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## Research Article

### Characterization of *Jatropha* hybrid clones grown under subtropical conditions of south India

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#### Abstract

*Jatropha curcas* L. is a tree borne oilseed crop and growing as a shrub as a living fence in a farmers' field. Characterization is an initial step for the development of any plant database. The characterization of plant characters (plant height and growth habit), stem characters (stem colour and young shoot colour) and leaf characters viz., juvenile leaf colour, leaf shape, leaf texture, leaf length, leaf width, petiole length and petiole colour was recorded in 56 *Jatropha* hybrids. There was no difference in stem characters and leaf shape in all the hybrids. The other traits viz., plant height, growth habit, juvenile leaf colour, leaf texture, leaf length, leaf width, petiole length and petiole colour showed variation and categorized qualitatively as per the PPV&FRA descriptors. The plant height varies from 65.6 cm (CJH 1 and CJH 22) to 162.8 cm (CBM 1) and mature leaf length ranged between 4.4 cm (CBM 5) and 17.7 cm (TNMC 7). The results obtained in the present study could be useful for making the plant database for the *Jatropha* hybrids.

#### Key words

*Jatropha*, Hybrids, Characterization, Distinctiveness, Uniformity, Stability

#### INTRODUCTION

*Jatropha curcas* L. is a shrub commonly known as physicnut that belongs to the family Euphorbiaceae. This shrub seed oil is processed to provide a diesel fuel substitute which made scientists to keep sight on this crop in tropical areas (Heller, 1996). Attempts are now being made to promote the cultivation of this underutilized and neglected crop for essential purpose. The centre of origin for physicnut is Mexican and Central America. But it is cultivated in Latin America, Asia and African countries grown as a hedge crop. When comparing with other oilseed species, *Jatropha* stands out for its economic and social viability for biodiesel production and despite being a perennial species it can reach the productive stage from the second year after growing. The potential of this crop was nowadays identified by scientists and it is being characterized and categorized for different traits. In India, *Jatropha curcas* L. has been prioritised as a promising Tree Borne Oilseed (TBO) for biofuel production by the National Oilseeds and Vegetable Oils Development

(NOVOD) Board and has identified fruiting, as one of the major constraints limiting collection and utilization of *Jatropha* (Anandalakshmi *et al.*, 2015). Many studies on the botanical classification (Pimenta *et al.*, 2014) and multiple uses of *Jatropha* have been reported. From its seeds, it is possible to produce insecticides, larvicides (Sakthivadivel and Daniel, 2008), fungicides (Cordova-Albores *et al.*, 2014), and biodiesel (Kazembe and Chaibva, 2012). In 2001, the Indian government passed the Protection of Plant Varieties and Farmers' Rights (PPV&FRA) Act. This provides for the registration of new varieties of agricultural plants if they conform to the criteria of distinctiveness, uniformity and Stability (DUS). The characterization is the critical step for the development guidelines for testing *Jatropha* hybrids for the utilization and protection of hybrids. This study made an attempt to record DUS traits in *Jatropha* hybrids for their utilization in the breeding programme.

## MATERIALS AND METHODS

The experimental material includes 56 hybrids derived from *Jatropha curcas* and *J. integerrima* of *Jatropha* which were raised with a spacing of 3 x 3 m in Forest College and Research Institute, Mettupalayam in RBD with three replications. The 56 hybrid clones were maintained by applying fertigation once in 20 days and irrigation once

in seven days. These hybrids were regularly pruned and maintained. DUS traits were observed during the 2<sup>nd</sup> year (2019-20) based on the PPV&FRA descriptors (<http://www.plantauthority.gov.in/crop-guidelines.htm>) for three plants in each replication before flowering for all the hybrids. The comparison of 56 hybrid clones for both quantitative and qualitative attributes as shown in **Table 1**.

