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Short Communication: Sex types in flowering of *Jatropha curcas*

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Abstract. *Dasumiati, Miftahudin, Triadiati T, Hartana A. 2017. Short Communication: Sex types in flowering of* Jatropha curcas. *Biodiversitas 18: 275-279.* Commonly, *Jatropha curcas* (jatropha) produces male and female flowers in the different flower. But, the other jatropha have male and hermaphrodite flowers in the different flower. The combination of those flowers in one plant causes sex differentiation in jatropha. This study aimed to identify the sex types of flowers and plant in jatropha, as well as to know the stability of sex types after stem cuttings propagation. The survey was conducted to the population of jatropha in Cikampek, Karawang and Pakuwon, Sukabumi, West Java, Indonesia. We found three sex types in both plantations: monoecious that have male and female flowers, andromonoecious that have male and hermaphrodite flowers, trimonoecious that have male, female, and hermaphrodite flowers in the same plant. Andromonoecious and monoecious jatropha have stable sex type, but trimonoecious jatropha has unstable sex type. The stability of sex type is related to the number of primary branch and distance between nodes.

Keywords: Andromonoecious, *Jatropha curcas*, monoecious, trimonoecious

INTRODUCTION

Jatropha (*Jatropha curcas* L) is members of the family Euphorbiaceae. This plant is native to Mexico and Central America and spreads to other areas brought by Portuguese sailors (Heller 1996, Gubitz et al. 1999, Mishra 2009). Currently, jatropha has been scattered in various regions in Indonesia. Jatropha cultivation is done because of its potential as biodiesel (Sharma et al. 2009).

Along with the development of jatropha as a biodiesel feedstock, Indonesian Agency for Agricultural Research and Development has conducted exploration of jatropha Plantation into several regions in Indonesia since 2005. Exploration was conducted to West Sumatra, Lampung, Banten, West Java, Central Java, East Java, West Nusa Tenggara, East Nusa Tenggara, and Sulawesi. The plant materials were collected in *Kebun Induk Jarak Pagar* (KIJP) Pakuwon, Sukabumi, West Java in an area of 33.9 ha, in Muktiharjo, Karawang, Central Java, covering an area of 13 ha, and in Asembagus, East Java area of 10 ha (Hasnam 2006). In addition to that Research and Development Center, a company that also developed the jatropha is in *Kawasan Industri Bukit Indah* (KIBI), Cikampek, West Java.

Accessions of jatropha that planted in both plantations were from various regions. Jatropha plantation of Cikampek planted accession of Dompu, Tangerang, West Java, Malaysia, and Mexico. Whereas jatropha plantation of Pakuwon planted accession of Lampung, Banten, Tangerang, Central Java, and West Java. The flowering of jatropha on both plantations is fascinating, because it was found that jatropha produces hermaphrodite flowers. Hermaphrodite flowers are rarely found in jatropha (Heller 1996; Jones and Csurhes 2008).

Jatropha has three sex types of flowers that can be generated by the same or different plant, i.e., male, female, and hermaphrodite. Therefore, each jatropha plant possibly can have a different type of sex that is hermaphrodite, monoecious, dioecious, gynoecious, androecious, gynomonoecious, andromonoecious, or trimonoecious. Hermaphrodite plants produced only hermaphrodite flowers. Monoecious plants produced male and female flowers, while dioecious plants produced male and female flowers on separate plants. Gynoecious plants produced only female flowers, while androecious plants produced male flowers only. Plants that produce female and hermaphrodite flowers called gynomonoecious, while andromonoecious is a plant that produces male and hermaphrodite flowers, while plants produced male flowers, female, and hermaphrodite called trimonoecious (Dellaporta and Urrea 1993; Miller and Diggle 2007).

Sex-types found on jatropha are monoecious, andromonoecious, and trimonoecious. The Sex-type of flower affect pollination and indirectly affects the production and seeds of jatropha. Plant sex type which has hermaphrodite flowers are very favorable for yield, due to they committed to self-pollination (Hartati 2009). Therefore, it is critical to analyze the stability of sex types of jatropha. This study aimed to identify sex types and stability in the flowering of jatropha in two plantations i.e. Cikampek, West Java, Indonesia and Pakuwon, Sukabumi, West Java, Indonesia.

MATERIALS AND METHODS

The plant materials were collection of jatropha in *Kawasan Industri Bukit Indah* (KIBI) Cikampek (Karawang, West Java, Indonesia) and *Kebun Induk Jarak Pagar* (KIJP) Pakuwon (Sukabumi, West Java, Indonesia) plantations. The Cikampek plantation has latosol soil and an average monthly temperature of 27°C, average rainfall monthly of 127 mm. The Pakuwon plantation has latosol soil and an average monthly temperature of 26°C, average monthly precipitation of 263 mm. Each plantation has five accessions of jatropha. The stability of sex types observed from stem cuttings jatropha (vegetative propagation) which already flowering in both plantations and open-pollinated jatropha (generative propagation) from flowering stem cuttings jatropha.

