSMENT OF GENETIC VARIABILITY, CORRELATION AND PATH ANALYSES FOR YIELD AND ITS COMPONENTS IN SOYBEAN

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Abstract

A study was conducted at the National Agriculture Research Center, Islamabad during summer 2001 on 27 genotypes of soybean to determine the correlation and path analyses of yield and its components. Significant differences among genotypes for characters viz., leaf area, chlorophyll content, first 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 unfilled pods, number of shattered pods, 100-seed weight, grain yield and oil content were observed while protein content was statistically non-significant. Genotypic correlations were higher than the phenotypic and environmental ones for most of the characters exhibiting high degrees of genetic association among traits under consideration. Correlation coefficient for bean yield was positive with leaf area, first pod height, days to flowering, days to maturity, plant height and number of branches per plant. Therefore, increase in these traits will ultimately increase the grain yield. Path coefficient analysis revealed that days to flowering completion had maximum direct contribution to yield followed by days to pod initiation, chlorophyll content, number of pods per plant and plant height. It is suggested that these characters can be considered as selection criteria in improving the bean yield of soybean genotypes.

1introduction

Soybean (*Glycine max* L.) is a legume that grows in tropical, subtropical and temperate climates. Soybean is now cultivated throughout east and South East Asia where people depend on it for food, animal feed and medicine. Soybean is an important source of high quality, inexpensive protein and oil. Soybean has the highest protein content (40 to 42%) of all other food crops and is second only to groundnut in terms of oil content (18 to 22% comprising 85% unsaturated fatty acids and is free from cholesterol) among food legumes, so it is highly desirable in the human diet (Antalina *et al*., 1999). In Pakistan, it is grown on a very small area at present only in NWFP and Sind provinces. Average yield of soybean in the country is low as compared to other soybean growing countries. On an average of 5 years (2001-2005), the yield was only 1178 kg/ha. (Anon., 2004-2005).

Examination of genetic variance is important for plant breeder in general and particularly in a new introduced crop like soybean, which is not grown commercially in Pakistan. New genotypes are an important source to help and meet our national food/oil demand as well as in the development of commercial varieties on the basis of desirable plant traits (Dong *et al*., 2001). Correlation analysis is a handy technique, which provides information about the degree of relationship between important plant traits and is also a good index to predict the yield response in relation to the change of a particular character. However, many workers have expressed apprehension about total reliance on yield components analysis (Hardwick & Andrews, 1980; Arshad *et al*., 2006).

In soybean, grain yield, as in other crops, is a complex character, which is dependent on a number of variables. To increase its yield, the study of direct and indirect effects of yield and its components provide the basis for its successful breeding program and thus increase of bean yield can be more effectively tackled on the basis of performance of yield components and selection for closely associated traits. Path co-efficient analysis measures the direct and indirect effect for one variable upon another and permits the separation of the correlation co-efficient into components of direct and indirect effect (Dewey & Lu, 1959). Present research work is one of such efforts to study the genetic variability and performance in soybean genotypes.

Materials and Methods

The experiment was carried out during July to October 2001 at the experimental farm of Oilseed Programme, National Agriculture Research Center, located at 33^0 $42^/$ N latitude, 73^0 $08^/$ E longitude at an altitude of 518 m above sea level in Islamabad. Experimental material consisting of 27 genotypes were sown in randomized complete block design with three replications; each plot consisted of a single row of 5m long with row to row distance of 60cm maintaining 20 plants per meter. Sowing was done with the help of hand drill. Five random plants were used to take the data viz., leaf area, chlorophyll content, first pod height, plant height, number of pods per plant, number of branches per plant, number of unfilled pods and number of shattered pods from each plot of each replication whereas days to 50% flowering, days to flowering completion, days to pod initiation, days to 50% maturity, 100-seed weight, grain yield, oil content and protein content were recorded on line bases.

The data were analysed for analysis of variances using MSTATC computer software (Steel & Torei, 1980). Co-heritibility estimates in broad sense (h^2) correlation and path analysis were conducted according to method followed by Singh & Chaudhary (1979), Correlation coefficient were calculated as according Al-Jibouri *et al*., (1958), whereas path analysis was conducted according to Dewey & Lu (1959).

