



Seed Source Variation in *Jatropha curcas*: Oil, Seed and Germination Characteristics of Twenty Diverse Populations in Himachal Pradesh

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ABSTRACT

Jatropha curcas as biodiesel plant prove very important to Indian economy owing to continuously increasing energy demand. The seeds of this plant yield oil suitable as fuel for diesel engine. *Jatropha* plants found to grow at various places in Himachal Pradesh at different altitudinal/ microhabitat conditions in their wild state. The present study was conducted to determine the variation in oil yield, seed characters, germination and growth parameters by taking composite seed samples of twenty seed sources of *Jatropha curcas* from various parts of Himachal Pradesh. The oil content of whole seed varies from 24.51% to 41.83%. Seed weight of 100 seeds varies from 42.0 g to 72.75 g. Where as seed length varies from 17.04 mm to 18.79 mm & seed breadth varies from 10.60 mm to 11.25 mm. Similarly, germination and growth parameters were also studied and found to have significant variations. On the basis of present investigation seven seed sources having oil content >35% (whole seed basis) can be considered for any large scale planting programme of this species in the state of Himachal Pradesh.

Key words: *Jatropha curcas*, seed source, variation, oil yield, seed characters, microhabitat.

Introduction

Due to the concern on the availability of recoverable fossil fuel reserves and the environmental problems caused by the use of those fossil fuels, considerable attention has been given these days to biodiesel production as an alternative to petro diesel. However, as the biodiesel is produced from vegetable oils and animal fats, there are concerns that biodiesel feed stock may compete with food supply in the long-term. Hence, the recent focus is to find oil bearing plants that produce non-edible oils that can be used for biodiesel production. Moreover, due to uncertain supplies and fluctuations in prices for fossil fuel in international market, the need to search renewable, safe and non polluting sources of energy assumes top priority. Non-edible oil bearing trees like *Jatropha* have great potential to act as biofuel crop of the future. *Jatropha curcas* (L.) is a perennial plant of the spurge family (Euphorbiaceae). It is commonly known as Physic nut, Ratanjot, Jamalghota, Jangaliarandi or Kala-aranda in India, Recently, it has received much attention as a potential source of vegetable oil

as a replacement for diesel. *Jatropha curcas* is believed to be a native of Mexico and Central America. It was introduced in Africa and Asia a few centuries ago and is now cultivated worldwide. Portuguese introduced physic nut as an oil yielding plant in India. It is a multipurpose, deciduous, small tree (or large shrub), reported to be cultivated in drier sites of central and western parts of India.

Jatropha usually grows below 1400 meters of elevation from sea level and requires a minimum rainfall of 250 mm, with an optimum rainfall between 900-1200 mm (Bosswell, 2003). *Jatropha* seed yields up to 50% by weight, a slow drying oil, and known as "curcas oil". Biodiesel is produced by transesterification of oil obtained from the plant. Since *Jatropha* is an industrial crop the adequate oil content in the varieties is must. Its kernel is found to contain 45-60 per cent oil (Jones and Miller, 1991). The standard of 30% oil on mechanical expeller basis has been accepted. Poor quality oil with high saturation has also been found in some germplasm of this species. Since the oil is the basic product, the breeding needs to be focused on this aspect. The variability for oil content has been observed in India by many researcher e.g. Kandpal and Madan, 1995 (34.4% for one accession), Ginwal *et al.*, 2004 (33--39% for 10 accessions), Patolia *et al.*, 2007 (26--35% for 23 accessions) and Sharma, 2007 (29--39% for 7 provenances).

The present study was under taken to assess the variability with respect to oil, seed & germination characteristics in twenty diverse populations of *Jatropha curcas* collected from various parts of Himachal Pradesh. In addition to variability estimation, the degree of their transmission by estimating heritability in this potential biodiesel species also calculated for those studied parameters

Material and Methods

The study was conducted at Bir Plassi, Nalagarh Field Research Station of Himalayan Forest Research Institute, Shimla (H.P.). The station is located at Nalagarh-Ropar highway, which is 8 Km from Nalagarh town of Solan district (H.P.). It is situated at 31⁰ 02'07" N latitude and 76⁰ 36'24" E longitude and 306 m above msl. The land is flat with sandy loam soil texture. The area enjoys sub tropical type of climate of foothills of Himalayas.