We observed the sex type in flowers and the plants. The accessions of jatropha were propagated with stem cuttings to determine the stability of sex type. Observation of the sex types stability was conducted in the two populations, i.e. the population of vegetatively propagated and the population of generatively propagated.

The sex types stability were observed from vegetative propagation. Accessions of jatropha at Cikampek and Pakuwon were propagated through stem cuttings (3 plants were Dompu accession andromonoecious, 3 plants were Dompu accession monoecious, 1 plant was Lampung accession trimonoecious, and 1 plant is Banten accession trimonoecious). Each of accession and sex type was made of 60 stem cuttings. These entire stem cuttings were planted in jatropha plantation, Bogor, West Java. Observation of the character based on flowers sex types stability or plant sex types, number and angle of the primary and secondary branch. The seeds from open-pollinated were planted again to observe the sex types stability in the next generation.

The sex types stability were also observed through generative propagation. The jatropha seeds have produced from open pollination of various sex types on jatropha plantation in Dramaga, Bogor and Pakuwon were planted in Bambu Apus, Pamulang, Tangerang, Banten, Indonesia. The 30 plants were observed in each sex type (andromonoecious, monoecious, and trimonoecious). Observation of the character based on flowers sex types stability or plant sex types, number and angle of the primary and secondary branch. Observations were made during the first flowering period.

The difference between the sex type and the sex types stability of jatropha were shown in the description.

RESULTS AND DISCUSSION

Flower sex-types in jatropha

Flower Sex-types in of jatropha were found as male, female and hermaphrodite flowers, so the individual plants have three possible option i.e. monoecious, andromonoecious, and trimonoecious plants. The plantation in Cikampek was found two types, which were monoecious and andromonoecious plants. The monoecious jatropha produced male and female flowers on the same flower inflorescence, while andromonoecious jatropha produced male and hermaphrodite flowers on the same inflorescence flower. The plant sex type was found in the Cikampek was commonly monoecious plants, whereas only 10 Dompu accession plants as andromonoecious plants. It was also found that two jatropha accessions did not flowering until the end study, namely Tangerang and Malaysian accessions (Table 1).

Monoecious sex type was found in the five accessions of jatropha in Pakuwon. Each plant of Lampung and Banten accessions produced hermaphrodite flowers (Table 1). They can be presumed as an andromonoecious or trimonoecious plants. Characteristics of the fruits produced from hermaphrodite flowers have stamens rest on the base of the fruits, while the fruits that produced from female flowers did not have the rest of stamen. Therefore, both jatropha (Lampung and Banten accessions) have sex-type of trimonoecious which produced male, female, and hermaphrodite flowers on the same inflorescence.

Plants sex types of monoecious were commonly found in both locations jatropha plantation (Cikampek and Pakuwon). The andromonoecious and trimonoecious plants sex type were rare. In fact, most researchers claimed that jatropha is a monoecious plant with flower inflorescence produced unisexual flowers - male and female flowers (Raju and Ezradanam, 2002; Makwana et al. 2010; Alam et al. 2011; Wu et al. 2011; Kaur et al. 2011). In addition to producing male and female flowers, jatropha also produced hermaphrodite flowers (Heller 1996). It is uncommon that jatropha produced bisexual or hermaphrodite flowers (Hasnam 2006). Hartati et al. (2009) found that 8 of 60 genotypes of jatropha in Pakuwon were trimonoecious. Andriano-Anaya et al. (2016) found that most of jatropha have typical inflorescences with separate sexes (monoecious). Meanwhile, the rest were atypical (gynoecious, androecious, andromonoecious, and androgynomonoecious).

Table 1. Sex-types of jatropha in the Cikampek and Pakuwon plantation

Plantation origin & accessions	Sex types	Number of plant
Cikampek		
Dompu	Andromonoecious	10
	Monoecious	476
Tangerang	Not flowering	12
West Java	Monoecious	10
Malaysia	Not flowering	6
Mexico	Monoecious	12
Pakuwon		
Lampung	Trimonoecious	1
	Monoecious	14
Banten	Trimonoecious	1
	Monoecious	4
West Java	Monoecious	22
Central Java	Monoecious	10
West Sumatra	Monoecious	14

The monoecious and andromonoecious jatropha of Dompu accession in plantation Cikampek has different branching pattern which influenced plants performance. The andromonoecious of jatropha have many primary branches at the base of the stem, where the tertiary branches were formed. The number of branch in monoecious jatropha less than that of the andromonoecious. Branching position of the monoecious jatropha is apart from one branch to another (Figure 2B). As a consequence of the branching pattern, the performance of andromonoecious jatropha more dense than that of monoecious jatropha.

