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GENETIC VARIABILITY FOR SEEDLING VIGOUR TRAITS AND THEIR ASSOCIATION WITH SEED YIELD AND PROTEIN CONTENT IN SOYBEAN [*GLYCINE MAX* (L.) MERRILL]

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SUMMARY

Seed and seedling characters in 40 genotypes of soybean were studied to estimate the variability, heritability and association between them. Among seedling characters, root length exhibited the highest variability, heritability and genetic advance as % of mean followed by fresh root weight. None of the seedling characters showed significant positive correlation with seed yield and protein content. Path analysis indicated high positive direct effect of total seedling dry weight and total seedling length on seed yield and protein content. These two seedling characters may be used as early indicators in selection programmes in soybean.

Key words : Soybean, seedling vigour, variability, correlation, path analysis, yield and protein

Soybean (*Glycine max* L. Merrill) is one of the most important legume crops and major source of high quality protein for human daily diet and livestock feed in the world (Lie *et al* 2006). It belongs to family Papilionaceae and is believed to be originated in Northeastern China. It is widely distributed in Asia, USA, Brazil and Argentina. This crop is aptly called as "Golden Bean" or "Miracle crop" of the 20th century and is one of the most important oil seed crops in the world (Aduloju *et al* 2009). In addition to its rich protein (35-45%) and oil content (15-25%), soybean seed also contains about 33% carbohydrates, 16.6% of which are soluble sugars (Hou *et al* 2009). Besides being an important source of protein for human diet and animal feed, soybean has been considered to be one of the most promising crops for producing bioenergy (biodiesel) in the near future (Soy Stats 2010). Soybean is a short day plant and majority of its genotypes exhibit both photo and thermo sensitivity. Environmental factors such as day length and temperature affect production potential and quality characters in soybean (Kane *et al* 1997). The performance of genotypes depends upon environment and the effect of interaction between genotype and environment on growth has been established. When genotypes are grown under varying environmental conditions, they are expected to exhibit different magnitude of genetic variability for both agronomic and quality characters. The seeds are endowed with genetical, physiological and biochemical properties and all of which are present in the embryo. The embryo and environments largely decide the characteristics of seedling that later develop into juvenile phases and further into adult phases. In the present investigation, genetic variability and related parameters of seedling characters and their relationships with seed yield and protein content in soybean have been made and the results are discussed.

MATERIALS AND METHODS

Healthy seeds of 40 genotypes of soybean belonging to the different geographical regions and different maturity groups were chosen. Seeds of uniform size were selected and allowed to germinate on moist filter paper in Petridishes separately. In each treatment, 30 seeds were used and arranged in three replications following randomized complete block design experiment and consequently 10 seeds were placed in each replication. On the 5th day after sowing, the germination

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was recorded (normal seedlings) and on the 8th day after sowing, observations were made on 10 seedlings in each replication for shoot length (cm), root length (cm), fresh shoot weight (g), fresh root weight (g), dry shoot weight (g) and dry root weight (g). Seedling vigour index I and II were calculated by using the formula, germination (%) × seedling length and germination (%) × seedling dry weight (g), respectively.

A part of the seed sample were also sown in the field at the same time in a randomized complete block design with three replications during spring and rainy seasons of 2007 and 2008. The data were subjected to statistical analysis. Phenotypic and genotypic correlations were worked out and tested for significance (Johnson *et al.*, 1955). Path coefficient analysis (Dewey and Lu, 1959) was utilized to partition the genotypic correlation coefficients into direct and indirect effects. The genotypic and phenotypic coefficients of variation (GCV and PCV) were worked out according to the method given by Singh and Chaudhary (1977). Heritability in broad sense and expected genetic advance on the basis of per cent of mean at five per cent intensity of selection were worked out according to the method given by Allard (1960).

RESULTS AND DISCUSSION

The mean values, the range of different characters and the estimates of genetic parameters are presented in Table 1. Among the characters studied root length exhibited the highest genotypic and phenotypic coefficients of variance (GCV and PCV) (35.39 and 36.51) followed by root weight (30.51 and 30.60) and dry root weight (28.75 and 29.00). Other characters recorded moderate to low variability. Similar results were obtained by Mehetre *et al*. (1997), and Aditya *et al*. (2011) in soybean, Shanmugam and Sree Rangasamy (1983) in blackgram and Sree Rangasamy and Shanmugam (1984) in green gram. The heritability was observed to be high (79-99%) for all the characters except for shoot length. Higher genetic advance over mean (>25 %) was observed for all the characters except for shoot length, dry shoot weight and dry root weight. The GA as percentage of mean coupled with heritability for a character provides a reliable and meaningful indication for affective utilization in selection programmes (Allard, 1960). All the characters except shoot length, dry shoot weight and dry root weight had high heritability together with high genetic advance, indicating that variability was due to additive gene effects (Panse, 1957). Therefore, simple selection would be effective for improvement of these characters.

