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Genetic variability and correlation in seed characters in *Jatropha curcas* L. accessions of South India.

S. Kalyanasundaram[1]*, Rajeev K. Srivastava[2], M. Paramathma[3],

[1]Conservator of Forests, Chennai circle, Chennai, Tamilnadu, India.

[2] Director & Chief Conservator of Forests, Mudumalai Tiger Reserve, TN, India.

[3]Director of Research, Tamilnadu Agriculture University, Coimbatore, TN, India.

Abstract

Sixteen accessions of *Jatropha curcas* collected from different agroclimatic zones of South India were studied for variability on seven seed characters at Forest Research Institute, Kolapakkam, Chennai, India. The seed sources CJC 29, CJC 30, CJC 31 and CJC 32 were found as the best sources in comparison to others. The Phenotypic coefficient of variation (PCV) and Genotypic coefficient of variation (GCV) of the seven seed traits showed considerable variability. Germination value, germination energy and germination per cent showed higher GCV while seed weight, oil content, kernel weight and hull weight registered low GCV. Seed weight recorded moderate value of heritability and the germination per cent recorded highest heritability. The genetic advance as per cent of mean also was high for germination traits, suggesting that germination is under strong genetic control and good amount of heritable additive genetic component can be exploited for improvement of this species. Positive and significant genotypic correlation values were registered for all the six traits which signified that selection of any one of these traits would lead to improvement of the yield in the expected direction.

Keywords: genetic advance, germination energy, germination value, heritability, *Jatropha curcas*, seed sources, variability

INTRODUCTION

The energy crisis due to ever growing energy needs, the environmental damage due to fossil fuel use, ever increasing exchequer for import of crude oil, the need to implement various acts and policies related to environment and the need to have minimum energy security are the main factors, that made India to go for alternate, indigenous, renewable energy resources, especially for the ethanol and bio-diesel. Any alternative to petroleum based fuels must at least be as economical and as readily available. *Jatropha curcas* L. (Physic nut or *Ratanjot* or *Kattamanakku*) a species of family Euphorbiaceae, is considered as one of the traditional alternative feed stocks for which an assessment was done on life cycle basis (Razon, 2009). *Jatropha* is a morphologically diverse genus which comprises of 176 species of rhizomatous subshrubs and herbs (Paramathma *et al.*, 2004). *Jatropha* is easy to establish, grows relatively quickly and is hardy. *Jatropha* has immense economic potential and ecological and environmental significance. The uses of this crop range from traditional medicine for common human and animal ailments, protection against land erosion, as a boundary fence or live hedge to newly found highly economic potential of fossil fuel replacement (Openshaw, 2000). This latter use has significant implications for meeting the demand for rural energy and counter green house gas accumulation in the atmosphere. *Jatropha curcas* L seems to be the most sustainable option among bio-energy crops. However, the very fact that *Jatropha* has adapted itself to a wide range of edaphic and ecological conditions suggests that there exists considerable amount of genetic variability yet to be exploited for potential realization. The International Plant Genetic Research Institute (IPGRI) states that the low yields in several *Jatropha* projects may have been caused by the fact that unadopted provenances have been used. Non-availability of improved varieties of *Jatropha curcas* L was expressed as a constrain by large section of farmers in Rajasthan (Meena *et al.*, 2006). In order to reduce the risk of future unsustainable practices and to improve future crop performance, further selection, breeding and domestication of *Jatropha* is primordial (Achten *et al.*, 2010) Success of commercial cultivation of *Jatropha curcas* L is much dependent on the use of high yielding genotypes (Das *et al.*, 2010).

For any tree improvement programme a determination of species or geographic sources within species, amount, kind and causes of variation within species are very important initial steps (Zobel and Talbert, 1984). Seed related traits are more complex as it depends on the action and interaction of various component traits. Hence an attempt was made in the present study to know the variation and correlation of biometric traits of

*Corresponding Author
email: *sundaramifs@yahoo.co.in*

the 16 accessions of *Jatropha curcas* L collected from southern states of India, inclusive of one local ecotype.