Stability of sex types of flowering on jatropha

The stability of sex type through vegetative propagation.

The stability of sex type was observed in jatropha as the results of vegetative propagation (60 plants of monoecious jatropha Dompu accession, 60 plants of andromonoecious jatropha Dompu accession, and trimonoecious jatropha of Lampung and Banten accessions each of 60 plants). The monoecious and andromonoecious sex types were stable at all jatropha through vegetative propagation. However, trimonoecious jatropha showed varying sex types (Figure 1, Table 2).

Sex-types of trimonoecious jatropha were varied from beginning to end of the first flowering season. The trimonoecious jatropha of Lampung accessions showed 3.3% monoecious, 3.3% andromonoecious, and 93.4% trimonoecious at the beginning of the first flowering season. But at the end of the first season were found only 1.7% monoecious and 98.3% showed trimonoecious. The trimonoecious jatropha of Banten accessions showed 10% monoecious, 16.7% andromonoecious, and 73.3% trimonoecious at the beginning of the first flowering season. At the end of the first flowering season only 3.3% showed andromonoecious and 96.7% trimonoecious (Table 2).

Performance and branching were also observed in conjunction with the stability of sex type in flowering jatropha. The performance was showed by andro-monoecious jatropha denser than trimonoecious and monoecious jatropha (Figure 2). The andromonoecious jatropha have many primary branches (5-9 branches), whereas the trimonoecious jatropha has 3-5 primary branches, monoecious jatropha only has 0-3 primary branches.

The stability of sex types through generative propagation

Plants through the generative propagation of andromonoecious jatropha (F_{TA}) produced hermaphrodite and male flowers on the same flower inflorescence (as an andromonoecious), whereas from monoecious jatropha (F_{TM}) produced female and male flowers (as a monoecious). The trimonoecious jatropha (F_{TT}) produced hermaphrodite and male flowers on the same flower inflorescence (as an andromonoecious), and female flowers, hermaphrodite and male on same flower inflorescence (as a trimonoecious) (Table 3). Sex-types of andromonoecious and monoecious plants were stable during flowering but were not in the trimonoecious plants. All types of jatropha showed as an andromonoecious sex at the beginning of the flowering season, but at the end of the flowering season, only 4 F_{TT} plants which still showed as an andromonoecious and 26 plants remaining already showed as a trimonoecious.

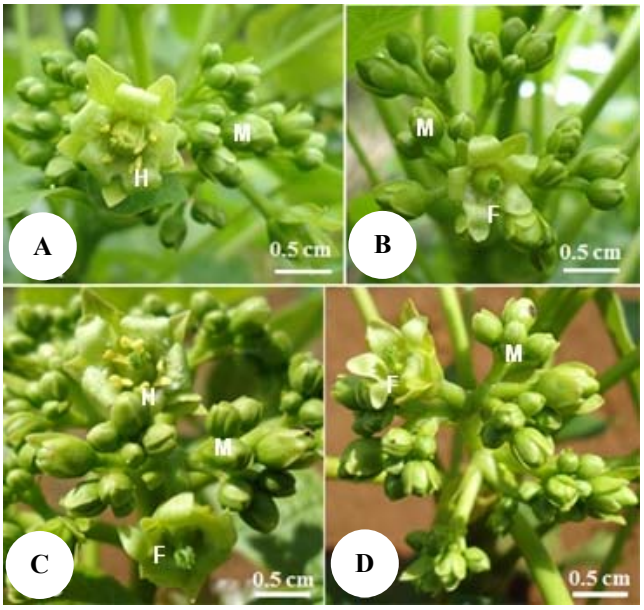

Figure 1. Flowers and sex types through the vegetative propagation of andromonoecious jatropha (A), monoecious jatropha (B), trimonoecious jatropha (C), trimonoecious which features monoecious jatropha (D). (M = cluster of male flowers, H = hermaphrodite flowers, F = female flowers)