**Table 1. The morphological characterization of *Jatropha* hybrids clones**

Traits	Description of the trait	Type of trait
<b>Plant characters</b>		
Plant height	The observation on the plant height was made on mature plants with a fully developed stem and crown and classified as short (<130 cm), medium (130-200 cm) and tall (>200 cm).	Quantitative trait
Growth habit	The growth habit measured on mature plants with a fully developed stem and crown with complete foliage and classified as erect, spreading and bushy.	Qualitative trait
<b>Stem characters</b>		
Stem bulginess	The stem bulginess observed on the mature plants for their presence or absence.	Qualitative trait
Young shoot colour	The developing young shoot colour from the mature plants recorded and categorized as green and pinkish red.	Qualitative trait
<b>Leaf characters</b>		
Juvenile leaf colour	Juvenile leaf colour was observed on actively growing spring flush in the mature plant and sorted as dark pink, green and greenish pink	Qualitative trait
Leaf shape	The shape of leaf is grouped as cordate and palmate.	Qualitative trait
Leaf texture	The leaf texture was recorded based on the touch sensitiveness of the observer and categorized as smooth, coarse, rough and leathery	Qualitative trait
Leaf length	The length of the mature leaf was measured on the central part of leaf and grouped as short leaf (<8.0 cm), medium leaf (8.0-15.0 cm) and long leaf (>15.0 cm).	Quantitative trait
Leaf width	The width of the mature leaf was measured on the central part of leaf and sorted as narrow leaf (<7.0 cm), medium leaf (7.0-14.0 cm) and broad leaf (>14.0 cm).	Quantitative trait
Petiole length	The length of petiole was measured on the leaf in which the leaf length and width measured and classified the length as short (<10.0 cm), medium (10.0-16.0 cm) and long (>16.0 cm)	Quantitative trait
Petiole colour	Based on the visual observation, the petiole colour was recorded on the leaf on which the petiole length was measured. The colour is grouped into greenish pink and green	Qualitative trait

## RESULTS AND DISCUSSION

*Jatropha* plant is a shrub used as bio-diesel and classified as tree borne oilseeds (TBOs). This little shrub is nowadays getting more attention on the research platform due to its oil quality for diesel engines. This shrub was raised in farmers' field as bio-fence for many crops protection from animals damage.

The characterization of *Jatropha* hybrids was essential to differentiate the hybrids for distinctiveness in each plant trait and for the precise plant database. The *Jatropha* hybrids were characterized for plant traits (2), stem traits (2) and leaf traits (7). These hybrids exhibited a difference in all traits except stem bulginess, young shoot colour and leaf shape. The height of the plant varies from 65.6 cm (CJH 1 and CJH 22) to 162.8 cm (CBM 1). The hybrids

were classified as short plant height in 42 hybrids (<130 cm) and medium plant height in the remaining 14 hybrids (130 to 200 cm) (**Fig.1**). Plant height plays a major role in lodging due to stem thickness and fruit weight. Among the hybrids, 75 per cent of hybrids showed short height, 25 per cent of hybrids exhibited medium plant height (**Table 2**). Being a shrub, short height hybrids were preferable due to lodging problem. When the fruiting starts in *Jatropha* shrub, due to fruit weight the branches will be bending and the fruit yield would be lost. The plant height of *Jatropha* hybrids varies from 40 to 150.67 cm as reported by (George *et al.*, 2016) and 117.4 to 225.4 cm in 16 genotypes of *Jatropha* by (Das *et al.*, 2010). Maftuchah and Zainudin (2018) reported a maximum height of 178 cm and a minimum of 118.17 cm in *Jatropha* genotypes.



Medium – TNAU 102

Short – CJH 9

Fig.1. Variation in plant height

The growth habit was observed as a qualitative trait and the hybrids were grouped as bushy, spreading and erect. Bushy type plant growth was recorded in 17 hybrids, spreading type in two hybrids (CJH 3 and CJH 7) and erect type of plants in the remaining 37 hybrids (Table 2). Growth habit was categorized as bushy type in 30 per cent hybrids, 4 per cent hybrids in spreading type and 66 per

cent hybrids in an erect type of growth. The plant canopy in two years old *Jatropha* plantations were observed and categorized as narrow, intermediate and spreading (Sunil *et al.*, 2013). The plant growth habit was sorted into tall erect, bushy and spreading in the *Jatropha* hybrid clones (George *et al.*, 2016).

