References (cont'd)

Shorter, R., D. E. Byth and Y. E. Mungomery. 1977. Estimates of selection parameters associated with protein and oil content in soybean seed. Aust. J. Agric. Res. 28: 211.

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1) Genetic and altitude effects on seed protein content in soybean.

Summary: Sixty germplasm lines were raised in replicated trial at 700 m above m.s.l. and 1300 m above m.s.l. in the western zone of sub-Himalayan region to understand the genetic and altitude effects on seed protein in soybean. A larger influence of genetic effect was recorded; however, an appreciable influence of altitude, and genotype x altitude interaction effects were also noticed. Expression of protein content was maximum at the lower altitude, as compared with higher altitude. At lower altitude, the range was from 38.28 to 47.25% whereas at higher altitude, it was from 30.40 to 43.31%. EC14451 genotype exhibited high and stable protein content over altitude (43.32%). Various other genotypes also had above-average protein content. On the basis of high heritability (62.7%) recorded in the present study, the expected genetic gain expressed as percent of mean, would be around 14% at 5% selection intensity.

Introduction: Seed protein content in soybeans and other grain legumes depend on its genotypic constitution and environmental factors (Kamal *et al*., 1970; Gupta *et al*., 1974). Due to considerable influence of locations and seasons, genotypic difference among genotypes should not be based on the estimates of one season and one location. Introduction of soybeans is being attempted vigorously in India as a good oilseed and pulse crop. Hilly areas in the country were the first to have taken up its cultivation. Present study was undertaken to assess the genetic variation for protein content in the exotic collections and influence of altitudes and growing season on this character.

Materials and methods: Fifty exotic germplasm lines and ten extensively evaluated varieties of soybean were sown in randomized block design with two replications at Kulu, situated at an altitude of 1300 m on July 12, 1973, with a plot size of 2.7 m^2 and at Kangra situated at an altitude of 700 m on June 18, 1973, with a plot size of 2 m^2. A dose of 20 kg N plus 80 kg P_2O_5 per hectare was applied at the time of sowing to the experimental plots. Crude protein was determined on replication basis according to A.O.A.C. (1960) specification. Appropriate statistical analysis was carried out as per Panse and Sukhatame (1961). Heritability and expected genetic advance were estimated by the formula suggested by Warner (1952) and Johnson et al. (1955).

Results and discussion: Breeders have long been aware of the problem of genotype-environmental interaction which contributes substantially to the non-realization of expected genetic gains from selection for the economic trait under consideration whether it is seed yield or protein content (Comstock and Moll, 1963), but the main difficulty has been in measuring this component of variability. One approach to such measurement which has been used in the present study is to grow a set of genotypes under diversified environments and from a combined analysis of variance of such experiments, extract measures of genotype x environment interaction (Sandison and Bartlett, 1958).

The results obtained in the present study from individual and combined analyses of variance for 60 genotypes evaluated at the different altitudes are given in Table 1. Analysis of variance indicated highly significant differences among the various genotypes studied at both the altitudes (Kulu and Kangra) suggesting the presence of sufficient genetic variation for the protein content. The combined analysis of variance, where total observed variability for the expression of protein content is partitioned into genotypic, altitude, and genotype x altitude interaction components after removing the experimental error component, revealed that mean sum of square (m.s.s.) due to all these three components was highly significant from experimental error component. The m.s.s. due to genotypes was also highly significant from the significantly genotype x altitude interaction m.s.s. This indicated the role of genetic, altitude, and genotype x altitude interaction effects for the expression of protein content in soybean. The magnitude of variances due to genotype (σ^2g), genotype x altitude interaction (σ^2gl), altitudes (σ^2l), and experimental error or variation due to unknown factors (σ^2e) as estimated from the expected m.s.s. as per Panse and Sukhatame (1961), were 12.765, 4.53,

Table 1

Analysis of variances for protein content in soybean

Altitude	Source due to	d.f.	M.s.s.
Kangra 700 m above m.s.l.	Genotypes	59	6.33*
	Error	59	2.25
Kulu 1300 m above m.s.l.	Genotypes	59	18.84*
	Error	59	3.87
Combined over altitudes	Genotypes	59	63.18*
	Altitudes	1	851.84*
	Genotypes x altitude	59	12.12*
	Pooled error	118	3.06

6.997, and 3.06, respectively, and the relative contribution of these components would be 46.67%, 16.56%, 25.58%, and 11.19%, respectively, for the protein content expression. This indicated the larger influence of genetic effects for grain protein in soybean. However, there was an appreciable influence of altitude. Similar results have also been reported by Gupta et al. (1974) in chickpea and Meiyan et al. (1977) in wheat.

