Minimal Descriptors of *Jatropha curcas* L.

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Foreword

Rapid industrialization coupled with population growth has tremendously increased the demand for different sources of energy viz. coal, electricity (nuclear and hydro), natural gas and oil. As industrialization progressed, the per capita energy use has increased, rising from a global average of 1.2 toe (tonnes of oil equivalent)/person in 1966 to 1.7 toe/person in 2006. Concomitantly as the global energy supply tripled during that time, the population has doubled. Among the energy sources, oil is the most convenient (portable) sources of energy. World oil production is 84,789,040.8148 bbl/day and India, with 3.2% of the consumption, is among the top ten consumers of the oil (6th position). However, it is not among the top producers of oil in the world. The oil imports have cost the exchequer 2.72 lakh crores during 2007-08. With finite oil reserves and increasing demand for oil, it is pertinent to look for alternative sources. Among these, bio-fuel (fuel from organic sources), which is renewable and environment friendly has been considered as an alternative.

In India, bio-fuel from non-edible oil producing plants, which perform well under the limited resources, is seen as a potential source. The Planning Commission of India gave an impetus to cultivation of Jatropha curcas L., as it was reported to yield non-edible oil suitable for biodiesel production, for its sturdy nature and multifarious uses of other parts of the plant. The government of Andhra Pradesh had established a specialized department namely Rain Shadow Areas Development (RSAD)
department with an objective to uplift the rural poor in the low rainfall areas. A total of 10 districts have been identified as rain shadow districts in Andhra Pradesh. The government sought to amalgamate the requirement of bio-fuel production with the upliftment of resource poor farmers in the rain shadow districts of Andhra Pradesh by encouraging mass propagation of *Jatropha*, *Pongamia* and *Simarouba* trees among the target farmers. With this noble objective, the department has initiated a Research and Development project so as to give preliminary inputs on the availability, agro-techniques to be followed and optimization of oil extraction protocol. Under this initiative, apart from on-station experiments, on-farm trials were also taken up in 10 Rain Shadow districts of Andhra Pradesh. The consortium for R&D project involved research organizations located at Hyderabad such as, National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Central Research Institute for Dryland Agriculture (CRIDA), Directorate of Oilseeds Research (DOR), Indian Institute of Chemical Technology (IICT), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), and Acharya N G Ranga Agricultural University (ANGRAU), which also was the coordinating agency, with the budget outlay of Rs 5.86 crores for three years (from 2005 to 2008) and later it was extended for another two years (2008-10).

Three of the consortium partners, NBPGR, CRIDA and DOR, have developed a 'Minimal Descriptors of *Jatropha curcas* L'. This will facilitate to document the diversity available in *Jatropha* in the country for its effective utilization. The book deals with 38 important traits, which distinguish the individual plants phenotypically. The descriptors were developed based on documentation of the diversity of more than 400 accessions of *Jatropha* collected from all over India and established in a germplasm block at NBPGR and CRIDA. This would act as reference guide for further improvement programs in *J. curcas*.

It gives me immense pleasure to be associated with this unique project, which would greatly help all those involved in research on *J. curcas* throughout the country.

I appreciate and compliment the whole team for bringing out this resourceful, authentic and timely publication.

Date : 24-03-2010
Place : Hyderabad
Preface

The National Bureau of Plant Genetic Resources (NBPGR) with a mandate of collection, characterization and evaluation, conservation, documentation of genetic resources has collected and conserved more than 3.5 lakh accessions of agri-horticultural crops with the various conservation facilities such as National Gene Bank (NGB) (orthodox seeds), Cryo-preservation (recalcitrant seeds), NFPTCR (difficult to seed plants). Characterization and evaluation of various agri-horticultural crops has aided the breeders in the development and release of new varieties and hybrids. NBPGR has also been instrumental in the development of minimal descriptors for a large number of agri-horticultural crops, which included Minimal Descriptors Part-I for Agricultural Crops, Part II for Vegetable Crops, Part III for Fruit Crops and Part IV for Medicinal and Aromatic Plants. However, new crops and crops those were missed out need to be added for facilitating better utilization of the germplasm in crop improvement programmes, and these include Tree Borne Oilseeds (TBOs) such as Jatropha and Pongamia.