Table 2. DUS plant characters of *Jatropha* hybrids

Traits	Category	Name of the hybrids	Per cent of variation	Type of assessment
Plant height	Short	CJH 1, CJH 2, CJH 3, CJH 5, CJH 6, CJH 7, CJH 8, CJH 9, CJH 10, CJH 11, CJH 12, CJH 13, CJH 15, CJH 16, CJH 17, CJH 18, CJH 19, CJH 20, CJH 21, CJH 25, CJH 26, CJH 27, CJH 28, CJH 29, CJH 30, CJH 32, CJH 33, CJH 34, CJH 35, TNMC 7, DOPS 101, DOPS 102, BCGSA 101, BCGSA 102, BCGSA 103, UACH 102, TNAU 101, MJH 1, MJH 2, CJ 1, CBM 5 and CBM 9	75	MG
	Medium	CJH 4, CJH 14, CJH 22, CJH 23, CJH 24, UACH 101, TNAU 102, MJH 3, CBM 1, CBM 2, CBM 4, CBM 6, CBM 8 and HC 4	25	
	Tall	Nil	-	
Growth habit	Erect	CJH 1, CJH 2, CJH 5, CJH 12, CJH 13, CJH 15, CJH 16, CJH 17, CJH 18, CJH 19, CJH 20, CJH 22, CJH 25, CJH 26, CJH 27, CJH 28, CJH 29, CJH 30, CJH 32, CJH 34, CJH 35, DOPS 101, DOPS 102, BCGSA 101, BCGSA 102, BCGSA 103, UACH 102, TNAU 101, TNAU 102, MJH 1, MJH 2, MJH 3, CBM 2, CBM 4, CBM 6, CBM 8 and CBM 9	66	VG
	Bushy	CJH 4, CJH 6, CJH 8, CJH 9, CJH 10, CJH 11, CJH 14, CJH 21, CJH 23, CJH 24, CJH 33, TNMC 7, UACH 101, CJ 1, CBM 1, CBM 5 and HC 4	30	
	Spreading	CJH 3 and CJH 7	4	

**MG:** Measurement by a single observation of a group of plants or parts of plants

**MS:** Measurement of a number of individual plants or parts of plants

**VG:** Visual assessment by a single observation of a group of plants or parts plants

**VS:** Visual assessment by observation of individual plants or parts of plants

Stem bulginess and young shoot colour are described under stem characters as per the descriptors and these two traits had no difference in the 56 hybrids studied. The trait stem bulginess was absent in all 56 *Jatropha* hybrids. The young shoot colour was found to be a green colour in

all the hybrids. The observation on the main stem colour was grouped as green and grey colour (Sunil *et al.*, 2013). The young stem colour was recorded as light green, green, light greyish green and light greyish brown in 27 *Jatropha* hybrid clones by Parthiban *et al.*, (2009).

