Indian Journal of Agricultural Sciences **81** (2): 125–28, February 2011

Performance and stability of jatropha (*Jatropha curcas*) for seed yield and its components

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Received: 3 August, 2009; Revised accepted: 3 November 2010

ABSTRACT

This study was conducted during 2004–07 on 8 genotypes of jatropha (*Jatropha curcas* L.) at four locations for stabilizing productivity over seasons and regions. All the genotypes differed significantly in their seed yield in different environments. The environment (linear) and genotypes × environment (linear interaction) were also significant on the basis of stability analysis. The genotype 'Chhatrapati' can be successfully cultivated in plains as it gives higher seed yield (0.90 tonnes/ha), oil content (57.70%) and better stability (b_i = 1.32, Sd_i^2 = –0.09) for favourable environment. However 'Hansraj' gave higher seed yield (0.76 tonnes/ha) with better stability (b_i = 1.05, Sd_i^2 = –0.37) across the environments for seed yield.

Key words: Jatropha, Stability, Stability parameters, Variety

Jatropha (*Jatropha curcas* L.) is a drought-resistant perennial crop growing well in marginal/poor soils. It is easy to establish, grows quickly and may survive even up to 50 years producing seeds. It is a multipurpose shrub and is considered to have originated in Latin America but presently it grows throughout the arid, semi-arid, tropical and sub-tropical regions of the world (Makkar *et al.* 1997). Jatropha plant produces seeds with an oil content of 37%. The oil can be combusted as fuel without being refined. It burns with clear smoke-free flame, tested successfully as fuel for simple diesel engine. The seed oil can be easily processed to partially for fully replace petroleum-based diesel fuels (Forson 2004). The press cake, which is a byproduct is good organic fertilizer and the oil is an insecticide as well. The use of this plant for large-scale biodiesel production is of great interest with regard to solving the energy shortage, reducing the carbon emission and increasing the income of the farming community (Banerji *et al.* 1985).

Medically it is used for diseases, like cancer, piles, snakebite, paralysis, dropsy etc. The kernels consist of oil up to about 60% which can be transformed into biodiesel fuel through esterification (Parmathma *et al.* 2006).

The utilization of *J. curcas* oil as a new source for diesel engine has tremendous scope in contributing to the growing needs of energy resources in the country. However, there are many questions about its production, commercialization and genetic improvement in India. No work has been taken up on genetic improvement and environmental interaction of this species so far in India (Saikia *et al.* 2009). At global level information on genetic improvement, adaptability and genotype-environment interactions of *J. curcas* is restricted to few publications. The objective of this study was to understand the magnitude of genetic variation, genotype - environment interaction and its adaptability in jatropha to identify the best genotype to the utilize for reforestation and future genetic improvement work.

To increase and stabilize the production and productivity, identification of suitable varieties with high yield potential are of paramount importance. Stability analysis helps in understanding the varietal adaptation under variable environmental. Thus, use of highly adaptable varieties is important in stabilizing productivity over seasons and regions.

MATERIALS AND METHODS

The experiment was laid out in randomized bock design with three replications at four locations, viz Rahuri (Maharashtra), Bhubaneswar (Orissa), Hisar (Haryana) and SK Nagar (Gujarat) during 2004–07. Observations were recoded on five competitive plants on plant height, number of branches and 100-seed weight while seed yield on plot basis. The data were analysed for stability parameters, viz mean $(\bar{X})$, regression coefficient (b_i) and deviation from

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regression (S^2d_i) as per model proposed by Eberhart and Russell (1966).

Eight genotypes ('Chhatrapati', 'Hansraj', 'ISJ 1', 'JH 1', 'Phule 1', 'SK Nagar Big', 'SKNJ 4' and 'Urlikanchan') were planted during rainy (*kharif*) season 2001. The genotypes were maintained in polythene bags for 30 days for rooting. One-month old rooted plants were planted in the field (pit size 50 cm × 50 cm × 50 cm) in randomized complete block design with three replications at four location , viz Rahuri, Bhubaneswar, Hisar and S K Nagar, and the spacing between the plants was 2m×2 m. Observation was recorded after four years on seed yield (tonnes/ha), plant height (cm), No. of primary branches, 100-seed weight (g) and oil content for the present investigation.