Results and Discussions

Considerable genetic variability among 27 soybean genotypes was observed for characters under study. Analysis of variance revealed highly significant differences among genotypes for all the characters under study (Table 1). The highest yield of 39.50 g per plant was obtained in Soy 95-1 that was followed by PR 16 with 36.14 g. The results are supported with the findings of Ghatge & Kadu (1993) and Rasaily *et al*., (1986) who obtained considerable genotypic variability for seed yield. Maximum leaf area was found in EXP-15 and Decade (132 cm^2). The highest amount of chlorophyll content (48.47) was found in Spritto followed by EXP-15 (48.10) and Decade (46.73). The mean value of first pod height was 20.33 cm for genotype M-83-104 to 6.33 cm in Rahim-98. Joseph *et al*., (1983) recorded a range of 6.4 to 17.3 cm for 1st pod height in different genotypes of soybean.

Table 1. Means and analysis of variance for yield and its components of 27 lines of soybean grown during autumn-2001.

Genotype	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
Duiker	89	45.40	17.60	63	79	71	97	71.1	98	7	5	1	14.0	18.75	20.20	40.17
Platte	88	44.87	14.00	48	64	56	99	65.7	90	6	3	2	12.4	18.86	19.66	40.10
Ocepar	90	450	12.13	50	66	58	97	62.5	113	8	5	1	11.8	19.76	19.34	40.10
M-83-104	90	41.20	20.33	48	64	56	98	95.9	127	5	5	1	14.2	34.11	21.00	39.27
NS-82-5250	124	44.93	18.73	58	74	66	96	81.9	116	4	5	1	13.8	31.31	20.95	39.40
EXP-15	132	48.10	15.87	48	57	65	89	88.7	83	3	2	1	16.0	21.81	18.31	39.50
Decade	132	46.73	16.67	50	57	65	98	83.8	122	5	5	1	13.0	25.83	20.47	39.50
Spritto	128	48.47	14.80	50	66	58	102	83.6	83	5	5	1	13.3	18.81	21.68	39.27
Ciangman	119	45.73	13.40	49	65	57	97	83.1	103	3	4	1	18.3	31.24	18.54	40.00
PR-16	114	45.80	12.13	50	66	58	101	66.3	146	6	7	1	15.1	37.03	21.74	38.60
PSC-62	53	40.87	06.80	30	46	38	89	74.4	50	2	1	1	16.0	15.75	20.77	39.63
NARC-7	62	46.03	8.73	31	47	39	92	80.9	70	3	1	2	14.2	23.66	20.82	39.50
Ajmeri	62	46.03	17.00	51	67	59	100	90.1	124	5	2	2	12.8	29.59	20.05	40.30
V-I	60	43.40	14.53	50	66	58	101	76.9	55	4	2	1	13.1	17.21	20.16	39.73
Soy-95-I	53	45.47	14.33	51	67	59	100	84.5	152	8	6	2	14.2	39.50	20.01	40.20
Davis	44	44.10	8.93	31	43	35	85	72.6	52	3	2	1	13.3	16.66	19.85	40.23
NARC-6	51	45.90	13.80	51	67	59	102	66.9	67	5	4	1	14.4	16.51	21.07	39.20
S-69-94	52	43.80	9.93	50	66	58	103	56.3	125	6	7	1	10.0	36.14	20.95	39.83
PSC-56	52	44.13	14.20	50	66	58	100	67.4	66	4	2	1	11.9	12.69	20.71	40.17
S-72-60	26	45.23	8.60	30	46	38	86	53.3	46	5	2	1	13.9	13.32	21.07	40.10
NARC-3	26	44.57	6.80	30	45	37	85	51.7	55	4	1	1	16.3	18.85	21.82	39.20
Cumberland	26	45.87	10.47	31	47	39	89	51.2	51	2	1	2	15.3	13.85	20.53	40.17
NARC-5	44	38.90	9.93	46	62	54	91	69.9	70	3	2	1	14.7	22.96	21.10	39.77
NARC-1	34	38.60	8.87	32	48	40	86	70.9	48	4	1	1	14.9	15.57	21.19	39.67
William-82	31	37.30	10.20	32	48	40	86	68.0	48	3	1	1	15.4	16.47	20.61	39.53
Century-84	42	38.27	12.87	45	61	53	89	73.4	96	4	2	2	10.9	24.73	21.12	40.50
Rahim-98	38	41.63	6.33	43	59	51	87	55.4	68	3	2	2	20.2	23.07	20.71	40.00
MS(Var)	3859	26.6	43.5	280.3	290.6	326.7	117.0	448.8	3199	8.50	10.90	0.60	13.50	183.1	2.20	0.60
MS(reps)	2.20	16.20	4.80	32.00	5.00	4.10	205.7	11.6	4.71	0.01	2.57	0.24	2.31	0.53	0.08	0.14
MS(Error)	8.30	5.50	5.10	3.80	3.20	3.20	0.30	34.3	205.1	0.70	2.20	0.30	0.01	9.97	0.40	0.40
F.Ratio(V)	465.8**	4.9**	8.5**	75.6**	90.3**	101.0**	417.4**	13.1**	15.6**	12.8**	5.1**	1.7*	2548 **	18.4**	6.0**	1.7 ns
G.Var.	1283.66	7.07	12.78	92.21	95.80	107.83	38.91	138.16	997.99	2.62	2.92	0.08	4.51	57.71	0.62	0.08
P.Var.	1291.94	12.52	17.93	95.92	99.02	111.06	39.19	172.50	1203.10	3.29	5.08	0.41	4.51	67.69	0.98	0.43
G.Cov	51.94	6.05	28.56	21.67	16.43	19.68	6.61	16.30	36.70	35.91	55.15	22.28	14.96	33.40	3.82	0.70
P.Cov	52.11	8.05	33.82	22.10	16.70	19.97	6.64	18.22	40.30	40.22	72.72	50.02	14.97	36.18	4.83	1.65
COH	0.99	0.56	0.71	0.96	0.97	0.97	0.99	0.80	0.83	0.80	0.58	0.20	1.00	0.85	0.63	0.18

