GENETIC EVALUATION OF JATROPHA (*JATROPHA CURCAS* LINN.) GENOTYPES

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ABSTRACT

A study was conducted at Jatropha Research Station of Phytosalinity Discipline, Central Salt and Marine Chemical Research Institute, Chorvadla, Bhavnagar, Gujarat, India. The objective was to determine the extent of variability, GCV, PCV, heritability, genetic advance and genetic gain for 14 characters in nine genotypes (including two non-toxic sp.) of *Jatropha curcas* L. i.e. Buret, Chikhla, Kangaroo, PC-26, PC-27, Ranpur, Rotinda, Shamlaji and Zanjmer. Healthy branch cuttings collected from nine sources from western India representing the states of Rajasthan and Gujarat were evaluated for their growth performance from nursery stage (3 months) to first bearing in field (1.5 years). Highly significant differences among genotypes were observed for most of the characters except primary branches in all genotypes. Higher phenotypic coefficients of variations were observed for plant height, plant canopy, collar diameter, number of primary and secondary branches, average seed weight, number of seeds and capsules, number of leaves, seed yield and oil content. The traits like seed yield, plant canopy, number of leaves, seed oil and kernel oil had higher genetic components than environmental components. Study concludes that plant canopy, seed yield and number of leaves, seed oil and kernel oil content showed high heritability coupled with high genetic advance. So these may be considered for selection to improve jatropha varieties/genotypes.

KEYWORDS: ***Jatropha curcas;*** **genotypes; variation; testing; agronomic traits; India.**

INTRODUCTION

Jatropha curcas L. (Euphorbiacea) is a non-edible oilseed and a drought tolerant perennial shrub. It has gained importance in recent past as a potential bio-fuel crop. It is a multipurpose crop and is valued not only for its medicinal properties but also for its use as a substitute of bio-diesel (4, 9). In India, initiatives have been taken up by several development organizations

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(both public and private) to promote *J. curcas* L. for greening wastelands and also for meeting the fuel demand. However, major limitation is the use of plant material that is available 'wild' locally (3). Further, differences in qualitative characters observed in candidate plus tree seem to be less influenced of environment on growth and yield related characters of the crop.

If variability in population is largely due to genetic cause with least environmental effect, probability of isolating superior genotype is a prerequisite for obtaining higher yield. As yield is ultimate expression of various yield-contributing characters, direct selection for yield could be misleading (5, 8). This is difficult to judge what proportion of observed variability is heritable and what proportion is non-heritable i.e. environmental. The process of breeding such population is primarily conditioned by magnitude and nature of interactions of genotypic and environmental variations in plant characters. So it becomes necessary to partition the observed variability into its different components and to have an understanding of parameters such as genetic coefficient of variation, heritability and genetic advance.

The present research work was undertaken to find out and establish suitable selection criteria for higher pod yield in jatropha through variability study.

MATERIALS AND METHODS

This study was conducted in highly eroded forest land on hill slope (undulated) at Jatropha Research Station of Phytosalinity Discipline, Central Salt and Marine Chemical Research Institute, Chorvadla, Bhavnagar (Gujarat), India (21° 40' N, 071° 47' E) at an altitude of approximately 682 feet (207.9 meter). In this area mean annual rainfall averages 650 mm. Average annual potential evapo-transpiration (PET) is 1800 m, maximum and minimum temperature are 31.1 and 22.8°C, respectively. There is no salinity or alkalinity problem in this region. The soil is a gravelly sandy clay loam. The excessive drainage, rapid permeability, shallowness of soil, lithic contact at a very shallow depth and presence of rock out crops in moderate amounts ultimately have resulted in poor irrigation and land capability.

Healthy intermediate branches (with pale green colour and slender whitish spots on branch) of nine *J. curcas* genotypes (Buret, Chikhla, Kangaroo, PC-26, PC-27, Ranpur, Rotinda, Shamlaji and Zanjmer) were collected through the field surveys representing the states of Rajasthan and Gujarat. These branches were evaluated for their growth performance from nursery stage to one year old plants. Parent plants were chosen randomly from each population, located at about 40m apart.