In soybean, most of the earlier reports have revealed the larger influence of environments and agro-climatic factors on protein content (Cartter and Hartwig, 1963; Kamel et al., 1970; Kesasvan and Morachan, 1974; Chapman et al., 1976). However, these and some other workers have also reported varietal differences for protein content but they have ignored the effect of experimental error and altitude (Lal et al., 1971; Sood et al., 1977). To quantify whether high expression of protein content is at lower or higher altitude, environmental index (Finlay and Wilkinson, 1963) expressed as deviation of each altitude mean over genotypes from the grand mean over altitudes and genotypes (39.1% $\pm$ 0.22), was estimated for Kulu (-2.7) and Kangra (2.7). This estimate indicated the significant superiority of lower altitude over high altitude for the maximum expression of protein content in soybean.

At lower altitude (Kangra), this might be due to availability of larger green leaf area and high photosynthetic activity due to high rainfall and comparatively high average minimum temperature during vegetative growth and seed developmental phases (Table 2).

Table 2

Average (over past 5-10 years) monthly meteorological observations during growing period of soybeans at lower (700 m above m.s.l.) and higher (1300 m above m.s.l.) altitudes

Meteorological observations	Altitude	Months					
		June	July	Aug.	Sept.	Oct.	Nov.
Average mean temp. (C°)	Low	26.5	25.5	25.0	24.3	21.3	15.4
	High	24.3	23.8	24.0	22.0	19.5	15.4
Average minimum temp. (C°)	Low	17.5	21.3	21.0	18.8	14.2	8.4
	High	18.5	17.7	18.5	15.1	10.6	5.1
Average maximum temp. (C°)	Low	35.5	29.7	29.0	29.7	28.4	23.0
	High	30.1	29.9	29.5	28.9	28.4	25.7
Average rainfall (mm)	Low	136.3	402.3	649.9	141.1	33.5	7.8
	High	25.3	60.1	58.2	19.7	10.4	1.9

From breeding angle, it would be desirable to examine the mean protein content of individual genotypes, at each altitude (Table 3). At Kangra, highest percentage protein content was obtained for IC 13056 (47.25%) which was also highest when averaged over altitude along with EC 14451 (43.31%). At Kangra, other genotypes which had protein content statistically at par with IC 13056 were 'Kandaghat', IC 547, EC 93595, EC 14451, IC 10684, IC 2716 and EC 14424 in order. Genotype EC 93596 gave the lowest protein value (38.28%) at Kangra. At Kulu, highest protein (43.31%) was obtained for the genotype EC 41318 and the lowest (30.40%) was for IC 7217. Other genotypes which had protein content statistically at par with EC 41318 (43.31%) at Kulu, were

Table 3

Mean seed protein % of different genotypes at two locations (Kangra and Kulu)

Sr. No.	Genotype	Kangra	Kulu	Sr. No.	Genotype	Kangra	Kulu
1	IC 326-1	46.37	38.50	31	EC 18226	43.13	34.56
2	IC 547	44.18	37.18	32	EC 18555	41.12	34.56
3	IC 574	41.12	31.93	33	EC 39494	40.90	37.18
4	IC 1619	43.53	37.19	34	EC 41318	43.09	35.43
5	IC 2043	43.09	35.82	35	EC 39483	43.97	37.18
6	IC 2063	43.96	36.53	36	EC 39486	42.65	36.09
7	IC 2241	45.28	36.84	37	EC 50086	40.47	35.65
8	IC 2716	43.53	38.46	38	EC 63298	42.66	39.37
9	IC 7217	42.22	43.31	39	EC 76753	38.93	36.93
10	IC 9452	38.93	33.25	40	EC 76756	42.87	39.81
11	IC 9454	42.87	34.12	41	EC 76758	42.22	37.62
12	IC 9460A	43.74	31.93	42	EC 93595	43.09	39.81
13	IC 10678	40.24	32.81	43	EC 93596	39.59	39.59
14	IC 10684	42.87	34.12	44	EC 93599	40.47	34.78
15	IC 13008	42.00	32.81	45	EC 93604	39.15	36.53
16	IC 13009	43.74	35.00	46	EC 93741	40.02	40.25
17	IC 13050	42.66	39.81	47	EC 93745	43.31	30.40
18	IC 13056	47.25	39.37	48	EC 93747	42.66	34.12
19	EC 329-4	41.99	40.68	49	EC 93748	43.53	35.21
20	EC 9308	43.74	41.69	50	EC 93751	45.28	31.72
21	EC 9309	45.06	41.56	51	Hardee	43.74	34.78
22	EC 14424	43.96	38.06	52	Bienville	42.00	32.15
23	EC 14425	44.40	38.28	53	Bragg	41.78	35.21
24	EC 14427	43.53	39.59	54	Hampton	42.43	33.90
25	EC 14450	42.87	35.43	55	Punjab-I	40.69	35.00
26	EC 14451	44.62	37.62	56	Lee	40.89	35.00
27	EC 14452	42.00	41.34	57	Jackson	42.87	34.33
28	EC 14475	42.86	39.15	58	Davis	42.87	32.59
29	EC 18108	42.00	33.68	59	Pickett	38.28	39.15
30	EC 18196	42.43	34.56	60	Kandaghat	42.22	40.25
					S.E. (Mean) = ±	1.12	1.39