Jatropha curcas L., an oil yielding tree has been the focus of collection and conservation efforts in our country because of its potential use as biodiesel. As a result of multiple efforts to collect the germplasm, a total of 1805 accessions have been collected and conserved in the National Gene Bank (NGB). Comprehensive information regarding its variability as required by the breeder for evaluation and characterization of various traits, to enhance its productivity and commercial value is lacking. In an effort to meet the requirement of documentation of diversity for crop improvement, an earnest attempt was made to study the crop in detail for various traits under uniform agro-climatic conditions. Based on such a study, the minimal descriptors have been developed and a simple working botanical classification has been provided for convenience of the researchers. It is not an exhaustive descriptor as still there exists an unexplored and untapped genetic potential in the country at large. Nevertheless, it gives an opportunity to characterize the germplasm and develop a data base of the collected material for utilization in the J. curcas improvement programmes.

We take this opportunity to appreciate the efforts of the RSAD department of the Government of Andhra Pradesh for supporting a research programme on “Collection, Evaluation of Germplasm, Standardization of Agro-techniques and Pilot Demonstrations for a Jatropha curcas L. and Pongamia in Rain Shadow Districts of A.P.” with a consortium of ICAR institutes (NBPGR, CRIDA and DOR), Acharya N.G. Ranga Agricultural University, ICRISAT and IICT, which we feel was a pioneering decision to harvest the benefit of bio-fuel in terms of economics and environment.

Authors
Introduction

*Jatropha curcas* L. or Ratanjyot or Physic nut of the genus *Jatropha* belongs to tribe Joannesieae of Crotonoideae in the Euphorbiaceae family and contains approximately 170 known species. Dehgan and Webster (1979) revised and distinguished two subgenera (*Curcas* and *Jatropha*) of the genus *Jatropha*, with 10 sections and 10 subsections to accommodate the Old and New World species. It is a diploid species having chromosome number 2n=22. It is believed to have originated in Mexico and Central America. Burkill (1966) proposed that the Portuguese seafarers have introduced *Jatropha* in Asia from where it has spread to south-east Asia including India.

*J. curcas* is a tree or shrub showing articulated growth and branches containing latex. It is a hardy plant, which can be propagated easily through seeds and stem cuttings. Normally, five roots are formed from seedlings, one central and four peripheral. A tap root is not usually formed in vegetative propagated plants. It has 3-7 shallow lobed leaves with length and width of 6 to 15 cm. Inflorescences are formed terminally on branches and are complex, possessing main and co-florescence with paracladia. It produces monoecious flowers, which are unisexual and sometimes, hermaphrodite with greenish white colored petals. Stamens are arranged in two distinct whorls of five each in a single column in the androecium, and in close proximity to each other. In the gynoecium, the three slender styles are connate to about two-thirds of their length, dilating to massive bifurcate stigma. Self as well as cross pollination is observed. Fruits are trilocular, ellipsoidal with rudimentary caruncle. Oil from seed is important as it is being used as bio-fuel.

Molecular studies in India and around the world have reported, as not extensive, the existence of diversity in *Jatropha*. However, the crop is known to respond well to climatic conditions and exhibits phenotypic plasticity. The crop has acclimatized well in diverse agro-ecological niches of the country and has accumulated variation over the years. Hence, documentation of the variation in the morphological traits is necessary to effectively tap the available diversity in the crop improvement programmes. Against this background, an attempt has been made to characterize and categorize, the morphological diversity in the germplasm collected and conserved from all over India, in the form of *Minimal Descriptors of Jatropha curcas* L. The best efforts were put in describing the plant taking into consideration all the important agro-morphological traits derived from a large germplasm collection maintained at NBPG, Regional Station, CRIDA and DOR, Hyderabad. This is a first and initial attempt to document the diversity pictorially in *J. curcas*. There is further scope for addition on the traits, where variation is observed. However, it is hoped that the descriptor will serve as a reference to characterize the available diversity to a large extent.
Descriptor and Descriptor States

D1 - Growth habit

Recorded on 3-year-old plantations raised under uniform agronomic practices, soil and weather conditions

1. Shrub (< 5 m)
2. Tree (> 5 m)
D2 - Plant canopy

Recorded on 3-year-old plantations raised under uniform agronomic practices, soil and weather conditions