RESULTS AND DISCUSSION

Environment-wise analysis revealed that significant difference exists among the genotypes under each environment for all the four characters studied (Table 1). Significant mean square due to environment (season/year/ location) indicated substantial differences among the environments. The high magnitude of mean square due to environment (linear) compared with the genotype-environment interaction (linear) indicated that the regression of the environments on performance for various characters accounted for the major part of the total variation for all traits (Rai *et al.* 1989). Significant mean square due to pooled deviation suggested that the deviation from linear regression also contributed substantially towards the differences in the stability of genotype. The significant G×E interaction indicated that genotypes under different environment behaved differently for the expression of characters under study and significant environment interaction in jatropha was reported at Senegal and Cape Verde (Heller 1996). It means a particular variety may not exhibit the same phenotypic performance under different environments or different varieties may respond differently to a specific environment.

According to Eberhart and Russell (1966) genotype having regression coefficient approximately to unity (b_i=1), deviation from regression slope as small as possible and high mean performance are considered as stable (Table 2).

Seed yield is an important attribute in jatropha which is a deciding factor for obtaining the high economic returns. The genotypes 'ISJ 1' (bi=0.59, S^2di=1.93), 'JH 1' (bi=1.69, S^2di=12.10), 'Phule 1' (bi=0.57, S^2di=1.68) and 'SKNJ 4' (bi=0.55, S^2di=3.24) with highly significant regression coefficient and deviation from regression were not stable for seed yield. The higher yielding genotypes, such as 'Chhatrapati' (bi=1.32, S^2di=-0.09), 'S K Nagar Big' (bi=1.16, S^2di=0.02) had higher regression coefficient and less

Table 1 Analysis of variance for stability of seed yield during 2004–07

Source of variation	df	Mean sum of square			
		Seed yield (tonnes/ha)	Plant height (cm)	No. of branches	100-seed weight (g)
Genotypes (G)	7	0.33**	856.36**	28.21**	34.50**
Environments (E)	8	4.28**	74581.06**	898.56**	577.381**
G × E	56	0.12**	635.74**	10.29**	21.33**
E (linear)	1	34.26**	596648.16**	7188.45**	4622.46**
G × E (linear)	7	0.74**	3628.61**	14.85**	8.35**
Pooled deviations	56	0.03**	182.17**	8.43**	20.29**
Pooled error	126	0.01	104.88	0.82	5.67

** $P < 0.01$ and * $P < 0.05$

Table 2 Mean performance and stability parameters for different characters in *Jatropha curcas* during 2004–07

Genotype	Seed yield (tonnes/ha)			Plant height (cm)			No. of primary branches			100-seed weight (g)			Oil content
	Mean	b_i	sd_i^2	Mean	bi	sd_i^2	Mean	b_i	sd_i^2	Mean	b_i	sd_i^2	(%)
'Chhatrapati' (C)	0.90	1.32	–0.09	259.15	1.16	102.59	13.62	1.13	8.65*	53.88	1.13	17.23**	57.70
'Hansraj'	0.72	1.05	–0.73	244.95	1.01	32.62	10.90	0.90	6.19*	52.01	1.04	3.83	56.20
'ISJ 1'	0.48	0.59	1.93*	231.20	0.66	148.28*	11.32	0.89	6.23*	50.51	0.90	23.26**	54.80
'JH 1'	0.95	1.69	12.10**	251.10	1.36	479.33**	15.61	1.24	24.32**	54.17	1.06	28.06**	54.40
'Phule 1'	0.49	0.57	1.68*	231.04	0.75	-12.12	10.26	0.88	6.69*	50.36	0.77	14.38**	52.50
'S K Nagar (Big)'	0.80	1.16	0.02	249.62	1.08	7.50	13.15	1.02	4.93*	51.35	0.91	8.05	56.20
'SKNJ 4'	0.47	0.55	3.24**	248.88	1.01	-80.27	11.44	0.96	4.31*	48.18	1.14	13.22**	56.60
'Urlikanchan'	0.75	1.10	–0.08	242.30	0.97	-59.63	11.40	0.98	–0.41	50.79	1.03	8.90	55.10

