Available at www.sciencedirect.com

ScienceDirect

http://www.elsevier.com/locate/biombioe

Assessing *Jatropha curcas* L. germplasm *in-situ*—A case study

N. Sunil[a,*], K.S. Varaprasad[a], N. Sivaraj[a], T. Suresh Kumar[b], Babu Abraham[a], R.B.N. Prasad[c]

[a]*National Bureau of Plant Genetic Resources, Regional Station, Hyderabad 500 030, India*
[b]*Fruit Research Station, Acharya N.G. Ranga Agricultural University, Sangareddy, Andhra Pradesh, India*
[c]*Indian Institute of Chemical Technology, Hyderabad, Andhra Pradesh, India*

ARTICLE INFO

Article history:
Received 6 April 2007
Received in revised form
5 July 2007
Accepted 15 September 2007
Available online 22 October 2007

Keywords:
Jatropha curcas
Germplasm
Traits
Ecogeographic
Variability
Biofuel
Sampling

ABSTRACT

A systematic collection of *Jatropha curcas* germplasm has been carried out from four distinct ecogeographic zones of peninsular India in 2005. This involved recording of passport data, documentation of important plant traits *in-situ*, ecogeographic parameters and assessment of variability. By using the Soxhlet method, the oil content of 162 collected accessions was estimated, which ranged from 22% to 42%. A method has been developed for identification of superior lines by assessing the phenotypic traits of plants recorded *in-situ*. This method facilitates selection of promising accessions for multi-location evaluation and hastens the process of utilization of germplasm. The traits for the plus trees of Jatropha have been discussed.

1. Introduction

The availability of oil in a sustained manner with an added advantage of less greenhouse gases emission is the ideal option [1]. Biofuel has both these advantages. Biofuel is being looked at as an important alternative fuel in the overall energy security world over. Among the important sources of biofuel, *Jatropha curcas* has received special mention in India [2]. Jatropha has been introduced in Asia by the Portuguese [3], it has been naturalized well in the country and also some introductions from centers of diversity have been made in early and mid-1980s. Jatropha has the adaptability to perform well in marginal soils in semi-arid tropics, its oil is suitable as a diesel substitute and it has other multiple uses [4–6]. India with its diverse agro-ecological regions and climatic conditions offers a good opportunity for propagating variation. Systematic collection and investigation of the genetic distinctness in the regions where Jatropha has been introduced is identified as research gap [6]. The importance of a ecogeographic database in providing information on conservation priorities of the germplasm has already been established [7]. Hence, four explorations were undertaken in four distinct ecogeographic zones of Andhra Pradesh and Chhattisgarh states of India during 2005. The utilization of these tree germplasm lines warrants extensive study in the form of multi-locational trials, which is both time and resource consuming. Hence, the present investigation was aimed to develop a method of identifying superior lines using the plant traits, recorded *in-situ*.

*Corresponding author. Tel.: +91 40 24015478; fax: +91 40 24014072.
E-mail address: sunilneelam9@yahoo.com (N. Sunil).
0961-9534/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.biombioe.2007.09.003

2. Characteristics of the study area

The study area comprises parts of Andhra Pradesh and Chhattisgarh states in the peninsular India. As the study area is endowed with a variety of soils and varied climatic conditions, descriptions on physiography, soils, climate and rainfall are described zone-wise.

2.1. North Telangana zone of Andhra Pradesh (AP) state

The germplasm was collected from Adilabad, Nizamabad and Medak districts in this zone, ranging 17.58.40–19.35.53N to 77.52.44–78.55.27E. The important soil types mainly encountered are chalkas, red sandy, deep red loamy, very deep black cotton soils. The explored area is dry, tropical in nature. The annual rainfall varies from 900 to 1500 mm. The average minimum and maximum temperatures vary between 21 and 25 °C and 30 and 37 °C, respectively.

2.2. South Telangana zone of AP state

The surveys covered Ranga Reddy and Mahabubnagar districts in this zone, ranging from 17.09.31–17.56.05N to 77.15.17–78.09.15E. The soils are of red earths with loamy sub-soils (chalkas). The annual rainfall varies from 700 to 900 mm. The average minimum and maximum temperatures vary between 22 and 23 °C and 28 and 34 °C, respectively, in the surveyed region.

2.3. Southern zone of AP state

The southern parts of Prakasham district were surveyed in this zone, which ranged from 15.1029–15.23.48N to 80.00.55–80.07.38E. The soils encountered in the district are red loamy, shallow to moderately deep soils. The annual rainfall varies from 700 to 1100 mm. The average minimum and maximum temperatures vary between 23 and 25 °C and 33 and 46 °C, respectively, in the surveyed region.