The phenotypic, genotypic and environmental correlation coefficients were worked out between pairs of characters and are presented in Table 2. In general, the genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients. This indicates masking effects of environment in modifying total expression of the genotype and hence phenotypic expression was reduced. Among 66 possible combinations, non of the seedling characters showed significant positive association with seed yield and

TABLE 1
Pooled genetic parameters of different seedling characters in soybean

Characters	Mean	Range		GCV	PCV	Heritability (%)	GA as % of mean
		Min.	Max				
Shoot length (cm)	4.27	5.62	5.40	7.61	9.88	59.4	12.17
Root length (cm)	1.95	0.70	3.15	35.39	36.51	93.9	70.62
Total seedling length (cm)	6.22	4.65	8.25	14.52	14.86	95.4	29.25
Shoot weight (g)	0.184	0.12	0.25	17.55	17.79	97.3	37.63
Root weight (g)	0.0194	0.01	0.03	30.51	30.60	99.3	51.54
Dry shoot weight (g)	0.0191	0.01	0.02	7.55	8.48	79.1	5.23
Dry root weight (g)	0.0100	0.01	0.02	28.75	29.00	98.1	10.00
Total seedling dry weight (g)	0.029	0.02	0.04	13.29	13.37	98.8	34.01
Seedling vigour index I	439.790	290.17	751.43	23.18	23.74	95.3	46.60
Seedling vigour index II	2.085	1.42	3.27	19.52	21.92	79.3	35.97
Seed yield (g)	8.876	6.18	12.20	17.42	18.17	92.5	34.58
Protein content (%)	36.47	30.22	45.05	12.65	12.58	99.5	25.80

TABLE 2

Genotypic (G), phenotypic (P) and environmental correlation coefficient among ten seedling characters and two maturity characters in soybean on the basis of pooled analysis

Characters		1	2	3	4	5	6	7	8	9	10	11	12
Shoot length	G	1.00	0.515**	0.751**	0.656**	0.715**	0.807**	0.478**	0.606**	0.645**	0.526**	-0.485**	-0.23
	P	1.00	0.415*	0.567**	0.486**	0.553*	0.575**	0.368*	0.473**	0.493**	0.372*	-0.360*	-0.18
	E	1.00	0.193	0.013	-0.120	0.084	0.075	0.044	0.128	0.051	0.040	-0.004	-0.044
Root length	G		1.00	0.953**	0.612**	0.712**	0.829**	0.981**	0.951**	0.766**	0.743**	0.042	-0.132
	P		1.00	0.900**	0.583**	0.689**	0.731**	0.938**	0.909**	0.721**	0.636**	0.036	-0.127
	E		1.00	-0.040	-0.055	0.032	0.142	-0.109	-0.248	-0.068	0.041	-0.052	0.042
Total seedling length	G			1.00	-0.709**	0.805**	0.930**	0.930**	0.952**	0.817**	0.762**	-0.127	-0.180
	P			1.00	0.682**	0.790**	0.817**	0.909**	0.924**	0.817**	0.662**	-0.119	-0.174
	E			1.00	-0.040	0.309	0.087	0.286	-0.012	0.806	-0.003	0.015	0.078
Fresh shoot weight	G				1.00	0.607**	0.847**	0.688**	0.755**	0.491**	0.482**	-0.189	-0.276
	P				1.00	0.595**	0.744**	0.669**	0.739**	0.471**	0.422**	-0.173	-0.271
	E				1.00	-0.141	0.009	-0.16	-0.039	-0.048	-0.019	0.132	0.059
Fresh root weight	G					1.00	0.937**	0.760**	0.860**	0.534**	0.528**	-0.285	-0.305
	P					1.00	0.833**	0.753**	0.852**	0.524**	0.468**	-0.273	-0.304
	E					1.00	0.054	0.194	-0.052	0.243	-0.017	-0.019	-0.056
Dry shoot weight	G						1.00	0.970**	1.017**	0.693**	0.699**	-0.17	-0.300
	P						1.00	0.857**	0.896**	0.604**	0.551**	-0.144	-0.267
	E						1.00	0.046	-0.065	0.028	-0.012	0.013	-0.005
Dry root weight	G							1.00	0.988**	0.682**	0.678**	0.040	-0.207
	P							1.00	0.974**	0.665**	0.601**	0.038	-0.204
	E							1.00	0.126	0.188	0.059	0.009	-0.035
Total seedling dry weight	G								1.00	0.696**	0.675**	-0.024	-0.238
	P								1.00	0.677**	0.604**	-0.022	-0.237
	E								1.00	0.092	0.127	-0.012	-0.083
Vigour Index-I	G									1.00	0.989**	-0.123	-0.065
	P									1.00	0.862	-0.117	-0.062
	E									1.00	0.020	-0.021	0.080
Vigour Index-II	G										1.00	-0.040	-0.110
	P										1.00	-0.05	-0.099
	E										1.00	-0.085	-0.057
Seed yield	G											1.00	0.034
	P											1.00	0.033
	E											1.00	0.019
Protein Content	G												1.00
	P												1.00
	E												1.00

* : Significant at 0.05 P; ** : Significant at 0.01 P.