Seed collection: Fruits of 20 seed sources were collected during November 2006 by Himalayan Forest Research Institute, Shimla. At least 10 parent trees from each population were randomly selected with at least 20 m distance between any two trees. Fruits from each tree were collected and pooled to make composite sample. The fruits were dried in the sun and seeds were extracted manually.

Oil extraction: Seed oil analysis was done through TERI (The Energy Research Institute) New Delhi. 50 g sample of each seed source sent to TERI for oil analysis. The oil yield was expressed in term of percentage of powdered whole seed sample.

Seed size: Four samples each of 100 seeds were randomly selected from each seedlot and measured for maximum seed length and width in centimetres.

Seed weight: For each population seed weight of ten randomly taken samples, each of hundred seeds, were obtained.

Germination test: 400 seeds of each seed source of *Jatropha curcas* were sown in the nursery in the mixture of sand, soil and farmyard manure (1:1:1) in polybags (size 9'× 6') in lots of 100 seeds using randomized complete block design with four replications as per ISTA rules (1976). A uniform pre-treatment was given to the seeds by soaking them in cold water for 18 hours. Watering was done daily and the number of seed germinated was recorded every day till the end of the experiment. Germination data was collected up to the one month of sowing and growth parameters were taken after four months of sowing.

The data thus obtained were subjected to analysis of variance (ANOVA) to establish the significance of differences between the seed sources. The least significant difference (LSD) was calculated and seed sources were ranked for variable studied using computer programme 'SX'. Coefficient of variation and heritability were calculated using the method of Kempthorne (1957).

Results and Discussion

The seed collection areas from the state of Himachal Pradesh are presented in Table 1 with geographical locations. The Table 2 depicts the data pertaining to oil contents in whole seeds. The oil percent in *Jatropha* seeds of various seed sources varies from 24.51% (HP-29) to 41.83% (HP-21). Except HP-27 and HP-29 seed sources, oil (%) in all other sources was found to be > 30%. In 7 seed sources, the oil content was found to be >35%. The extent of variation in oil content among the studied seed sources was also noticeable (CV-13.19%).

Table 1: Geographical Location of various seed sources of *Jatropha curcas*

S. No.	Code no.	Seed source	District	Latitude °N	Longitude °E	Altitude (m)
1	HP-2	Nangal Jarial	Una	31° 45'	76° 1'	440
2	HP-3	Nadaun	Hamirpur	31° 46'	76° 21'	520
3	HP-4	Bhorang	Hamirpur	31° 38.3'	76° 41'	1010
4	HP-5	Ladror	Hamirpur	31° 36'	76° 36.5'	940
5	HP-8	Nagrota	Kangra	31° 48.2'	76° 17'	620
6	HP-9	Jawalaji	Kangra	31° 52.2'	76° 20'	900
7	HP-10	Indora	Kangra	31° 47'	76° 20'	860
8	HP-11	Manai	Kangra	31°37.5'	76°28'	750
9	HP-12	Jawali	Kangra	31° 41.8'	76° 13.8'	760
10	HP-13	Nurpur	Kangra	31° 60.4'	75° 3'	470
11	HP-14	Dehra	Kangra	31° 18'	76° 52'	545
12	HP-18	Deoli	Bilaspur	31° 24.2'	76° 80.2'	960
13	HP-19	Ghumarwin	Bilaspur	31° 27'	76° 45'	940
14	HP-20	Brahmpukkar	Bilaspur	31° 16.4'	76° 47'	960
15	HP-21	Laraghat	Bilaspur	31° 35'	76° 47.5'	1070
16	HP-25	Parwanoo	Solan	31° 9'	76° 9.3'	927
17	HP-26	Lana-cheta	Sirmour	31° 59.4'	77°31.9'	1200
18	HP-27	Kangra	Kangra	32° 5'	76°15'	607
19	HP-28	Panjagi	Bilaspur	31°-22'	76°-50'	781
20	HP-29	Amb	Una	31°-44'	76°-0'	554