A uniform pretreatment was given to branch cutting prior to sowing them in LSF (liquid sea weed fertilizer), kept soaked for 24 hours at 5 percent concentration. Branch cuttings were sown directly in polythene bags (one cutting per bag) containing potting mixture of sand, soil and farm yard manure in ratio of 1:1:1 (by volume) in three replications of 100 cutting each using randomized block design as per ISTA rules (1). Prior to sowing, polythene bags containing potting mixture were treated with fungicide (0.2% Bavistin) and covered with plastic sheet for 24 hours. Sprouting observation was taken daily till sprouting in all treatments was completed (upto 20 days). Branch cuttings were maintained in the nursery till their field plantation. Four month old branch cuttings were planted in the field (pit size 45x45x45 cm) in a randomized block design in three replications, maintaining 3 x 3 meter distance. Observations were recorded on phenotypic characters (plant height, plant canopy, girth diameter, number of primary, secondary and tertiary branches, number of leaf per plant, total capsules per plant, average seed weight, number of seeds per plant and basal height for 1^{st} branch initiation). Five plants were randomly selected from each entry to collect data. Data were subjected to analysis of variance and least significant difference (LSD) test using statistical program SPSS (Version 6.1). The genotypic and phenotypic coefficients of variation and heritability (broad sense) were computed as per Singh and Chaudhary (13), while genetic advancement and genetic gain was calculated using the method of Johnson *et al.* (6).

RESULTS AND DISCUSSION

Analysis of variance showed highly significant variations among the genotypes for almost all traits (Table 1). It indicated the presence of considerable amount of variability in material to improve different characters including seed yield provided the germplasm collected from wild is subjected to judicious selection. PC-27 had higher canopy (420.0 cm) and Ranpur had lowest (221.11cm)(Table 2). While considering plant height, PC-26 produced the tallest plant (159.2 cm) and Chikhla was dwarf (119.43 cm) among all genotypes. Considering number of primary branches, genotype Kangaroo bore maximum primary branches (25.0) and Ranpur had minimum (2.8). PC-26 produced higher number of capsules per plant (55.33) against lowest (4.66) by Chikhla. PC-26 also excelled in number of seeds per plant (63.0) while Chikhla produced minimum (10.66). Similarly maximum seed weight

Table 1. Anaysis of variance for 14 morpho-physiological traits of nine jatropha genotypes.

Source of variance	Mean square with level of significance		
	Replications (2df)	Treatment adjusted (8df)	Error-effective (16 df)
Plant height (cm)	567.1632	616.721*	211.0720
Plant canopy (cm)	20586.9	17419.2**	2787.4
Collar diameter (cm)	24.41	9.83*	2.75
No. of primary branches	1.9002	2.28	1.55
No. of secondary branches	3.61	3.12	2.60
No. of tertiary branches	7.09	11.95*	4.54
No. of leaves	8320.5	26850.7**	5501.3
No. of capsules	5.03	663.19*	241.14
No. of seeds	444.9	925.41**	297.3
Collar height (at branching)	7.64	22.38*	7.83
Average seed weight.	0.0042	0.042**	0.011
Oil content (kernel)	0.0994	569.35**	8.5170
Oil content (seed)	9.2977	152.83**	5.6011
Seed yield (g)	330.02	2160.7**	361.01

and collar height (at branching) were noted in Zanjmer (0.83 g) and Rotinda (11.2 br.) against minimum in Chikhla (0.46g) and PC-26 (3.7 br), respectively.

Number of secondary branches was maximum in PC-27 (8.2) and lowest in Rotinda (5.1). In case of number of tertiary branches per plant, Zanjmer had higher (11.1) and Ranpur had the lowest (5.6). Highest number of leaves and seed yield per plant was found in PC-27 (420) and PC-26 (97.6 g), respectively. Minimum values of these parameters were given by Shamlaji (115) and Chikhla (8.4 g). The data (Table 3) further revealed that genetic components of variance for different characters (seed yield, plant canopy, number of leaves, seed oil and kernel oil) had higher genetic components than environmental components and exhibited a close correspondence with phenotypic variance in above mentioned characters.

