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Understanding the Genetic Variability for Growth and Leaf Yield of Coriander (*Coriandrum sativum* L.)

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ABSTRACT

Background: Coriander (*Coriandrum sativum* L.) is a popular herbaceous annual seed spice crop. It is mainly grown for seed as well as green leaf, the leaf and seed yield is varied with the genetic background of genotypes. Therefore, the selection of genotypes with high leaf yield is highly desired, along with the magnitude of heritability and genetic advance for wider adaptation and cultivation. In this view, the accessions were collected and their genetic variables were assessed.

Methods: The experimental material included 48 coriander accessions along with two check varieties CO4 and CO5. The plant materials were obtained from the coriander germplasm repository at the Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, India. The experiment was laid out in Randomised Block Design with two replications.

Result: The results of the analysis of variance revealed significant differences among the accessions. High heritability coupled with high GAM was observed for the economical trait (87% and 48.93% for leaf yield) indicating that, the traits were highly heritable in nature, hence selection breeding is most effective. The PCV and GCV were moderate to high for all traits except the number of days for harvest and moisture content among all the accessions of coriander. The leaf yield was highly significant and positively correlated with all the traits except the number of days for harvest and leaf protein. The genotypic correlation was greater than the phenotypic correlation among the genotypes. Therefore, to increase the leaf yield of coriander accessions, either simple selection or mass selection of desirable traits and their associated traits would be effective.

Key words: Coriander, Correlation, GCV, Heritability, PCV.

INTRODUCTION

Coriander (*Coriandrum sativum* L.) is an annual herb grown for its leaves and seed fruit as a spice and condiment. It is an important member of the Umbelliferae family with 2n=22 chromosomes and is native to the Mediterranean and near eastern regions (Bhandari and Gupta 1993). Because of its wide adaptation to a variety of eco-geographic conditions, it is grown all over the world for its aromatic leaves and spicy seed (Arif *et al*., 2014; Purseglove *et al*., 1981; Simon 1990). It is mostly grown in North Africa, Europe, India, China and Thailand. India is well-known for its diverse and rich traditional cuisine. Coriander stems, leaves and fruits have a pleasant aroma, making them ideal for flavouring continental curries and soups. The fruits are widely used in the preparation of curry powder, pickling, spices, sausages and seasoning, as well as to flavour pastry, biscuits, buns, cakes and liquors, particularly gin (Gauhar *et al*., 2018). The recent discovery of the leaves nutraceutical and medicinal properties has elevated the crop's status as a foliage crop. Critical assessment of the nature and magnitude of variability of germplasm is a prerequisite for any efficient breeding programme and it provides an opportunity to identify the superior lines with desirable yield and quality traits, which further enables to develop a high yielding variety. In order to breed better varieties, it is essential to gather data on agronomically significant characters when starting a breeding programme for a crop with genetic variation (Dubley and Moll 1969). The success of a breeding programmes depends on traits related to yield, the relationships between various traits and their direct and indirect effects on one another (Ali *et al*., 2003). According to Deb and Khaleque (2009), understanding the relationship and interaction of various traits with yield greatly aids breeders in developing more predictive and accurate selection programmes. The GCV and PCV were used to estimate the direction and intensity of association of the

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various traits with yield (Mode and Robinson 1959). The relative importance of the component characters direct and indirect influences on leaf yield is accurately depicted by path analysis (Bhatt 1973). This offers detailed information for selecting significant characters for the improvement programme to be considered. In order to identify key traits to be taken into account in crop improvement programmes, the current study was carried out to estimate the relative importance of direct and indirect influences of component traits on leaf yield.

MATERIALS AND METHODS

The experimental material included 48 coriander accessions along with two check varieties CO4 and CO5. The plant materials were obtained from the coriander germplasm repository at the Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, India. The experiment was laid out in randomised block design with two replications. The seeds were sown at 30 × 15 cm spacing with plot size of 1.8 m × 1.8 m. The recommended package of practises was implemented as recommended by Tamil Nadu Agricultural University in Coimbatore, Tamil Nadu, India. The observations were made on five randomly selected plants for characters *viz*., number of days for germination, plant height (cm), number of branches, number of leaves per plant, number of days to harvest, fresh and dry weight of the plant (g/plant), moisture content (%), chlorophyll content of the leaves (mg/g), vitamin C (mg/100gm) and protein content (mg/g). For the estimation of chlorophyll (Shoaf and Lium 1976), vitamin C (Tauber and Kleiner 1934) and protein content (Lowery 1951) following methodology was used. The GCV and PCV were interpreted as low (0-10%), moderate (11-20%) and high (>20%). The rate of genetic advancement was determined to be low (0-10%), moderate (11-20%) and high (>20%). Heritability is often defined as the ratio of genotypic variance to total phenotypic variance and estimates of heritability are given as percentages using the symbol h^2 (BS). Heritability (h^2) and GAM were classified as low (0-30%), moderate (31-60%) and high (>60%) (Burton and De-Vane 1953; Hanson *et al*., 1956; Johnson *et al*., 1955). The R software version 4.3.1 was developed at Bell Laboratories was used for statistical analysis of data.

