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Full Length Research Paper

Estimation of genetic variability in *Phyllanthus emblica* L. - Towards a contribution in sustainable rural development

Bhupendra Singh[1]*, A. K. Uniyal[1], J. S. M. Rawat[2] and D. K. Rana[2]

[1]Department of Forestry, Post Box-59, H.N.B. Garhwal University, Srinagar Garhwal, 246 174, Uttarakhand, India.
[2]Department of Horticulture, Post Box-59, H.N.B. Garhwal University, Srinagar Garhwal, 246 174, Uttarakhand, India.

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The fruits of *aonla* (*Phyllanthus embilica* L.) were collected from four natural sites and were subjected to various morpho-chemical components for estimation. The observed variation was partitioned into heritable and non-heritable components in order to identify the characters for which selection will be most effective. This study revealed that morpho-chemical characters of *P. embilica* exhibited considerable genetic variability in fruit morphology, especially those based on fruit weight, which has high genotypic variation, higher heritability and greater potential for genetic gain. Vitamin C had moderate genetic variance, moderate heritability but greater genetic gain. Selection can therefore be effective based on these two characters and their phenotypic expression should be an indication of their high genotypic potential.

Key words: *Phyllanthus emblica,* fruit length, fruit weight, moisture percent, genetic variation, heritability.

INTRODUCTION

Phyllanthus emblica L. (V. Anwla or Aonla) is a deciduous tree of the family Euphorbeaceae, a native of India (Gaur, 2003), it has also been reported from Sri Lanka, Thailand, China, Japan and Vietnam. It is probably the only edible fruit to fill the gap of astringent food recommended by the Ayurvedic system of medicine for a balanced diet and sound health. The fruits are rich in vitamin C (Kumar and Singh, 2002) and are consumed fresh, pickled and processed into a variety of sweet and tasty food products. Aonla has great potential as a cash-generating tree for the farming communities in the Uttarakhand hills of India. The tree has been promoted as a multi-purpose crop suitable for cultivation in the mountain farms of Uttaranchal by the local government which has emphasized the importance of producing and processing high medicinal value agroforestry tree crops. This investigation was conducted to identify and select superior germplasm of Anola from natural populations in the Uttarakhand hills of Uttaranchal before too much genetic erosion takes place.

*Corresponding author: E-mail: butola_bs@yahoo.co.in.

MATERIALS AND METHODS

Fruits of *P. emblica* were collected from four sites (Table 1) ranging from 30° 12'N to 30° 51' N latitude, to 78° 37' 4' E to 78 56' E longitude and at elevations ranging from 1050 to 1550 m asl. The average rainfall is 112 to 165 mm per year. The maximum average temperature ranges between 26 to 29°C and the minimum from 10 to 12°C (Table 1). During April 2005, ripe fruits of Aonla were collected from ten healthy trees at each of the four sites. Damaged fruits were rejected. The bulk sample of all the parent trees for each site was then put into cotton bags and allotted an accession number (seed source) before bringing them to laboratory. Each sample was stored in a cool incubator (5°C) until further analysis. The moisture content (%) of each fruit sample was determined on a fresh weight basis by drying the fruits at 103±3°C as per ISTA 1999 rules. Fruit length, diameter, weight and pulp: stone ratio was evaluated on five replicates samples, each consisting of 20 fruits randomly drawn from each bulked fruit lot. Fruit length and diameter was measured using a micrometer (Besto). The fruit weight of five more replicates samples (each of 100 fruits) was recorded using electronic top pan balance (ISTA, 1999). Total soluble solids (TSS) were determined at 20.0°C using a hand held refractrometer and values correlated. Acidity was determined by titrating the fruit pulp against 0.5 N/NaOH and expressed as percent malic acid. Vitamin C was analysed according to A.O.A.C (1975). Similarly, soluble sugar was determined by the method of Mc Cready et al. (1950).