** $P < 0.01$ and * $P < 0.05$

Table 3 Correlation between yield and quality traits

Trait	Seed yield (tonnes/ha)	Plant height (cm)	No. of primary branches	100-seed weight (g)	Oil content (%)
Seed yield (tonnes/ha)	0.10				
Plant height (cm)	0.74*	1.00			
No. of primary branches	0.81**	0.69*	1.00		
100-seed weight (g)	0.88**	0.51	0.74*	1.00	
Oil content (%)	0.36	0.77	0.26	0.15	1.00

** $P < 0.01$ and * $P < 0.05$

deviation from regression were stable for favourable environments. However, genotypes such as 'Hansraj' (bi=1.05, S^2di= –0.73) and 'Urlikanchan' (bi=1.10, S^2di=-0.08) had better seed yield (>0.75 tonnes/ha) and had non-significant regression with non-significant deviation from regression. Thus the genotypes were categorized as stable genotypes.

Data on plant height revealed that genotypes were observed to be stable. The genotype 'ISJ 1' (bi=0.60, S^2di=148.20) and 'JH 1' (bi=1.36, S^2di=479.30) had the highest significant deviation from regression.

Number of primary branches all the genotypes except 'Urlikanchan' had significant deviation from regression and thus were rated as non-stable.

Genotypes for 100-seed weight, such as 'Hansraj' (bi=1.04, S^2di= 3.83) and 'S K Nagar Big (bi=0.91, S^2di=8.05) had non-significant regression with non-significant deviation from regression.

Seed yield difference was observed among the locations as well as among the years/season at the same location. The mean yield over a genotype was more at Hisar (2.1 tonnes/ha) and Bubaneswar (1.11 tonnes/ha) in 2007 indicating that these area were highly suitable for growing the jatropha. Based on average over locations and years, the genotype 'JH 1' (0.94 tonnes/ha) was top yielder, followed by 'Chattrapati' (0.90 tonnes/ha).

Mean plant height over a genotype was highest at Hisar (409.0 cm) in 2007, moderate at Bhubaneswar and S K Nagar (from 214.0 to 241.7 cm) and very low at Rahuri (134.11 cm) in 2004. The genotype 'Chhatrapati' had the highest plant height (259.15 cm) based on the average over location/season.

Primary branches was highest at Bhubaneswar (35.65), followed by Hisar (20.47) in the 2007. Based on average over location/season the genotype, 'JH 1' had the highest no. of branches (15.65) followed by 'Chhatrapati' (13.62).

100-seed weight was the highest at Bhubaneswar (64.56 g) in 2007 and 2006 and very low at S K Nagar (40.54 g) in 2006. Based on average over location/season, the genotype 'JH 1' had the boldest seed (54.17 g).

The 8 genotypes in 2006 were analyzed for oil content on the basis of kernel weight. The best genotype for oil content was 'Chhatrapati' having 57.70%, followed by S K Nagar Big (56.20%). In 2007, the chemical analysis for its oil content in the whole seed which ranged from 27.50 to 38.80% with the mean value of 36.10%. The genotype 'ISJ 1' had the highest oil content (38.80%).

The seed yield (tonnes/ha) was found to have highly significant positive relationship with plant height (0.74), number of primary branches (0.81), 100-seed weight (0.88) and oil content (0.36) (Table 3). The 100-seed weight was also found to have significant positive correlation with plant height, number of primary branches. Similar type of relationships were reported by Saikia *et al.* (2009). Such relationship can be explored in selecting the genotypes to have an early indication about oil yield and yield performance. It is interesting to note that none of the traits showed negative correlation with each other. Thus, these characters may be used to the advantage of the breeder for easily bringing simultaneous improvement of the trend. The inter correlation found among the 100-seed weight and seedling characters is consistent with earlier studies (Ginwal *et al*. 2004).

It can be concluded that the genotype 'Chhatrapati' can be successfully cultivated in plains on account of its higher seed yield, oil content and better stability for favourable environment. However 'Hansraj' which had higher seed yield with better stability across the environments for seed yield, could be used in further breeding programmes for improvement of *J. curcas*.

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