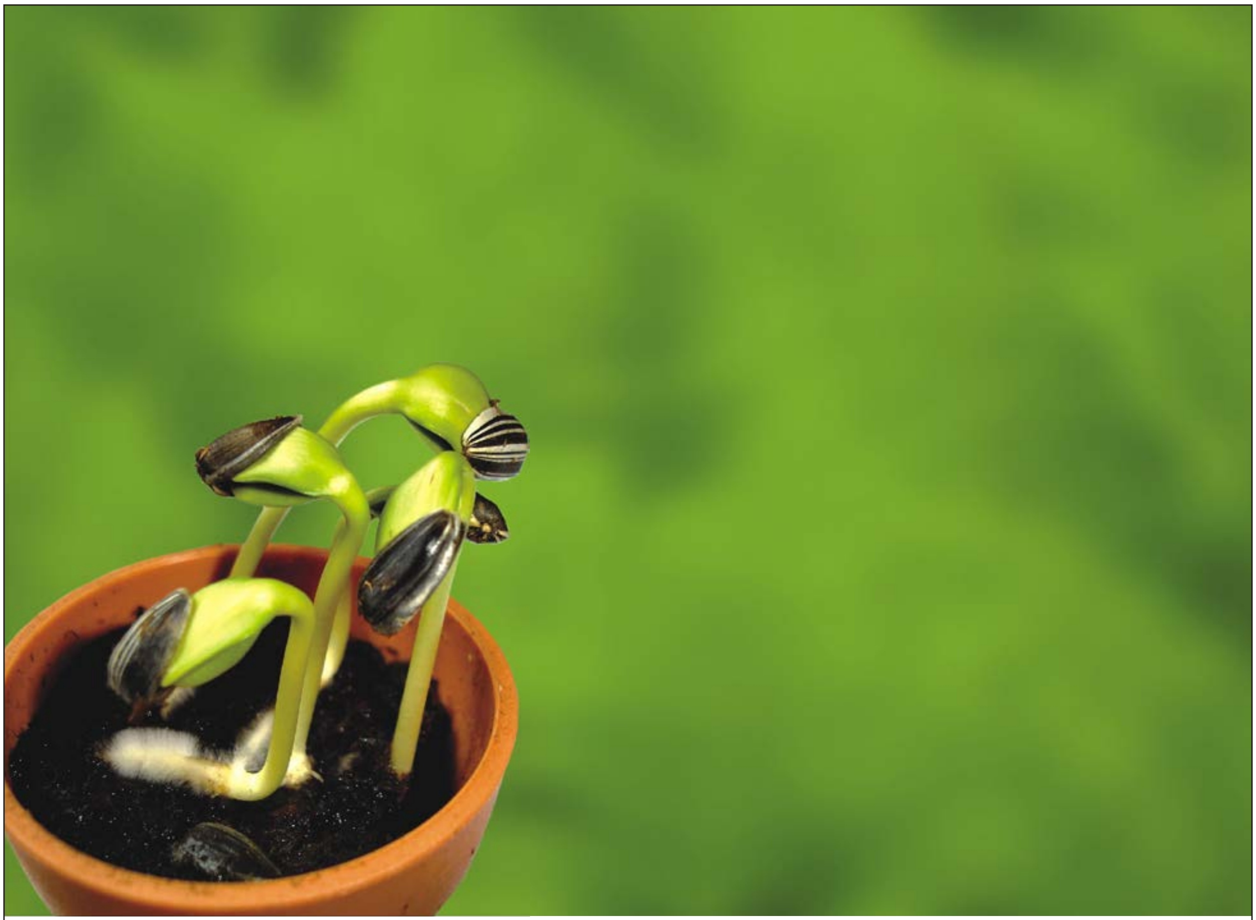

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Genetic Association Studies among Growth Attributes of Jatropha Hybrid Genetic Resources

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ABSTRACT

This study had been carried out at Forest College and Research Institute, Mettupalayam during 2009-2010 in Jatropha hybrid genetic resources to elicit information on performance, variability in seed and biometric traits, heritability, association analysis and biochemical properties. Twenty seven hybrid clones were used for the investigation and the experimental design followed was RBD. Significant variability was observed among the 27 hybrids with regard to the biometric traits viz., plant height, basal diameter, sturdiness quotient, number of primary and secondary branches and seed yield. The hybrid clones viz., HC 10, HC 21 and HC 22 recorded significantly higher seed yield than the rest of the clones. High and significant positive phenotypic and genotypic correlations were registered between number of primary and number of secondary branches on seed yield followed by basal diameter. Path analysis indicated that sturdiness quotient, basal diameter, number of primary branches and number of secondary branches expressed positive direct effect on seed yield.

