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Genetic studies in *Jatropha curcas* L

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Abstract
The materials used in this study consisted of twenty seed sources of *Jatropha curcas* collected from different locations within the country and one from outside the country. These seed sources were evaluated for genetic variability and association studies in plant growth characters. Significant differences (p=0.01) were observed among seed sources for all the traits studied viz., plant height, basal diameter, number of branches and seed yield. The phenotypic and genotypic coefficient of variation and heritability also showed a sizeable variability. This offers a breeder ample scope to undertake screening and selection of seed sources for the desired traits. Correlation and path co-efficient analysis showed that genotypic correlation were higher than phenotypic correlation in all the traits studied. The traits also expressed a positive and significant genotypic inter correlation between themselves. Path coefficient analysis revealed that number of branches registered the highest direct effect. Maximum positive indirect effect on seed yield was exerted by basal diameter through number of branches.

Keywords: correlation, heritability, path analysis, seed source, variability

1. Introduction

India is endowed with abundant renewable energy resources. In recent times, efforts are being made to explore plant based resources as a substitute for fossil fuels, which are renewable and environmentally safe. The Indian approach to biofuels, in particular, is somewhat different to the current international approaches. It is solely based on non-food feedstocks that can grown in degraded and wastelands that are not suited to agriculture [1]. The source for tree biofuels is the forests which is the storehouse of more than 400 tree borne oilseeds. Among them, *Jatropha curcas* is considered as a prospective feedstock for the production of biodiesel [2], particularly due to its hardiness and drought tolerant nature, wide adaptability, rapid growth, high oil content [3] and therefore its possibility of cultivation in dry and marginal lands [4]. Sufficient production of biodiesel to meet the 20% blend with diesel could not be achieved currently by the Indian govt mostly due to the unavailability of adequate feedstock (seeds) and lack of high yielding drought tolerant *Jatropha* cultivars [5].

Assessment of the plant for its natural genetic variability is an essential step in any tree improvement programme. Selection is an important tool in a tree improvement programme, which determines the magnitude of genetic gain that can be obtained and it provides the basis for subsequent recurrent selections in succeeding generations. As *Jatropha curcas* is a cross-pollinated crop, genetic improvement programmes utilizing additive variation can be followed.

Sufficient and Systematic provenance studies at different locations has not yet been carried out widely with *Jatropha curcas.* The performance of different accession in tropical climate of Madhya Pradesh showed considerable variability in seed characteristics [6]. Seed source variability was also reported in *J. curcas* collected from Central India [7]. Considerable morphological variations in fruit and seed characteristics were exhibited in eleven phenotypic superior plants of *Jatropha curcas* [8]. Variability studies on growth and phenology in Jatopha progeny trial were studied [9]. In another trial conducted in 16 genotypes of *J. curcas*, the fruit and seed characteristics in three trials were found to be significant [10]. The genetic variability and divergence studies in seed traits and oil content of *J. curcas* revealed that most of the traits in plants are polygenic and have environmental effect [11]. So it is difficult to find out whether variability shown by various traits in *J. curcas* is heritable or due to certain environmental factors. Studying genetic variability is very important in improving this species in future selections.

Jatropha curcas L., a member of Euphorbiaceae family, is a tropical shrub native to Mexico and Central America. It grows to a height of 3-5 m and comes under all type of soils [12]. It grows well under subtropical and tropical climates with an average annual rainfall of between 300 and 1000 mm [13] and thus distributed throughout the world. In India, it was first introduced by Portuguese navigators in the sixteenth century. It occurs in almost all parts of India including Andaman Island. It is generally grown as live fence. It is a hardy and drought tolerant crop and can be raised in marginal lands with lesser input. It is resistant to high degree of aridity [8] and thus suitable for sand dune stabilization and soil conservation areas.

2. Materials and Methods

The experimental material for the present study comprised of twenty seed sources of *Jatropha curcas* collected from different locations within the country and one from outside the country and maintained at the regulations for seed source sampling concerning minimum number of trees and distance between parent trees, were followed [14]. The details of the seed sources are dealt in table 1. Seeds from individual trees were mixed and used as seed source in the present investigation.