All possible character combinations' genotypic and phenotypic correlation coefficients were calculated (Miller *et al*., 1958). The quality of the group affects how effectively the selection method operates. The degree of linkage between independent and dependent variables was first hypothesised by Galton (1988), extended by Pearson (1904) and then explained mathematically at the phenotypic, genotypic and environmental levels by Searle (1961). The total correlation coefficient was split into direct and indirect effects using path coefficients analysis. It clarifies the connection between leaf yield and several leaf yield-related factors. The correlation coefficient can be divided into direct and indirect effect components using path coefficients, which are standardised partial regression coefficients that assess the direct and indirect effects of one variable on another. The product of all direct and indirect effects via all other traits must match the correlation coefficient between dependent and independent traits (Dewey and Lu 1959; Wright 1992). The direct and indirect effects of total leaf yield per plant were calculated at both the genotypic and phenotypic levels using R software.

RESULTS AND DISCUSSION

Growth and yield attributes performed considerably, in accordance with the analysis of variance results, which are presented in Table 1. Plant height, number of leaves per plant, number of branches, chlorophyll content, leaf protein, ascorbic acid, number days for harvest, moisture content, fresh and dry weight of plant were varied significantly. The accessions CS 56 (6.3 g/plant), CS 58 (6.00 g/plant), CS 191 (5.00 g/plant), CS 43 (5.45 g/plant), CS 69 (4.5 g/plant) and CS 5 (4.45 g/plant) recorded the highest fresh weight of plant compared to other accessions. High breeding potential is facilitated by the enormous variation both within and among populations. Various authors reported the comparable large difference in yield and yielding attributes among the coriander accessions (Megeji and Korla 2002; Nair *et al*., 2012). Based on the result, these accessions can be used in the breeding improvement programme for the interested parameters.

For GCV, the variance for characteristics were ranged from 1.50 to 30.82%, while for PCV, the variance was ranged from 2.60% to 31.68%. The heritability estimates ranged from 33.0 to 94.0% and GAM was measured between 1.79% and 61.77% (Table 2). Among the accessions, which are determined by growth and yield features, the fresh weight of plant varied from 1.5 to 6.30 g, these findings were supported by Meena *et al*. (2013) and Dhakad *et al*. (2017) for GCV, PCV, GAM and for heritability. The most effective indices for comparing characters with different test units of their coefficients of variance. There was only a small difference between them, despite the fact that the phenotypic coefficient of variation (PCV) was higher than the equivalent genotypic coefficient of variation (GCV) for all of the features in this study (Table 2). This demonstrated improved character stability against environmental variation, suggesting that dependable phenotypic performance-based selection methods will be used. For the majority of the characteristics, a significant part of PCV was contributed by GCV, indicating that genetic factors were predominantly responsible for the observed variance. Similarly, Bhargava *et al*. (2007) and Panda *et al*. (2017) in coriander reported earlier on this resemblance between PCV and GCV, it is obvious that selection will be fruitful. Heritability estimation is necessary since the GCV does not give enough details to calculate the amount of variation that is inherited. Heritability information and genetic progress enable us to make wise decisions for successful selection based on phenotypic performance. High heritability values imply that the phenotype of the characteristic strongly reflects the genotype and that the genotypic makeup has a significant influence in determining how the character is expressed. Except for the number of branches, moisture content and number of days for harvest, all the traits in the study had high heritability (>60%) together with strong genetic progress (>20%).

The interactions of various interrelated features affect coriander leaf yield. When decisions are made based on yield components, a logical approach to yield improvement will offer better results. The effectiveness of yield selection is determined by the direction and strength of the correlation between yield and its components as well as among themselves. The plant height, number of leaves, number of branches, ascorbic acid and dry weight of the plant in the study, the genotypic and phenotypic correlation showed a highly significant positive association with the fresh weight of the plant (Table 3). Thakur (2018); Meena *et al*. (2010)

Table 1: Analysis of variance for growth, yield and quality parameters in coriander germplasm accessions.

