DOI : 10.5958/0974-0112.2016.00056.6

Indian J. Hort. 73(2), June 2016: 251-255

Genetic variability, correlation and path coefficient analysis of some yield-related traits in aloe (*Aloe barbadensis* Mill.)

M.A. Ahmad* and L.M. Gupta

Division of Agroforestry, Sher-e-Kashmir University of Agricultural Sciences and Technology, Main Campus, Chatha, Jammu 180009, Jammu and Kashmir

ABSTRACT

Eleven *Aloe barbadensis* accessions were evaluated under subtropical conditions of Jammu during 2011-12 and 2012-13 in a three replicate complete randomized block design to estimate genetic variation, broad sense heritability, correlation and direct and indirect effects between yield and yield components. Genotypic and phenotypic coefficients of variability were highest for dry latex per plant (66.82 and 68.45%) followed by gel yield per plant (66.76 and 68.04%, respectively). Broad sense heritability ranged from 22.92% (leaf length) to 71.11% (gel yield per plant). Leaf yield per plant exhibited positive and significant correlation with all growth and yield attributes except number of suckers per plant and leaf: gel ratio. The path coefficient analysis based on leaf yield per plant, as a dependent variable, revealed that all the other traits, except no. of suckers per plant and leaf: gel ratio exhibited high positive direct effects. Gel yield per leaf, fresh weight per leaf and plant spread showed the highest direct influence of 0.686, 0.342 and 0.169, respectively. From the present investigation, it is concluded that gel yield per leaf, fresh weight per leaf and plant spread having direct strong bearing on leaf yield per plant must be considered, while designing the selection indices for improving leaf yield in *Aloe*.

Key words: *Aloe barbadensis*, correlation, genetic variation, path coefficient analysis, leaf yield.

INTRODUCTION

Aloe (*Aloe barbadensis* Mill.) is a xerophytic perennial belonging to family Liliaceae. Aloe is in high demand owing to its therapeutic, cosmetic and neutraceutical properties. Its leaves contain a very small quantity of viscous yellow fluid known as aloe latex, which is embedded in the pericyclic cells of the vascular bundles. The dried latex known as aloin is laxative in nature. The aloe gel (mucilaginous pulp of leaf parenchyma) is widely used in cosmetic industry as a skin tonic (Rajeswari *et al.*, 9). It is used to sooth the burn pains, rashes, insect bites and other skin irritations (Reddy *et al.*, 10).

It is a well known fact that chemical constituents of medicinal plants and so their biological activities are influenced by the genetic and environmental factors (Heywood, 6). Owing to adaptation of aloe to a wide range of environmental conditions, the aloe accessions show genetic variation which may have impact on the composition and biological activity of active constituents of the crop. Genetic variation among traits is of great importance for breeding and in selecting desirable genotypes. In addition, an analysis of the correlation between yield and yield components is essential for determining selection criteria; however, path coefficient analysis helps to determine the direct effect of traits and their indirect effects on other traits. Hence, to identify the accessions with best performance to be used as initial materials for a successful breeding programme, the present study was conducted to study the genotypic variation and association of yield and yield influencing characters in *Aloe barbadensis*.

MATERIALS AND METHODS

Eleven *Aloe* accessions, procured from ICAR-National Bureau of Plant Genetic Resources, New Delhi were evaluated in a completely randomized block design at the Experimental Farm of Division of Agroforestry, SKUAST-Jammu during 2011-12 and 2012-13. Raised beds of 1.8 cm × 1.8 m were prepared and aloe plantlets, 12-15 cm long were planted at a spacing of 60 cm × 45 cm accommodating 12 plants bed^{-1}. Growth characters such as plant spread, number of suckers plant^{-1}, number of leaves plant^{-1}, leaf length, leaf width, leaf thickness and leaf volume were recorded for five plants per treatment per replication. The leaves from randomly selected plants were harvested and observations like leaf weight, leaf and gel yield were estimated. Leaf: gel ratio was calculated by dividing leaf weight by gel weight. Wet latex was collected by giving a transverse cut 2 cm above the base of leaves and allowing for half-an-hour for the latex to drain from the leaves in a petridish and kept in oven at 45°C for 6 h in order to remove the moisture and measured as average dry