**Table 3. DUS leaf characters of *Jatropha* hybrids**

Traits	Category	Name of the hybrids	Per cent of variation	Type of assessment
Juvenile leaf colour	Dark pink	CJH2 and CJH 26	4%	VS
	Green	CJH 8, CJH 9, CJH 10, CJH 19, CJH 21, CJH 23, CJH 30, DOPS 101, DOPS 102, BCGSA 101, BCGSA 102, UACH 102, MJH 2, CBM 2, CBM 4, CBM 6, CBM 8, CBM 9 and HC 4	34	
	Greenish pink	CJH 1, CJH 3, CJH 4, CJH 5, CJH 6, CJH 7, CJH 11, CJH 12, CJH 13, CJH 14, CJH 15, CJH 16, CJH 17, CJH 18, CJH 20, CJH 22, CJH 24, CJH 25, CJH 27, CJH 28, CJH 29, CJH 32, CJH 33, CJH 34, CJH 35, TNMC 7, BCGSA 103, UACH 101, TNAU 101, TNAU 102, MJH 1, MJH 3, CJ 1, CBM 1, CBM 5	62	
	Cordate	Nil	-	
Leaf shape	Palmete	CJH 1, CJH 2, CJH 3, CJH 4, CJH 5, CJH 6, CJH 7, CJH 8, CJH 9, CJH 10, CJH 11, CJH 12, CJH 13, CJH 14, CJH 15, CJH 16, CJH 17, CJH 18, CJH 19, CJH 20, CJH 21, CJH 22, CJH 23, CJH 24, CJH 25, CJH 26, CJH 27, CJH 28, CJH 29, CJH 30, CJH 32, CJH 33, CJH 34, CJH 35, TNMC 7, DOPS 101, DOPS 102, BCGSA 101, BCGSA 102, BCGSA 103, UACH 101, UACH 102, TNAU 101, TNAU 102, MJH 1, MJH 2, MJH 3, CJ 1, CBM 1, CBM 2, CBM 4, CBM 5, CBM 6, CBM 8, CBM 9, HC 4	100	VG
		Smooth	CJH 1, CJH 9, CJH 10, CJH 12, CJH 13, CJH 14, CJH 15, CJH 17, CJH 18, CJH 19, CJH 22, CJH 25, CJH 26, CJH 27, CJH 29, CJH 30, TNAU 101, MJH 1, MJH 2 and CBM 9	36
Leaf texture	Coarse	CJH 2, CJH 3, CJH 4, CJH 5, CJH 6, CJH 7, CJH 8, CJH 11, CJH 23, CJH 24, CJH 28, CJH 32, CJH 33, CJH 34, CJH 35, TNMC 7, DOPS 101, BCGSA 102, BCGSA 103, UACH 101, UACH 102, TNAU 102, MJH 3, CBM 1, CBM 2, CBM 4, CBM 5, CBM 6 and HC 4	52	VG
	Rough	CJH 16, CJH 20, CJH 21, DOPS 102, BCGSA 101, CJ 1 and CBM 8	12	
	Leathery	Nil	-	
	Short	CJH 2, CJH 13, CJ 1 and CBM 5	7	
Leaf length	Medium	CJH 1, CJH 3, CJH 4, CJH 5, CJH 6, CJH 7, CJH 8, CJH 9, CJH 10, CJH 11, CJH 12, CJH 14, CJH 15, CJH 16, CJH 17, CJH 18, CJH 19, CJH 20, CJH 21, CJH 22, CJH 23, CJH 24, CJH 25, CJH 26, CJH 27, CJH 28, CJH 29, CJH 30, CJH 32, CJH 33, CJH 34, CJH 35, DOPS 101, DOPS 102, BCGSA 101, BCGSA 102, UACH 101, UACH 102, TNAU 101, MJH 1, MJH 3, CBM 1, CBM 2, CBM 4, CBM 6, CBM 9 and HC 4	84	MG
	Long	TNMC 7, BCGSA 103, TNAU 102, MJH 2 and CBM 8	9	
	Narrow	CJH 11, CJ 1 and CBM 5	5	
Leaf width	Medium	CJH 1, CJH 2, CJH 4, CJH 5, CJH 7, CJH 8, CJH 9, CJH 10, CJH 12, CJH 13, CJH 14, CJH 15, CJH 16, CJH 17, CJH 18, CJH 19, CJH 20, CJH 22, CJH 23, CJH 25, CJH 26, CJH 27, CJH 29, CJH 30, CJH 32, CJH 33, CJH 35, TNMC 7, DOPS 101, BCGSA 101, BCGSA 102, UACH 102, TNAU 101, MJH 2, MJH 3, CBM 2, CBM 4, CBM 6 and HC 4	70	MG
	Broad	CJH 3, CJH 6, CJH 21, CJH 24, CJH 28, CJH 34, DOPS 102, BCGSA 103, UACH 101, TNAU 102, MJH 1, CBM 1, CBM 8 and CBM 9	25	