Tree breeding strategy largely depends upon extent of variability in base population which may be measured by different parameters viz. ‘genotypic, phenotypic variances’ and ‘genotypic, phenotypic coefficient of variation’. The genotypic coefficients of variation were comparatively lower than phenotypic coefficients of variation for all traits. Rathinam (11) also reported similar results for height and collar, Ginwal *et. al.* (2) for height, collar diameter and single leaf area and Subramanian *et. al.* (14) observed similar findings for height, collar and clear bole length in *Jatropha curcas*.

Table 2. Mean values of morpho-physiological traits of different genotypes of *Jatropha curcas* L.

Genotypes	Plant height (cm)	Plant canopy (cm)	Collar diameter (cm)	No of primary branches	No of secondary branches	No of tertiary branches	No of leaves/ plant	No of capsules/ plant	No of seeds/ plant	Collar height (br.)	Average seed wt. (g)	Kernel oil content	Seed oil content	Seed yield (g.)
Buret	129.4	330.0	14.2	3.7	7.1	10.7	290.7	15.4	45.9	8.4	0.517	40.7	20.5	23.0
Chikhla	113.8	246.7	12.0	3.1	7.6	8.0	201.0	4.7	10.7	8.4	0.456	42.7	21.1	8.4
Kangaroo	130.7	256.7	13.3	25.0	7.0	8.5	256.7	11.6	28.3	3.8	0.473	49.6	30.6	16.2
PC-26	159.2	400.0	16.3	5.5	7.3	8.5	400.0	55.3	63.0	3.7	0.513	55.5	30.1	97.6
PC-27	147.9	420.0	17.2	3.6	8.2	6.2	420.0	14.3	16.0	4.6	0.640	47.9	28.9	28.8
Ranpur	121.5	221.1	12.8	2.8	5.7	5.6	230.0	13.2	52.1	9.7	0.517	58.2	25.2	24.8
Rotinda	136.4	270.0	14.3	3.0	5.1	9.4	235.0	9.7	45.5	11.2	0.493	51.4	29.1	22.7
Shamlaji	119.4	259.4	12.1	3.1	6.2	6.0	115.0	12.4	39.0	9.3	0.490	56.2	25.2	18.5
Zanjmer	137.7	393.3	15.2	3.7	7.6	11.1	266.7	12.5	22.5	7.5	0.830	13.0	8.1	12.7
Range	113.9- 159.2	221 – 420	12.03- 17.17	5.08 -8.22	2.50 -5.50	5.55- 11.08	115- 420	4.67- 55.33	10.67- 63.00	3.67- 11.26	0.46- 0.78	13.0 -58.23	8.10- 30.6	8.35- 97.62
Mean + SD	132.89 + 6.86	310.78 +24.87	14.16 + 0.78	3.44 + 0.59	6.68 + 0.76	8.20+ 1.01	266.51+ 14.37	17.7 +7.12	35.88 +8.13	7.41 +1.32	0.559+ 0.041	46.14 +2.38	24.42 +1.93	28.07 +8.96

Table 3. Genotypic variance, phenotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, genetic advance in percentage of mean of yield and yield contributing traits of nine genotypes of *Jatropha curcas* L.