TABLE 3
Pooled direct and indirect effects of seedling characters on seed yield in soybean

Characters		1	2	3	4	5	6	7	8	9	10	11	r with seed yield
Shoot length	G	-0.816	-1.546	6.204	0.192	0.683	0.959	4.103	-8.485	4.811	3.094	-0.062	-0.485
	P	-0.643	0.337	0.703	-0.532	1.390	0.633	-2.010	2.905	0.556	0.154	0.039	-0.360
Root length	G	0-420	-3.003	7.872	0.179	0.681	0.985	8.432	-13.313	5.706	4.371	-0.036	0.042
	P	-0.267	0.812	1.116	-0.638	1.730	0.804	-5.120	5.580	0.813	0.263	0.028	0.036
Total seedling length	G	-0.613	-2.861	8.261	0.207	0.770	0.105	7.992	-13.327	6.092	4.480	-0.049	-0.127
	P	-0.365	0.731	1.240	0.746	1.983	0.899	-4.957	5.672	0.921	0.274	0.038	-0.119
Fresh shoot weight	G	-0.535	-1.839	5.856	0.292	0.580	1.006	5.911	-10.563	3.658	2.836	-0.075	-0.189
	P	-0.313	0.474	0.846	-1.094	1.495	0.819	-3.649	4.537	0.531	0.174	0.060	-0.173
Fresh root weight	G	-0.583	-2.138	6.654	0.177	0.956	1.113	6.529	-12.035	3.979	3.106	-0.083	-0.285
	P	-0.356	0.560	0.979	-0.651	2.512	0.917	-4.107	5.227	0.591	0.194	0.067	-0.273
Dry shoot weight	G	-0.659	-2.490	7.684	0.248	0.895	1.188	8.330	-14.234	5.161	4.111	-0.082	-0.170
	P	-0.370	0.594	1.013	-0.814	2.092	1.101	-4.678	5.498	0.682	0.228	0.059	-0.144
Total seedling dry weight	G	-0.390	-2.947	7.685	0.201	0.726	1.152	8.591	-13.823	5.082	3.985	-0.056	0.040
	P	-0.237	0.762	1.127	-0.732	1.891	0.944	-5.456	5.978	0.751	0.249	0.040	0.038
Vigour Index-I	G	-0.495	-2.856	7.866	0.221	0.822	1.209	8.485	-13.996	5.185	3.970	-0.065	-0.024
	P	-0.305	0.739	1.146	-0.809	2.139	0.986	-5.315	6.137	0.764	0.250	0.052	-0.022
Vigour Index-II	G	-0.527	-2.299	6.753	0.143	0.510	0.823	5.862	-9.737	7.452	5.818	-0.018	-0.123
	P	-0.317	0.586	1.013	-0.516	1.315	0.665	-3.630	4.156	1.128	0.356	0.014	-0.117
Seed yield	G	-0.429	-2.231	6.292	0.141	0.505	0.831	5.821	-9.448	7.572	5.872	-3.030	-0.040
	P	-0.240	.0.517	0.821	-0.462	1.176	6.607	-3.280	3.705	0.972	0.413	0.022	-0.045
Protein Content	G	-0.185	0.397	-1.484	-0.081	0.292	-0.357	-1.778	3.330	0.487	-0.646	0.273	0.034
	P	-0.113	-0.103	-0.216	0.297	0.764	-0.294	1.114	-1.451	0.070	-0.041	-0.220	0.033

Residual Effect : 0.409.

TABLE 4
Pooled direct and indirect effects of seedling characters on protein content in soybean