Key words: Jatropha, hybrid clones, seed yield, correlation, path analysis, heritability

INTRODUCTION

Tre-borne oilseeds are the best and potential alternative to mitigate the current and future energy crisis and also to transform the vast stretches of wasteland into green oil fields. The potential sources identified so far include *Jatropha curcas*, *Pongamia pinnata*, *Madhuca latifolia*, *Azadirachta indica*, *Calophyllum inophyllum* and *Simarouba glauca*. Among these*, Jatropha curcas* Linn. emerges as the most promising tree-borne oilseed on the basis of its adaptability to a wide range of edapho-climatic conditions, high oil content, easy propagation through seeds/cuttings coupled with the suitability of *Jatropha* oil as a source of biodiesel (Martin and Mayeux, 1985; Kureel, 2006). It has less gestation period, drought endurance (Achten *et al*., 2007) long productive period (40 years) rapid growth, produces seeds with average oil content of 34.4% (Achten *et al.,* 2008), not grazed by animals, which strengthen its promotion in waste lands (Subramanian *et al*., 2005). A committee on development of bio-fuel constituted by the Planning Commission (2003) in India recommended the cultivation of jatropha on account of several advantages to the economy. The processed jatropha oil (by trans-esterification) can be used as bio-diesel. It may be mixed with the petro-diesel up to 20% and used in engines without having to make any change in them (Planning Commission, 2003). It is an environment friendly fuel and has about 10% built-in oxygen. Blending with diesel results in reduced unburnt hydrocarbons, carbon monoxide and particulate matter in auto emissions and the sulphur content is less than 15 ppm. The viscosity of bio-diesel is higher and leads to gum formation. However, when used as a transportation fuel, blending up to 20% of bio-diesel with conventional diesel requires no modifications in engine specifications (MPNG, 2005).

Any crop improvement programme will be successful only after assessing our native genetic strength and the possible options towards yield improvement. In India, a decade ago few native *Jatropha* species were utilized in the castor improvement programme and interspecific hybridization has been attempted between different species of *Jatropha* with limited success (Dehgan, 1984; Sujatha and Prabakaran, 1997). Interspecific hybridization programme has been attempted between *Jatropha curcas* and eight other *Jatropha* species to develop new hybrids with higher yield potential and resistance to root rot and frost tolerance. The cultivated species *J. curcas* was used as the female parent and the species, viz., *J. integerrima*, *J. podagrica*, *J. villosa*, *J. tanjorensis*, *J. gossypifolia*, *J. glandulifera*, *J. multifida* and *J. maheswari* were used as pollen donors. Hybridization between *J. curcas* and *J. integerrima* produced successful hybrids with more seed set, whereas the other crosses failed to produce seeds due to existence of crossability barriers either in pre-zygotic state or in post-zygotic state (Senthil Kumar *et al*., 2009). In the successful hybrid also, the F1 progeny has exhibited vigorous growth, but the fruit was small in size resembling *J. integerrima* characters. Hence, a backcross was attempted to get progeny with unique fruit, seed and oil yield characteristics (Parthiban *et al*., 2009). The objective of the present investigation was to quantify the magnitude of genetic variability present in the hybrid clonal population, study the association among characters and to identify important yield attributing characters, selection for which would help in development of high yielding *Jatropha* hybrid clone.