1. Narrow
2. Intermediate
3. Spreading
D3 - Branching habit

Recorded on 3-year-old plantations raised under uniform agronomic practices, soil and weather conditions

1. Sparse
2. Intermediate
3. Dense
**D4 - Leafiness**

Recorded at peak vegetative growth stage of the plant

1. Abundant
2. Moderate
3. Scanty
D5 - Branching pattern

Recorded on 3-year-old plantations raised under uniform agronomic practices, soil and weather conditions

1. Basal
2. Intermediate
3. Top
4. Entire
D6 - Number of primary branches

Recorded on 3-year-old plantations raised under uniform agronomic practices, soil and weather conditions

1. Low (< 5)
2. Medium (5 - 10)
3. High (> 10)
D7 - Stem colour
Recorded on the base or collar region of the main stem
1. Green
2. Grey
Minimal descriptors of *Jatropha curcas* L.

**D8 - Latex colour**

Recorded on matured plants of 3-year-old plantations raised under uniform agronomic practices, soil and weather conditions

1. Cream
2. Red
D9 - Pigmentation of emerging leaves

Recorded on the young emerging leaves on the tertiary branches. Colour assigned as per the Royal Horticultural Society color chart (fifth edition)

1. Green (Code: 142 A)
2. Green greyed purple (Code: 140A+185D)
3. Yellow green (Code: 149 A)
4. Greyed purple (Code: 185 A, B)
5. Dark greyed purple (Code: 187 A)
6. Red (Code: 44 A)
D12 - Petiole length

Recorded on matured leaves on the tertiary branches

1. Small (< 12 cm)
2. Medium (12 - 22 cm)
3. Large (> 22 cm)
D13 - Leaf colour

Recorded on matured leaves of the current season growth on the tertiary branches. Colour assigned as per the Royal Horticultural Society colour chart (fifth edition).

1. Light green (Code: 140A)
2. Green (Code: 134A)
3. Dark green (Code: 136A)
**D14 - Number of leaf lobes**

Recorded on matured leaves of the current season growth on the tertiary branches

1. 0 - 2
2. 3 - 5
3. > 6

1. Zero
2. One
3. Two
4. Three

*contd...*
D14 - Number of leaf lobes

2. Four

2. Five

3. Six

Note: In general, number of leaf lobe varied from 0 to 6, however occurrence of two or three differently lobed leaves on the same plant was a common feature.
D15 - Phyllotaxy

Recorded on young tertiary branches of current season growth

1. Whorled
2. Alternate

1. Whorled
2. Alternate
D16 - Leaf angle with main stem
Recorded on young tertiary branches of current season growth

1. 0° - 15°
2. 15° - 45°
3. > 45°
**D17 - Inflorescence**

Recorded on current season growth of the tertiary (terminal) branches

1. Axillary (all along the axils)
2. Terminal
**D18 - Peduncle branching**

Recorded on the inflorescence during current season growth of the tertiary (terminal) branches

1. One
2. Two
3. Three
Minimal descriptors of *Jatropha curcas* L.

**D19 - Peduncle length (cm)**

Recorded on the inflorescence of the tertiary (terminal) branches on the current season growth

1. 0 - 5 cm
2. > 5 cm
Minimal descriptors of *Jatropha curcas* L.

**D20 - Inflorescence compactness**

Recorded at same growth stage of the inflorescence

1. Loose
2. Semi-loose
3. Compact
4. Very compact
D21 - Flower colour

Recorded on the fully expressed inflorescence

1. Cream yellow
2. White
3. Other

1. Cream yellow
D22 - Flower size

Recorded on the fully opened male and female flowers

1. Female (Small < 10 mm)
2. Female (Large > 10 mm)
3. Male (Small < 5 mm)
4. Male (Large > 5 mm)
D23 - Flower ratio

Female and male ratio recorded on the fully expressed inflorescence

1. 1: 10
2. 1: 11 - 20
3. 1: > 20
D24 - Inflorescence abundance
Recorded on 3-year-old plantations raised under uniform agronomic practices, soil and weather conditions
1. Poor
2. Average
3. Abundant

D25 - Flowering
1. One flush
2. Two flushes
3. Continuous flushes

D26 - Length of fruit stalk
Recorded at matured pod stage
1. Small (< 4 cm)
2. Medium (4 - 7 cm)
3. Large (> 7 cm)
D27 - **Number of fruits per cluster**

