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Variability, heritability and character association studies for growth and seed yield in *Jatropha Curcas* crosses

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Abstract

The present study was conducted on intraspecific crosses of Jatropha developed by using ten parents at Central Agroforestry Research Institute, Jhansi to evaluate variability, heritability and genetic advance of growth and seed yield traits. Study revealed that all the crosses differed significantly in growth and seed yield traits. The 100 seed weight varied from 49.8 g (NRCJ-35) to 61 g (NRCJ-26) whereas seed yield ranged from 177.5 g (NRCJ-30) to 733g (NRCJ-15). The genotypic and phenotypic coefficient of variation of 100 seed weight was 3.37 and 10.92, respectively whereas heritability (30.86%) and genetic advance as per cent of mean was moderate (3.73%). The genotypic and phenotypic coefficient of variation of seed yield was 8.42 and 21.61, along with 38.96 per cent heritability and 65.81 per cent genetic advance. The study indicates that the variation found in different traits can be effectively utilized in genetic improvement of this species and good performing crosses can be utilized for large plantation under biofuel development programme.

Keywords: Bio-fuel, Character association, Genetic parameter, Jatropha

The rise in the crude oil price and the uncertainty associated with ensuring uninterrupted supplies compelled the need to look for renewable source of energy and bio-fuels could be technically feasible alternatives for crude oil (Srinivasan, 2009). Biodiesel is expanding very fast because of demand, policy support and availability of technologies. Government of India launched National Mission on Biodiesel with a view to find a cheap and renewable liquid fuel based on vegetable oils (Shukla, 2005). The shortage of raw material to produce biodiesel is major constraint (Wani *et al.* 2006) and recently Government of India and other agencies promoted Jatropha as one of the alternative source of biodiesel.

Jatropha curcas is commonly known as Rantanjot belonging to family Euphorbiaceae. This is a hardy plant with high adaptability due to its phenotypic plasticity and potential to grow under arid and semi-arid conditions. The plant has green leaves with a length and width of 6 to 15 centimeters. The branches of the Jatropha plant contain white, sticky latex that leaves brown stains, which is difficult to wash out. The root system of Jatropha plants is well developed, roots growing both laterally and vertically into deeper soil layers. The plant is monoecious, male and female flowers are on the same plant. The lifespan is more than 50 years and it can grow on marginal soils with low nutrient content. The seed is having high level of oil content (30-38%). Therefore, there is immense scope to identify promising Jatropha accessions with good growth, seed yield and oil content.

The present study was conducted at Central Agroforestry Research Institute, Jhansi under Jatropha crosses evaluation trial. The 45 intraspecific crosses were made in half-diallel method using ten best parents and established in the field during July, 2006 at the spacing of 4x4m. Each cross was planted in three replications under randomized block design with 5 plants (F_1 generation) of each cross. At the age of four years they were evaluated for growth and seed yield traits. Analysis of variance was carried out to estimate, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance by using SPAR 2.0 and SPSS 11.5.

Results revealed that all the crosses exhibited significant variations for all the characters studied in this experiment. The data pertaining to growth is presented in Table 1. The plant height was recorded 2.59m with the range of 2.03 m (NRCJ-39) to 2.88 m (NRCJ-42). The other superior crosses were NRCJ-15 (2.82 m), NRCJ-36 (2.80 m), NRCJ-6 (2.78 m) and NRCJ-35 (2.77 m). The average collar girth was 75.6 cm which ranged from 54.1 cm (NRCJ-39) to 86.3 cm (NRCJ-18).