The seedlings of twenty seed sources were planted as a seed source evaluation trial at Forest College and Research Institute, Mettupalayam. The trial was laid out in Randomized Block Design (RBD) with two replications and spacing adopted was 3 x 3 m with nine plants per plot. Recommended silvicultural operations were carried out uniformly. Data were recorded for the species under consideration at 12, 24 and 36 MAP and were used for the present study. The following growth attributes were recorded on all twenty seed sources in each replication. (a)Plant Height (b) Basal diameter (c) Number of branches (d) Seed yield per plant.

2.1 Statistical analysis

The data gathered from the field experiments were subjected to analysis of variance (ANOVA) to establish the significance of differences between the seed sources. Estimates of mean, variance and standard error were worked out [15]. The significance test was carried out by referring to the standard 'F' table [16].

Phenotypic and genotypic variances were estimated as per the method described by [17]. Phenotypic and genotypic coefficients of variances (PCV and GCV) were computed following [18]. Heritability (h^2) in the broad sense was calculated according to [19]. Genetic advance was worked out after [18].Phenotypic and genotypic correlation coefficients were calculated according to the method suggested by [20]. Path co-efficient analysis was estimated after [21] to apportion the genotypic correlation coefficients into direct and indirect effects.

3. Results and Discussion

The genetic parameters can be very useful tools in predicting the amounts of gain expected from seed sources in a short period. The greater the variation, the more genetic gain is likely to be obtained. The variation among seed sources is commonly used to calculate the degree of genetic control for a particular trait. Significant difference in the growth attributes were observed among the seed sources.

3.1 Mean performance

The current investigation revealed that Jatropha seed sources differed significantly among themselves for the growth parameters studied such as plant height, basal diameter, number of branches and seed yield per plant. At 36MAP, the plant height ranged between 144.41 cm (TNMC 24) to 205.73 cm (TNMC 7). The basal diameter in this period ranged between 55.17 mm (TNMC 24) to 124.83 mm (TNMC 7). The branches numbered between 2.25 (TNMC 24) to 5.05 (TNMC 7). Regarding seed yield, TNMC 7 produced maximum yield of 1766.34 g followed by TNMC 1(1693.68g) and TNMC 2(1652.35g). The seed sources viz., TNMC 24, TNMC 21, TNMC 20, TNMC 15, TNMC 22 and TNMC 14 recorded the minimum seed yield.

The wide range of mean values registered by the twenty seed sources for all the four characters studied indicated that these characters were highly variable. Number of branches was relatively more reliable component as the increase in the number of branches will have a proportional increase in the number of fruits as well and hence seed yield.

Among twenty seed sources used for the study, eight seed sources viz., TNMC 7, TNMC 1, TNMC 2, TNMC 6, TNMC 3, TNMC 4, TNMC 16 and TNMC 19 registered significant values for majority of the traits and expressed consistent mean performance in all the three growth periods viz., 12, 24 and 36 MAP (Tables 2,3 and 4).

Significant differences for growth performance among the seed sources of Jatropha at the age of four months for height, collar diameter and number of branches were reported earlier [22]. Wide significant variation in mean values for growth traits under field conditions were reported in *Jatropha curcas* [23].

3.2 Variability studies

The genotypic and phenotypic coefficient of variation also provided evidences for existence of adequate genotypic variations. The high estimates of heritability help the breeder in the selection programmes. Heritability estimates in conjunction with genetic advance are usually more helpful in predicting its resultant effect for selecting the best individuals [24]. High heritability (broad sense) may be due to non-additive gene action (dominant and epistasis) [25], so it shall be reliable only if accompanied by genetic advance [26].

In the present investigation, seed yield had recorded high phenotypic and genotypic coefficient of variation of 32.17 and 32.13 followed by number of branches (25.27 and 24.93) and basal diameter (22.45 and 22.27) (Table 5). Seed yield recorded the highest genetic advance as percentage of mean of 66.10 followed by number of branches (50.65). All the four traits recorded higher values for heritability, seed yield being the highest (99.75) (Table 5).

