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The potential of physic nut (*Jatropha curcas* Linn.) hybrid plant as a source of biodiesel at different planting location for dry land utilization

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Abstract

Physic nut (*Jatropha curcas* Linn.) is the one of prospective plants to be developed as biodiesel source in the tropical region. Hence, it is very important to expand the cultivation area of this plant. The purpose of this research was examined the crossed results of four genotypes of physic nut plant that potential to be developed as the promising genotypes for dry land area, namely JCUMM-5, JCUMM-6, JCUMM-7, and JCUMM18. The potential production of the four genotypes plant of *J. curcas* were selected for five years planting at two different locations which represent the dry land area, i.e., Pasuruan Regency of East Java, and North Lombok Regency of West Nusa Tenggara, Indonesia. The observations on the number of fruit bunches, fruits number, seeds dry weight, 100 seeds dry weight and seed oil content showed that JCUMM5, JCUMM7, and JCUMM18 were not significantly different ($P>0.05$) and the seeds production in kilogram of dry weight/ha/year higher than IP3A and IP3P as a control genotypes. Whereas the JCUMM18 genotype was the highest average on seeds dry weight (328.5 kg/ha/year) and North Lombok, West Nusa Tenggara location was higher on a number of fruit bunches, fruits number and 100 seeds dry weight than those in Pasuruan, East Java. However, the seed oil content from North Lombok was lower than in Pasuruan location.

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Keywords: Dry land; Genotype; *Jatropha curcas* Linn.; Physic nut; Seed oil

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1. Introduction

Indonesia has a huge biodiversity of plants species that also have the potential to become an alternative of renewable energy source such as biofuel. The one of prospective plants that has a potentiality to be used as biofuel is physic nut (*Jatropha curcas* Linn.). The *J. curcas* seed has been known containing a high content of vegetable oil [1,2] and has the potential to be developed as biodiesel fuels [1,3].

To avoid land competition with food crops hence the development of the *J. curcas* plant is directed to non-productive lands or marginal lands. In the future, the *J. curcas* planting in Indonesia will focus on the utilization of dry land or marginal land wherein 2015 reached a total of 8 087 393 hectares [4]. Dry and marginal land is vast in the eastern part of Indonesia, and until now, it has not been utilized optimally. The Indonesia Directorate General of Plantation has planned for J. curcas cultivation, especially in West Nusa Tenggara, East Nusa Tenggara, Southeast Sulawesi, Gorontalo, Maluku, and Papua areas (Direktorat Jenderal Perkebunan- Kementerian Pertanian. Directorate General of Plantation Ministry of Agriculture, 2005) [5].

The general problem causing a low success of *J. curcas* planting was an incompatibility of plants with the existing characters of the land condition. The crossing between several local *J. curcas* accessions has been carried out to obtain the hybrids that tolerant to drought stress [6,7]. In the previous research was obtained four genotypes of *J. curcas* that have potential to be developed as promising genotype for dryland condition, namely JCUMM5 (HS49 × SP34), JCUMM6 (HS49 × SM35), JCUMM7 (HS49 × IP1A), and JCUMM18 (SP16 × SM35) [7]. Then, in the study on the seed oil content of *J. curcas* was found the seeds oil content varying from 27.04% to 35.24% and the highest seed oil content was obtained from the results of a crossed-genotype between SM35 × SP38 that was 32.035% [6].

The purpose of this study was to assay the four promising genotypes of *J. curcas*, i.e., JCUMM5, JCUMM6, JCUMM7, and JCUMM18 that were planted on two dryland locations for five years of planting. *J. curcas* seeds oil is useful for biodiesel production. Therefore the developing of specific varieties related to cultivating the *J. curcas* plant in a dryland with high yield is very important for the contribution of raw material for biodiesel production sustainable.

2. Materials and methods

The four genotypes of *J. curcas* plant were planted for five years from 2012 to 2016 located in two locations, i.e. Kedung Pengaron Village of Pasuruan Regency (7°43′59.99″S, 112°49′59.99″E), East Java Province and Alok Barat Village of North Lombok (8°21′0″S, 116°9′0″E), West Nusa Tenggara Province, Indonesia (Fig. 1). Whereas, the analysis of seed oil content was carried out at the Laboratory of Vegetable Oil Technology, University of Muhammadiyah Malang, Indonesia.

The planting designed of *J. curcas* each location was arranged by Randomized Completely Block Design with 4 replications. The genotypes of *J. curcas* that used in this study were consisted of JCUMM5 (HS49 × SP34), JCUMM6 (HS49 × SM35), JCUMM7 (HS49 × IP1A), and JCUMM18 (SP16 × SM35) [6,7], while the control plants were the superior selected breeds from the Ministry of Agriculture, Indonesia namely IP3A and IP3P [8]. The data variables were collected from the observations on the number of fruit bunches, fruits number, seed dry weight, 100 seeds dry weight and seed oil content. While, seed oil content was analysis by using the Soxhlet extraction method according to Akpan et al. [9].

The performance difference of yield production on each genotype per location was analysis by Analysis of Variance (ANOVA) test with 5% of error level and if any significant difference between genotypes then followed by an Honestly Significantly Different (HSD) test. The data analysis performed by using the Statistical Analysis System (SAS) software version 9.0 (SAS Institute, 2013).