Recorded on fruit clusters during peak podding stage

1. 0 - 5
2. 6 - 10
3. 11 - 15
4. > 15
D28 - **Average number of seeds per fruit**
Recorded on healthy and matured pods
1. < 3
2. 3
3. > 3

D29 - **Pod length**
Recorded as a mean of 100 physiologically matured pods
1. < 2 cm
2. > 2 cm

D30 - **Pod breadth**
Recorded as a mean of 100 physiologically matured pods
1. < 1.8 cm
2. > 1.8 cm

D31 - **Pod width**
Recorded as a mean of 100 physiologically matured pods
1. < 1.8 cm
2. > 1.8 cm

D32 - **Seed length**
Recorded as a mean of 100 physiologically matured seeds
1. < 1.8 cm
2. > 1.8 cm
**D33 - Seed breadth**
Recorded as a mean of 100 physiologically matured seeds
1. $< 1.1$ cm
2. $> 1.1$ cm

**D34 - Seed width**
Recorded as a mean of 100 physiologically matured seeds
1. $< 0.9$ cm
2. $> 0.9$ cm

**D35 - 100 Seed weight (g)**
Recorded on fully matured and dried seed

**D36 - Seed surface**
Recorded on physiologically matured seeds
1. Rough
2. Smooth
3. Shiny
D37 - Fruit shape
Recorded on physiologically matured fruits
1. Oval
2. Round

D38 - Oil content
Oil content analysed by Soxhlet method
1. Low (0 - 20%)
2. Medium (21 - 30%)
3. High (31 - 40%)
4. Very high (> 40%)
References


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Glossary

Growth habit: The form of plant in which it grows.

Plant canopy: It refers to the form in which plant produces its branches.

Branching habit: A stem growing from the trunk of a tree and from where it spreads further.

Leafiness: A plant abounding in leaves.

Branching pattern: Production of branches at crown region of the plant.

Number of primary branches: Number of branches produced on the main stem.

Latex: A milky exudate from certain plants that coagulates on exposure to air.

Leaf pigmentation: Any substance whose presence or absence in the tissues of leaves colours them.

Petiole pigmentation: Presence of certain specific substances which colours the slender stem that supports the blade of a leaf.

Leaf blade: The thin, usually flat part of leaf excluding the petiole.

Petiole length: Size of the slender part of the stem that supports the leaf blade.

Leaf colour: Colour intensity of leaf.

Leaf blade size: The length and breadth of flattened portion of leaf excluding the petiole.

Leaf lobe: Leaf having deeply indented margins on the periphery.

Phyllotaxy: Arrangement of leaves on a stem. Depending on the species, the leaf origin on the stem may be opposite-leaves arise in pairs on opposite sides of the stem; whorled-three or more leaves arise from the same locus on the stem, or alternate-leaves are arranged in a helix along the stem.

Peduncle branching: Stalk of an inflorescence and its pattern of branching.

Peduncle length: The length of the stalk of inflorescence.

Inflorescence compactness: Density of florets borne on a single axis or stem.

Flower colour: Colour intensity of the flower has been considered for the study.

Flower size: Size of the female and male flowers borne in the inflorescence.

Flower ratio: Number of female to male flowers in a given inflorescence.
Inflorescence abundance: Production of inflorescences by a plant under uniform agronomic, soil and weather conditions.

Seasonality of flowering: Occurrence of flowering in a plant during a calendar year.

Length of fruit stalk: Size of the stalk attached to the fruit.

Number of fruits per cluster: Occurrence of fruits in given fruit cluster.

Average number of seed/fruit: Number of seeds produced in a given fruit.

Pod length: Length of the vessel which contains seeds.

Pod breadth: Breadth of the vessel which contains seeds.

Pod width: Width of the vessel which contains seeds.

Seed length: Length of the ripened plant ovule containing an embryo.

Seed width: Width of the ripened plant ovule containing an embryo.

Seed breadth: Breadth of the ripened plant ovule containing an embryo.

100 seed weight: Weight of 100 physiologically matured plant ovule / seeds.

Seed surface: Refers to the texture of the seed.

Fruit shape: Refers to the form in which a plant produces the seed.