*Corresponding author's E-mail: guptalm@gmail.com

latex per leaf. The data of both the years were pooled and analysis of the data was performed according to the Randomised Complete Block Design (RCBD) following the standard procedure. Range, arithmetic mean, genotypic coefficient of variation, phenotypic coefficient of variation, heritability estimates in broad sense and genetic advance were estimated (Johnson *et al.*, 7). Genotypic and phenotypic correlation coefficients between all possible combinations of variables were worked out following the methods of Snedecor and Cochran (11). The path coefficient analysis was conducted following the method of Dewey and Lu (3).

RESULTS AND DISCUSSION

The aloe accessions exhibited considerable amount of variation in ten characters studied (Table 1). The highest range was observed in leaf fresh weight (69.91-150.00 g), gel yield per leaf (35.36-83.50 kg) and plant spread (30.50-75.83 cm). The lowest range was recorded for dry latex per leaf (0.09-0.22 g), gel yield plant^{-1} (0.12-0.56 g) and leaf: gel ratio (1.70-2.07). Similar findings have been reported by Ganesh and Alagukannan (4) on *Aloe barbadensis*. The high range of values indicates good scope for selection of suitable basic material for breeders for further improvement. The phenotypic coefficients of variation (PCVs) were higher than the corresponding genotypic coefficients of variation (GCVs) for all of the characters under study, indicating the influence of environmental factors in the expression of characters. PCVs were the highest in gel yield plant^{-1} (68.45%) and dry latex plant^{-1} (68.04%). The lowest PCVs were obtained for leaf: gel ratio (17.51%) and leaf thickness (20.57%). Gupta *et al.* (5) have also observed higher PCVs than their corresponding GCVs, while evaluating different sources of *Bunium persicum.*

Genotypic coefficient of variation together with heritability estimates would give the best information on extent of the advance to be expected from selection. The estimates of heritability have a role in determining the effectiveness of selection of character provided they are considered in conjunction with the predicted genetic advances. In the present study, broad-sense heritability values ranged from 22. 92 to 71.11 per cent (Table 1). Higher heritability coupled with higher genetic advance was observed for gel yield per plant, dry latex per plant and fresh weight per leaf. High heritability coupled with high genetic advance observed for these characters revealed the additive gene-effects and selection pressure could be profitably be applied on these characters for yield improvement. On the other hand, low heritability coupled with low genetic advance was recorded for leaf: gel ratio and number of leaves plant^{-1} indicating that these traits were greatly influenced by environment. These findings are in accordance with those of Kumar (8) in *Gerbera jamsonii.*

The yield in a plant is the effect of several yield related component characters and environment. Therefore, selection based on yield performance only, may create confusion and give a biased performance; consequently a rational approach towards the improvement of yield necessitates the selection of desirable components of yield. Thus, this assumes a special importance as the basis for selecting desired genotypes. The biometrical tool for this purpose is "correlation", which indicates the intensity and direction of association of a character with yield. The interrelationship of characters of

Table 1. Genetic parameters of yield and yield components in *Aloe*.