MATERIALS AND METHODS

The hybrid clones were developed during 2004-2006 through interspecific crosses between *Jatropha curcas* and *Jatropha integerrima* at Forest College and Research Institute, Mettupalayam. The F1 plants exhibited wider variation in terms of stem character (semi hard wood), flower colour (pink, white and yellow) and fruit size (small and round). The seeds size and the yield of F1 plants were very low as the character of *Jatropha integerrima* but exhibited robust growth particularly in stem characters. The promising F1 plants were then back crossed with *Jatropha curcas* clones to increase the seed size. The BC1F1 progenies were raised in second generation field and screened for flowering and fruiting character. This BC1F1 plants exhibited significantly different results in terms of morphological feature, fruit characteristics coupled with seed and oil content. Among these back crosses derivatives, 27 distinct clones were identified for their superiority in terms of growth, distinctness, seed and oil yield (called as hybrid clones) and were deployed for clonal evaluation trial. The experiment was established in the form of RBD with five replications and in each replication 5 ramets were used. Observations on plant height, Basal diameter, sturdiness quotient, number of primary and number of secondary branches and seed yield were recorded on all the plants at twenty four month after planting.

The data on the 6 traits was analyzed in RBD. Genetic variability parameters, heritability and genetic advance of the traits were estimated following (Johnson *et al*., 1955; Nya and Eka, 2007). Replication-wise mean values of these data of each accession were subjected to statistical analysis. The Analysis of Variance (ANOVA) (Panse and Sukhatme, 1978) was carried out to separate genetic components of variability from total variability and broad-sense heritability (Lush, 1940) was estimated. Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV) for each trait were estimated as:

$$\text{PCV} = \frac{\text{Phenotypic standard deviation}}{\text{Grand mean of the trait}} \times 100$$

$$\text{GCV} = \frac{\text{Genotypic standard deviation}}{\text{Grand mean of the trait}} \times 100$$

The phenotypic correlation between pairs of characters were computed according to formulae suggested by Goulden (1952) and the correlations of the component traits with yield was partitioned into direct and indirect effects by path co-efficient analysis (Dewey and Lu, 1959; Ahmed *et al*., 2003).

RESULTS

Variability in growth and yield characteristics: The hybrid clones exhibited significant variations for plant height at twenty four months after planting. Five hybrid clones viz., HC 1 (148.8 cm), HC 3 (161.4 cm), HC 13 (158.4 cm), HC 16 (154.2 cm) and HC 26 (153.4 cm) recorded significantly higher plant height values compared to general mean (132.73 cm). Nine hybrid clones viz., HC 9 (10.24 cm), HC 10 (11.12 cm), HC 12 (11.23 cm), HC 16 (10.76 cm), HC 17 (10.21 cm), HC 19 (10.59 cm), HC 20 (10.46 cm), HC 21 (10.06 cm) and HC 24 (10.26 cm) recorded significantly higher values for basal diameter compared to general mean (3.88 cm) (Table 1).

Sturdiness quotient ranged from 29.51 (HC 18) to 14.30 (HC 8). The average sturdiness quotient recorded was 20.01. Three hybrid clones viz., HC 1 (25.27), HC 6 (26.99) and HC 18 (29.51) recorded significantly higher sturdiness quotient compared to the general mean. The number of primary branches varied significantly and ranged between 4.66 (HC 16) and 2.82 (HC 8). The average number of primary branches recorded was 3.69. Three hybrid clones viz., HC 16 (4.66), HC 21 (4.54) and HC 22 (4.36) expressed significantly higher values over general mean. Only one hybrid clones viz., HC 8 (2.82) recorded significantly lower value for this character. The number of secondary branches ranged between 24.88 (HC 16) and 13.1 (HC 8). Five hybrid clones viz., HC 12 (24.7), HC 14 (21.87), HC 16 (24.88), HC 20 (21.88) and HC 22 (22.44) expressed significantly higher values over general mean (Table 1).

The seed yield from the hybrid clones collected for 12 months varied significantly and ranged from 857.51 g (HC 21) to 131.78 g (HC 5). The mean value for yield was recorded as 382.86 g. Seven hybrid clones viz., HC 9 (578.28 g), HC 10 (657.77 g), HC 12 (513.52 g), HC 18 (494.67g), HC 20 (528.83 g), HC 21 (857.51 g) and HC 22 (763 g) showed high significant value for seed yield over the general mean(Table 1).

The variability estimates viz., Phenotypic Coefficient of Variation (PCV), Genotypic Coefficient of Variation (GCV), heritability and genetic advance as per cent of mean are presented in Table 2.