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 (%).

The range of days to maturity was between 85 and 109 days. The results are well supported by the findings of Ghatge & Kadu (1993) who observed high variability for days to maturity. Maximum plant height (95.9 cm) was observed in M-83-104 followed by Ajmeri (90.1 cm) and EXP-15 (88.7 cm). These results are similar with the findings of Ghatge & Kadu (1993), Arshad *et al*., (2004) and Rasaily *et al*., (1986). Maximum 100-grain weight (20.17 g) was observed in Rahim-98. The results are similar to the findings of Maestri *et al*., (1998). A range of 21.82% (NARC-3) to 13.85% (95012) was recorded for oil content in the genotypes. Maestri *et al*., (1998) also reported similar results. The highest amount of protein content (40.5 %) was found in Century-84. Similar results were found by Maestri *et al*., (1998) and Rao *et al*., (1998).

Correlation coefficient analysis: The results regarding genotypic, phenotypic and environmental coefficients of correlation showed that the genotypic correlations were higher than the phenotypic and environmental ones for most of the characters exhibiting high degrees of genetic association among traits under consideration (Table 2). The environmental correlation coefficients were not very important in most of the cases indicating low environmental influence in the experiment. Chand (1999) performed experiments on different varieties of soybean and revealed that the genotypic correlation coefficients for all characters studied were higher than the phenotypic and environmental correlation coefficients.

Grain yield was positively correlated with first pod height, days to 50% flowering, days to 50% maturity, plant height, number of branches per plant, leaf area and number of pods per plant which illustrated that higher mean values for these traits can increase the bean yield. Positive correlation of bean yield with days to 50% flowering and days to 50% maturity showed that delay in these characters would increase the yield whereas increase in oil content and protein content may lead to decrease in yield due to negative and non-significant correlation of bean yield with 100-seed weight, protein content and oil content. The results are also supported by Jagtap & Choudhary (1993) and Malik *et al*., (2006).

Leaf area showed significant positive correlation with chlorophyll content, 1st pod height, days to 50% flowering, days to flowering completion, plant height, number of pods per plant, days to pod initiation, days to 50% maturity and grain yield. Increase in leaf area produced more number of pods with increased 100-seed weight and grain yield while negative and significant correlation with protein content was observed. This showed that broad leaves genotypes gave low protein content. The association of chlorophyll content was positive and significant with days to 50% maturity, 1st pod height and days to pod initiation. More chlorophyll content leads to increase in plant height, 100-seed weight, grain yield, oil content and delayed maturity.

There was significant positive correlation of days to 50% maturity with number of pods per plant and 100-seed weight. This revealed that late maturity increased the number of pods per plant and 100-seed weight. Chand (1999) also reported that days to 50% maturity was positively associated with number of pods per plant. Rajanna *et al*., (2000) also reported similar results. Plant height was positively and significantly correlated with number of pods per plant. Taller plants are more likely to produce greater number of branches and number of pods per plant. Chand (1999) and Rajanna *et al*., (2000) observed similar results and showed positive and significant correlations of plant height with number of pods and number of branches. Number of pods per plant was positively and significantly correlated with number of branches per plant, whereas number of branches per plant was negatively correlated with 100-seed weight. The 100-seed weight

Table 2. Genotypic, phenotypic and environmental correlation coefficients among for yield and its components of 27 genotypes of soybean grown during autumn-2001.