The results were statistically analysed using ANOVA, Tukey test (Bartz, 1988), phenotypic coefficient of variation (PCV), genotypic

Table 1. Morphological-chemical variation in fruit characters of *P. emblica.*

Source	Altitude	Fruit length (cm)	Fruit diameter (cm)	Fruit weight/100 fruits (g)	Moisture (%)	Pulp/stone ratio	Total soluble solids (%)	Sugar (%)	Vitamin C (mg/100 g)	Malic acid (%)
Gajeli	1050	1.78±0.03^{b}	1.99±0.10^{ab}	498.48±19.76^{b}	75.13±0.63^{ab}	11.90±0.28^{bc}	14.32±0.11^{a}	4.25±0.06^{a}	508.00±2.71^{b}	2.64±0.34^{a}
Thadiyar	1150	1.67±0.06^{c}	1.88±0.05^{b}	415.03±7.24^{c}	77.37±0.75^{a}	11.31±0.36^{c}	12.960.26^{c}	2.90±0.16^{b}	529.53±2.28^{a}	2.01±0.34^{b}
Dagar	1300	1.83±0.06^{b}	2.13±0.17^{a}	527.49±38.08^{b}	76.14±0.66^{a}	12.68±0.90^{b}	13.200.14^{b}	4.39±0.05^{a}	491.73±7.23^{c}	2.30±0.08^{ab}
Kandikhal	1550	1.95±0.05^{a}	2.15±0.10^{a}	651.22±17.12^{a}	73.39±0.87^{b}	14.29±0.11^{a}	13.920.11^{a}	2.59±0.03^{c}	506.43±3.36^{b}	1.85±0.17^{b}
	Mean	1.81	2.13	523.06	75.51	12.55	13.35	4.03	508.92	2.20
	C.V	6.63	12.68	18.70	2.22	10.28	7.19	8.93	3.06	15.91
	'r'	0.77**	0.84**	0.69**	-0.35^{NS}	0.64**	-0.09^{NS}	-0.90**	0.17^{NS}	0.77**

** Significant at P = 0.01, NS = non significant. Means followed by same later within each column are not significantly (P< 0.05) different, (± S.D.)

Table 2. Estimation of genetic variable for various fruit and biochemical characteristic of *P. embilica.*

Estimates	FL	F D	FW	M %	P/S ratio	TSS	Sugar	VC	MA
Phenotypic variance	0.016	0.026	9375.77	3.981	1.88	0.429	0.850	344.58	0.174
Genotypic variance	0.013	0.011	8773.12	2.080	1.57	0.371	0.845	191.38	0.091
PCV	6.99	7.57	18.51	2.64	10.92	4.91	22.88	3.15	18.96
GCV	6.29	4.92	17.91	1.01	9.98	4.56	22.81	2.35	13.71
Heritability (h^2)	0.81	0.42	0.94	0.52	0.83	0.86	0.99	0.55	0.523
Genetic advance	21.07	13.92	187850.16	213.16	234.24	115.15	187.62	2102.28	44.67
Genetic gain (%)	1164.08	653.52	3584.70	282.29	1866.15	862.54	4655.58	356.97	2030.45

Abbreviation: PCV - Phenotypic coefficient of variation, GCV - genotypic coefficient of variation, Heritability (h^2) - heritability (broad-sense), FL = fruit length, FD = fruit diameter, FW = fruit weight, M% = moisture percent, P/S ration = pulp/stone ratio, TSS = total soluble solid, VC = vitamin c, MA = malic acid.

coefficient of variation (GCV) were calculated as done by Barton and Devena (1953) while heritability (H), genetic advance (GA) and genetic gain were workout following Johnson et al. (1955) and simple correlation coefficients (Gupta, 1981).

RESULTS

Morphological characters

Fruit dimensions varied significantly (p = 0.05) among the four accessions. Fruit length ranged from 1.67 to 1.95 cm; diameter from 1.88 to 2.15 cm; fruit weight from 415.0 to 651.2 g/100 fruits; moisture contents from 73 to 77% and pulp:stone ratio ranged from 11.31 to 14.29. Values for all these characters were greatest at Kandikhal (1550 m asl) and lowest at Thadiyar (1150 m asl). The moisture content was highest at Thadiyar (1150 m asl) and lowest at Kandikhal (1550 m asl). Fruit length, diameter, weight and pulp:stone ratio were positively correlated (p = 0.01) with the mean elevation of the source (Table 2).

Biochemical variation

The total soluble solids ranged from 12.96 (Thadiyar) to 14.32% (Gajali); sugar from 2.59 (Kandikhal) to 4.39% (Dagar); Vitamin C from 491.73 (Dagar) to 529.53 mg/100 g (Thadiyar) and malic acid from 1.85 (Kandikhal) to 2.64% (Gajali). Total soluble solids and vitamin C were not correlated with elevation, while sugar content was negatively correlated with elevation (P=0.01) and malic acid was positively correlated (P=0.05) with elevation of the seed source (Table 2).