2.4. Bastar Plateau Zone of Chhattisgarh state

Bastar and Dantewada districts were explored in the zone, ranging from 18.57.20–20.01.24N to 81.21.50–82.06.35E. The soil types seen are red sandy to black cotton soils. The explored area is tropical in nature. The annual rainfall varies from 1400 to 1600 mm. Maximum and minimum temperatures range from 33 to 35 °C and 26 to 27 °C, respectively.

3. Materials and methods

A viable itinerary was prepared for the collection of *J. curcas* germplasm in parts of Andhra Pradesh and Chhattisgarh states of peninsular India. The general logistics were taken care of as suggested [8]. Four region-specific explorations were undertaken for the collection of Jatropha germplasm as stated above. Collections were made from different habitats ranging from range lands, farm fence and backyards in villages. The basic and appropriate sampling strategy was followed as indicated [9]. For the majority of accessions, random sampling of germplasm followed by bulking of the sampled population was followed. It was also ensured to collect fruits from all sides of the plant with similar number of seeds from each plant sampled. Passport data were recorded for each accession collected [10]. Important agro-morphological traits like plant height, collar height, collar thickness, number of primary branches, petiole length, number of fruits per cluster, pedicel length and yield (visual observation) were recorded on the plant *in-situ*. Standard measuring scales and tapes were used for recording data. The age of the plant was recorded based on the information given by the locals. Data on plants aged 5 years and above only were recorded as it was assumed that yield stabilizes in *Jatropha* after 5 years.

The altitude, topography and soil color were recorded for ecogeographic conditions of the site of collection. Latitude, longitude and altitude values for the germplasm collection site were recorded using the Global Positioning System (Garmin GPS-12). DIVA-GIS software (version 3.2) was used for mapping the collections. The oil content of the germplasm lines was analyzed using the *Soxhlet method*. All the collected germplasms were assigned an indigenous collector number (IC No.).

4. Results and discussion

One hundred and sixty-two accessions of *J. curcas* germplasm lines were collected during four surveys undertaken in parts of Andhra Pradesh and Chhattisgarh states (Fig. 1). The germplasm accessions collected zone-wise were 28 from Northern Telangana zone of AP, Southern Telangana zone of AP—53, South zone of AP—13 and Bastar Plateau Zone of Chattisgarh—68. These accessions were grouped based on ecogeographic conditions and their plant traits (Table 1). Germplasm was collected from different soil types. Most of the germplasm collected was from level land. Based on plant height, accessions were grouped into two categories, viz.,

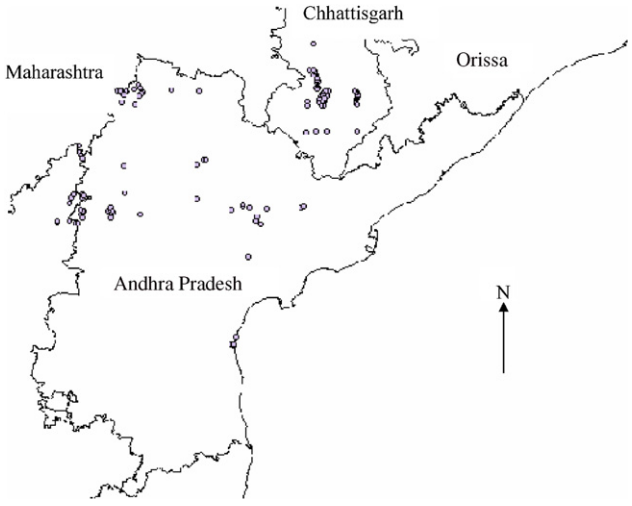

Fig. 1 – Mapping of *Jatropha curcas* collections in Andhra Pradesh and Chhattisgarh states of India.

<1.5 m (57%) and >1.5 m (43%). Collar height of >0.6 m was recorded in 33% of the accessions and collar diameter of more than 50 cm in 31% of accessions. Most of the accessions had primary branches <3 (61%). Petiole length mostly ranged 10–15 cm (47%) and was high in the Southern Telangana zone (33%). Number of fruits per cluster mostly ranged 5–10 (73%) and only one accession—IC537900—recorded more than 15 fruits per cluster. Four accessions, viz., IC537934, IC537879, IC537888 and IC544675 were found to be very high yielders. The majority of the accessions recorded oil % between 35%

Table 1 – Classification of the *Jatropha* germplasm collected based on ecogeographic condition and plant traits recorded *in-situ*