Characters		1	2	3	4	5	6	7	8	9	10	11	r with seed yield
Shoot length	G	27.474	27.170	-65.965	-0.326	-1.685	-1.434	-8.208	22.162	17.959	-11.337	-0.037	-0.270
	P	-0.596	0.449	0.778	-0.449	-1.118	0.665	-1.857	2.108	-0.368	0.072	0.142	-0.176
Root length	G	11.054	52.783	-83.704	-0.304	-1.679	-1.472	-16.867	34.770	21.302	-16.017	0.003	-0.132
	P	-0.247	1.082	1.235	-0.538	-1.392	0.844	-4.730	4.050	-0.540	0.124	-0.014	-0.127
Total seedling length	G	16.127	52.298	87.839	-0.353	-1.899	-1.651	-15.987	34.807	22.742	-16.416	-0.010	-0.180
	P	-0.338	0.974	1.372	-0.629	-1.595	0.943	-4.579	4.116	-0.612	0.129	0.046	-0.174
Fresh shoot weight	G	14.087	32.324	-62.269	-0.498	-1.430	-1.504	-11.825	27.590	13.656	-10.393	-0.015	-0.276
	P	-0.290	0.631	0.936	-0.923	-1.202	0.859	-3.371	3.292	-0.353	0.082	0.067	-0.271
Fresh root weight	G	15.351	37.591	-70.748	-0.302	-2.358	-1.663	-13.062	31.434	14.855	-11.382	-0.022	-0.305
	P	-0.329	0.745	1.083	-0.549	-2.020	0.962	-1.794	3.793	-0.393	0.091	0.106	-0.304
Dry shoot weight	G	17.337	43.766	-81.700	-0.423	-2.203	-1.776	-16.664	37.177	19.268	-15.066	-0.013	-0.300
	P	-0.343	0.791	1.121	-0.686	-1.683	1.155	-4.321	3.990	-0.453	0.107	0.056	-0.264
Total seedling dry weight	G	10.256	51.302	-81.708	-0.342	-1.792	-1.772	-17.186	36.103	18.983	14.604	0.003	-0.207
	P	0.219	1.015	1.247	-0.617	-1.521	0.990	-5.040	4.338	-0.499	0.117	-0.015	-0.204
Vigour Index-I	G	13.019	50.206	-83.639	-0.376	-2.027	-1.806	-16.974	36.555	19.356	-14.550	-0.002	-0.238
	P	-0.282	0.984	1.268	-0.682	-1.721	1.035	-4.910	4.453	-0.508	0.117	0.009	-0.237
Vigour Index-II	G	13.861	40.413	-71.803	-0.244	-1.259	-1.230	-11.727	25.432	27.822	-21.322	-0.010	-0.065
	P	-0.293	0.780	1.121	-0.435	-1.058	0.698	-3.354	3.016	-0.750	0.167	0.046	-0.062
Seed yield	G	11.295	39.223	-66.898	-0.240	-1.245	-1.241	-11.645	24.676	27.522	-21.554	-0.003	-0.110
	P	-0.222	0.689	0.909	-0.389	-0.946	0.637	-3.030	2.688	-0.696	0.194	0.017	-0.099
Protein Content	G	10.405	2.225	11.194	0.094	0.671	0.301	-0.681	-0.874	-3.427	0.860	0.077	-0.034
	P	-0.214	0.039	-0.163	0.160	0.552	-0.166	-0.192	-0.100	0.088	-0.009	-0.389	-0.033

protein content. Similar results were obtained by Mehetre *et al*. (1997), and Aditya *et al*. (2011) in soybean, Shanmugam and Sree Rangasamy (1983) in black gram. But in green gram, Sree Rangasamy and Sahnmugam (1984) reported positive significant association between seed yield and dry root weight. In soybean, usually seed yield and protein content are known to be negatively correlated (Momirovic, 1957). However, in the present study, the inter-correlation between these two traits was positive though non-significant. Hence, a thorough study of linkage between these two traits is required in soybean.

The path coefficients were computed to find out the direct and indirect effects of seedling characters on seed yield and protein content using genotypic and phenotypic correlation coefficients (Table 3). The direct effect of total seedling dry weight and total seedling length on seed yield and protein content though high, got neutralized by its high indirect negative effects through dry root weight, resulting is non-significant association with seed yield and protein content. Shoot length, the only trait which showed highly negative association with seed yield has low negative direct effect. But, its negative influence on seed yield was mainly due to high negative indirect effect through dry root weight. Even all the traits had non-significant association with seed yield and protein content except shoot length with seed yield only, the direct effect only through total seedling dry weight and total seedling length. The residual effect for seed yield and protein content was 40.9 and 72.40 percent respectively, indicating the contribution of seedling characters on final seed yield and protein content was however not substantial. Similar results were reported by Mehetre *et al*. (1997), and Aditya *et al*. (2011) in soybean.

The study indicates that the supremacy in a particular seedling trait need not be carried over upto yield level in soybean. The early vigorous vegetative growth appeared desirable in achieving better establishment and plant stand. But the results do not encourage using the early seedling characters as selection indices for final yield and protein content in soybean. However, fresh shoot weight, root weight and seedling length had high heritability and high genetic advance as % of mean indicating that these characters were under additive gene action and offers scope for lot of improvement. Since, it has significant positive correlation with all the seedling characters as such it can be taken as a better trait for selection.

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