Traits	Mean	Sem	CD
Plant height (cm)	17.89	1.14	3.26
Number of leaves	21.63	1.44	4.09
Number of branches	8.70	1.11	3.16
Ascorbic acid (mg/100g)	99.91	3.06	8.70
Chlorophyll content (mg/g)	1.75	0.09	0.25
Leaf protein (mg/g)	3.27	0.14	0.40
Moisture content (%)	86.13	1.29	3.68
Number of days for harvest	38.65	1.19	3.39
Dry weight of plant (g/plant)	1.92	0.13	0.36
Fresh weight of plant (g/plant)	3.61	0.24	0.68

Table 2: Estimates of genetic variability for growth, yield and quality parameters in coriander germplasm genotypes.

Traits	Range	GCV	PCV	h^2	GA	GAM
Plant height (cm)	11.60-27.20	16.84	19.14	0.77	5.46	30.54
Number of leaves	13.00-35.00	17.00	19.44	0.76	6.63	30.64
Number of branches	3.5-15.00	19.82	26.85	0.54	2.62	30.16
Ascorbic acid (mg/100g)	62.50-133.50	16.81	17.36	0.93	33.51	33.54
Chlorophyll content (mg/g)	0.48-2.72	30.82	31.68	0.94	1.08	61.77
Leaf protein (mg/g)	1.73-6.63	18.76	19.74	0.90	1.20	36.74
Moisture content (%)	78.21-89.47	1.50	2.60	0.33	1.54	1.79
Number of days for harvest	35.00-45.00	4.46	6.24	0.51	2.54	6.57
Dry weight of plant (g/plant)	0.81-3.31	24.90	26.67	0.87	0.92	47.90
Fresh weight of plant (g/plant)	1.50-6.30	25.29	26.98	0.87	1.76	48.83

Table 3: Genotypic (above diagonal) and phenotypic (below diagonal) correlation matrix among different characters of 50 coriander germplasm accessions.

	PH	NL	NB	Asco. Acid	Chlo. content	Leaf protein	MC	NDH	DWP	FWP
PH	1 **	0.755 **	0.761**	0.211	0.205	0.333 *	0.206	0.101	0.543**	0.556**
NL	0.568 **	1 **	0. .602 **	0.282*	0.332 *	0.144	0.312 *	-0.231	0.398**	0.414**
NB	0.403 **	0.378 **	1 **	-0.013	0.475 **	0.411**	0.287 *	-0.202	0.411	0.424**
Asco. acid	0.171	0.233 *	0.016	1 **	-0.066	0.056	-0.050	-0.375**	0.365**	0.366**
Chlo. content	0.192	0.281**	0.294 **	-0.068	1 **	0.130	-0.118	-0.084	0.264	0.263*
Leaf protein	0.272 **	0.097	0.312 **	0.05	0.117	1 **	-0.070	-0.089	0.162	0.163
MC	0.192	0.057	0.198 *	0.036	-0.053	-0.031	1 **	-0.091	0.403**	0.438**
NDH	0.026	-0.149	-0.094	-0.278 **	-0.081	-0.054	-0.099	1**	-0.110	-0.108
DWP	0.421 **	0.343 **	0.280**	0.336 **	0.225*	0.129	0.169	-0.124	1**	0.999*
FWP	0.430 **	0.351**	0.2915 **	0.341**	0.227 *	0.129	0.207 *	-0.121	0.997**	1**

PH- Plant height; NL- Number of leaves; NB- Number of branches; AA- Ascorbic acid; CC- Chlorophyll content; LP- Leaf protein; MC- Moisture content; NDH- Number of days for harvest; DWP- Dry weight of plant; FWP- Fresh weight of plant.

Table 4: Estimates of genotypic path coefficients analysis in 50 coriander germplasm accessions.

	PH	NL	NB	AA	CC	LP	MC	NDH	DWP	FWP
PH	0.12568	-0.04620	-0.05849	0.00267	0.01150	0.00220	0.01734	-0.00309	0.50483	0.556**
NL	0.09489	-0.06119	-0.04627	0.00357	0.01860	0.00096	0.02626	0.00710	0.37018	0.414**
NB	0.09573	-0.03687	-0.07679	-0.00017	0.02658	0.00272	0.02414	0.00619	0.38289	0.424**
AA	0.02656	-0.01731	0.00106	0.01262	-0.00373	0.00037	-0.00427	0.01152	0.33949	0.366**
CC	0.02584	-0.02036	-0.03650	-0.00084	0.05592	0.00086	-0.00991	0.00259	0.24559	0.263*
LP	0.04190	-0.00887	-0.03162	0.00071	0.00727	0.00661	-0.00590	0.00274	0.15059	0.163
MC	0.02595	-0.01913	-0.02207	-0.00064	-0.00660	-0.00046	0.08399	0.00280	0.37468	0.438**
NDH	0.01269	0.01419	0.01551	-0.00474	-0.00473	-0.00059	-0.00768	-0.03065	-0.10232	-0.108
DWP	0.06826	-0.02437	-0.03163	0.00461	0.01477	0.00107	0.03386	0.00337	0.92950	0.999*