Table 1. Variability in growth and seed yield of *Jatropha* crosses

Cross	Plant height (m)	Girth (cm)	Number of primary branches	Number of secondary branches	Branch length (m)	Canopy diameter (m)	100 Seed weight (g)	Seed yield (g)
NRCJ 1	2.52	71.9	10	97	2.42	3.22	53.7	191.0
NRCJ 2	2.70	78.2	9	108	2.57	3.53	51.9	231.0
NRCJ 3	2.66	85.5	10	118	2.61	3.36	53.8	239.4
NRCJ 4	2.69	69.4	9	94	2.56	3.30	53.9	350.6
NRCJ 5	2.67	70.3	8	103	2.52	3.36	59.4	422.5
NRCJ 6	2.78	84.4	10	95	2.66	3.65	54.4	224.0
NRCJ 7	2.68	74.5	9	102	2.55	3.57	53.7	215.0
NRCJ 8	2.73	81.0	9	88	2.57	3.35	53.5	261.7
NRCJ 9	2.76	80.9	9	111	2.68	3.87	58.4	269.5
NRCJ 10	2.40	80.8	7	83	2.27	3.10	60.2	462.5
NRCJ 11	2.58	83.3	7	82	2.44	3.43	53.0	265.7
NRCJ 12	2.52	73.3	9	106	2.39	3.55	51.6	260.7
NRCJ 13	2.66	83.7	10	128	2.54	3.69	54.7	488.6
NRCJ 14	2.63	80.8	10	115	2.49	3.52	58.6	571.4
NRCJ 15	2.83	79.6	9	126	2.70	3.92	58.9	733.0
NRCJ 16	2.61	74.2	8	101	2.38	3.36	55.6	442.3
NRCJ 17	2.74	84.0	9	125	2.59	3.52	53.5	404.8
NRCJ 18	2.75	86.3	10	121	2.63	3.71	57.4	521.9
NRCJ 19	2.55	76.2	8	107	2.41	3.42	53.3	372.5
NRCJ 20	2.38	69.4	8	82	2.23	2.80	57.9	272.5
NRCJ 21	2.41	73.5	8	89	2.30	3.15	57.1	290.0
NRCJ 22	2.46	74.6	9	100	2.31	3.29	55.5	443.0
NRCJ 23	2.58	79.8	8	98	2.46	3.14	55.5	337.7
NRCJ 24	2.64	76.1	9	113	2.50	3.59	54.7	432.3
NRCJ 25	2.39	64.7	8	84	2.24	3.01	57.5	600.8
NRCJ 26	2.57	81.3	11	111	2.45	3.33	61.0	411.4
NRCJ 27	2.44	76.0	8	94	2.32	3.25	55.0	507.5
NRCJ 28	2.32	71.7	8	93	2.20	3.13	56.1	260.8
NRCJ 29	2.43	83.3	8	86	2.30	3.17	53.8	301.0
NRCJ 30	2.45	80.0	9	85	2.38	3.20	52.5	177.5
NRCJ 31	2.48	76.3	9	101	2.40	3.28	57.0	302.5
NRCJ 32	2.60	79.9	9	115	2.47	3.67	56.9	447.3
NRCJ 33	2.72	72.2	9	116	2.67	3.58	56.7	439.6
NRCJ 34	2.50	66.1	9	94	2.38	3.04	56.2	413.9
NRCJ 35	2.77	79.3	10	120	2.64	3.61	49.8	327.9
NRCJ 36	2.80	70.6	11	94	2.66	3.63	54.0	202.9
NRCJ 37	2.74	81.1	10	111	2.56	3.56	52.6	430.0
NRCJ 38	2.67	78.0	8	103	2.54	3.55	57.0	452.9
NRCJ 39	2.03	54.1	5	50	1.94	2.55	54.4	332.5
NRCJ 40	2.54	59.4	8	82	2.39	3.10	56.6	336.7
NRCJ 41	2.76	68.2	8	103	2.61	3.50	53.8	311.3
NRCJ 42	2.88	81.2	9	109	2.75	3.82	54.2	453.3
NRCJ 43	2.64	75.9	9	115	2.49	3.60	55.2	407.2
NRCJ 44	2.71	75.6	9	101	2.60	3.70	55.1	610.8
NRCJ 45	2.40	56.2	7	74	2.23	2.83	60.4	463.0
Average	2.59	75.6	9	101	2.47	3.39	55.5	375.4
CD 5%	0.06	3.08	0.47	6.11	0.06	0.10	1.16	52.90

The crosses NRCJ-3 (85.5 cm), NRCJ-6 (84.4 cm), NRCJ-17 (84 cm) and NRCJ-13 (83.7 cm) were found next to NRCJ-18. Number of primary branches ranged from 5 (NRCJ-39) to 11 (NRCJ-26 & 36) with the population mean of 9. However, average branch length of 2.47 m was recorded with the range of 1.94 m (NRCJ-39) to 2.75 m (NRCJ-42). The cross NRCJ-42 was recorded for highest branch length followed by crosses NRCJ-15 (2.70 m), NRCJ-9 (2.68 m), NRCJ-33 (2.67 m) and NRCJ-36 (2.66 m). Average number of secondary branches were 101 plant^{-1} and ranged from 50 (NRCJ-39) to 128 (NRCJ-13). The other crosses noted next to NRCJ-13 were NRCJ-15 (126), NRCJ-17 (125), NRCJ-18 (121) and NRCJ-35 (120). Canopy diameter ranged from a minimum of 2.55 m (NRCJ-39) to a maximum of 3.92 m (NRCJ-15) with an average of 3.39 m and crosses NRCJ-9 (3.87 m), NRCJ-42 (3.82 m), NRCJ-18 (3.71 m) and NRCJ-44 (3.70 m) showed superiority after NRCJ-15. Ginwal *et al*. (2005) also reported significant variation in growth parameters like seedling height, collar diameter and leaves plant^{-1} in 10 accessions of *Jatropha curcas*. Seed yield plant^{-1} was also recorded for all the crosses. Average seed yield was 375.4 g with the range of 177.5 g (NRCJ-30) to 733 g (NRCJ-15) and crosses NRCJ-44 (610.8 g), NRCJ-25 (600.8 g), NRCJ-14 (571.4 g) and NRCJ-18 (521.9 g) were recorded superior next to NRCJ-15. Average 100 seed weight was recorded 55.5 g with the range from 49.8 g (NRCJ-35) to 61g (NRCJ-26). The crosses NRCJ-44 (60.4 g), NRCJ-10 (60.2 g), NRCJ-5 (59.4 g) and NRCJ-15 (58.9 g) were found next maximum to NRCJ- 26 for seed weight.