The phenotypic and genotypic coefficients of variations for plant height were 14.42 and 12.47%, respectively. The plant height recorded higher heritability of 0.75. The genetic advance, as percentage of mean was 22.23. The basal diameter recorded phenotypic and genotypic coefficient of variations of 17.43 and 16.27%, respectively. Basal diameter recorded a high heritability of 0.87

Table 1: Variability in growth attributes of Jatropha hybrid clonal genetic resources (24 MAP)

Hybrids	Plant height (cm)	Basal diameter (cm)	Sturdiness quotient	Primary branches	Secondary branches	Seed yield (g)
HC 1	148.8*	8.63	25.27*	3.32	14.42	317.16
HC 2	128.2	8.08	22.73	3.38	15.62	316.85
HC 3	161.4*	8.32	23.96	3.22	14.14	259.67
HC 4	120.4	9.34	17.42	3.22	13.99	203.06
HC 5	141.6	8.83	20.24	3.70	18.25	131.78
HC 6	126.0	8.47	26.99*	3.46	17.79	348.40
HC 7	128.6	7.82	21.87	3.56	18.50	303.85
HC 8	115.7	5.78	14.30	2.82	13.10	151.15
HC 9	121.2	10.24*	19.75	4.00	17.22	578.28*
HC 10	143.2	11.12*	20.16	4.10	19.48	657.77*
HC 11	138.0	9.64	17.53	3.72	14.55	292.91
HC 12	145.2	11.30*	16.89	3.72	24.70*	513.52*
HC 13	158.4*	7.64	22.20	3.72	18.70	283.68
HC 14	139.2	8.81	19.84	3.62	21.87*	469.08
HC 15	130.4	7.88	20.51	3.84	16.95	218.28
HC 16	154.2*	10.76*	14.77	4.66*	24.88*	369.70
HC 17	102.2	10.21*	16.53	3.44	17.47	370.91
HC 18	115.2	5.92	29.50*	3.72	17.48	494.67*
HC 19	115.8	10.59*	15.29	3.64	16.52	222.09
HC 20	106.4	10.46*	15.66	3.98	21.88*	528.83*
HC 21	127.2	10.06*	20.29	4.54*	21.55	857.51*
HC 22	134.8	9.37	21.07	4.36*	22.44*	763.00*
HC 23	141.8	9.24	19.05	3.56	18.45	365.84
HC 24	148.0	10.26*	17.26	3.94	18.50	189.80
HC 25	97.2	6.76	19.54	3.52	17.28	267.16
HC 26	153.4*	9.51	20.39	3.22	18.06	369.51
HC 27	141.2	7.62	21.28	3.74	17.72	492.79
MEAN	132.73	8.99	20.01	3.69	18.20	382.86
Sed	6.07	0.35	1.82	0.22	1.30	38.41
CD(.05)	12.05	0.69	3.60	0.43	2.59	76.17
CD(.01)	15.94	0.91	4.77	0.57	3.42	100.78

*Significant at 1% level. MAP: Month after planting

and the resultant genetic advance, as per cent of mean was 31.28 (Table 2). The phenotypic and genotypic coefficients of variations for sturdiness quotient were 21.38 and 18.63%, respectively. This trait recorded high heritability value of 0.76. The genetic advance as per cent of mean recorded by this trait was 33.43 (Table 2).

The phenotypic and genotypic coefficient of variation for number of primary branches was 13.90 and 10.32%, respectively. Number of primary branches recorded a moderate heritable value of 0.55. This trait also recorded a maximum of 15.78 genetic advance, as per cent of mean. The phenotypic and genotypic coefficient of variation for this trait was 20.34 and 15.98%, respectively. Number of secondary branches recorded a slightly higher heritability value of 0.62. This trait also recorded a maximum of 25.86 genetic advance, as per cent of mean (Table 2).

The phenotypic and genotypic coefficient of variation for this trait viz., seed yield was 51.31 and 46.38%, respectively. Seed yield recorded a slightly higher heritability value of 0.82. This trait also recorded a maximum of 86.38 genetic advance, as per cent of mean (Table 2).