Genetic variability

Highest phenotypic (9375.77) and genotypic (8773.12) variance was found in fruit weight. However, the lowest values (0.016 and 0.011) were found in fruit length and fruit diameter for genotypic and phenotypic variance, respectively. The heritability (broad sense) values were highest (0.99) for sugar content whereas, and lowest (0.42) for fruit diameter. Genetic advance was found to be maximum (187850.27) for fruit weight and minimum (13.92) for fruit diameter. On the other hand, the highest genetic gain was for sugar (4655.58%) and least (282.29%) for moisture content.

Site variation

Analysis of variance found that the different physicochemical characteristics (except for fruit diameter, moisture content and malic acid) were highly significant (p = 0.01) between sites, but that all traits were not significantly different among the families (replicate sample) within the different sources.

DISCUSSION AND CONCLUSION

Morphological variation in fruit characters of *P. emblica* between populations could have been a result of differences in the environmental conditions, for example, nutrient, light or water to which the mother trees were subjected during growing season (Gutterman, 1992; Murali, 1997). Significant variations have also been observed in the different physio-chemical constituents of selected cultivars of *Emblica officinalis* by Sanjeev and Singh (2002). Similar variation in morphological characters of fruits have been previously reported for *Arachis* species (Chandran and Pandya, 2000), *Cola nitida*, (Adebola et al., 2002); *Dioscorea cayenensis* (Dansi et al., 1998); *Irvingia gabonensis* (Leakey et al., 2000); *Dacryodes edulis* (Waruhiu et al., 2004); *Sclerocarya birrea* (Leakey et al., 2005a, b); *Barringtonia procera* (Pauku et al., 2010) and for different chemical contents in *Choerospondies axillaries* (Paudel et al., 2002) and *Canarium indicum* (Leakey et al., 2008). Dubey (2000) has also reported variations in physicochemical properties in different cultivars of *Citrus sinensis*. The heritability provides measures of genetic variation upon which all the possibilities of improving the genetic composition of the species depend. While genetic gain express the degree of genetic improvement achieved within a selection process during the domestication of a species. Heritability estimates along with genetic gain are more useful than the heritability alone in predicting the resultant effect for selecting the best genotypes for a series of given traits (Volker et al., 1990; Singh and Chaudhary, 1993). The highest PCV was observed for sugar content followed by fruit weight and malic acid. Greater improvement could therefore be expected in the selection for these characters. The GCV values of present investigation were lower than the PCV values. A similar trend was found in *Prunus persica* (Khajuria et al., 1986); in *Sphenostylis stenocarpa* (Okoye and Ene-obong, 1992); in *Anacardium occidentale* (Vijulan et al., 1994), in *Prunus dulcis* (Sharma and Chandrababu, 1997), in *Cola nitida* (Adebola et al., 2002); and in *Musa* spp. genotypes (Kulkarni et al., 2002).

In this study, high heritability computed with high genetic advance was observed in fruit weight, Vitamin C, pulp:stone ratio, moisture content percent and sugar content, showing that the variability in these characters might be attributed to additive action. On the other hand, moderate to high heritability but low genetic advance was observed in fruit length, fruit diameter, total soluble solid and malic acid, suggesting non additive gene action and limited scope for improvement in respect of these characters. The genetic variability characters estimated for *P. emblica* reveals that fruit weight have high genotypic variation, higher heritability and greater genetic gain while Vitamin C have a moderate genetic variance, moderate heritability and greater genetic gain. Thus, selection can be effectively based on these two characters and their phenotypic expression should be an indication of their genotypic potentiality. The remaining characters had lower genetic variance, and genetic advance but moderate to higher heritability can be offered less scope for selection as they are much more under the influence of the environmental condition and accounted for non additive gene effects, as observed in tomato (Shan and Mishra, 1995). *P. emblica* is an important medicinal tree growing in traditional agroforestry systems, woodlots and forest near villages of Garhwal Himalayan region. The increasing pressure of human population and abrupt demand of plant materials consumed as fresh, pickled, variety of sweet and tasty food products those highly medicinal values has depleting at an alarming rate. Besides this, young trees in natural forests are lopped for fodder, fuel and timber, thus their over- exploitation is threatening the species in its natural habitat.

Future collection and evaluation of *P. emblica* should include new areas of Garhwal Himalaya. New parameters such as seed characters, germination potential, seedling growth should be assessed, and field trials should be considered for subsistence farming to enhance opportunities for poor farmers to improve their livelihoods and to maintain the sustainable status of this native species. This approach to agroforestry is seen as a means of developing multifunctional agriculture (Leakey, 2010).

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