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VARIATION FOR LEAF CHARACTERISTICS AND RELATIONSHIP WITH GRAIN YIELD AND SEED SIZE IN PIGEON PEA

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ABSTRACT

Five leaf characters, namely, leaf fresh weight, petiole fresh weight, leaf area, petiole length, and specific leaf weight were studied in 27 pigeon pea cultivars and in an F_1 diallel set involving nine diverse parents, representing early, medium and late maturity groups, to determine the extent of variation for these characters and their inheritance. Also, the relationship between these leaf characters and yield, days to flowering, and seed size was determined to identify those leaf characters that might be easily used as selection criteria for yield. Griffing's diallel analysis showed that GCA variances for all the leaf components were very high and SCA non-significant, which indicated that the additive genetic component of variance was predominent for this population. Long duration cultivars generally had more leaf area, higher leaf weight, and greater petiole length than early and medium duration ones. Seed size was found to be positively associated with all the leaf characteristics (r=0·57 to 0·67 for different traits). Except petiole fresh weight, all characteristics of individual leaves had positive phenotypic and genotypic association with yield. The genotypic correlation coefficients ranged from 0·27 to 0·58 for the characters studied. The multiple correlation coefficient (R=0·66; p= ·01) with yield as dependent variable indicated that factors other than leaf characteristics affected grain yield to a great extent. Therefore, though leaf characters had a positive association with yield, the predictive value of any single leaf component was not high enough to be of practical use in a breeding program.

STUDIES on the importance of leaf characteristics in determining yield of crop plants are of interest to plant breeders. Among individual leaf components, specific leaf weight has been shown to be positivly associated with net photosynthetic rate per unit leaf area (Pearce *et al.*, 1969; Wolf and Blaser, 1971; Delaney and Dobrenz, 1974) and has been suggested as a selection criterion in forage crops. Auckland and Lambert (1974) suggested the use of leaf blade size, petiole length, and petiole weight in selecting for yield in soybeans. In pigeonpea [*Cajanus cajan* L. (Millsp.)] wide variation has been observed in all leaf characteristics. However, information on their inheritance and their relationship with yield and seed size is lacking. The present work was undertaken to study inheritance of leaf components and to determine if any leaf character, which could be measured easily, could be used as a selection criterion for yield.

MATERIALS AND METHODS

Materials for the present study were selected from an F_1 diallel set of 28 cultivars, planted in 1975 in black soil. The parents and their hybrids were grown in two replications in a randomized complete block design. Four rows, each 5 m long, constituted a plot. Spacing between and within rows was 150

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and 30 cm respectively. Twenty-seven of the parents and an F_1 diallel set of nine cultivars were selected for studying leaf characteristics. Parents for the diallel set were identified randomly, three each from early, medium and late maturity groups. Ten competitive plants in each plot were identified at random for sampling. Our earlier observations (unpublished) indicated that leaf components in mature leaf samples obtained from different positions of the pigeonpea plant did not differ significantly. Therefore, a sample of five fully developed leaves was taken at random from each plant at the time of flowering. The samples were placed in moist polythene bags and immediately processed to determine leaf fresh weight (mg), petiole length (cm), and petiole fresh weight (mg). Leaf area (cm^2) was estimated using an automatic leaf area meter (Model AAM-7). Thereafter , the samples were transferred to glassine bags and dried at 80° C for 40 hours before recording dry weight of leaf and petiole. Specific weight (mg/cm^2) was calculated by dividing the sample leaf dry weight by sample area. In addition, data on seed yield per plant, 100-seed weight and days to flower were recorded on the sample plants.

For the 27 parents, components of variance were estimated using the expected mean squares, and the broad-sense heritability and genotypic coefficients of variation were calculated (Burton and De Vane, 1953). Covariance analysis was used to compute correlation coefficients at phenotypic, genotypic and environmental levels. Data collected on nine parents and their F_1's were subjected to combining ability analysis (Griffing, 1956).