MATERIALS AND METHODS

Seed sources

High yielding Candidate Plus Trees (CPTs) of *Jatropha curcas* L from different locations in Tamil Nadu, Karnataka, Andra Pradesh and Kerala were identified and seeds were collected (Table I) at Forest College and Research Institute and Center of Excellence in Biofuels, TNAU, Coimbatore, Tamil Nadu under National net work project on integrated Development of *Jatropha*, Karanja and wild Apricot implemented by National Oilseeds and Vegetable Oils Development Board (NOVOD Board), Gurgaon and ICAR, New Delhi. Along with the 15 seed sources from the above two centers of TNAU, one local check of *Jatropha curcas* L was added which resulted in 16 seed sources for evaluation.

Table 1. Location Details of 16 Seed Sources of *Jatropha curcas* of the present study

Accession code	Place of collection	State	Latitude (°N)	Longitude (°E)
TNMC - 2	Palapatty	Tamil Nadu	11.32	76.96
TNMC - 4	Thayanoor	Tamil Nadu	11.21	76.75
TNMC - 5	Sirumugai	Tamil Nadu	11.32	77.01
TNMC - 6	Kunnadamalai	Tamil Nadu	11.24	76.95
TNMC - 7	Thondamuthur	Tamil Nadu	10.99	76.84
TNMC - 19	Sathyamangalam	Tamil Nadu	11.50	77.24
TNMC - 21	Anaikatti	Tamil Nadu	11.10	76.76
TNMC - 22	Siruvani	Tamil Nadu	10.96	76.67
TNMC - 26	Vadhambachery	Tamil Nadu	11.32	76.99
TNMC - 33	Anthiyur	Tamil Nadu	11.57	77.59
CJC-29	Bangaluru	Karnataka	12.97	77.59
CJC - 30	Dharwar	Karnataka	15.46	75.00
CJC-31	Sirsi	Karnataka	14.61	74.83
CJC-32	Sathisveda	Andhrapradesh	13.43	79.95
CJC-33	Thirussur	Kerala	10.51	76.20
Check	Kolapakkam	Tamil Nadu	12.87	80.10

The 16 seed sources were raised in mother beds during 2006 and the germinated ones were pricked out and placed in 16x30cm poly bags and maintained for 150 days. Experiments were carried out at State Forest Research Institute (SFRI) Kolapakkam (N:12°.87"18.1'; L:80°.10"37.2') 25 MSL Chennai, Tamil Nadu, India, during the period 2006-2009, with annual rainfall of 1200mm. The experimental plots of 15m X 15m size were laid and 25 plants were planted in each plot by 3mx3m spacement in Randomized Block Design (RBD) in three replications. 45cm³ pits were dugout and 150 days old poly bag seedlings were planted. Life watering was given on the 3rd, 10th and 17th days after planting and there after were kept under rainfed condition with no inputs and management practices except weeding around the plant twice annually.

Observations were made and the seeds were collected 30 Months After Planting (MAP) and the data were subjected to statistical analysis. The germination percent, germination value and germination energy were calculated by following the method of Czabator (1962). Hundred seed weight, kernel weight of 100 seeds and hull weight of 100 seeds were calculated separately.

Oil extraction The oil extraction process was carried out at Center of Excellency in Biofules, TNAU, Coimbatore in "soxhlet extractor" using three replicates for each seed lot. For estimating oil content the selected purified seeds were dried at 50° C for 16 hrs and allowed to cool in a desiccator. Five grams of seeds were pulverized to a fine powder in a porcelain mortar. Grounded samples were placed in a filter paper and fastened in such a way to prevent escape of the meal and then carefully transferred to an extraction thimble. The thimble was then placed in a soxhlet extractor to which sufficient quantity of solvent petroleum ether (40°C-60°C) was added and heated until eleven siphonings were completed. The percentage of oil content was then calculated by using the formula.

$$\text{Oil percent} = \frac{\text{Oil weight (g)}}{\text{Sample weight (g)}} \text{ X } 100$$

The data collected were subjected to the Analysis of Variance (Panse and Sukhatme 1961) using the software package 'GENRES' at TNAU, Coimbatore. The test of significance was carried out by referring to the standard 'F' table given by Snedecor (1961). Phenotypic and genotypic variances and co-variances were estimated as per the method described by Johnson *et al.* (1955). Phenotypic and genotypic coefficients of variances (PCV and GCV) were computed following Burton (1952). Heritability in the broad sense (H^2) was calculated using the formula suggested by Lush (1940) and Hanson *et al.*, (1956) and expressed in percentage. The genetic advance was calculated using the formula given by

Lush (1940) and Johnson *et al.* (1955). Genotypic and phenotypic correlations were calculated according to the method suggested by Goulden (1952).