Trait	Type	Northern Telangana zone of AP	Southern Telangana zone of AP	Bastar Plateau zone of Chhattisgarh	South zone of AP
Soil type	Black	16	16	–	13
	Red	–	20	–	–
	Brown	12	17	68	–
Topography	Level	26	34	38	13
	Undulating	–	2	28	–
	Swamp	1	11		–
	Steeply dissected	–	1	01	–
	Flood plain	1	5	01	–
Plant height (m)	<1.5	9	26	53	5
	>1.5	19	27	15	8
Collar height (m)	<0.6	20	38	39	10
	0.6–1.5	08	15	29	03
Collar diameter (cm)	<20	11	5	11	11
	20–30	15	5	16	02
	30–40	02	4	04	
	40–50	–	10	15	
	>50	–	29	22	
Primary branches (no.)	<3	18	36	49	4
	3–6	09	17	19	9
	>6	01	–	–	
Petiole length (cm)	5–10	20	8	10	4
	10–15	08	27	38	5
	>15		18	20	4
Fruits/cluster (no.)	<5	06	13	04	–
	5–10	19	34	60	6
	10–15	02	05	04	7
	>15	–	01		–
Pedicel length (cm)	<3	–	01	–	–
	3–6	28	36	41	8
	>6	–	16	27	5
Health	Average	3	09	53	4
	Good	23	43	15	8
	Very good	2	1	–	1
Oil content (%)[a]	<30	5	–	–	13
	30–35	14	7	24	
	35–40	3	38	31	
	>40	–	1	01	

[a] Data recorded on accessions wherever seed was collected.

and 40% (44%) and only two accessions (IC541650—40.6% and IC537939—42.0%) recorded more than 40% oil.

Identification of promising lines among the germplasm collections would entail a concerted study over a period of time, usually 5–10 years in a tree species like Jatropha. A method of scoring these accessions *in-situ* for certain specific traits has been attempted to identify superior accessions. Eight traits were listed, for evaluating Jatropha germplasm by Zangemeister's method [11], in which each trait has been assigned weight. Among these traits plant height, collar diameter, oil percentage and health could be recorded. In addition to the above traits, number of primary branches and number of fruits per cluster were also considered after observing the variation in the germplasm, their contributory role in the final yield of the plant along with the heritability of the traits. A score of 1–3 was adopted to rank the germplasm lines giving higher score to the greater number of primary

Table 2 – Scoring scale adopted for evaluation traits

Character	Range	Score
Plant height (m)	<1.5	2
	>1.5–3.0	3
	>3.0	4
Collar diameter (cm)	<20	3
	20–30	4
	30–40	5
	40–50	6
	>50	7
Health	Average	3
	Good	6
	Very good	9
Oil %	20–25	4
	25–30	8
	30–35	12
	35–40	16
	>40	21
Primary branches (no.)	<3	1
	3–6	2
	>6	3
Fruits per cluster (no.)	<5	1
	6–10	2
	>10	3

Table 3 – Top performing accessions of *Jatropha curcas* (zone-wise)

Zone	Accession no.
Northern Telangana zone of AP	IC537862, IC537872 and IC537876
Southern Telangana zone of AP	IC537924 and IC537939
Bastar Plateau zone of Chattisgarh	IC541650, IC541634 and IC541651
Southern zone of AP	IC544675

Table 4 – Ecogeographic and plant traits recorded *in-situ* for the promising accessions

Accession no.	Score	Altitude (m)	Soil type	Topography	Plant height (m)	Collar height (m)	Collar thickness (cm)	Primary branches (no.)	Petiole length (cm)	Fruits/ cluster (no.)	Pedicel length (cm)	Age of the tree (years)	Yield
IC537862	35	550	Brown	Level	>1.5	<0.6	30–40	<3	10	6–10	4	5–10	Good
IC537872	35	441	Black	Level	>1.5	<0.6	20–30	3–6	10	6–10	4	5–10	Good
IC537876	35	438	Black	Level	>1.5	>0.6	20–30	3–6	10	6–10	4.5	5–10	Very good
IC537924	40	617	Red	Level	>1.5	<0.6	>50	<3	13	6–10	5	>10	Very good
IC537939	40	571	Brown	Level	>1.5	>0.6	>50	3–6	15	6–10	8	>10	Average
IC541634	37	568	Brown	Level	>1.5	>0.6	40–50	<3	15	6–10	5	5–10	Good
IC541650	40	566	Brown	Level	>1.5	>0.6	>50	3–6	15	6–10	10	>10	Good
IC541651	35	556	Brown	Level	>1.5	>0.6	>50	3–6	15	6–10	10	>10	Average
IC544675	34	12	Brown	Level	<1.5	>0.6	<20	3–6	11	>10	10	>10	Very good

Table 5 – Guiding traits for plus trees of *Jatropha curcas*

Trait	Value
Plant height (m)	1.5–2.0
Collar height (m)	0.6–0.9
Collar thickness (cm)	30–40
Primary branches (no.)	3–6
Petiole length (cm)	10–15
Fruits per cluster (no.)	6–10
Pedicel length (cm)	4–5
Oil (%)	35–40

branches and fruits per cluster, respectively. The scoring scale of the germplasm lines is depicted in Table 2. The scores in the Northern Telangana Zone of AP ranged from 12 to 35, in the Southern Telangana Zone of AP were from 12 to 40, in the South Zone of AP were between 19 and 34 and in the Bastar Plateau Zone of Chhattisgarh the scores were from 13 to 40. Based on the scoring, superior accessions for each zone were identified (Table 3).