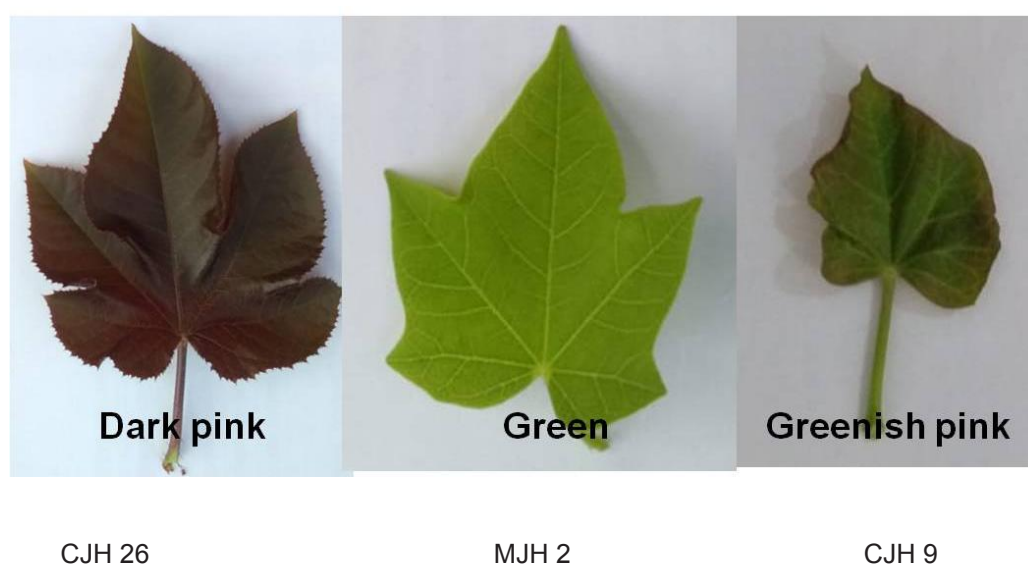
Petiole length	Short	CJH 1, CJH 2, CJH 11, CJH 12, CJH 13, CJH 14, CJH 16, CJH 19, CJH 20, CJH 25, CJH 26, CJH 30, CJH 32, CJH 33, CJH 35, BCGSA 102, UACH 101, MJH 2, MJH 3, CJ 1, CBM 2, CBM 4, CBM 5, CBM 6 and HC 4	45	MG
	Medium	CJH 3, CJH 4, CJH 5, CJH 6, CJH 7, CJH 8, CJH 9, CJH 10, CJH 15, CJH 17, CJH 18, CJH 21, CJH 22, CJH 23, CJH 24, CJH 27, CJH 28, CJH 29, CJH 34, TNMC 7, DOPS 101, DOPS 102, BCGSA 101, UACH 102, TNAU 101, MJH 1, CBM 1, CBM 8 and CBM 9	52	
	Long	BCGSA 103 and TNAU 102	3	
Petiole colour	Green	CJH 1, CJH 8, CJH 9, CJH 10, CJH 11, CJH 19, CJH 21, CJH 22, CJH 25, CJH 26, CJH 30, DOPS 101, DOPS 102, BCGSA 101, UACH 101, TNAU 102, MJH 2, CBM 2, CBM 4, CBM 8, CBM 9 and HC 4	39	VS
	Greenish pink	CJH 2, CJH 3, CJH 4, CJH 5, CJH 6, CJH 7, CJH 12, CJH 13, CJH 14, CJH 15, CJH 16, CJH 17, CJH 18, CJH 20, CJH 23, CJH 24, CJH 27, CJH 28, CJH 29, CJH 32, CJH 33, CJH 34, CJH 35, TNMC 7, BCGSA 102, BCGSA 103, UACH 102, TNAU 101, MJH 1, MJH 3, CJ 1, CBM 1 and CBM 6	59	
	Pink	CBM 5	2	

The leaf characters namely juvenile leaf colour, leaf shape, leaf texture, leaf length, leaf width, petiole length and petiole colour were observed and has variation in the hybrids except for leaf shape. The leaf characters for 56 hybrids were presented in **Table 3**.

The freshly opened flush in the mature plant was observed as dark pink in two hybrids (CJH 2 and CJH 26), green colour in 19 hybrids and greenish pink in 35 hybrids (**Fig.2**). The variation was categorized as dark pink (4%), green (34%) and greenish pink (62%). In the present study, the juvenile leaf colour was grouped as dark pink in 4 per cent hybrids, green colour in 34 per

cent hybrids and greenish pink in 62 per cent hybrids. Pigmentation in emerging leaves was classified as green, green-grey purple, yellow green and greyed purple as grouped by Sunil *et al.* (2013). Pale green and light green tender leaf colour was reported in *Jatropha* hybrid clones by Parthiban *et al.*, (2009).

The leaf shape of all *Jatropha* hybrids was palmate. There is no difference in the leaf shape in the hybrids but there was difference in leaf lobes. The leaf shape as the heart and round shaped was recorded in eight *Jatropha* genotypes by (Maftuchah and Zainudin, 2018) and cordate leaf shape in *Jatropha* hybrids by George *et al.* (2016).