Trait	Range	Mean	Coefficient of variability (%)		Heritability (%)	Genetic advance (%)
			Genotypic	Phenotypic		
Plant spread (cm)	30.50-75.83	50.15	27.30	29.07	38.21	2.48
No. of suckers plant^{-1}	2.00-6.00	3.75	39.87	43.42	44.31	1.49
Leaf length (cm)	31.56-54.91	41.36	18.04	20.57	22.92	4.02
No. of leaves plant^{-1}	8.00-14.00	10.62	14.48	23.54	37.84	1.04
Fresh wt. leaf^{-1} (g)	69.91-150.00	103.86	24.90	26.59	57.65	7.30
Dry latex leaf^{-1} (g)	0.09-0.22	0.15	41.12	44.42	38.22	1.97
Dry latex plant^{-1} (g)	0.35-1.50	0.82	66.82	68.04	66.46	6.93
Gel yield leaf^{-1} (g)	35.36-83.50	56.14	44.95	45.91	45.86	3.11
Gel yield plant^{-1} (kg)	0.12-0.56	0.30	66.76	68.45	71.11	17.09
Leaf : gel ratio	1.70-2.07	1.88	12.56	17.51	31.48	0.18
Leaf yield plant^{-1} (kg)	0.23-0.96	0.55	44.24	46.60	51.13	0.43

growth and yield attributing characters provides the information about the likely consequences of selection for simultaneous improvement of desirable characters under consideration.

In the present investigation, the genotypic correlation coefficients were higher than phenotypic correlation coefficients for majority of the characters, suggesting a good chance of selection for these traits. Plant spread, leaf length, number of leaves per pant, fresh weight per leaf, dry latex per leaf, dry latex per plant, gel yield per leaf and gel yield per plant showed high positive genotypic association with leaf yield, thus suggesting that these characters are important yield components and the effective improvement in yield can be achieved through selection based on these characters (Table 2). On the other hand, number of suckers per plant and leaf: gel ratio exhibited a negative correlation with leaf yield per plant. Negative correlation of number of suckers with yield parameters has earlier been reported by Alagukannan and Ganesh (1) in *A. barbadensis*. Leaf length, number of leaves per plant, fresh weight per leaf, dry latex per leaf, dry latex per plant, gel yield per leaf, gel yield per plant and leaf yield per plant have in most of the cases significant positive correlation among themselves at phenotypic level (Table 2). These characters showing strong inter-relationships with other characters can be considered for their inter-dependence in their expression.

The correlation analysis only provides information on the relationship but does not give an idea on the underlying causes. Significant correlation may or may not be a proof of very direct causal relationship. Again when more variables are considered in the correlation study, the association becomes more complex, less obvious and sometimes confusing. At this point, it appears appropriate to employ a method of analysis which will take into account the knowledge that we have with regard to the causal relation between the characters of correlation. Partitioning of phenotypic and genotypic correlation into direct and indirect effects reveals the interesting picture regarding character association and could best be done by utilizing the technique of path coefficient of analysis as developed by Wright (12) and further enunciated by Dewey and Lu (3).

Path analysis is a standardized partial regression coefficient as it measures the direct influence of one variable upon other and permits the separation of correlation coefficient into components of direct and

Table 2. Genotypic and phenotypic correlations among different traits in *Aloe*.

Trait		No. of suckers plant^{-1}	Leaf length (cm)	No. of leaves plant^{-1}	Fresh weight leaf^{-1} (g)	Dry latex leaf^{-1} (g)	Dry latex plant^{-1} (g)	Gel yield leaf^{-1} (g)	Gel yield plant^{-1} (kg)	Leaf: gel ratio	Leaf yield plant^{-1} (kg)
Plant spread (cm)	G	0.328	0.677*	0.906**	0.734**	0.507	0.550	0.740**	0.977**	-0.940**	0.963**
	P	0.226	0.554*	0.677*	0.432	0.343	0.403	0.484	0.551	-0.508	0.876**
No. of suckers plant^{-1}	G		0.922**	-0.503	-0.879**	0.615*	0.662*	-0.847**	-0.645*	-0.902**	-0.830**
	P		0.758**	-0.341	-0.460	0.506	0.424	-0.569	-0.333	-0.488	-0.645*
Leaf length (cm)	G			0.907**	0.917**	0.741**	0.778**	0.997**	0.998**	-0.885**	0.995**
	P			0.577*	0.901**	0.666*	0.670*	0.866**	0.839**	-0.535	0.872**
No. of leaves plant^{-1}	G				0.922**	0.866 **	0.977**	1.027**	0.955**	0.989**	0.944**
	P				0.628*	0.553*	0.578*	0.668*	0.740**	0.684*	0.700**
Fresh weight leaf^{-1} (g)	G					0.646*	0.677*	0.991**	0.960**	0.954**	0.951**
	P					0.564*	0.598*	0.921**	0.878**	0.646*	0.903**
Dry latex leaf^{-1} (g)	G						0.968**	0.595*	0.681*	-0.670*	0.556*
	P						0.909**	0.371	0.444	-0.408	0.305
Dry latex plant^{-1} (g)	G							0.677*	0.790**	-0.802**	0.625*
	P							0.648*	0.736**	-0.535	0.468
Gel yield leaf^{-1} (g)	G								0.989**	0.943**	0.962**
	P								0.951**	0.760**	0.896**
Gel yield plant^{-1} (kg)	G									0.871**	0.917**
	P									0.815**	0.933**
Leaf: gel ratio	G										-0.882**
	P										-0.692*