Table 2: Oil contents in various seed sources of *Jatropha curcas*

S. No.	Code no.	Seed source	Oil contents (%)
1	HP-2	Nangal Jarial	40.66
2	HP-3	Nadaun	32.64
3	HP-4	Bhorang	30.01
4	HP-5	Ladror	38.32
5	HP-8	Nagrota	31.60
6	HP-9	Jawalaji	31.44
7	HP-10	Indora	35.16
8	HP-11	Manai	38.57
9	HP-12	Jawali	38.73
10	HP-13	Nurpur	34.69
11	HP-14	Dehra	33.92
12	HP-18	Deoli	32.08
13	HP-19	Ghumarwin	33.82
14	HP-20	Brahmpukhar	32.13
15	HP-21	Laraghat	41.83
16	HP-25	Parwanoo	31.38
17	HP-26	Lana-cheta	32.75
18	HP-27	Kangra	28.04
19	HP-28	Panjagi	40.73
20	HP-29	Amb	24.51
CV (%)			13.19

The data pertaining to various seed characteristics of different seed sources of *Jatropha curcas* is given in Table 3. Analysis of variance indicated statistically significant differences among the seed sources for all studied parameters. The seed source HP-4 had maximum seed length (18.79 mm) though it is at par with HP-20, HP-10, HP-5, HP-29, HP-19, HP-12 and HP-28 seed sources, while HP-3 seed source had smallest seed length (17.04 mm). Seed breadth was observed maximum (11.25 mm) in HP-9 seed source which was statistically observed at par with HP-10, HP-13, HP-14, HP-8, HP-29, HP-11, HP-4 & HP-12 seed sources, while it was minimum in HP-18 seed source (10.60 mm). Seed weight (100 seeds) was observed maximum (72.75 g) in HP-19 followed by 72.25 g (HP-5) & 71.75 g (HP-4) which were statistically at par with each other. Seed source HP-27 depicted smallest seed weight *i.e.* 42.5g. Coefficient of variation (CV %) between the populations was estimated maximum *i.e.* 18.15% for seed weight followed by 2.40% for seed length and 1.84% for seed breadth. Analysis of variance (ANOVA) for the data obtained on seed characteristics showed that the differences between seed sources were statistically significant ($P < 0.001$) for all the characters studied.

Germination percent (nursery) and growth data of different seed sources & result of coefficient of variation (CV %) are given in Table 4. The range of seed source means were found to be approximately broad for germination percent 4.00 – 100% (HP-3 – HP-25 respectively); height 45.40 cm – 72.25 cm (HP-5 – HP-27 respectively) and collar diameter 11.47 mm – 24.41 mm (HP-3 – HP-13). Analysis of Variance resulted in a highly significant difference ($P < 0.001$) among the seed sources in respect of the studied traits. Coefficient of variation (CV %) calculated for those traits showed a maximum of 52.70% for germination percent, 16.69% for height and

14.86% for collar diameter. More than 80% germination was recorded for 12 seed sources whereas four seed sources recorded less than 30% germination.

Table 3: Variation in seed characteristics of different seed sources of *Jatropha curcas*