**Fig. 2. Variation in juvenile leaf colour**

The texture of mature leaf was measured based on the sensitivity of the observer. The hybrids were grouped as coarse texture in 29 hybrids, rough texture in seven hybrids and smoothness observed in 20 hybrids. The variations for leaf texture for coarse type in 52 per cent, rough type in 12 per cent and smooth type in 36 per cent. Parthiban *et al.*, (2009) and George *et al.* (2016) sorted the texture of leaf into velvety, coarse, leathery and smooth in hybrid clones.

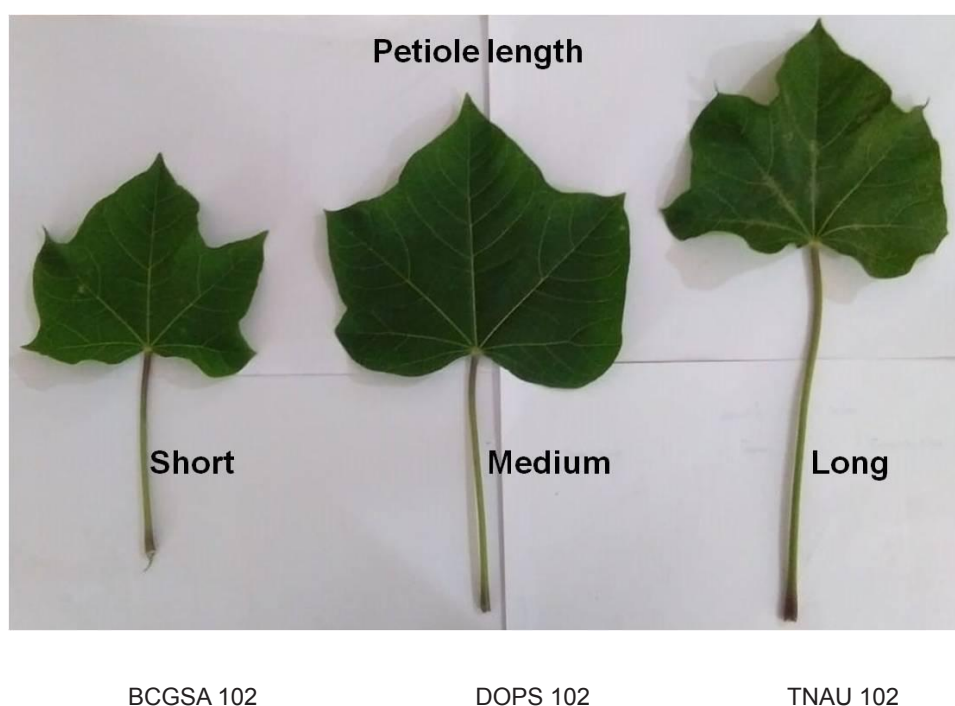
The length of the mature leaf ranged between 4.4 cm (CBM 5) and 17.7 cm (TNMC 7). Short leaf length (<8.0 cm) was recorded in four hybrids (CJH 2, CJH 13, CJ 1 and CBM 5), 47 hybrids recorded medium leaf length (8.0 – 15.0 cm) and the remaining five hybrids classified in long leaf length (>15.0 cm). The variation in leaf length categorized as short in seven per cent, medium in 84 per cent and long in nine per cent hybrids. The longest leaf length was 11.43 cm and the shortest length was 6.52 cm in *Jatropha* was reported by Maftuchah and Zainudin, (2018). George *et al.* 2016 reported the leaf length ranged from 12.5 cm (HC 27) to 7.6 cm (HC 19) in *Jatropha* clones and the length varied from 7.6 to 12.5 cm in hybrid clones as reported by Parthiban *et al.* 2009 and the leaf length varied between 13.6 to 18.1 cm in four *Jatropha* species (Nwokocha *et al.*, 2012).

The width of mature leaf variation was found to be narrow in five per cent hybrids (<7.0 cm), medium width in 70 per cent (7.0 – 14.0 cm) and broad in 25 per cent (>14.0 cm). The leaf width ranged between 3.6 cm in CBM 5 and 16.4 cm in BCGSA 103. The leaf width of the mature

leaf was found to be narrow in three hybrids (CJH 11, CJ 1 and CBM 5), medium width in 39 hybrids and broad in 14 hybrids. HS-49 genotype has the shortest leaf width (7.71 cm) and SM-35 has the broader width (13.01 cm) as reported by Maftuchah and Zainudin, (2018). The mean leaf breadth of hybrids was 10.2 cm and varied from 13.2 cm (HC 5) to 7.0 cm (HC 19) (George *et al.*, 2016).