The top ranked accessions within each group were selected and analyzed for the ecogeographic conditions, and other traits recorded are provided in Table 4.

Results indicated that Jatropha seems to perform better in black to brown soils with clay and sandy loam texture having level topography. Inferring from the traits exhibited by the promising accessions, a list of traits to look for in the plus trees has been arrived at for use by researchers and explorers (Table 5). Correlation between the plant height and number of leaves has been reported by Ratree [12]. However, to facilitate easy harvesting of pods, a plant height of 1.5–2.0 m would seem ideal. A collar height of >0.6 m might provide better aeration, facilitating good exchange of gases and aiding in increased photosynthetic activity. A collar thickness of 30–40 cm was found sufficient in giving up to six primary branches, which translates into good to very good yields. A petiole length of 10–15 cm seemed to optimize the primary function of utilization of sunlight and the energy spent on the petiole length. The number of fruits per cluster of 6–10 seems to balance the number of fruits and oil content. Most of the accessions had a pedicel length of 4–5 cm. An oil content of 35–40% coupled with the above traits would translate into very good yields as evidenced by the superior lines.

Acknowledgments

The authors are thankful to Dr. S.K. Sharma, Director, National Bureau of Plant Genetic Resources (NBPGR), New Delhi, Dr. R.K. Khetarpal, Head, Division of Plant Quarantine, NBPGR, New Delhi, and Dr. D.C. Bhandari, Head, Division of Germplasm Exploration, NBPGR, New Delhi, for facilities, encouragement and help. The funds provided by the Department of RSAD, Government of Andhra Pradesh, to carry out the research are highly acknowledged.

REFERENCES

[1] George F, Raphael E, Klaus B. A concept for simultaneous wasteland reclamation, fuel production and socio-economic development in degraded areas in India: need, potential and perspectives of *Jatropha* plantations. Natural Resources Forum 2005;29:12–24.
[2] India Vision 2020. Planning commission, Government of India. December, 2002, available at 〈http://planningcommission.nic.in/plans/planrel/pl_vsn2020.pdf〉.
[3] Burkill IH. A dictionary of the economic products of the Malay peninsula, vol. II. Kuala Lumpur: Ministry of Agriculture; 1966.
[4] Norman J, Joan HM. *Jatropha curcas*: A multipurpose species for problematic sites. Land Resource Series No. 1. World Bank; 1991. p. 1–12.
[5] Foidl N, Foidl G, Sanchez M, Mittlebach M, Hackel S. *Jatropha curcas* L. as a source for the production of biofuel in Nicaragua. Bioresource Technology 1996;58:77–82.
[6] Heller J. Physic nut—*Jatropha curcas* L. Promoting the conservation and use of underutilized and neglected crops. Rome, Italy: International Plant Genetic Resources Institute; 1996. p. 1–66.
[7] Maxted N, van Slageren MW, Rihan JR. Ecogegraphic surveys. In: Guarino L, Ramanatha Rao V, Reid R, editors. Collecting plant genetic diversity: technical guidelines. Oxon, UK: CAB International; 1995. p. 255–86.
[8] Engels JMM, Arora RK, Guarino L. An introduction to plant germplasm exploration and collecting: planning methods and procedures, followup. In: Guarino L, Ramanatha Rao V, Reid R, editors. Collecting plant genetic diversity: technical guidelines. Oxon, UK: CAB International; 1995 p. 31–63.
[9] Brown AHD, Marshall DR. A basic sampling strategy: theory and practice. In: Guarino L, Ramanatha Rao V, Reid R, editors. Collecting plant genetic diversity: technical guidelines. Oxon, UK: CAB International; 1995 p. 75–91.
[10] Adriana A, Stefano D, Thomas M. Multicrop passport descriptors published by FAO/IPGRI multicrop descriptors, 2001. p. 1–4 〈http://www.bioversityinternational.org/Publications/Pdf/124.pdf〉.
[11] Srivastava RL, Mishra DK, Tewari VP, Omar UK. Operational guidelines for the project supported under micromission on Jatropha by DBT, 2004. p. 1–27 〈http://www.afri.res.in〉.
[12] Ratree S. A preliminary study on physic nut (*Jatropha curcas* L.) in Thailand. Pakistan Journal of Biological Sciences 2004;7(9):1620–3.