Among the morphometric traits investigated, seed yield and basal diameter had registered high phenotypic and genotypic coefficients of variation in all the three growth periods followed by number of branches. The results revealed that plant height registered moderate values for GCV during the first two growth periods and low values for GCV during the last growing period which in turn indicated that the influence of the environment on the trait was quite high (Table 5). For all the four characters taken up for the study, it was found that the effect of the environment on the genotypes was minimum indicating the superiority of the genotypes or it may also be the earliness of evaluation age of plantation. The results are in close association with the findings in *Jatropha curcas* [22] in *Pongamia pinnata* [27, 28] and in *Azadirachta indica* [29].

3.3 Association studies

3.3.1 Correlation studies

Improvement of productivity in terms of seed yield is the ultimate objective of the genetic improvement programme in

Jatropha curcas. However, the improvement of yield based on *per se* performance alone might prove to be less effective as this trait is highly complex and is dependent on many physiological and morphological attributes. Hence for formulating an effective and viable breeding programme for improving the yield, information on the strength and direction of association of the component characters with yield and also the inter se association among themselves is useful [30, 31].

In the present study, the correlation analysis in the twenty seed sources of *Jatropha curcas* indicate strong and positive correlation of two characters viz., number of branches and basal diameter with Seed yield (Table 6). No negative correlation was observed among the morphometric attributes used in the study. Also the trait basal diameter exhibited positive and significant phenotypic and genotypic *inter* correlation with number of branches (Table 5). Similar positive and significant correlation between seed yield and growth parameter was registered in *Jatropha curcas* [22] and in *Azadirachta indica* [26, 32].

3.3.2 Path analysis

Selection is the most important activity in all breeding programmes. In the integrated structure of the plant, the overall correlation observed between two variables is a function of a series of direct and indirect relationship between different variables. Path analysis gives an insight into a complex relationship between different characters in a biological system. To understand the specific forces in building up the total correlation, it is essential to resort through path coefficient [33]. Correlation simply measured mutual association without regard to causation while path coefficient analysis indicates the causes and measures of their relative importance of the causal factors [21].

In the present investigation, number of branches contributed maximum to the seed yield with its highest positive direct effect, whereas plant height showed negative direct effect. Basal diameter exerted maximum indirect effects on seed yield via number of branches (Fig 1). The traits under consideration *viz*., number of branches and basal diameter expressed high positive direct effect on seed yield and hence selection of these traits in future improvement programmes would aid in yield improvement in this species.

4. Figures and Tables

Table 1: Details of the Seed sources

Sl. No.	Accession number of the seed sources	Location	State
1.	TNMC 1	Uppupallam	Tamil Nadu
2.	TNMC 2	Palapatty	Tamil Nadu
3.	TNMC 3	Vedarcolony	Tamil Nadu
4.	TNMC 4	Thayanoor	Tamil Nadu
5.	TNMC 6	Kurundamalai	Tamil Nadu
6.	TNMC 7	Thondamuthur	Tamil Nadu
7.	TNMC 8	Palayampudur	Tamil Nadu
8.	TNMC 9	Nagarcoil	Tamil Nadu
9.	TNMC 10	Rajapalayam	Tamil Nadu
10.	TNMC 11	Valapadi	Tamil Nadu
11.	TNMC 12	Belur	Tamil Nadu
12.	TNMC 13	Chittur	Kerala
13.	TNMC 14	Rewari	Haryana
14.	TNMC 15	Thindivanam	Tamil Nadu
15.	TNMC 16	Pethikuttai	Tamil Nadu
16.	TNMC 19	Sathyamangalam	Tamil Nadu
17.	TNMC 20	Anthiyur	Tamil Nadu
18.	TNMC 21	Anaikatti	Tamil Nadu
19.	TNMC 22	Siruvani	Tamil Nadu
20.	TNMC 24	Zimbabwae	South Africa

Table 2: Mean performance for the measured biometric traits in *Jatropha curcas* at 12 MAP

