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Increasing Hermaphrodite Flowers using Plant Growth Regulators in Andromonoecious *Jatropha curcas*

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***Jatropha curcas* (JC) is a crop with potential for use in biodiesel. Production of biodiesel requires plant seed as raw material, so the viability of JC for use in biodiesel will dependent greatly on the plant's production of flowers. Generally, this plant is monoecious, meaning it has both male and female flowers. However, very rarely JC plants may be andromonoecious. Andromonoecious specimens of JC produce hermaphrodite and male flowers in the same plant. The number of hermaphrodite flowers per inflorescence is generally low compared to the number of male flowers. The aim of this study was to increase the proportion of hermaphrodite flowers by using plant growth regulators (PGRs) in andromonoecious JC. Our experiment was conducted in Randomized Block Design (RBD) with 9 treatments, namely kinetin, GA_3, and IAA with concentrations of 0 ppm as a control, 50 and 100 ppm of each PGRs. The treatments were applied to stem cuttings from each plant and repeated 4 times. PGRs were applied by spraying the leaves within the buds of each plant. Applications took place weekly beginning when the plants entered flower initiating phase, until inflorescence produced. Observations were conducted during the treatment period (10 weeks). Results showed that plants treated with IAA, GA_3, and kinetin at 50 and 100 ppm produced increased inflorescence per plant. The increases measured were 155.4 and 92.9% of (IAA), 120.4 and 151% (GA_3), 96.6 and 51.7% (kinetin) respectively. In addition, we found that application and GA_3 at concentrations of 50 and 100 ppm, and kinetin at 50 ppm, increased the number of hermaphrodite flowers per inflorescence by 50%, and increased the number of hermaphrodite flowers per plant by 275.6 and 183.1% (IAA), 219.5 and 254.1% (GA_3), 162.9 and 103.1% (kinetin) respectively. As would be expected, the number of fruit per plant increased in those specimens treated with IAA, GA_3, and kinetin at 50 and 100 ppm. The increases measured were 301.7 and 167.4% (IAA), 211.7 and 257.0% (GA_3), 162.5 and 101.4% (kinetin) respectively.**

Key words: GA_3, IAA, inflorescence, *Jatropha curcas*, kinetin

INTRODUCTION

Jatropha curcas (Euphorbiaceae) is a plant of commercial importance due to its potential to produce biodiesel from it seeds, which have high oil content. (Sharma *et al.* 2009; Wang & Ding 2012). Production of *J. curcas* (JC) biodiesel requires seeds as raw material. Thus, indirectly, production of biodiesel using JC is highly dependent on production of JC flowers, because the seed is produced by hermaphrodite or female flowers.

Generally, JC plant produces both male and female flowers on the same plant (monoecious) (Alam *et al.* 2011); however sometimes JC might also produce hermaphrodite flowers (Jones & Csurhes 2008; Yi *et al*. 2010). JC specimens that produce hermaphrodite and male flowers, but not female flowers, are called andromonoecious (Dellaporta & Urrea 1993). Andromonoecious JC rarely found. The JC flower is the unlimited compound flower type (*racemosa*) with a *dichasial* branch pattern, where female flowers are located between two male flower branches, on monoecious JC plants (Raju & Ezradanam 2002). In monoecious JC, there are about five female flowers in one inflorescence (Wijaya *et al.* 2009). The ratio of female to male flowers is about 1:20 (Wu *et al.* 2011) to 1:29 (Raju & Ezradanam 2002). The low proportion of female flowers in monoecious JC limits fruit production. The low level of fruit production not only results in low seed production, but also causes lack of seed continuity. This problem is the focus of JC improvement efforts (Wahyudi & Wulandari 2007).

Andromonoecious plants were a great opportunity to produce much fruit (Miller & Diggle 2007).

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In andromonoecious JC, as in other plants, the number of fruit is dependent on the number of hermaphrodite flowers. Based on previous research, andromonoecious JC has the number of hermaphrodite flowers per inflorescence which is low in comparison to male flower (1:15). Nonetheless the potential for high fruit yield is strong. Andromonoecious JC flowers throughout the year and hermaphrodite flowers have high rates of fruit set, reaching 100%. High numbers of hermaphrodite flowers will produce more fruit. Therefore, it is very important to improve hermaphrodite flower production in andromonoecious JC.

