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Genetic variability in *Jatropha curcas* in Himachal Pradesh

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Abstract

The study on *Jatropha curcas* was conducted in Himachal Pradesh to estimate the genetic variability for the plant phenotypical characters, seed traits and nursery growth parameters among the different altitudinal provenances. The characters like number of fruits/tree, seed yield / tree, oil content and one hundred seed weight had high genotypic coefficient of variation, heritability and genetic advance indicating importance of these characters for selection purposes. Results also revealed that germination percentage, germination energy, number of branch/tree and seed pulp ratio were ineffective for selection because of low genetic estimates. Nineteen characters of *Jatropha curcas* were classified in to four factors contributing to 85.14 per cent of total variation.

Keywords : Genotypic coefficient of variation, Genetic advance, Heritability, Nursery growth characters, Seed traits, Stratified random sampling,

Introduction

Jatropha curcas, popularly known as Ratanjot, have an immense potential for producing oil, which finds large-scale industrial uses. *Jatropha curcas* is a medium, soft wooded, deciduous, multipurpose tree of 4-7 meter height that belongs to the family Euphorbiaceae. Plant displays vigorous growth in early periods. Plants from seed develop a taproot and four lateral roots whereas cuttings do not develop a tap root (Heller, 1996). In field condition, it may produce seed yield as high as 12 t/ha/ year after five years of plantation (Jones and Miller, 1992), while 0.8 to 1.0 kg of seed per meter of live fence can be obtained if it is planted for hedge (Henning, 1996). Flower and seed production responds positively to rainfall/ moisture and fertility of soil. With one rainy season per year, there is generally one annual fruiting, which may go up to 2-3 under irrigated condition. The plant is easy to establish, grows relatively quickly and is hardy being. In low rainfall areas and in prolonged drought, the plant sheds its leaves as a counter to drought, therefore, the plant can be well adapted in the state of Rajasthan and other parts of the country on marginal soils with low to medium rainfall conditions. The oil content of seeds represents a reasonable opportunity for renewable fuels (Princen, 1983; Schultz and Morgan, 1985, Harrington,1986). A study on energy yield from different plants in terms of the liquid fuel/acre/year/inch of water indicated that *Jatropha curcas* yielded the highest energy among many processes under test (Calvin, 1987). The seed of *Jatropha curcas* contains about 38-40 per cent non-edible oil. The oil is much more viscous than diesel and has low ignition quality (Keith, 2000).

In India the species has started gaining importance in recent years due to the increased demand of biofuels. Variation studies in general help us to compare the population and to select superior trees for regeneration purposes. For effective utilization of natural variation, the genetic and environmental components are first and foremost to be identified. Univariate statistical analysis are not adequate as they ignores the correlation among the variables and sometimes the conclusions may be misleading, while the multivariate analysis takes into account the interdependence and relative importance of the various characters involved and yield more meaningful information. The present study was conducted in Himachal Pradesh to evaluate the genetic variability for different plant phenotypical chacters, seed traits and nursery growth parameters in *Jatropha curcas* population. Principal component technique is also applied to various characters of *J. curcas*.

Materials and Methods

Variation study of *J. curcas* was conducted in Himachal Pradesh where it grows up to an elevation of 1000 m amsl. Stratified two stage random sampling technique

was used for the selection of sample trees. The state of Himachal Pradesh was divided in to three altitudinal provenances i.e. (below 600 m amsl), P_2 (600-800 m amsl) and P_3 (above 800 m amsl). Under each altitudinal provenance) five sites were selected randomly from different parts of the state making it to a total of fifteen sites. From each site fifteen phenotypically superior trees of approximately same height and stem diameter were selected during September-October, 2004. The observations on the number of branches tree, number of fruits/branch, number of fruits/tree, seed yield /tree(gms), seed-pulp ratio, oil content (%) oil yield (kg/tree), seed length (cm), seed width (cm), one hundred seed weight (g) and seed viability (%) were recorded and denoted as X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10} and X_{11} and seeds were collected during October, 2004. Seeds were sown in the nursery during the first week of April, 2005 and the observations on time taken to initiate germination (in days), germination percentage, germination energy (%), shoot length (cm), collar diameter (mm), number of leaves / seedling, root length (cm) and seedling height (cm) were recorded and denoted as X_{12}, X_{13}, X_{14}, X_{15}, X_{16}, X_{17}, X_{18} and X_{19} respectively. Randomised Block Design was used to test the significance of altitudinal provenances.

Genotypic and phenotypic coefficient of variability, heritablility in broad sense and genetic advance were worked out by the formula suggested by Burton and Devane (1953) and Johnson *et al*. (1955). Genetic gain was calculated by the method suggested by Johnson *et al.* (1955). Factor analysis is applied in accordance with Lawley and Maxwel (1963), and Sharma and Chaudhary (1985).