Seed source	Plant height (cm)	Basal diameter (cm)	No. of branches	Seed yield (g)
TNMC 1	88.01**	43.55**	1.22	68.05**
TNMC 2	89.42**	36.30**	1.68*	63.00**
TNMC 3	83.40*	32.64**	1.50	67.12**
TNMC 4	83.36*	34.23**	1.36	52.82*
TNMC 6	87.80**	36.40**	1.33	50.26*
TNMC 7	91.72**	46.29**	1.10	57.49**
TNMC 8	76.94	23.56	1.65*	48.80
TNMC 9	79.75*	22.55	1.77*	59.88**
TNMC 10	76.23	22.85	1.00	41.39
TNMC 11	74.66	22.37	1.22	39.56
TNMC 12	78.57	24.45	1.55	44.06
TNMC 13	74.89	29.76*	1.50	44.86
TNMC 14	80.03*	20.45	1.00	30.56
TNMC 15	50.71	20.66	0.94	24.71
TNMC 16	80.90*	29.60*	1.55	47.02
TNMC 19	84.88**	25.22	1.39	46.58
TNMC 20	55.56	16.88	1.17	21.52
TNMC 21	48.76	15.22	0.77	19.20
TNMC 22	82.04*	19.91	1.11	22.75

TNMC 24	48.50	14.22	0.77	13.84
Grand mean	75.80	26.85	1.28	43.17
Grand mean + 1 SEd	79.59	28.99	1.62	49.60
Grand mean + 2 SEd	83.74	31.34	2.00	56.62

*Significant at 5% level
**Significant at 1% level

Table 3: Mean performance for the measured biometric traits in *Jatropha curcas* at 24 MAP

Seed source	Plant height (cm)	Basal diameter (cm)	No. of branches	Seed yield (g)
TNMC 1	155.88**	86.39**	2.22	834.51**
TNMC 2	138.57**	77.01**	2.77**	766.20**
TNMC 3	128.16**	60.45**	2.26	630.10**
TNMC 4	135.12**	62.55**	2.28	636.88**
TNMC 6	137.71**	70.58**	2.60*	731.02**
TNMC 7	151.92**	85.81**	2.58*	773.80**
TNMC 8	106.56	49.06	2.55*	484.58
TNMC 9	114.19	47.57	2.20	385.71
TNMC 10	114.55	44.91	2.32	466.17
TNMC 11	110.66	50.65	2.16	418.52
TNMC 12	113.04	59.01**	2.28	522.25**
TNMC 13	109.12	60.21**	2.19	538.52**
TNMC 14	111.40	45.37	2.33	356.92
TNMC 15	94.69	38.51	1.88	261.89
TNMC 16	124.95*	64.49**	2.34	562.07**
TNMC 19	134.96**	53.95	2.35	692.84**
TNMC 20	102.10	29.84	2.28	244.88
TNMC 21	76.11	29.88	1.76	101.46
TNMC 22	99.90	42.34	2.20	232.39
TNMC 24	75.16	26.73	1.30	69.33
Grand mean	116.74	54.26	2.24	485.50
Grand mean + 1 SEd	121.99	55.92	2.47	499.77
Grand mean + 2 SEd	127.74	57.74	2.73	515.38

*Significant at 5% level
**Significant at 1% level

Table 4: Mean performance for the measured biometric traits in *Jatropha curcas* at 36 MAP

Seed source	Plant height (cm)	Basal diameter (cm)	No. of branches	Seed yield (g)
TNMC 1	199.41**	119.45**	4.61**	1693.68**
TNMC 2	196.49**	111.21**	4.32**	1652.35**
TNMC 3	177.09**	97.78**	3.95**	1489.70**
TNMC 4	178.39**	97.73**	4.05**	1491.75**
TNMC 6	190.47**	105.40**	4.22**	1619.16**
TNMC 7	205.73**	124.83**	5.05**	1766.34**
TNMC 8	171.67	90.72*	3.23	1236.25**
TNMC 9	165.31	82.42	2.73	967.74
TNMC 10	165.86	83.31	2.96	1164.30
TNMC 11	165.30	87.89	3.01	1066.85
TNMC 12	172.00	89.31	3.33	1249.20**
TNMC 13	167.04	91.33*	3.43	1257.49**
TNMC 14	165.30	77.40	2.71	872.27
TNMC 15	155.95	64.15	2.45	718.88
TNMC 16	178.51**	96.86**	3.93**	1339.46**
TNMC 19	181.80**	98.98**	4.06**	1557.74**
TNMC 20	152.70	62.41	2.39	693.65
TNMC 21	146.44	58.08	2.32	648.79
TNMC 22	158.40	67.64	2.52	748.77
TNMC 24	144.41	55.17	2.25	610.02
Grand mean	171.91	88.10	3.37	1192.22
Grand mean + 1 SEd	173.62	90.61	3.51	1211.45
Grand mean + 2 SEd	175.48	93.35	3.67	1232.47