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
	rG	0.61**														
X2	rP	4.70*														
	rE	0.19														
	rG	0.71**	0.40*													
X3	rP	0.59**	0.27													
	rE	-0.13	0.06													
	rG	0.63**	0.37	0.83**												
X4	rP	0.62**	0.29	0.69**												
	rE	0.12	0.11	0.02												
	rG	0.52**	0.29	0.77**	0.98**											
X5	rP	0.51**	0.21	0.64 **	0.98**											
	rE	0.08	0.01	0.04	0.91**											
	rG	0.70**	0.42*	0.85**	0.98**	0.91**										
X6	rP	0.69**	0.32	0.71**	0.97**	0.92**										
	rE	0.09	0.01	0.03	0.91**	0.99**										
	rG	0.51**	0.51**	0.68**	0.79**	0.80**	0.74**									
X7	rP	0.50**	0.37	0.58 **	0.77**	0.79**	0.73**									
	rE	-0.02	-0.16	0.09	-0.02	-0.01	-0.01									
	rG	0.62**	0.19	0.74**	0.39 *	0.32	0.44*	0.36								
X8	rP	0.55**	0.11	0.60**	0.36	0.30	0.41*	0.31								
	rE	0.08	-0.06	0.14	0.20	0.19	0.19	-0.24								
	rG	0.59**	0.36	0.66**	0.71**	0.68**	0.71**	0.66**	0.45*							
X9	rP	0.54**	0.24	0.51**	0.65**	0.62**	0.64**	0.60**	0.40*							
	rE	0.09	-0.03	0.03	0.25	0.11	0.11	0.12	0.17							

Table 2. (Cont'd.).

	rG	0.29	0.34	0.48*	.6466**	.6671**	0.59**	0.65**	0.06	0.73**						
X10	rP	0.27	0.23	0.34	.5831**	.593 **	0.53**	0.57**	0.08	0.69**						
	rE	0.20	0.01	-0.12	0.19	0.09	0.09	-0.13	0.16	0.52**						
	rG	0.65**	0.49**	0.56**	0.81**	0.79**	0.76**	0.80 **	0.26	0.92 **	0.95**					
X11	rP	0.47 *	0.22	0.40*	0.59**	0.58**	0.56**	0.61**	0.03	0.67**	0.60**					
	rE	-0.36	-0.14	0.12	-0.10	-0.07	-0.07	0.14	-0.49**	0.14	-0.17					
	rG	-0.49**	0.16	-0.23	-0.19	-0.12	-0.23	-0.09	-0.08	0.08	-0.12	-0.58**				
X12	rP	-0.22	0.04	-0.01	-0.08	-0.04	-0.09	-0.02	0.05	0.12	-0.01	-0.14				
	rE	-0.01	-0.02	0.17	0.05	0.10	0.10	0.20	0.19	0.24	0.09	0.10				
	rG	-0.03	-0.06	-0.35	-0.28	-0.28	-0.25	-0.44*	-0.06	-0.28	-0.50**	-0.36	0.14			
X13	rP	-0.03	-0.05	-0.29	-0.28	-0.28	-0.25	-0.44 *	-0.06	-0.26	-0.44 *	-0.27	0.06			
	rE	0.16	0.04	-0.03	-0.06	-0.08	-0.07	0.51 **	-0.27	0.04	-0.08	0.02	0.06			
	rG	0.41*	0.15	0.41 *	0.48*	0.48*	0.47*	0.45*	0.44*	0.90**	0.45*	0.77**	0.25	-0.04		
X14	rP	0.38	0.10	0.30	0.44*	0.43*	0.42*	0.42*	0.38*	0.85**	0.44*	0.50**	0.10	-0.04		
	rE	-0.08	-0.03	-0.08	0.11	-0.05	-0.05	0.16	0.10	0.61**	0.42*	-0.16	0.00	0.10		
	rG	-0.37	-0.35	-0.31	-0.25	-0.15	-0.31	-0.06	-0.37	-0.17	-0.05	0.09	-0.12	-0.12	-0.07	
X15	rP	-0.29	-0.21	-0.20	-0.18	-0.11	-0.24	-0.06	-0.24	-0.06	0.05	-0.01	-0.02	-0.10	0.02	
	rE	0.11	0.01	0.02	0.10	0.10	0.09	-0.20	0.09	0.23	0.31	-0.16	0.04	-0.10	0.31	
	rG	-0.58**	-0.38*	-0.13	0.01	0.05	-0.07	-0.24	-0.20	-0.08	0.15	-0.49**	1.13**	-0.40*	-0.32	-0.49**
X16	rP	-0.25	0.01	-0.01	-0.02	0.00	-0.05	-0.08	-0.09	-0.12	-0.01	-0.09	0.14	-0.16	-0.12	-0.43*
	rE	-0.15	0.21	0.07	-0.12	-0.11	-0.12	0.23	-0.03	-0.23	-0.17	0.11	-0.09	0.13	0.00	-0.49 *

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 (%).