The variability estimated in terms of genotypic and phenotypic coefficient of variation (GCV and PCV), heritability and genetic advance (GA) as per cent of mean is presented in Table 2. The GCV and PCV for plant height was 8.71 and 16.45 whereas heritability and the GA was 52.95 and 45.92 per cent, respectively. Girth exercised GCV and PCV as 11.98 and 26.99 whereas heritability and the GA was 44.39 and 18.76 per cent. The GCV, PCV and heritability for number of primary branches were estimated high (22.89, 39.63 and 57.76%, respectively) but GA was low (4.15%) for this trait. Number of secondary branches exhibited GCV and PCV 20.35 and 40.90, respectively coupled with high heritability (49.76%) and GA (42.02%). The GCV and PCV estimated for branch length was 9.08 and 17.29, whereas heritability and GA for this trait was 52.52 and 45.97 per cent, respectively. Canopy diameter showed GCV and PCV 11.70 and 21.90 along with high heritability and GA *i.e*. 53.42 and 81.44 per cent, respectively. In yield traits, the GCV and PCV of 100 seed weight was 3.37 and 10.92 whereas for seed yield it was 8.42 and 21.61. However, heritability and GA was estimated 30.86 and 3.73 per cent for seed weight and 38.96 and 65.81 per cent for seed yield. Kaushik *et al*. (2007) also observed significant differences in seed size and 100 seed weight while studying variability in seed traits of 24 *Jatropha curcas* accessions. Rao *et al*. (2008) studied thirty-two candidate plus trees (CPTs) of *J. curcas* and observed significant differences for traits like plant height and seed yield.

Table 2. Genetic estimates for growth and seed yield attributes of *Jatropha* crosses

Traits	GCV	PCV	Herita-bility (%)	GA (%) of mean
Plant height	8.71	16.45	52.95	45.92
Girth	11.98	26.99	44.39	18.76
Number of primary branch	22.89	39.63	57.76	4.15
Number of secondary branch	20.35	40.90	49.76	42.02
Branchlength	9.08	17.29	52.52	45.97
Canopy diameter	11.70	21.90	53.42	81.44
100 Seed weight	3.37	10.92	30.86	3.73
Seed yield	8.42	21.61	38.96	65.81

Table 3. Correlation between growth characters and seed yield in *Jatropha* crosses

Traits	Girth	Number of primary branch	Number of secondary branch	Branch length	Canopy diameter	100 Seed weight	Seed yield
Plant height	0.437**	0.565**	0.640**	0.942**	0.622**	0.174*	0.337*
Girth	1	0.601**	0.557**	0.422	0.514**	0.055*	0.182*
Number of primary branch		1	0.635**	0.550**	0.556**	0.123*	0.252*
Number of secondary branch			1	0.628**	0.761**	0.180*	0.390*
Branch length				1	0.627**	0.140*	0.334*
Canopy diameter					1	0.124*	0.344*
100 Seed weight						1	0.329*

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed)

The moderate to high heritability accompanied with high GA for seed yield, number of primary branch plant^{-1} and canopy diameter could be due to additive gene action and selection for these characters and may be effective for further improvement. Kumar *et al*. (2012) studied assessment of genetic variability in growth, reproductive phenology, seed characters and yield in 27 accession of *Jatropha* and observed similar results. Mukta *et al*. (2009) studied variability assessment in *Pongamia pinnata* germplasm and finding was as per this experimental results. The relative values of PCV and GCV give an idea about the magnitude of variability present in a genetic population. Estimation of heritability along with GA has a crucial role in tree improvement, as it provides an index of the relative role of heredity and environment in the expression of various traits. The present results also confirms the findings of Ahlawat *et al*. (2010) and Das *et al.* (2010) who had reported vast variability in *Jatropha curcas*.

All the hybrids were also assessed for correlation coefficient for the traits under study and revealed that almost all the traits having positive and significant correlations with each other except girth and branch length (Table 3).

The present study shows existence of considerable amount of genetic variability in crosses with respect to growth and seed yield attributes which offer scope for selection. This kind of study can help to develop the better Jatropha crosses having better yield and oil content and also good performing crosses may be used for further Jatropha breeding/ improvement which can be utilized for large scale plantation under biofuel development program.

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