Genetic association in growth and yield characteristics: Plant height showed positive and significant correlation with sturdiness quotient both at phenotypic (0.506) and genotypic (0.424) levels. The phenotypic and genotypic inter correlations were positive for basal diameter (0.155 and 0.203), number of primary branches (0.067 and 0.151), number of secondary branches (0.099 and 0.197) and was negative for seed yield (-0.013 and -0.041). Basal diameter exhibited positive and significant phenotypic and genotypic correlation for number of primary branches (0.387 and 0.547), number of secondary branches (0.429 and 0.525) and non significant correlations for seed yield (0.308 and 0.363). The inter association at phenotypic (-0.756) and genotypic (-0.791) levels were found to be negative for sturdiness quotient (Table 3, 4).

Sturdiness quotient exhibited negative phenotypic and genotypic correlation for number of primary branches (-0.298 and -0.407), number of secondary branches (-0.312 and -0.353) and seed yield (-0.256 and -0.338). Number of primary branches showed positive and significant correlation with number of secondary branches at phenotypic (0.512) and genotypic (0.829) levels. It also exhibited positive and significant inter association with seed yield both at phenotypic (0.442) and genotypic (0.711) levels. Number of secondary branches exhibited positive and significant inter association with seed yield both at phenotypic (0.470) and genotypic (0.625) levels (Table 3, 4). Among five parameters studied, sturdiness quotient (0.979) exerted maximum positive direct effect on seed yield followed by basal diameter (0.872), number of primary

Table 2: Genetic estimates for biometrical traits of hybrid clonal genetic resources

Traits	PCV	GCV	Heritability	GA (%) of mean
Plant height	14.421	12.474	0.748	22.228
Basal diameter	17.43	16.27	0.871	31.288
Sturdiness Quotient	21.379	18.626	0.759	33.428
No. of primary branches	13.897	10.317	0.551	15.778
No. of secondary branches	20.341	15.98	0.617	25.86
Seed yield	51.306	46.384	0.817	86.384

Table 3: Phenotypic correlation coefficient among biometrical traits on seed yield

Traits	Basal diameter	Sturdiness quotient	No. of primary branches	No. of secondary branches	Seed yield
Plant height	0.155	0.506*	0.067	0.099	-0.013
Basal diameter		-0.756	0.387*	0.429*	0.308
Sturdiness quotient			-0.298	-0.312	-0.256
No. of primary branches				0.512*	0.442*
No. of secondary branches					0.470*

*Significant at 5% level

Table 4: Genotypic correlation coefficient among biometrical traits on seed yield

Traits	Basal diameter	Sturdiness quotient	No. of primary branches	No. of secondary branches	Seed yield
Plant height	0.203	0.424*	0.151	0.197	-0.041
Basal diameter		-0.791	0.547*	0.525*	0.363
Sturdiness quotient			-0.407	-0.353	-0.338
No. of primary branches				0.829*	0.711*
No. of secondary branches					0.625*

*Significant at 5% level

Table 5: Path coefficient analysis of biometric traits on seed yield

Traits	Plant height	Basal diameter	Sturdiness quotient	No. of primary branches	No. of secondary branches
Plant height	-0.756	0.177	0.415	0.096	0.026
Basal diameter	-0.153	0.872	-0.774	0.347	0.07
Sturdiness quotient	-0.32	-0.69	0.979	-0.259	-0.047
No. of primary branches	-0.114	0.477	-0.398	0.635	0.111
No. of secondary branches-	0.149	0.458	-0.345	0.526	0.134

Residual Effects = 0.1689. Diagonal values are direct effect

branches (0.635) and number of secondary branches (0.134). The plant height alone (-0.756) exerted direct negative effects on seed yield (Table 5).

Plant height exerted its positive indirect effect via basal diameter (0.177), sturdiness quotient (0.415), number of primary branches (0.096) and number of secondary branches (0.026) (Table 5). Basal diameter registered its positive indirect effect on seed yield via number of primary branches (0.347) and number of secondary branches (0.070) and expressed negative indirect effects through plant height (-0.153) and sturdiness quotient (-0.774) (Table 5). Sturdiness quotient exerted its negative indirect effect on seed yield through plant height (-0.320), basal diameter (0.690), number of primary branches (-0.258) and number of secondary branches (-0.047) (Table 5).