*,**Significant at 5 & 1% levels, G = Genotypic correlation coefficient, P = Phenotypic correlation coefficient

Table 3. Direct and indirect contributions of various traits to leaf yield per plant in *Aloe*.

Trait	Plant spread (cm)	No. of suckers plant^{-1}	Leaf length (cm)	No. of leaves plant^{-1}	Fresh wt. leaf^{-1} (g)	Dry latex leaf^{-1} (g)	Dry latex plant^{-1} (g)	Gel yield leaf^{-1} (g)	Gel yield plant^{-1} (kg)	Leaf: gel ratio	Leaf yield plant^{-1} (kg)
Plant spread (cm)	**0.169**	0.017	0.077	0.006	-0.330	0.160	-0.057	0.645	0.011	0.157	0.963**
No. of suckers plant^{-1}	0.140	**-0.021**	0.072	0.005	-0.301	-0.140	-0.051	0.581	0.010	0.135	-0.830**
Leaf length (cm)	0.165	0.019	**0.078**	0.007	0.348	0.168	-0.059	0.684	0.011	0.162	0.995**
No. of leaves plant^{-1}	0.182	0.016	0.087	**0.006**	0.350	0.196	-0.075	0.753	0.013	0.181	0.944**
Fresh wt. leaf^{-1} (g)	0.163	-0.018	0.080	0.006	**0.342**	0.147	-0.052	0.680	0.011	0.143	0.951**
Dry latex leaf^{-1} (g)	0.119	0.013	0.058	0.005	-0.221	**-0.127**	-0.074	0.408	0.008	0.100	0.556*
Dry latex plant^{-1} (g)	0.127	-0.014	0.061	0.006	-0.232	-0.220	**-0.076**	0.465	0.009	0.120	0.625*
Gel yield leaf^{-1} (g)	0.159	0.017	0.078	0.007	0.339	-0.135	-0.052	**0.686**	0.011	0.156	0.962**
Gel yield plant^{-1} (kg)	0.165	0.017	0.078	0.007	0.329	0.155	-0.060	0.679	**0.011**	0.160	0.917**
Leaf : gel ratio	-0.177	-0.019	-0.085	-0.007	-0.327	-0.152	-0.061	-0.716	-0.012	**-0.150**	-0.882**

Residual = 0.0009 *,**Significant at 5 & 1% levels

indirect effects of a set of independent variables on a dependent variable. Path coefficient analysis was carried out by taking leaf yield per plant as dependent variable to partition the correlation coefficients into direct and indirect effects in order to determine the contribution of different characters towards the leaf yield per plant. Direct and indirect effects of various characters on leaf yield per plant indicated that there is an agreement between direction and magnitude of direct effect of various characters and correlation with leaf yield per plant. Thus, a significant improvement in leaf yield per plant can be expected through selection in the component traits with high positive direct effects (Table 3).