PH- Plant height; NL- Number of leaves; NB- Number of branches; AA- Ascorbic acid; CC- Chlorophyll content; LP- Leaf protein; MC- Moisture content; NDH- Number of days for harvest; DWP- Dry weight of plant; FWP- Fresh weight of plant.

Table 5: Estimates of phenotypic path coefficients analysis in 50 coriander germplasm accessions.

	PH	NL	NB	AA	CC	LP	MC	NDH	DWP	FWP
PH	-0.00342	0.00513	0.00102	0.00160	0.00126	0.00061	0.00780	0.00030	0.41601	0.430**
NL	-0.00195	0.00902	0.00095	0.00219	0.00185	0.00022	0.00231	-0.00169	0.33869	0.35**
NB	-0.00138	0.00341	0.00252	0.00016	0.00193	0.00070	0.00804	-0.00107	0.27698	0.2915**
AA	-0.00058	0.00210	0.00004	0.00937	-0.00045	0.00011	0.00148	-0.00315	0.33257	0.34**
CC	-0.00066	0.00254	0.00074	-0.00064	0.00656	0.00026	-0.00217	-0.00092	0.22139	0.227*
LP	-0.00093	0.00087	0.00079	0.00047	0.00077	0.00225	-0.00128	-0.00061	0.12748	0.129
MC	-0.00066	0.00052	0.00050	0.00034	-0.00035	-0.00007	0.04048	-0.00112	0.16747	0.207*
NDH	-0.00009	-0.00135	-0.00024	-0.00261	-0.00053	-0.00012	-0.00402	0.01130	-0.12333	-0.121
DWP	-0.00144	0.00310	0.00071	0.00316	0.00147	0.00029	0.00687	-0.00141	0.98557	0.997**

PH- Plant height; NL- Number of leaves; NB- Number of branches; AA- Ascorbic acid; CC- Chlorophyll Content; LP- Leaf protein; MC- Moisture content; NDH- Number of days for harvest; DWP- Dry weight of plant; FWP- Fresh weight of plant.

reported earlier on this similarity of association between the fresh weight of a plant with the number of leaves, number of branches and dry weight of a plant in coriander.

Studies of correlation shed light on the favourable and unfavourable relationships between various traits and yield as well as between them. The kind and degree of these features' contributions to the yield are uncertain, though. A more accurate picture of the correlations between distinct features can be obtained by path coefficient analysis, which takes into account both the direct and indirect effects of the various yield components. Plant breeders can quickly determine the qualities that have the most effects on yield by determining the correlations between and among yield and yield components. The analysis of genotypic path coefficients demonstrated that dry weight of plant, moisture content, plant height and chlorophyll content, had a highly significant and favourable direct effect on fresh weight of plant (Table 4). Phenotypic path coefficient study revealed that the dry weight of plant, moisture content, number of leaves and number of branches, had a highly significant and favourable direct effect on leaf yield per plant (Table 5). Similar results were noticed by Meena *et al*. (2010); Singh *et al*. (2006) and Vijayalatha and Cheziyan (2004) in Coriander. The study concluded that genotype selection with the maximum number of branches, number of leaves, plant height and dry weight of plant should receive more attention. Therefore, either simple selection or mass selection for these traits would be helpful in increasing coriander leaf yield. It may be difficult to determine the direct and indirect influences on yield components through other features. The results indicated that an increase in leaf yield was a result of moderate to high variability, heritability and genetic progress of characteristics. The most efficient method would be to breed suitable accessions by simple or mass selection.

CONCLUSION

The study demonstrated a high frequency of genotypic and phenotypic genetic variation among accessions. High GCV and PCV were observed for growth and yield traits with a wide genetic background, which could be helpful in genotype selection in coriander breeding upcoming generations. We assumed from the study's results that the plant height, number of leaves, ascorbic acid, chlorophyll content, leaf protein, dry and fresh weight of plant and genetic progress over percent mean all exhibited substantial heredity. Additive gene action provides a basis for high heritability estimates and genetic advance over percent mean of traits, hence selection of genotypes based on these traits through simple selection will be more effective in improvement of coriander leaf yield.

Conflict of interest

The authors declared that they have no conflict of interest.

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