S. No.	Code No.	Seed Source	Seed Length (mm)	Seed Breadth (mm)	Seed Weight/ 100 seeds (gms)
1	HP-2	Nangal Jarial	17.62	10.92	42.50
2	HP-3	Nadaun	17.04	10.62	43.25
3	HP-4	Bhoranj	18.79	10.99	71.75
4	HP-5	Ladror	18.34	10.72	72.25
5	HP-8	Nagrota	17.70	11.10	53.50
6	HP-9	Jawalaji	17.42	11.25	59.50
7	HP-10	Indora	18.45	11.21	62.25
8	HP-11	Manai	17.96	11.03	64.75
9	HP-12	Jawali	18.17	10.97	43.25
10	HP-13	Nurpur	17.84	11.20	64.00
11	HP-14	Dehra	17.69	11.17	45.75
12	HP-18	Deoli	18.07	10.60	64.25
13	HP-19	Ghumarwin	18.21	10.80	72.75
14	HP-20	Brahmpukhar	18.53	10.80	67.75
15	HP-21	Laraghat	17.60	10.75	64.25
16	HP-25	Parwanoo	17.50	10.92	58.50
17	HP-26	Lana-cheta	17.64	10.73	54.00
18	HP-27	Kangra	17.86	10.73	42.50
19	HP-28	Panjagi	18.16	10.93	66.50
20	HP-29	Amb	18.27	11.05	50.24
Critical T value			2.002	2.002	2.002
S. E m.±			3.3065	1.4760	2.4395
C.D. (0.05)			6.6211	2.9556	4.8851
CV (%)			2.40	1.84	18.15

Variation refers to the observable differences in individuals for a particular trait. These differences may partly be due to the genetic factors and partly due to the environmental effects. The observed value of a trait is the phenotypic value of that individual. The related magnitude of these components determines the genetic properties of any particular species (Jain, 1982). Table 3 & 4 shows that the extent of variation in germination, seed weight, height & collar diameter was more as compared to the seed length and seed breadth in the studied seed sources of *Jatropha curcas*. The extent of variability is also assessed by genotypic and phenotypic coefficient of variation (Subramanian *et al.*, 1995). The figures of variance & coefficient of variability in different characters of *Jatropha curcas* seed sources were depicted in Table 5 & 6. In the present study, germination, seed weight and height gave comparable values for genotypic and phenotypic variances and coefficient of variability indicating that these parameters are under genetic control. Higher values of environmental variance and coefficient of variation were observed as compared to genotypic variance & coefficient of variation for collar diameter, seed breadth and seed length indicating that these are under strong environmental influence. The observed variation in a character is partly composed of genetic (heritable) variation & partly non-genetic (non-heritable) variation. The proportion of total variation which is heritable is termed as heritability in broad sense (Lush, 1937). The knowledge of its

magnitude provides an idea about the scope of effecting genetic improvement through selection. Johnson & Comstock (1955) observed that a high genetic gain is usually more useful than the heritability value alone, in predicting the resultant effect from selecting the best individual/seed source and therefore, a heritability estimate does not necessarily mean an increased genetic advance. Variations in several seeds and germination trials and their significance in seed sources studies have been documented in a number of tree *spp. viz. Albizzia lebbeck* (Kumar & Toky, 1993), *Prosopis juliflora* (Sharma *et.al.*, 1994) and *Acacia nilotica* (Bagchi and Dobriyal, 1990; Ginwal *et.al.*, 1995)

Table 4: Variation in germination and growth characteristics of different seed sources

S. No.	Code No.	Seed Source	Germination percentage (%) (Nursery)	Height (cm)	Collar Diameter (cm)
1	HP-2	Nangal Jarial	26.00	48.99	15.49
2	HP-3	Nadaun	4.00	39.75	11.47
3	HP-4	Bhoranj	6.00	65.25	15.62
4	HP-5	Lador	36.00	45.40	14.88
5	HP-8	Nagrota	84.00	46.46	15.44
6	HP-9	Jawalaji	96.00	59.61	16.01
7	HP-10	Indora	99.00	59.54	16.55
8	HP-11	Manai	98.00	58.85	16.56
9	HP-12	Jawali	96.00	69.16	18.25
10	HP-13	Nurpur	82.00	69.96	24.41
11	HP-14	Dehra	98.00	63.11	17.44
12	HP-18	Deoli	99.00	69.04	15.27
13	HP-19	Ghumarwin	96.00	69.00	16.03
14	HP-20	Brahmpukhar	27.00	54.39	14.73
15	HP-21	Laraghat	81.00	66.07	15.79
16	HP-25	Parwanoo	100.00	70.60	16.68
17	HP-26	Lana-cheta	34.00	47.32	13.90
18	HP-27	Kangra	56.00	72.25	17.79
19	HP-28	Panjagi	29.00	66.18	17.43
20	HP-29	Amb	99.00	70.18	16.89
Critical T value			2.002	2.002	2.002
S. E. m. ±			5.3094	6.8142	1.8960
C.D. (0.05)			10.632	13.645	3.7967
CV (%)			52.70	16.69	14.86