Among the 10 characters studied, seven showed direct positive association with leaf yield. Positive direct effect on leaf yield per plant was highest *via* gel yield per leaf (0.686) followed by fresh weight per leaf (0.342) and plant spread (0.169) indicating that there is a higher scope for selection through these traits to improve the leaf yield per plant. At the same time all these three characters exhibited a high positive indirect effect on leaf yield per plant via plant spread, leaf length, number of leaves per plant, gel yield per plant and leaf: gel ratio. The genotypic correlation coefficients of dry latex per leaf and dry latex per plant were positive but their direct effect was negative, therefore, the indirect causal factors are to be considered for selection. Chitra and Rajamani (2) have also observed positive and negative direct effect of characters on seed yield in *Gloriosa superba.*

The residual effect determines how best the casual factors account for the variability of the dependent factors, *i.e.* leaf yield per plant in this study. Its estimate of 0.0009 indicated that the variables under study (plant spread, No. of suckers per plant, leaf length, No.of leaves per plant, fresh weight per leaf, dry latex per leaf, dry latex per plant, gel yield per leaf, gel yield per plant and leaf: gel ratio) explain 99 per cent of the variation in the leaf yield. The reason seems to be high and significant correlation of plant spread, fresh weight per leaf and gel yield per leaf with leaf yield per plant. It also clearly indicates that the variables considered in the present study are sufficient to explain the variation in leaf yield per plant.

From the present study of path coefficient analysis, it emerged that gel yield per leaf, fresh weight per leaf and plant spread are important traits that have direct strong bearing on leaf yield per plant and therefore, these traits must be considered, while designing the selection indices for the germplasm improvement of this species.

REFERENCES

1. Alagukannan, G. and Ganesh, S. 2006. Variation and correlation studies in *Aloe vera* L. ecotypes. *Madras Agric. J.* **93**: 88-94.

2. Chitra, R. and Rajamani, K. 2010. Character association and path analysis in glory lily (*Gloriosa superba* L.). *Comm. Biometry Crop Sci.* **5**: 7882.

3. Dewey, D.R. and Lu, K.H. 1959. A correlation and path co-efficient analysis of components of crested wheat grass and seed production. *Agron. J.* **51**: 515-18.

4. Ganesh, S. and Alagukannan, G. 2009. Growth, yield and quality of ecotypes of *Aloe vera* L. *Madras Agric. J.* **96**: 88-94.

5. Gupta, S.K., Kumar, S. and Raina, N.S. 2010. Collection and evaluation of kala zeera- *Bunium persicum* (Bioss.) Fedtsch. *J. Med. Arom. Plant Sci.* **32**: 37-41.

6. Heywood, V. H. 2002. The conservation of genetic and chemical diversity in medicinal and aromatic plants. **In**: *Biodiversity: Biomolecular Aspects of Biodiversity and Innovative Utilization*. Sener, B. (Ed.), Kluwer Academic/Plenum Publishers, New York, pp. 13-22.

7. Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.* **47**: 314-18.

8. Kumar, R. 2015. Genetic variability and character association among quantitative traits in gerbera. *Indian J. Hort.* **72**: 88-91.

9. Rajeswari, R., Umadevi, M., Sharmila, R.C., Pushpa, R., Selvavenkadesh, S., Sampath, K.K.P. and Debjit, B. 2012. *Aloe vera:* The miracle plant, its medicinal and traditional uses in India. *J. Pharma. Phytochem.* **1**:118-24.

10. Reddy, C.U., Komar, S.R. and Jaddu, J.R. 2011. Aloe vera - A wound healer. *Asian J. Oral Health Allied Sci.* **1**: 91-92.

11. Snedecor, W. and Cochran, W.G. 1987. *Statistical Methods*, Oxford and IBM, Calcutta, 593 p.

12. Wright, S. 1921. Correlation and causation. *J. Agric. Res.* **20**: 557-87.

Received : July, 2015; Revised : March, 2016; Accepted : April, 2016