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Short Communication

Genetic association in *Chenopodium*

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Chenopodium spp. are being cultivated since centuries for leafy vegetable (*C. album*) as well as an important subsidiary grain crop (*C. quinoa* and *C. album*) for human and animal foodstuff due to high protein (10-14%) and a balanced amino acid spectrum with high lysine (5.1-6.4%) and methionine (0.4-1.0%) contents [1]. The present study on correlation and path analysis was conducted to elucidate the interrelationship among different agronomic traits in *Chenopodium* spp. The material comprised 44 germplasm lines of *Chenopodium* spp. which were grown in a randomized block design with 3 replications in the crop year 2000-2001. Each entry was sown in two rows of 3m long. The row-to-row and plant-to-plant distances were maintained 45cm and 15cm respectively. The observations were recorded on 5 plants from each entry and replication for seed yield/plant (g) and its 10 agronomic traits. The genotypic and phenotypic correlations were computed as suggested by Mullar *et al.* [2] and path coefficient as described by Dewey and Lu [3].

The genotypes were significantly different for all the traits, which indicates scope for further genetic studies. At phenotypic level the grain yield showed a significant positive association with all the characters except for 100 seed weight, which had significant negative association with grain yield (Table 1). Similarly all the characters showed significant negative correlation with 100 seed weight. The characters *viz.* days to flowering, days to maturity, plant height, leaf area and stem diameter had significant positive association with all the traits except number of inflorescence/plant. Number of primary branches/plant, inflorescence length and dry weight of plant showed significant positive association with all the traits. The grain yield showed a strong positive genotypic association with all the traits except for 100 seed weight, which was negatively significant, indicating that selection for these traits would lead to an improvement in yield as the changes in yield is accompanied by changes in one or more components. The significant positive association of leaf area with grain yield showed that leaves are more responsible for higher grain yield due to high photosynthetic activity, it is also positively and significantly associated with all the characters except for 100 seed weight and number of inflorescence/plant. The genotypic values for days to flowering, days to maturity, plant height and stem diameter showed significant positive association with all the characters except for number of inflorescence/plant similarly as phenotypic values. Simultaneously number of primary branches/plant, inflorescence length and dry weight of plant had significant positive association with all the traits. The 100 seed weight was negatively significant with dry weight of plant, number of inflorescence/plant and grain yield. The positive significant genotypic and phenotypic association of all the traits with grain yield clearly indicated that the germplasm lines under study had wide genetic variation among themselves. Hence all the traits except 100 seed weight would be of great impetus towards enhancing the grain yield manifold.

The estimates of correlation alone may be often misleading due to mutual cancellation of component traits, so it becomes necessary to study the path coefficient analysis, which takes into account the causal relationship in addition to the degree of relationship. Hence, the genotypic correlations were partitioned into direct and indirect effects to know the relative importance of the components (Table 2). The days to flowering showed positive correlation with grain yield but had low direct path. The traits plant height, number of primary branches/plant and stem diameter showed a positive correlation with grain yield and had negative path (–0.226, –0.333 and –0.005 respectively). However, in these cases the negative direct path is nullified via positive indirect effect of inflorescence length, dry weight of plant, leaf area, days to flowering, days to maturity and number of inflorescence. Contrary to this, 100 seed weight, which had significant negative correlation, exhibited moderate positive direct path towards yield. It was also negatively indirectly associated via all the traits except plant height, stem diameter and number of primary branches/plant, which confirmed the conclusion drawn from correlation. The leaf area had significant positive genotypic correlation and exhibited high direct path towards grain yield. Leaf area was

Table 1. The genotypic and phenotypic (in parenthesis) correlation coefficients among 11 agronomic traits in *Chenopodium* spp.