RESULTS AND DISCUSSION

Variability and heritability

The study of seed traits with respect to germination and oil content is often considered to be useful step in the improvement programmes. Significant ($P<0.05$) variations were recorded for germination percent, germination energy, germination value, 100 seed weight, kernel weight, hull weight and oil content (Table 2). Variation in *Jatropha curcas* seed sources with respect to the seed traits could be due to the significant variability in the genotypes. Such variations in relation to seed traits have also been reported in *Jatropha curcas* by Ginwal *et al.*, (2004, 2005), Kaushik *et al.*, (2007), Rao *et al.*, (2008), Gururaja Rao *et al.*, (2009), Prasanthi *et al.*, (2009), Saikia *et al.*, (2009), Mohapatra *et al.*, (2010).

The seed sources CJC 29, CJC 30, CJC 31 and CJC 32 registered high germination percent, seed weight and oil content. Further more the above accessions are having higher values of germination characters. The accessions having maximum value can be considered in the selection process for future breeding programme. Kaushik *et al.*, (2007) reported that the genotypes having 100 seed weight to be more than 60 gms, will possess more than 30% oil content. In the present study also the seed sources having more seed weight have performed well both in germination traits and oil content. Ashraf *et al.*, (2007) reported the genotype (PAU-3) having maximum seed weight and to exhibit maximum germination per cent, germination value, germination index and oil content. The result obtained in the present study is similar to earlier findings. It is reported that the bigger seeds of *Jatropha curcas* registered more than 70% of germination and the seed germination levels have shown positive correlation with seedling quality. It is further emphasized that the seed must contain more than 30% oil, and then only extraction of oil is economical (Anon, 2007). Rao *et al.*, (2008) reported that larger seeds that produce more vigorous seedlings are with better chances of survival.

Table 2. Mean performance of germination, seed characters and oil content of seed sources of *Jatropha curcas*

Seed Sources	Germin. Percentage	Germin. Energy %	Germin. Value %	Kernel wt. (gm.)	Hull wt. (gm.)	Whole seed wt.	Oil content (percent)
TNMC – 2	71.733	56.267	40.417	38.200	23.540	61.833	33.753
TNMC – 4	57.600	43.733	18.610	37.067	22.900	60.033	32.064
TNMC – 5	52.000	39.733	17.403	36.800	22.257	59.200	31.240
TNMC – 6	67.467	55.733	29.580	37.650	22.850	60.800	31.814
TNMC – 7	68.533	54.400	36.377	35.750	22.417	58.200	30.973
TNMC – 19	63.200	48.000	25.323	37.083	22.900	60.233	30.522
TNMC 21	50.400	40.800	22.617	38.717	22.050	60.833	32.012
TNMC – 22	60.267	49.867	20.967	32.617	18.407	51.167	28.350
TNMC – 26	72.000	50.133	37.797	40.517	22.463	63.400	36.687
TNMC – 33	45.867	39.733	18.577	33.050	19.320	52.700	28.767
CJC-29	81.333	66.933	43.100	38.483	23.333	62.333	34.887
CJC – 30	83.200	74.933	44.003	40.733	23.200	64.133	37.548
CJC-31	84.267	70.400	56.717	40.633	23.400	64.333	34.593
CJC-32	74.400	61.067	42.917	36.200	27.270	63.900	35.991
CJC-33	75.200	55.733	46.303	38.540	21.900	60.967	33.316
Check	44.267	36.000	21.010	32.250	18.500	50.767	26.575
GENERAL MEAN	65.733	52.717	32.607	37.143	22.294	59.677	32.443
CD (0.05%)	7.368	6.887	8.744	2.868	1.384	8.320	2.139

Significant ($p<0.05$) mean performance have been recorded for the seed sources CJC 29, CJC 30, CJC 31 and CJC 32 for germination percent, germination energy, germination value and oil content. Substantial variation was evident in the mean expression of germplasm accessions (Table 2) as germination percent ranged from 44.27 to 84.27., seed weight ranged from 50.77 to 64.33 gm., and seed oil content from 26.58 to 37.55%.

The mean performance of the local ecotype namely, Cpt-TN, for the traits *viz.*, seed weight, oil content and germination per cent was very minimal.