Results and Discussion

Table 1 presents the mean, standard error of mean, range and coefficient of variation for the various characters of *Jatropha curcas* Mean seed yield per tree was 471.50g and it ranged from 327.50- 651.00 g, while oil content was 38.66 per cent and it varied from 22.68 to 45.00 per cent. Seed length ranged from 1.45 -2.00 cm while seed width varied from 1.14 to 1.42 cm. Munch (1986) reported that the seeds are black, 2 cm long and 1 cm thick. Seed viability, seed germination and germination energy was found to be 55.67,51.81 and 27.92 per cent respectively. The result. indicated that a wide range of variability was observed in almost all the characters. Coefficient of variation was ranging from 2.29 to 35.14 per cent and it had maximum value in the oil yield.

Table 2 presents the genotypic and phenotypic coefficient of variability, heritability, genetic advance and genetic gains for different characters. Genotypic coefficient of variation ranged from 1.00 to 52.75 per cent and it was maximum for seed length and minimum for time taken to initiate germination. Higher genotypic and phenotypic coefficient of variability for seed length, one hundred seed weight, seedling height, shoot length, oil contents, number of fruits/ branch, oil yield /tree, number of branch /tree, root length, number of leaves/seedling and collar diameter

Table 1 : Mean, standard error range and coefficient of variation for different characters of Jatropha curcus

Characters	Mean	SE (Mean)	Range	Coefficient of variation
Number of branch/tree	8.23	0.38	7.00-10.83	27.58
Number of fruit/branch	19.12	0.70	13.83-25.83	12.11
Number of fruits/tree	158.75	9.65	102.00-217.00	26.49
Seed yield/tree (g)	471.50	25.71	327.50-651.00	12.72
Seed : pulp ratio	0.37	0.007	0.34-0.40	5.89
Oil content (%)	38.66	0.86	22.68-45.00	33.28
Oil yield (kg/tree)	0.07	0.004	0.04-0.09	35.14
Seed length (cm)	1.73	0.03	1.45-2.00	5.25
Seed width (cm)	1.27	0.01	1.14-1.42	2.29
100 seed weight (g)	49.58	0.99	29.37-68.53	6.93
Seed viability (%)	55.67	1.98	45.00-67.00	12.32
Time taken to initiate germination (days)	8.58	0.15	7.00-9.33	10.49
Germination percentage	51.81	0.45	40.67-63.33	5.19
Germination energy (%)	27.92	0.51	21.67-42.67	10.83
Shoot length (cm)	23.07	0.62	16.80-38.30	16.11
Collar diameter (mm)	10.92	0.42	8.57-12.41	22.99
Number of leaves/seedling	12.50	0.32	9.08-12.41	15.24
Root length (cm)	18.11	0.43	13.07-28.83	14.49
Seedling height (cm)	38.73	0.89	29.13-67.13	13.83

Table 2 : Genetic estimates for the different characters of *Jatropha curcas*

Characters	Coefficient of Variability		Heritability	Genetic Advance	Genetic Gain
	Genotypic	Phenotypic			
Number of branch/tree	23.83	36.37	0.43	2.66	32.28
Number of fruit/branch	28.71	29.11	0.91	13.26	69.39
Number of fruits/tree	21.11	24.43	0.74	86.04	54.20
Seed yield/tree (g)	11.52	12.95	0.79	84.51	17.93
Seed : pulp ratio	4.17	5.61	0.55	0.14	37.83
Oil content (%)	35.10	37.53	0.87	26.14	67.82
Oil yield (kg/tree)	27.14	39.40	0.31	0.06	90.57
Seed length (cm)	52.75	55.25	0.91	1.19	69.19
Seed width (cm)	9.97	10.24	0.94	0.25	20.01
100 seed weight (g)	42.55	43.21	0.97	29.51	59.39
Seed viability (%)	16.68	22.46	0.69	11.19	20.72
Time taken to initiate germination (days)	34.83	38.37	0.85	8.50	35.32
Germination percentage	22.86	26.33	0.24	7.29	66.24
Germination energy (%)	24.80	29.11	0.73	6.94	56.28
Shoot length (cm)	26.38	30.09	0.77	2.62	14.96
Collar diameter (mm)	34.40	37.08	0.86	12.36	31.75
Number of leaves/seedling	1.00	1.54	0.09	0.02	0.25
Root length (cm)	5.31	7.42	0.51	1.96	3.71
Seedling height (cm)	16.37	19.63	0.70	3.82	13.64