	Characters	2	3	4	5	6	7	8	9	10	11
1	Days to flowering	0.918**	0.718**	0.658**	0.675**	0.573**	0.499**	–0.397**	0.581**	–0.024	0.515**
		(0.915**)	(0.716**)	(0.656**)	(0.667**)	(0.568**)	(0.498**)	(–0.395**)	(0.579**)	(–0.024)	(0.513**)
2	Days to maturity		0.758**	0.625**	0.699**	0.585**	0.616**	–0.477**	0.573**	0.079	0.602**
			(0.756**)	(0.624**)	(0.691**)	(0.582**)	(0.614**)	(–0.476**)	(0.571**)	(0.079)	(0.600**)
3	Plant height (cm)			0.688**	0.877**	0.814**	0.843**	–0.580**	0.764**	0.209	0.677**
				(0.687**)	(0.868**)	(0.811**)	(0.842**)	(–0.579**)	(0.763**)	(0.209)	(0.676**)
4	Leaf area (cm^2)				0.599**	0.499**	0.369*	–0.365*	0.509**	–0.053	0.466**
					(0.592**)	(0.497**)	(0.368*)	(–0.365*)	(0.509**)	(–0.053)	(0.465**)
5	Stem diameter (cm)					0.893**	0.821**	–0.496**	0.798**	0.290*	0.681**
						(0.882**)	(0.812**)	(–0.488**)	(0.788**)	(0.287*)	(0.673**)
6	No. of primary branches/plant						0.762**	–0.427**	0.744**	0.345*	0.578**
							(0.758**)	(–0.424**)	(0.739**)	(0.343*)	(0.575**)
7	Inflorescence length (cm)							–0.597**	0.675**	0.309*	0.701**
								(–0.595**)	(0.674**)	(0.309*)	(0.699**)
8	100 seed weight (g)								–0.533**	–0.335**	–0.453**
									(–0.531**)	(–0.334**)	(–0.452**)
9	Dry weight of plant (g)									0.343*	0.689**
										(0.342*)	(0.686**)
10	No of Inflorescene/plant										0.455**
											(0.455**)
11	Seed yield (g)										

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

Table 2. Path coefficient analysis for 10 agronomic traits of seed yield in *Chenopodium* spp.

	Characters	1	2	3	4	5	6	7	8	9	10	GC
1	Days to flowering	**0.028**	0.192	–0.162	0.202	–0.003	–0.191	0.329	–0.079	0.208	–0.009	0.515**
2	Days to maturity	0.025	**0.210**	–0.171	0.192	–0.004	–0.195	0.406	–0.095	0.205	0.028	0.602**
3	Plant height(cm)	0.020	0.159	**–0.226**	0.211	–0.004	–0.271	0.555	–0.115	0.274	0.075	0.677**
4	Leaf area (cm^2)	0.018	0.131	–0.156	**0.307**	–0.003	–0.166	0.243	–0.072	0.183	–0.019	0.466**
5	Stem diameter (cm)	0.019	0.147	–0.198	0.184	**–0.005**	–0.298	0.541	–0.098	0.286	0.104	0.681**
6	No. of primary br./ plant	0.016	0.123	–0.184	0.153	–0.004	**–0.333**	0.502	–0.085	0.267	0.124	0.578**
7	Inflorescence length (cm)	0.014	0.129	–0.191	0.113	–0.004	–0.254	**0.659**	–0.118	0.242	0.111	0.701**
8	100 Seed weight(g)	–0.011	–0.100	0.131	–0.112	0.002	0.142	–0.393	**0.198**	–0.191	–0.120	–0.453**
9	Dry wt of plant (g)	0.016	0.120	–0.173	0.157	–0.004	–0.248	0.445	–0.106	**0.358**	0.123	0.689**
10	No. of inflor-escence/plant	–0.001	0.017	–0.047	–0.016	–0.001	–0.115	0.204	–0.066	0.123	**0.359**	0.455**

Residual effect = 0.283, GC: Genotypic correlation, *,** Significance at 5% and 1% respectively.

indirectly associated via plant height, stem diameter, number of primary branches, 100 seed weight and number of inflorescence/plant, which indicates that leaf area played an important role in more grain yield due to photosynthetic activity. It is interesting to note that inflorescence length had highest genotypic correlation (0.701) with grain yield and also exhibited highest direct path (0.659), which is in general expectation i.e. larger the size of the inflorescence the better will be the grain yield. This was also indirectly positively affected via dry weight of plant, number of inflorescence/plant, leaf area, days to flowering and days to maturity. Similarly, dry weight of plant and number of inflorescence/plant showed high significant positive correlation and also had a high direct path. However, number of inflorescence/plant was indirectly affected via inflorescence length, dry weight of plant and days to maturity, while dry weight of plant was indirectly affected via inflorescence length, number of inflorescence/plant, leaf area, days to flowering and days to maturity. It was noticed that 100 seed weight decreases with the increase in grain yield as well as in increase of most of other traits except plant height and number of primary branches/plant. It seems that grain yield is inversely proportional to 100 seed weight. The value of residual effect indicates that there may be some other secondary components that should not be ignored. It is clear from the study that selection of plants with large inflorescence length, more number of inflorescence/plant, high dry weight of plant, larger leaf area and late maturing would be most desirable for breeding for high grain yield.

References

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