Characters	Plant height (cm)	Plant canopy (cm)	Collar diameter (cm)	No of primary branches	No of secondary branches	No of tertiary branches	No of leaves/ plant	No of capsules/ plant	No of seeds/ plant	Collar height (br.)	Average seed weight (g).	Kernel oil content	Seed oil content	Seed yield (g)
Genotypic	135.21	4877.26	2.36	0.245	0.17	2.47	7116.47	140.68	209.39	4.85	0.01	186.94	49.07	599.89
Phenotypic	346.28	7664.68	5.11	1.79	2.77	7.01	12617.79	381.83	506.62	12.68	0.022	195.46	54.67	960.91
Environment	211.07	2787.41	2.75	1.55	2.60	4.54	5501.31	241.14	297.29	7.83	0.012	8.51	5.60	361.01
GCV %	8.75	22.47	10.85	14.37	6.05	19.17	31.44	71.64	40.32	29.76	18.22	29.63	28.81	87.25
PCV %	14.01	28.16	15.97	38.92	24.27	32.29	41.86	118.02	62.73	48.12	27	30.29	30.41	110.43
ECV %	10.93	16.98	11.72	36.16	23.5	25.99	27.64	93.79	48.05	37.81	19.93	6.32	9.73	67.68
Heritability	39	63.6	46.1	13.6	6.2	35.2	56.4	36.8	41.3	38.2	45.5	95.6	89.7	62.4
GA	14.85	114.83	2.15	0.37	0.19	1.91	130.30	14.86	39.85	0.17	19.17	10.84	10.19	2.80
GA (% mean)	11.26	36.92	15.18	10.938	3.1	23.44	48.64	89.57	53.41	37.91	25.32	59.96	56.23	142.01
CD $_{(0.05)}$	25.14	91.38	2.87	2.15	2.79	3.69	128.38	26.87	29.84	4.84	0.189	5.05	4.09	32.88

On the other hand, phenotypic coefficients of variations were slightly higher than genotypic coefficient of variation for most of characters except number of secondary branches per plant. This suggests that phenotypic variability is reliable, as these characters were least influenced by the environment. Number of secondary branches per plant showed considerable difference between phenotypic coefficient of variation (24.27) and genotypic coefficient of variation (6.05) (Table 3), which reflected considerable environmental effect on that character. This may be due to difference in dominance relationship among maturity loci.

In the improvement of species, genetic component of variation is the only important factor to be transmitted to next generation. Heritability indicates the effectiveness with which genotypes selection would be based on phenotypic performance.

High heritability was observed for plant canopy, seed yield, number of leaves, seed oil and kernel oil content (Table 3). Plant height, collar diameter, number of tertiary branches, average seed weight, number of seeds and capsules and collar height (at branching) had moderate heritability while number of primary and secondary branches showed less heritability values. Heritability in broader sense may also give useful indication about the relative values for selection of material in hand, but to arrive at more reliable conclusion, heritability should be considered with genetic relevance (14). High heritability (>55%) with high genetic advance in percentage of mean i.e. genetic gain (>20%) was shown by seed yield [h^2(b):62.4 & GA = 142], plant canopy [h^2(b) = 63 & GA = 36.92], number of leaves [h^2(b) = 56.4 & GA = 48.6], seed oil [h^2(b): 89.7 & GA:56 = 23] and kernel oil [h^2(b): 95.6 & GA:59.96]. The highly heritable characters with high genetic advance and high genetic advance percentage of mean could be further improved through individual plant selection, which indicated that these characters should be governed by additive gene action. So it could be suggested having a definite scope for improving in these characters through direct selection. Similar results were also reported earlier in case of seed yield in sunflower (5, 8). Moderate heritability with high percent mean of genetic advance was coupled with number of capsules per plant [h^2 (b): 36.8 & GA = 89.57], number of seeds [h^2(b): 41.3 & GA = 53.4] and average seed weight [h^2(b): 45.5 & GA = 25.32]. These traits should be considered as a selection parameter for improvement program. The trait collar diameter exhibited good magnitude of heritability but with lower genetic advance over mean. Panse and Sukhatme(10) suggested that high estimation of broad sense heritability and low genetic advance is due to presence of non-additive gene effects and high genotypic and environment interaction. The estimation of broad sense heritability for growth traits indicates that a considerable portion of variance is additive. High additive genetic variance and variation between germplasm sources offer good scope for genetic improvement of this species.

Moderate heritability with low genetic advance as percent mean was exhibited by plant height. The reason behind should be non-additive gene action i.e. dominance or epistatic. Hence, for improving such characters diallel selection mating design would be more effective. The traits like number of secondary branches per plant recorded low heritability and low genetic advance indicating the predominance of non-additive gene effects. Hence, it could be suggested that improvement of these traits might be difficult through selection, which ultimately suggests the maintenance of heterozygosity in population which has also been observed by earlier workers (7, 12).

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