*Significant at 5% level
**Significant at 1% level

Table 5: Genetic estimates for morphometric attributes at 36MAP

Traits	GCV	PCV	Heritability	GA(%)of mean
Plant height (cm)	9.84	9.89	99.00	20.17
Basal diameter (cm)	22.27	22.45	98.39	45.50
Number of branches	24.93	25.27	97.31	50.65
Seed yield (g)	32.13	32.17	99.75	66.10

Table 6: Genotypic & Phenotypic correlation coefficient for three morphometric traits in *Jatropha curcas* at 36 MAP

Traits	Basal diameter	Number of branches	Seed yield
Plant height	0.982** 0.977**	0.970** 0.963**	0.955** 0.953**
Basal diameter		0.974** 0.965**	0.977** 0.972**
Number of branches			0.982** 0.973**

** Significant at 1% level

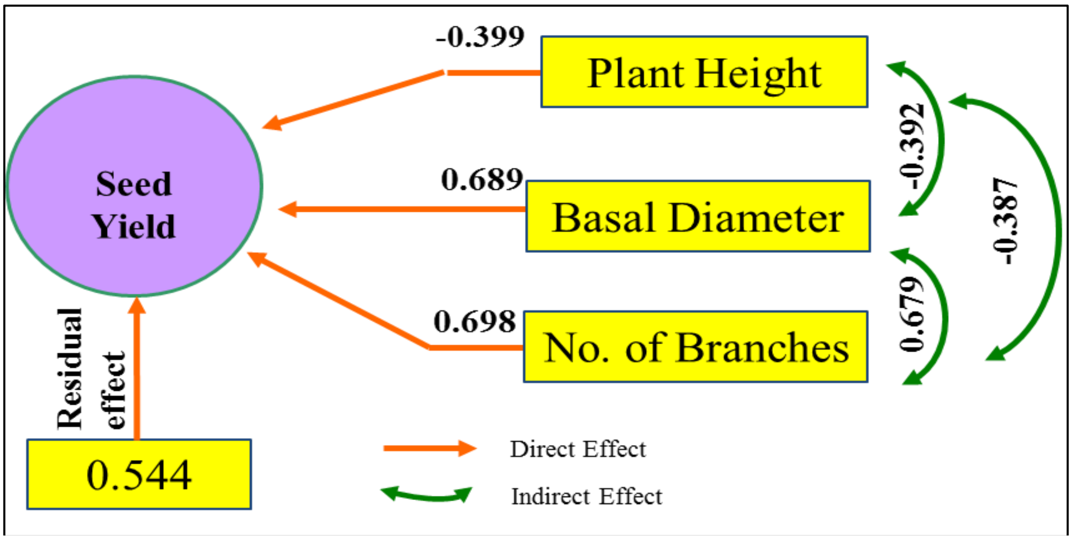

Fig 1: Path diagram showing direct and indirect effects on seed yield (g) in *J. curcas*

5. Conclusion

The present investigation envisaged that seed sources TNMC 7, TNMC 1, TNMC 2, TNMC 6, TNMC 3, TNMC 4, TNMC 19 and TNMC 16 expressed superiority over others for all the four characters used in the study. High and positive association coupled with intensive direct effect of number of branches followed by basal diameter could be used as a valuable, reliable and relevant yardstick for further screening cum selection and for future Jatropha based breeding programmes.

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