The enhancement of hermaphrodite flower production does not only increase the yield of fruits and seeds, but also improves seed quality. One study showed that pollination of hermaphrodite flowers occurs simultaneously with flower bloom, so that hermaphrodite flowers have a tendency to self-pollinate. Therefore, the seed produced from hermaphrodite flowers are nearly uniform, and have properties similar to the parent.

An increased number of hermaphrodite flowers on andromonoecious JC can be achieved by application of Plant Growth Regulators (PGRs), because PGRs influence the developmental process of flowers. PGRs are organic compounds naturally occurring in plants that affect physiological processes. PGR levels may impact the sex ratio of plants, since PGRs are one of the factors which determine sex in plants, aside from genetic and environmental factors (Meagher 2007). Ahoton and Quenum (2012) also suggested the use of plant growth regulator on female parent to increase the success of hybridization in JC. Several studies have attempted to influence sex in plants by using PGRs. Auxins, such as indol acetic acid (IAA), affected sex expression in hermaphrodite and andromonoecious plants of *Cucumis sativus* L. (Galun *et al.* 1964). Gibberellin (GA_3) increased the female to male ratio in spinach (*Spinacia oleracea*) (Komai *et al.* 1999) and also increased the number of female flowers in JC (Makwana *et al.* 2010). Application of benzylaminopurin (BA), triiodobenzoic acid (TIBA), and maleat hidrazide through the leaves can increase the number of female flowers and of fruits per plant in monoecious JC (Abdelgadir *et al.* 2009). However, the use of kinetin has not been studied yet for its potential to increase the number of hermaphrodite flowers on JC. Kinetin treatment has been shown to increase the number of flowers per plant in lentil crops (*Lens culineris*) (Khalil *et al*. 2006).

We found no research related to the improvement of hermaphrodite flower production for JC. Given the favorable properties of andromonoecious JC with their hermaphrodite flowers, high fruit set, and continuous flowering throughout the year, as well as the known effect of growth regulators to increase flowering and influence the sex of flowers produced, we conducted research that aims to enhance hermaphrodite flower producing by application of PGRs (kinetin, GA_3, and IAA) on andromonoecious JC. An increased number of hermaphrodite flowers in andromonoecious JC will increase the productivity and development of JC.

MATERIALS AND METHODS

Plant Material. The plant materials used were stem cuttings of three mother plants of andromonoecious JC Dompu accession. PGRs used as treatments consisted of kinetin, GA_3 and IAA. This study was conducted from March-November 2010 in Cibeureum, Dramaga, Bogor, and in the green house of the Department of Biology, Bogor Agricultural University.

Experimental Design. This study used a Randomized Block Design (RBD) with 9 treatments, namely kinetin, GA_3, and IAA with concentrations of 0 ppm as a control, 50 ppm, and 100 ppm of each PGRs. Each treatment was repeated 4 times over the course of 10 weeks.

PGRs Applications and Observations. PGRs treatments were carried out after the plant material had grown in the field to more or less a month old. At that point in time, the plant had flower initiation occurred in several plants. Foliar application of PGRs was conducted by spraying onto the leaves in the buds, until the leaf surface (abaxial and adaxial) was wet. Spraying took place once a week between 05:00 and 6:00 am. We chose a pre-dawn application time because IAA is light sensitive and easily oxidized. Spray treatment was discontinued when inflorescences appeared. The full observation period lasted for 10 weeks.

The parameters monitored were: number of hermaphrodite flowers per inflorescence, number of male flowers per inflorescence, percentage of hermaphrodite to male flowers, number of inflorescences per plant, number of hermaphrodite flowers per plant during 10 weeks of observation, number of fruit per inflorescence (fruit set per inflorescence), fruit size (length and width), number of seeds per fruit, seed size (length and width), dry weight of seed per inflorescence, and weight per 100 seeds.

Data Analysis. Data were analyzed by using SPSS version 16. The difference between PGR treatments and concentrations were shown in variation analysis

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