Positive indirect effect on seed yield was exerted by number of primary branches through basal diameter (0.477) and number of secondary branches (0.111). Number of primary branches registered negative indirect effect through plant height (-0.114) and sturdiness quotient (-0.398). Number of secondary branches exerted its positive indirect effect on seed yield through basal diameter (0.458) followed by number of primary branches (0.526). It registered negative indirect effects through plant height (-0.149) and sturdiness quotient (-0.345) (Table 5).

DISCUSSION

The amount of genetic variations and association was evident from the study of PCV, GCV and correlation analysis. In the present investigation, seed yield had registered high phenotypic and genotypic coefficients of variation followed by sturdiness quotient, number of secondary branches, basal diameter, plant height and number of primary branches (Table 2). The results are in close association with the findings of Das *et al.* (2010), Mohapatra and Panda (2010), Rao *et al.* (2008) and Ginwal *et al.* (2004) in *Jatropha curcas*. In the current study the estimates of PCV and GCV exhibited only small differences which indicate lesser environmental influence and stronger genetic control.

All the traits except number of primary branches recorded high heritability values ranging from 0.87 to 0.62. Basal diameter has recorded high heritability but moderate genetic advance whereas seed yield has achieved high heritability and also genetic advance as well. High to moderate heritability for morphometric traits have also been observed in *Jatropha curcas* by Das *et al.* (2010), Mohapatra and Panda (2010), Rao *et al.* (2008) and Ginwal *et al.* (2004) which support the outcome of the present investigation.

In the present investigation Jatropha hybrid clones expressed high heritability for plant height, basal diameter, number of primary branches, seed yield and sturdiness quotient and moderate heritability value for number of secondary branches, which indicates that a considerable portion of variance is additive. The estimates of broad sense heritabilities for growth traits indicate that a considerable portion of variance is additive. High additive genetic variance and large variation between seed sources offer good scope for genetic improvement of this species. Heritability in broad sense may also give useful indication about the relative value of selection of the material at hand, but to arrive at a more reliable conclusion, heritability and genetic advance may be considered jointly.

As long as the genes governing the characters are not combined at random, characters may show some correlations. The immediate effect of pleiotropy and close linkage is generally similar though their effect on potential breeding value could be different (Sprague, 1956). If the observed correlation is due to multiple effects of same gene, the selection for one character will improve another. Hence, correlation among traits influence effectiveness of selection.

Correlation studies in the present investigation indicated that seed yield exhibited a positive and significant association with number of primary branches and number of secondary branches at phenotypic and genotypic level, whereas plant height and sturdiness quotient showed a negative correlation with seed yield at genotypic and phenotypic level (Table 3, 4). Such positive and highly significant correlation was registered in *Jatropha curcas* and these characters may be used to the advantage of the breeder for bringing simultaneous improvement of these traits easily (Ginwal *et al.* 2004). Similar positive and significant correlation have been observed by Das *et al.* (2010) in *Jatropha curcas* Chauhan *et al.* (2005) and Dhillon *et al.* (2003) in neem. Further the basal diameter, number of primary branches and number of secondary branches exhibited strong association among themselves indicating that some genes controlling these characters might be closely linked.

Path analysis gives an insight into a complex relationship between different characters in a biological system (Table 5). To understand the specific forces in building up the total correlation, it is essential to resort through path coefficient (Wright, 1921). In the present investigation, sturdiness quotient expressed highest positive direct effect on seed yield followed by basal diameter and number of primary branches. Plant height had the maximum direct effect on volume in *Eucalyptus tereticornis* suggesting a better scope for improvement of volume by selecting for this trait (Patil *et al.*, 1997). Similarly plant height exercised positive direct effect on volume index in *Tectona grandis* (Parthiban, 2001). In the present study, basal diameter, number of primary branches and number of secondary branches exerted the highest indirect effect on seed yield via basal diameter and number of primary branches which suggested that the seed yield of Jatropha not only depends on the genotype but also due to crop management strategies to augment the number of branches.

CONCLUSION

From the current study it is known that the hybrid clones viz., HC 10, HC 21 and HC 22 performed exceedingly well than the rest of the hybrid clones in terms of seed yield which is the most economic trait among all other traits. Also the present investigation envisaged that high and positive association coupled with intensive direct effect by sturdiness quotient, basal diameter and number of secondary branches could be used as valuable, reliable and relevant yardstick for Jatropha breeding programme.

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