Table 3. Direct (diagonal) and indirect effects of 15 characters (independent variables) on grain yield (dependent variable) of 27 lines of soybean and genotypic correlation of independent variables with grain yield.

Variables	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	rG
X1	**-8.97**	3.37	-2.28	-27.89	17.08	13.62	-3.53	2.36	2.41	-1.60	1.98	1.19	0.11	1.18	1.38	0.41
X2	-5.51	**5.49**	-1.27	-16.30	9.34	8.25	-3.57	0.72	1.49	-1.84	1.49	-0.40	0.24	1.11	0.91	0.15
X3	-6.37	2.17	**-3.21**	-37.04	25.24	16.56	-4.76	2.84	2.68	-2.62	1.72	0.57	1.34	0.96	0.31	0.41
X4	-5.63	2.01	-2.67	**-44.45**	32.00	19.00	-5.49	1.51	2.98	-3.50	2.47	0.47	1.10	0.78	-0.01	0.48
X5	-4.68	1.57	-2.47	-43.43	**32.75**	17.75	-5.59	1.22	2.80	-3.62	2.42	0.30	1.10	0.48	-0.11	0.48
X6	-6.28	2.33	-2.73	-43.42	29.87	**19.46**	-5.16	1.70	2.88	-3.21	2.33	0.57	0.97	0.99	0.17	0.47
X7	-4.55	2.82	-2.19	-35.00	26.27	14.40	**-6.97**	1.39	2.70	-3.52	2.43	0.21	1.71	0.20	0.58	0.45
X8	-5.53	1.03	-2.38	-17.46	10.43	8.62	-2.52	**3.83**	1.85	-0.30	0.79	0.18	0.25	1.18	0.47	0.44
X9	-5.29	2.00	-2.10	-31.51	22.39	13.71	-4.60	1.74	**4.09**	-3.96	2.80	-0.20	1.09	0.54	0.19	0.90
X10	-2.64	1.86	-1.55	-28.74	21.85	11.51	-4.53	0.21	2.99	**-5.42**	2.91	0.29	1.92	0.15	-0.35	0.45
X11	-5.83	2.68	-1.81	-35.89	25.98	14.86	-5.55	0.99	3.75	-5.17	**3.05**	1.43	1.39	-0.30	1.18	0.77
X12	4.36	0.89	0.75	8.60	-4.06	-4.49	0.60	-0.29	0.34	0.63	-1.77	**-2.45**	-0.53	0.39	-2.70	0.25
X13	0.25	-0.34	1.11	12.65	-9.27	-4.85	3.07	-0.25	-1.15	2.69	-1.10	-0.34	**-3.87**	0.38	0.96	-0.05
X14	3.35	-1.93	0.98	10.92	-4.93	-6.12	0.44	-1.43	-0.70	0.26	0.29	0.30	0.47	**-3.16**	1.18	-0.07
X15	5.18	-2.07	0.41	-0.22	1.49	-1.35	1.67	-0.76	-0.32	-0.80	-1.50	-2.76	1.55	1.56	**-2.40**	-0.32

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 (%), rG= Genotypic Correlation Coefficient.

was negatively and significantly correlated with protein content. Oil content was negatively and significantly correlated with protein content. Leffel & Rhodes (1993) also reported that high-protein lines were superior for seed protein concentration; whereas inferior for seed yield and oil concentration.

Path coefficient analysis: results presented in Table 3 revealed that leaf area, first pod height, days to 50% flowering, days to maturity, number of branches per plant, 100-seed weight, 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) and Arshad *et al*., (2006) 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 contributed most to seed yield. The contradiction in results might be due to the influence of environmental factors. However, chlorophyll content, days to flowering completion, days to pod initiation, plant height and number of pods per plant exerted positive direct effects. The maximum direct effect was observed for days to flowering completion (32.75) followed by days to pod initiation (19.46). Days to flowering completion suggested important selection criteria. Harer & Deshmukh (1992), Das *et al*., (1989) and Lin & Nelson (1988) also reported similar type of results and suggested greater emphasis on longer duration during selection**.**

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