Results and Discussion

The data used in this report are from plots sampled from a much larger experiment, and thus may have involved some confounding of block and genotype × block effects. However, block effects were non-significant for yield and its components, both for the cultures used in this study and for the entire original population of entries and this suggests that the confounded effects were not strong enough to influence the validity of the results.

Treatment mean squares, range, mean, heritability in the broad sense, and genotypic coefficient of variation for the leaf characteristics, yield per plant, seed size, and days to flower for the population of 27 parents are presented in Table 1. Differences among lines were highly significant for all the traits. The highest genotypic coefficient of variation was observed for petiole fresh weight (33·09%) followed by leaf fresh weight, and leaf area. Relatively less variation was observed for specific weight and petiole length. Broad-sense heritability estimates were very high for all the leaf characteristics.

Correlation coefficients among various leaf characteristics, grain yield per plant, seed size, and days to flower at phenotypic, genotypic, and environmental levels are given in Table 2. A very close association ($r=0·98^{**}$) was observed between leaf fresh weight and leaf dry weight, and between petiole fresh weight and petiole dry weight ($r=0·90^{**}$). This indicates that leaf fresh weight and petiole fresh weight can be used directly for screening purposes in lieu of dry weights, which are cumbersome to determine, particularly where a large number of samples are involved.

Specific weight had negative environmental correlation with leaf fresh weight, petiole weight, and leaf area. The genetic and environmental correlations of specific weight with the rest of the leaf characteristics were of opposite sign, which indicated that the genetic and environmental effects influenced the two characters through different physiological mechanisms (Falconer, 1961).

All the leaf characteristics had positive genotypic association with yield. However, the genotypic correlations of yield with petiole fresh weight, petiole

TABLE 1

Analysis of variance, mean, range, genotypic coefficient of variation and broadsense heritability for various leaf characters in the 27 parents

Character	Mean Square		Mean ± SEm	Range	CV % for the test	Geno-typic CV %	Herita-bility % (broad-sense)
	Block	Treatment					
Leaf fresh weight (mg)	3897	66156**	568.1 ± 38.2	307.0—887.0	9.50	31.30	91.6
Petiole fresh weight (mg)	6.0	988**	65.3 ± 5.2	36.5—108.5	11.30	33.09	89.6
Leaf area (cm^2)	1.1	133**	33.9 ± 2.2	22.9— 50.5	9.05	23.17	86.8
Specific weight (mg/cm^2)	0.9	2.7**	6.4 ± 0.3	4.5— 8.5	7.28	17.33	84.8
Petiole length (cm)	0.5	1.4**	4.9 ± 0.4	3.4— 6.6	9.59	15.00	70.9
Seed yield/plant (g)	375	4973**	80.7 ± 17.5	14.5—179.7	29.53	57.50	69.1
100-seed weight (g)	0.3	32.8**	11.0 ± 0.8	6.5— 21.9	8.01	36.33	95.4
Days to flower	0.6	2097**	125.5 ± 46.7	69.0—178.0	5.14	25.53	96.1

**Significant at 1%.

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TABLE 2

Phenotypic (P), genotypic (G) and environmental (E) correlation coefficients among leaf characteristics, yield, 100-seed weight and days to flower in 27 lines

			2[a]	3	4	5	6	7	Days to flower
1.	Yield/plant	P	.42*	.22	.28	.36	.49**	−.06	.73**
		G	.52	.27	.38	.44	.58	.01	.83
		E	−.08	.03	−.12	.16	.16	.01	.15
2.	Leaf fresh weight	P		.88**	.91**	.73**	.60**	.65**	.77**
		G		.91	.93	.82	.73	.67	.80
		E		.60	.81	.53	−.42	.37	.27
3.	Petiole fresh weight	P			.91**	.83**	.41*	.52**	.52**
		G			.93	.87	.54	.60	.54
		E			.73	.86	−.38	.23	.31
4.	Leaf area	P				.73**	.34	.48**	.58**
		G				.78	.48	.59	.62
		E				.62	−.50	.17	.29
5.	Petiole length	P					.38*	.45*	.58**
		G					.60	.57	.63
		E					−.36	−.01	.55
6.	Specific leaf weight	P						.33	.71**
		G						.39	.82
		E						.19	.32
7.	100-seed weight	P							.72**
		G							.35
		E							−.20