High PCV and GCV (>20%) were observed for germination value, followed by germination energy and germination percentage (Table 3). The seed weight, kernel weight, hull weight and oil content registered low PCV and GCV. However all the traits registered a marginal variation between PCV and GCV, which revealed the less influence of environment. All the traits except seed weight recorded high heritability (broad sense). High estimates of heritability (>66%) also envisaged that environment has comparatively low influence for the seed traits and oil content. Estimates of genetic advance as percent of mean of 68.81% for germination value further suggested the potentiality of the test material for future improvement. In the present study the germination traits registered moderate to high PCV and GCV, high heritability (>83 %) and genetic advance as percentage of mean indicating that germination is under strong genetic control and good amount of heritable additive genetic component can be exploited for improvement programme. Dorman (1976) reported that heritability estimate is important in the improvement Programme. Heritability has an important place in tree breeding programmes as it provides an index of the relative role of heredity and environment in the expression of various traits (Kaushik *et al.*, 2007),

Table 3. Phenotypic and genotypic variances and heritability of seed characters, germination and oil content among different seed sources of *Jatropha curcas*

Traits	PCV	GCV	H^2	GA as (%) of mean
Germination percentage	20.4954	19.3446	0.8909	37.6123
Germination energy	22.7411	21.3730	0.8833	41.3798
Germination value	40.0244	36.5652	0.8346	68.8143
Kernel weight	8.2161	6.6834	0.6617	11.1994
Hull weight	10.0208	9.4232	0.8843	18.2541
Whole seed weight	7.2882	6.0877	0.4110	8.0393
Oil content (whole seeds)	9.9896	9.2436	0.8562	17.6199

Table 4. Genotypic (G) and phenotypic (P) correlation co-efficients among germination, seed characters and oil content among different seed sources of *Jatropha curcas*

Traits	G/P	Germination energy	Germination value	100 whole seed wt.	Total kernel wt. (100 seeds)	Total hull wt. (100 seeds)	Total oil content (100 whole seeds)
Germination %	G	0.965**	0.929**	0.914**	0.810**	0.666**	0.847**
	P	0.928**	0.899**	0.595**	0.557**	0.555**	0.754**
Germination energy	G		0.885***	0.832***	0.693***	0.604***	0.777***
	P		0.850**	0.492*	0.502*	0.492*	0.700**
Germination value	G			0.849**	0.749**	0.618**	0.782**
	P			0.536*	0.521*	0.476*	0.673***
100 whole seed wt.	G				0.891***	0.697***	0.851***
	P				0.643***	0.686***	0.672***
Total Kernel wt. (100 seeds)	G					0.679**	0.946**
	P					0.520*	0.730***
Total Hull wt. (100 seeds)	G						0.813***
	P						0.699**

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

Association of traits in *Jatropha*

The genotypic correlation is a derived value, where as, phenotypic correlation is the product of the genotypic and environmental interaction. The genotypic correlation is, therefore, a more reliable estimate for examining the degree of relationship between characters. The correlation coefficients (r) among the seed, germination and oil traits are presented in Table 4. Genotypic correlation co-efficient between various characters under study revealed that magnitude of genotypic correlation co-efficient was higher than their corresponding phenotypic co-efficient of correlations indicating all the seed traits are also less influenced by environment. These results are in concomitant with the findings of Kaushik *et al.*, (2007). The correlation matrix further revealed that statistically significant ($p<0.01$) correlation of seed weight existed with oil content, kernel weight, hull weight, germination value, germination energy and germination percent. The strong positive association among the traits indicate that some genes controlling these characters might be closely linked.

The whole seed weight was found to have higher significant positive relationship with germination percentage, kernel weight and oil content. Therefore seed weight can be considered as an important trait for early selection of seed sources. Similar findings between seed weight and other characters have been reported in *Jatropha curcas* by earlier authors as well (Kaushik *et al.*, 2007, Rao *et al.*, 2008, Gururaja Rao *et al.*, 2009, Mahopatra *et al.*, 2010). The consideration of seed weight in delineating and understanding the geographical variation has been advocated because of the least plasticity of this character (Harper *et al.*, 1970). The improvement in germination and seedling growth through seed size manipulation has been reported in *Jatropha curcas* by Kaushik et al., (2003). The estimation of seed weight being less expansive and laborious compared to seed oil content, the former need to be given greater emphasis during selection process.

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