have been found among altitudinal provenances, thus suggesting wide genetic variation for these traits. The high genetic variability revealed that the major part of total variation is due to genetic factors. The heritability was maximum in one hundred seed weight (0.97) followed by seed width (0.94), number of fruits /branch and seed length respectively. Higher value of genetic advance was noticed in number of fruits per tree (86.04) followed by seed yield per tree (84.51) and one hundred seed weight. Genetic gain was maximum in oil yield (90.57) followed by number of fruits per branch (69.39), seed length (69.19), oil content, (67.62) and collar diameter (66.24) respectively whereas minimum genetic gain was for time taken to initiate germination. Relatively high heritability and genetic advance for number of fruits/tree, seed yield/tree, oil content and one hundred seed weight indicated that selection can be carried out directly on phenotypyic basis for these characters. High heritabilty and low genetic advance for number of fruits /branch, seed length, seed width, shoot length, number of leaves /seedling, root length and seedling height implies that heritability was mostly due to non-additive gene effects. Thus, these characters should not be relied upon for the purpose of selection. High genotypic coefficient of variability, heritabilty followed by high genetic advance was observed for number of fruits/ tree, oil content and one hundred seed weight. These estimates indicate that the above three characters have good opportunities for practicing selection which is the basic tool of plant improvement Lantz (1975). Negligible genotypic coefficient of variation, heritability and genetic advance has been found for time taken to intiate germination, germination percentage, germination energy and number of branches/tree which implies that selection for these characters among the altitudinal provenances will be ineffective. The adaptation strategies along the altitudinal provenances have also been suggested for tree species by Rehfeldt (1985).

The study is in line with Cotterill and Dean (1988) and Gupta and Sehgal (2001). The genetic constitution of a population of trees reflect the environmental conditions under which the trees are evolved (Cambell, 1979) and the expression of the genetic variability depends upon the environment in which the trees are further grown. The existing variation may be due to the variation of individual stands and efficient selection can be based on the deep understanding of genetic variation between and within population in the breeding programme.

The factor analysis technique was applied to extract the basic factors underlying the observed traits of *Jatropha curcas*. The factors were extracted one by one on the basis of eigen values which are presented in Table 3. The other factors corresponding to eigen values less than unity have not been taken into consideration. These factors are ignored due to “Guttmen’s lower bound principle” according to which eigen value less than unity (A>1) should be ignored. Ignoring the non-significant correlations, orthogonal factors are extracted. The

Table 3 : Rotated factor matrix for various characters of *Jatropha curcas*

Characters	Factor			
	1	2	3	4
Number of branch/tree	0.174	0.299	0.365	0.771
Number of fruit/branch	0.484	0.625	0.485	-0.283
Number of fruits/tree	0.537	-0.519	0.636	0.033
Seed yield/tree (g)	0.540	-0.534	0.609	0.015
Seed : pulp ratio	0.466	0.714	0.285	0.015
Oil content (%)	-0.456	0.36	-0.449	0.612
Oil yield (kg/tree)	0.269	-0.244	0.301	0.838
Seed length (cm)	0.45	0.634	0.471	-0.226
Seed width (cm)	0.389	0.705	0.39	-0.225
100 seed weight (g)	0.749	0.495	0.114	0.097
Seed viability (%)	0.814	0.338	-0.115	-0.162
Time taken to initiate germination (days)	-0.32	0.093	-0.111	0.757
Germination percentage	0.695	0.631	-0.08	-0.149
Germination energy (%)	0.435	0.739	0.196	0.003
Shoot length (cm)	0.578	-0.459	-0.522	0.208
Collar diameter (mm)	0.628	-0.007	-0.606	-0.189
Number of leaves/seedling	0.874	-0.223	-0.352	-0.046
Root length (cm)	0.734	-0.319	-0.486	0.196
Seedling height (cm)	0.779	-0.189	-0.472	0.035
Eigen value	6.33	3.91	3.33	2.61
Per cent variation	33.32	20.60	17.50	13.72
Total variation	33.32	53.92	71.42	85.14

Centroid method of analysis (Lawley and Maxwell,1963) is used in arriving the factors. Thus, the following four factors were obtained

Factor 1: $0.749\ X_{10} + 0.814\ X_{11} + 0.695\ X_{13} + 0.578X_{15} + 0.628X_{16} + 0.874X_{17} + 0.734X_{18} + 0.779\ X_{19}$

Factor 2 : $0.625\ X_2 + 0.714\ X_5 + 0.634\ X_8 + 0.705X_9 + 0.739\ X_{14}$

Factor 3 : $0.636\ X_3 + 0.609\ X_4$

Factor 4: $0.771\ X_1 + 0.612\ X_6 + 0.838X_7 + 0.757X_{12}$

The first four factor had. variance 6.33,3.92,3.33 and 2.61 (33.32, 20.60, 17.51 and 13.72 per cent of total variation) aggregating to 85.14 per cent of total variation. The first factor extracted was the combination of hundred seed weight, seed viability, germination percentage, shoot length, collar diameter number of leaves per seedling, root length and seedling height. The second factor is a combination of number of fruits per branch, seed:pulp ratio, seed length, seed width and germination energy. The third factor signifies the combination of number of fruits per tree and seed yield per tree and fourth factor signifies the combination of number of branch per tree, oil content, oil yield and time taken to initiate germination. Results of such work have been reported by Zhang and Cui (1993) and Jaiswal and Kanaujia (1994). Thus nineteen characters of *Jatropha curcas* were classified into four basic factors by applying the factor analysis technique of multivariate analysis. These factors could be used for further breeding programme for exploiting the hybrid vigour for higher biomass.

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