Table 5: Variance in different Characters of *Jatropha curcas* seed sources

Character under study	Variance		
	Phenotype	Genotype	Environmental Factor
Seed weight	156.61	144.71	11.90
Seed length	0.45	0.23	0.22
Seed breadth	0.083	0.039	0.044
Germination (%)	1751.39	1695.01	56.38
Height	198.03	105.16	92.87
Collar diameter	12.64	5.45	7.19

The table 7 depicts the values of heritability, genetic advance & genetic gain of studied parameters. Heritability values for germination percent (96.78%) and seed weight (92.40%) were observed to be high as compared with height (53.10%), seed

length (51.11%), seed breadth (46.99%) and collar diameter (43.12%). The value of genetic advance was highest in germination percent (83.43) as compared with all other studied parameters. The lowest value of genetic advance was observed in seed breadth (0.28) followed by seed length (0.71). The germination percent was also found to be associated with higher genetic gain (123.96%) followed by seed weight (40.95%). The lowest value of genetic gain was observed in seed breadth (2.56%). There is a wide scope of genetic improvement in *Jatropha curcas* based on studied parameters. These results are in conformity with the findings of Kedarnath *et al.* (1969) that most growth attributes of teak are heritable. Moderately high heritability estimates associated with moderate genetic advance have earlier been reported for plant height by Srivastava *et al.* (1993) in *Terminalia arjuna*, for plant height and stem diameter in *Grewia optiva* by Sharma and Sharma (1995), in *Eucalyptus grandis* by Subramanian *et al.* (1995) and for collar diameter and survival percent in *Tectona grandis* by Gera *et al.* (2001).

Table 6: Co-efficient of variability in different Characters of *Jatropha curcas* seed sources

Characters	Coefficient of Variability		
	Phenotype	Genotype	Environmental Factor
Seed weight	21.51	20.68	5.93
Seed length	3.74	2.67	2.61
Seed breadth	2.64	1.81	1.92
Germination (%)	62.18	61.17	11.16
Height	23.24	16.93	15.91
Collar diameter	21.77	14.30	16.42

Table 7: Measures of genetic parameters of seed sources of *Jatropha curcas*

Characters	Heritability (%) Broad sense	Genetic advance	Genetic gain (%)
Seed weight	92.40	23.82	40.95
Seed length	51.11	0.71	3.96
Seed breadth	46.99	0.28	2.56
Germination (%)	96.78	83.43	123.96
Height	53.10	15.39	25.41
Collar diameter	43.12	3.16	19.35

For present investigation, it is inferred that considerable genetic variations in studied parameters exists among different seed sources of *Jatropha curcas*. Besides this, heritability and genetic gain were also high in some of the studied parameters like germination percent, seed weight, height etc; strengthening the probable reason that they are more under genetic control. Genetic factor and environmental factors have significant impact on oil yield production. Within the genetic resource base of 24 *J. curcas* accessions from Haryana state (India), environmental factors predominant over genetic factors, although seed size, seed weight and oil content could be genetically clustered and significantly differentiated (Kaushik *et al.*, 2007). This also suggests that judicious screening/ selection on the basis of these parameters can be an effective technique.

On the basis of present investigation seven seed sources namely Laraghat (HP-21), Panjgai (HP-28), Nangal Jarial (HP-2), Jawali (HP-12), Manai (HP-11), Lador (HP-5) and Indora (HP-10) having oil content >35% (whole seed basis) can be

considered for any large scale planting programme of this species in the state of Himachal Pradesh.

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