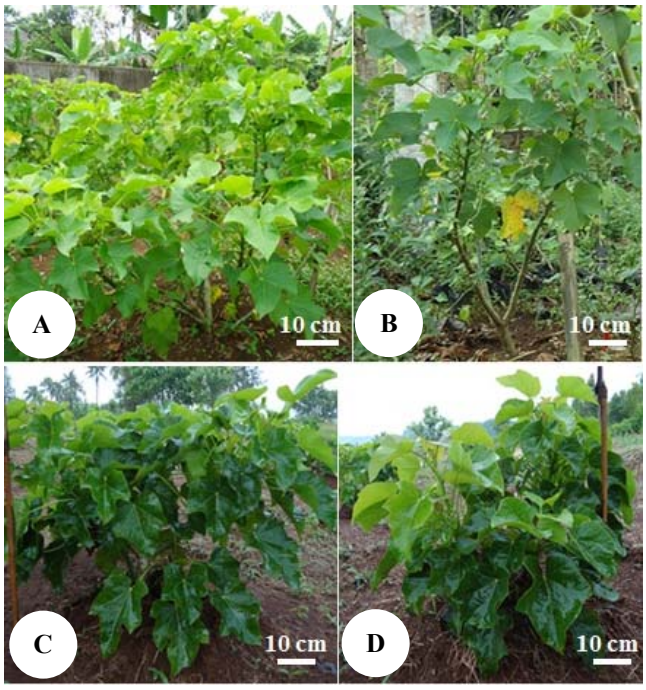

Figure 2. The performance jatropha from vegetative propagation; andromonoecious jatropha of Dompu accession (A), monoecious jatropha of Dompu accession (B), trimonoecious jatropha of Lampung accession (C), trimonoecious jatropha of Banten accession (D) (5 months after planting/MAP)

Table 2. Stability of number and plants sex type as the result of vegetative propagation of monoecious, andromonoecious, and trimonoecious jatropha during the first flowering season

Plant sex type	The percentage of stem cuttings with sex type					
	Beginning of first flowering season			End of first flowering season		
	M	A	T	M	A	T
Monoecious of Dompu	100	-	-	100	-	-
Andromonoecious of Dompu	-	100	-	-	100	-
Trimonoecious of Lampung	3.33	3.33	93.34	1.67	-	98.33
Trimonoecious of Banten	10	16.67	73.33	-	3.33	96.67

Note: M = Monoecious, A = Andromonoecious, T = Trimonoecious

Table 3. Sex-types and branching through generative propagation of andromonoecious, monoecious, and trimonoecious jatropha

Characters	Andromonoecious	Monoecious	Trimonoecious
Sex type	Andromonoecious	Monoecious	Trimonoecious, Andromonoecious
Total Primary Branch (pc)	9±3	2±1	7±3
Total Secondary Branch (pc)	6±4	3±1	3±1
Primary Branch Angle ($^{\circ}$)	60.5±8.2	45.6±3.7	59.2±7.8
Secondary Branch Angle ($^{\circ}$)	45.2±3.8	45.3±4.1	51.6±5.1

Note: The data showed ± SD

The F_{TA}, F_{TM}, and F_{TT} plants showed the different sex types, the number and angle of branches indicated different performance. The number of branches (primary and secondary) of F_{TA} plants higher than that of the F_{TM} plants, however, the F_{TT} plants produced more branch than that of the F_{TM} plants (Table 3). The F_{TA} plants performance was the densest. It was similar to the mother plant both before and after propagated vegetative.

Andromonoecious sex type of jatropha from generative propagation were stables. It can be due to by the hermaphrodite flowers on andromonoecious jatropha experienced a self-pollinated. Sex type of plant obtained through generative propagation is same as the mother plant. Dasumiati et al. (2015) stated that hermaphrodite flowers on andromonoecious jatropha experienced a self-pollinated.

After vegetative and generative propagations jatropha plants were planted at different location. The andromonoecious jatropha still produced hermaphrodite and male flowers and still stable until next flowering season. The stability of sexual types was also found in monoecious jatropha. The stability of this sex types were influenced by a genetic factor. This result was similar to the research conducted by Hartati (2009) that the hermaphrodite flowers produced by jatropha were influenced by genetic factor.

Stem cutting plants and open pollination plants of trimonoecious jatropha have not stable sex type, but it indicated a stable branching character. Few of plants that produced male and female flowers were monoecious. On the other side, few of plants that produced male and hermaphrodite flowers were andromonoecious, and most of plants were trimonoecious. Flower sex types were shown by trimonoecious jatropha due to by the instability of plants that produced male, female, and hermaphrodite flowers in the same plant and at the same time. Hartati et al. (2009) stated that the emergence of hermaphrodite flowers on trimonoecious jatropha influenced by a genetic factor, plants age, and the environment.

The unstable character of sex type on trimonoecious jatropha will affect other characters, especially related to the pollination, and seed production. Cross-pollination occurs if the plants produced female flowers (Hartati 2009), it depend on the presence of pollinators. Therefore, fruit production will be determined by pollinators.

In conclusion, jatropha in Indonesia that were collected at plantation Cikampek and KIJB Pakuwon have several sex types i.e. monoecious, andromonoecious, and trimonoecious plants. Commonly, sex type of jatropha is a monoecious, while andromonoecious and trimonoecious are still rare. The flower sex types of plants from stem cuttings propagation (vegetative) and seeds from open-pollinated (generative) of monoecious and andromonoecious plants were stable, while the trimonoecious sex type morphologically was unstable.

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