The petiole length of hybrids varied between 5.2 cm (CJH 13) to 17.0 cm (BCGSA 103). The hybrids were grouped in short length in 25 hybrids (45%), a medium length in 29 hybrids (52%) and long in two hybrids (3%) (**Fig.3**). The hybrids were grouped in short length in 25 hybrids, medium length in 29 hybrids and long in two hybrids. (Sunil *et al.*, 2013) categorized petiole length into small (<12 cm), medium (12-22 cm) and large (>22 cm) in *Jatropha* plantations, Maftuchah and Zainudin, (2018) observed the petiole length ranged from 9.86 cm to 12.51 cm in eight *Jatropha* genotypes and Nwokocha *et al.*, (2012) also observed the length of petiole varied between 15.3 to 27.5 cm.

There was a difference in the petiole colour in the 56 hybrids (**Fig. 4**). The hybrids sorted as green in 22 (39%), greenish pink in 33 (59%) and pink in one hybrid (CBM 1). The hybrids petiole colour was sorted as green in 22, greenish pink in 33 and pink in one hybrid. George *et al.* (2016) also reported petiole colour as light green with green ends, light green with pink ends, green and brown. The petiole base pigmentation was categorized into green, purple and brown in *Jatropha* as given by Sunil *et al.* (2013).