*, **Significant at 5% and 1% respectively. [a]As in col. 1

length and leaf area were weak. In the present study significant and positive correlation between yield and specific leaf weight was observed. Specific leaf weight, which has been shown to be positively associated with photosynthetic efficiency per unit of leaf area, was highly correlated with yield (dry matter production) in alfalfa (Delaney and Dobrenz, 1974; Wolf and Blaser, 1971). Therefore, it is likely that specific leaf weight may have a direct bearing on pigeonpea yield, where the production of total biomass is very closely associated with grain yield (Sharma *et al.*, 1971; Khan and Rachie, 1972; Singh and Malhotra, 1973; Akinola and Whiteman, 1974). Environmental correlations between yield and the leaf characters were very low, indicating little common environmental effect on leal characteristics and yield. Seed size was found to be positively correlated with all the leaf components. Singh *et al.*, (1977) reported very high association between seed size and trifoliate area both at phenotypic and genotypic levels in pigeonpea. Environmental correlations in all the combinations were very low, indicating that environmental components influencing leaf characteristics did not influence seed size. Correlation coefficients of leaf components with days to flower were positive and significant, showing that long duration cultivars generally had higher values for all leaf characteristics than did early and medium maturity cultivars. Environmental correlations of days to flower and petiole length were found to be high and positive.

The relationships of seed size and yield with leaf characteristics were further evaluated by multiple correlations. The multiple correlation coefficient with seed size as the dependent variable and leaf characteristics as independent variables was 0·70** and accounted for 49% of the variation in seed size.

The multiple correlation coefficient of leaf characteristics with yield as the dependent variable was found to be significant (r=0·66**). This indicated that 56% of the variation in yield was due to the factors other than leaf components.

Singh *et al.*, (1977) observed that total leaf area per plant was highly and positively correlated with yield, while individual leaf area and number of leaves per plant had no association with yield. Thus the simple individual leaf characteristics could not be used as selection oriteria for yield and since total leaf area per plant is much more complicated to determine with precision than is yield itself, the leaf characteristics do not provide a short-cut in selection.

For the diallel crosses of nine parents, there was highly significant variation for GCA and non-significant SCA variation for all the leaf characteristics, indicating the importance of additive genetic effects (Table 3). Similar genetic

TABLE 3

Combining ability analysis for various leaf characters in a 9 × 9 *diallel*

Source	df	Leaf fresh weight	Petiole fresh weight	Leaf area	Petiole length	Specific weight
Blocks	1	5168.04	302.50	62.30	1.50	0.42
Treatments	44	51502.24**	603.35**	102.74**	0.52*	1.51**
Error	44	5903.41	155.48	31.34	0.28	0.38
GCA	8	134508.63**	1419.83**	253.78**	0.89**	3.51**
SCA	36	1582.78	53.20	6.39	0.12	0.14
Error	44	2951.07	77.74	15.67	0.14	0.19

*, **Significant at 5% and 1% respectively.

effects were found for leaflet size and specific leaf weight in alfalfa (Song and Walton, 1975) and for leaf area in wheat (Balalic, 1974). This suggests that if the leaf characteristics have a strong association with total dry-matter production, selection for them could be much easier than for yield itself, which has low heritability.

The results of the study show that all the leaf components had high heritability (broadsense). Except for petiole fresh weight, all component characteristics of individual leaves had positive influence on grain yield. However, the magnitude was so small that they can hardly be of any value as selection criteria.

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