EC 76756, IC 13050, EC 14451, IC 13009, EC 32924, EC 76756, EC 63298, IC 326-1, EC 93599 and EC 9309 (39.81%) in order. After confounding the effect of altitudes, the highest protein content (43.31%) $\pm$ 1.236 was obtained for IC 13056 and EC 14451 and other genotypes which were statistically at par with the highest ones, were EC 41318, Kandaghat, EC 13050, IC 547, EC 63298, EC 13009, IC 94601, IC 2716, EC 76753, IC 10684, 'Lee', 'Davis', EC 93747, IC 326-1, EC 9309 and EC 76756. If one compares the genotypes having high protein and falling in the first non-significant group at both altitudes, EC 14451 happens to be the only genotype having stable high protein content over altitudes. This indicated that in spite of appreciable effects of altitudes and genotype altitude on the seed protein content in soybean, high protein genotype yielded consistently higher and had more protein in favorable environment. This genotype appears to be interesting from breeding point of view.

Genetic gain in protein content through breeding would depend upon its heritability and selection intensity. In the present material, heritability estimated as percent of $\sigma^2 g/\sigma^2 g + \sigma^2 ga + \sigma^2 e$ after eliminating the altitude effect on genotypes, was found to be 62.7 indicating very high heritability for protein content due to preponderance of high additive gene effects. The expected genetic advance expressed as percent of mean on the basis of above heritability estimate with 5% selection intensity would be around 14%.

With the above discussion, one can conclude that there is large influence of genetic effect on seed protein content in soybean; however, there is appreciable influence of altitude, and altitude x genotype interaction effects. There appears to be sufficient scope for upgrading the protein content through selection due to its high heritability recorded in the present material.

References

A.O.A.C. 1960. Official Methods of Analysis, 7th ed. Washington: Association of Agricultural Chemists.

Cartter, J. L. and E. E. Hartwig. 1963. The management of soybeans. Pp. 161-221 in A. G. Norman (Ed.), The Soybean. Academic Press, New York.

Chapman, G. W., J. A. Robertson, D. Burdick and M. B. Parber. 1976. Chemical composition and lipoxygenase activity in soybeans as affected by genotypes and environments. J. Am. Oil Chem. Soc. 53: 54-56.

Comstock, R. E. and R. H. Moll. 1963. Genotype-environment interactions. Statistical Genetics and Plant Breeding NAS-NRC Publ. 982: 164-196.

Finlay, K. W. and G. N. Wilkinson. 1963. The analysis of adaptation in a plant breeding programme. Aust. J. Agric. Res. 14: 742-754.

Gupta, V. P., S. Ramanujam and A. K. Kaul. 1974. Stability analysis in respect of protein, sulphur and protein value index of seed and its implication in the adaptation of chickpea. Genetika 6: 247-261.

Johnson, H. W., H. F. Robinson and R. E. Comstock. 1955. Estimates of genetic and environmental variability in soybeans. Agron. J. 47: 314-318.

Kamel, K. F. and F. Y. Refai. 1970. A study of protein and oil contents of soybean as influenced by location and date of cultivation. Agric. Rev. Arab. Republic of Egypt 48: 369-377.

Kesavan, G. and Y. B. Morachan. 1973. Response of soybean varieties to graded doses of nitrogen and phosphorus. Madras Agric. J. 60: 23-26.

Lal, M. S., S. K. Mehta, A. D. Deodhar and Y. K. Sharma. 1971. Protein and oil content, their correlation and phenotypic stability in soybean as influenced by different environments in M.P. Ind. J. Agric. Sci. 43: 14-17.

Meiyan, Koname, E. G. Heyne and K. F. Finney. 1977. Genetic and environmental effects on the grain protein content in wheat. Crop Sci. 17: 591-593.

Panse, V. G. and P. V. Sukhatame. 1967. Statistical Methods for Agricultural Workers, 2nd ed. ICAR.

Sandison, A. and B. O. Bartlett. 1958. Comparison of varieties for yield. J. Natl. Inst. Agric. Bot. 8: 351-357.

Sood, D. R., D. S. Wagle, H. S. Nainawatti and V. P. Gupta. 1977. Varietal differences in the chemical composition of soybean. J. Food Sci. Tech. 14: 177-179.

Warner, J. M. 1952. A method of estimating heritability. Agron. J. 44: 427-430.

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