**Fig.3. Variation in petiole length**

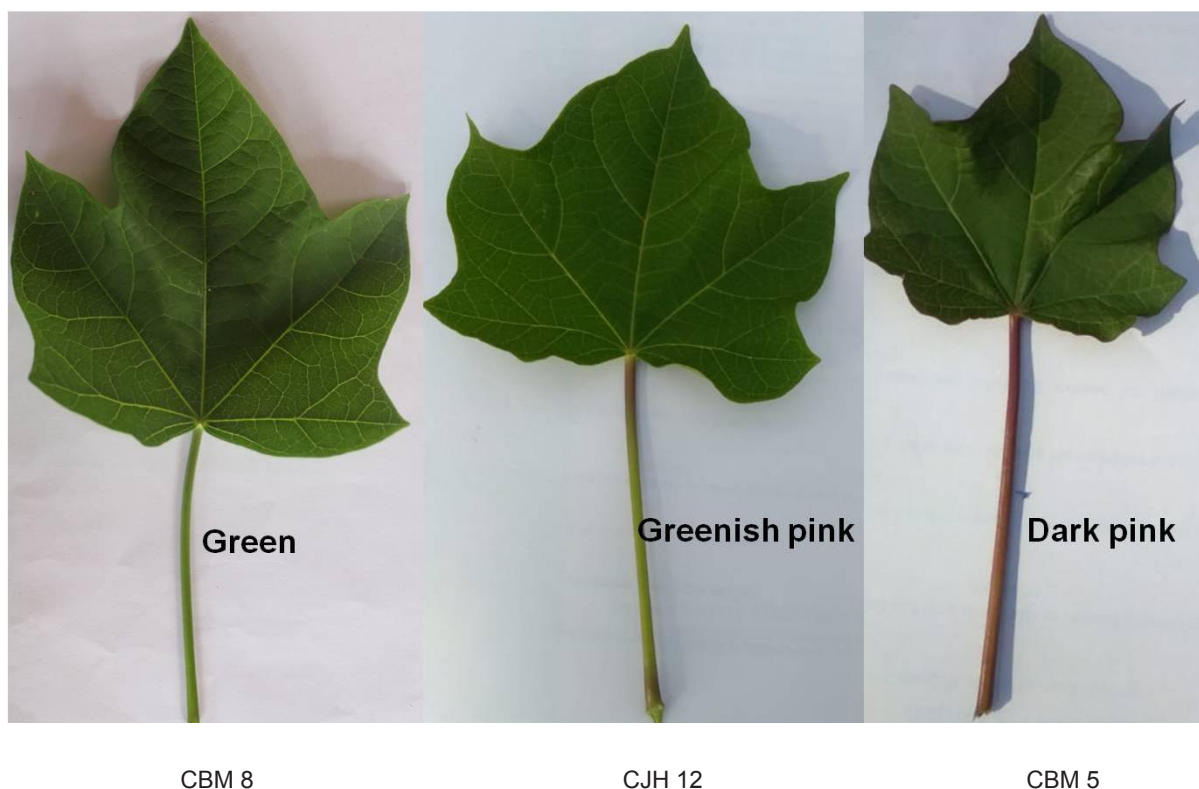


Fig. 4. Variation in petiole colour

Based on the descriptors, the plant, stem and leaf characters were recorded for all 56 hybrids. Among all the traits observed, three traits (Stem bulginess, young shoot colour and leaf shape) not showed variation in 56 hybrids and the remaining traits showed variation in all hybrids. This information could be useful for making the plant database for the *Jatropha* hybrids.

## REFERENCES

- Anandalakshmi, R., Sivakumar, V., Warriar R.R. and Narmatha Bai V. 2015. Dynamics of flowering and fruiting in *Jatropha curcas* L. and its implications. *Elec. J. Plant Breed.*, **6**(3): 813-825
- Cordova-Albores, L.C., Rios, M.Y., Barrera-Nechaa, L.L. and Bautista-Banos, S. 2014. Chemical compounds of a native *Jatropha curcas* seed oil from Mexico and their antifungal effect on *Fusarium oxysporum* f. sp. *gladioli*. *Industrial Crops and Products*, **62**: 166-172 [Cross Ref]
- Das, S., Misra, R.C., Mahapatra, A.K., Gantayat, B.P. and Pattnaik, R.K. 2010. Genetic variability, character association and path analysis in *Jatropha curcas*. *World Applied Science Journal*, **8**(11): 1304-1308
- Dias, L.A.S., Missio, R.F. and Dias, D.C.F.S. 2012. Antiquity, botany, origin and domestication of *Jatropha curcas* (Euphorbiaceae), a plant species with potential for biodiesel production. *Genetics and Molecular Research* **11**: 2719-2728. [Cross Ref]
- George, A.K., Parthiban, K.T. and Vikas kumar. 2016. Development and documentation of descriptors for *Jatropha* (*Jatropha curcas*) and their hybrid derivatives. *Indian Journal of Tropical Biodiversity* **24**(1):1-19
- Heller, J. 1996. Physic nut. *Jatropha curcas* L. Promoting the conservation and use of underutilized and neglected crops. 1. Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant Genetic Resources Institute, Rome, pp 61
- Kazembe, T.C. and Chaibva, M. 2012. Mosquito repellency of whole extracts and volatile oils of *Ocimum americanum*, *Jatropha curcas* and *Citrus limon*. *Bulletin of Environment, Pharmacology and Life Sciences*, **1**: 65-71.
- Maftuchah and Zainudin, A. 2018. Similarity analysis of stems and leaves morphological characters of some physic nut (*Jatropha curcas* Linn.) genotypes. Proceedings of ISER 138th International Conference, Phnom Penh, Cambodia. Pp. 10-13

- Nwokocha, B. A., Agbagwa, L.O. and Okoli, B.E. 2012. Vegetative and floral morphology of *Jatropha* species in Niger delta. *Journal of Plant Science*, **7**(5): 163-175. [\[Cross Ref\]](#)
- Parthiban, K.T., Senthil kumar, R., Thiyagarajan, P., Subbulakshmi, V., Vennila, S. and Rao, M.G. 2009. Hybrid progenies in *Jatropha* - a new development. *Current Science*, **96**(6): 815-823.
- Pimenta, A.C., Zuffellato-Ribas, K.C. and Laviola, B.G. 2014. Morfologia de frutos, sementes e plântulas de *Jatropha curcas*. *Floresta*, **44**: 73-80. [\[Cross Ref\]](#)
- Sakthivadivel, M. and Daniel, T. 2008. Evaluation of certain insecticidal plants for the control of vector mosquitoes viz. *Culex quinquefasciatus*, *Anopheles stephensi* and *Aedes aegypti*. *Applied Entomology and Zoology*, **43**: 57-63. [\[Cross Ref\]](#)
- Sunil, N., Kumar, V., Sujatha, M., Rao, G.R. and Varaprasad, K.S. 2013. Minimal descriptors for characterization and evaluation of *Jatropha curcas* L. germplasm for utilization in crop improvement. *Biomass and bioenergy*, **48**: 239-249. [\[Cross Ref\]](#)