3. Results and discussions

The analysis of variance showed that the *J. curcas* Linn. plant genotypes were significantly different ($P \leq 0.05$) on the average of fruit bunches number, the number of fruits per plant, seeds dry weight, 100 seeds dry weight, and seed oil content at two planting locations (Pasuruan, East Java and North Lombok, West Nusa Tenggara) for five-years plantation (2012 to 2016). In general the four genotypes of *J. curcas* Linn. crossbred (JCUMM5, JCUMM6, JCUMM7, and JCUMM18) were higher average on fruit bunches, number of fruits, seeds dry weight, 100 seeds dry weight, and seed oil content compared to IP3A and IP3P as a control plant (Table 1).

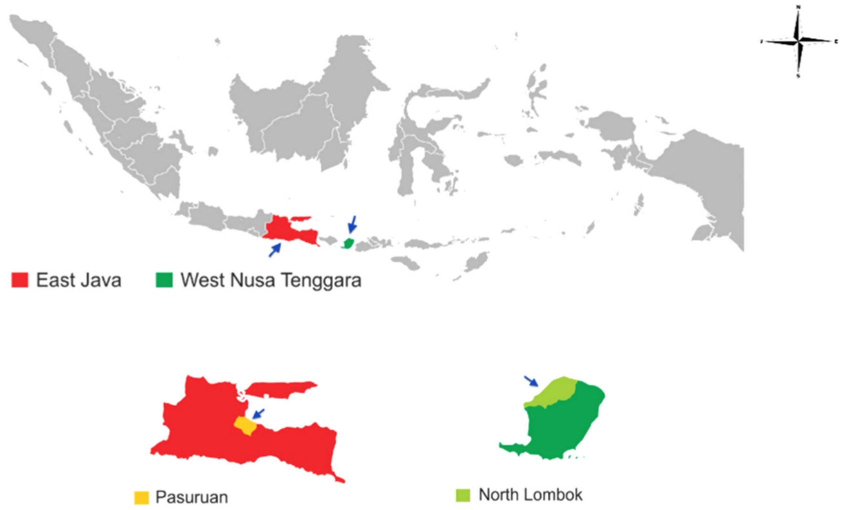

Fig. 1. The planting locations of *J. curcas* plant genotypes.

Table 1. The average number of fruit bunches, fruits number, seed dry weight, 100 seeds dry weight, and seeds oil content of *J. curcas* plant at two planting locations (Pasuruan and North Lombok) for five years of planting (2012–2016).

No.	Genotype	Average number of fruit bunches (plant/year)	Fruits number (plant/year)	Average of seeds dry weight (kg/ha/year)	Average of 100 seeds dry weight (g)	Average of seeds oil content (% DW seeds)
1	JCUMM5	42.8^{a}	260.4^{a}	300,6^{a}	70.4^{a}	33.9^{a}
2	JCUMM6	38.1^{b}	177.4^{b}	232,4^{b}	68.8^{a}	34.3^{a}
3	JCUMM7	41.1^{a}	244.6^{a}	296,9^{a}	69.9^{a}	33.5^{a}
4	JCUMM18	42.1^{a}	230.9^{a}	328,5^{a}	69.7^{a}	33.1^{ab}
5	IP3A	34.1^{bc}	190.2^{b}	209,2^{bc}	64.6^{b}	31.9^{b}
6	IP3P	32.9^{c}	173.8^{b}	200,8^{c}	65.5^{b}	31.8^{b}

Notes: (*) The number followed by similar small capital at the same column is not significantly different (P ≥ 0.05) based on HSD test at 5% of error.

The average total production of *J. curcas* from North Lombok was higher on fruit bunches (52.1 fruit bunches/plant/year) and the fruits number (345.3 fruit/plant/year) than in Pasuruan for five years of planting. While the average number of fruit bunches and fruits number from North Lombok was higher than in Pasuruan location (Tables 2 and 3).

Table 2. The average number of fruit bunches (plant/year) from both locations (Pasuruan and North Lombok) for five years of planting (2012–2016).

	Number of fruit bunches										Average of genotype for 5 years of planting
	North Lombok year					Pasuruan year					
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	
CV of location/season (%)	12.2	13.3	14.0	10.2	19.3	17.2	22.9	11.4	6.4	8.4	7.6
Average location/season*	19.5^{bc}	73.5^{a}	66.5^{a}	35.8^{b}	65.4^{a}	11.8^{c}	33.5^{b}	12.9^{c}	48.3^{ab}	17.7^{c}	
Average per location*			52.1^{a}					24.8^{b}			
CV per location (%)			7.66					7.66			

Note: (*) The number which followed by similar small capital at the same column is not significantly different (P ≥ 0.05) based on HSD test at 5% of error; CV: Coefficient of Variance.

Table 3. The average of fruits number of *Jatropha curcas* Linn. (plant/year) from both locations (North Lombok and Pasuruan) for five years of planting (2012–2016).

	Fruits Number										Average of genotype for 5 years of planting
	North Lombok year					Pasuruan year					
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	
CV of location/season (%)	15.7	6.2	18.6	8.2	5.2	15.3	22.8	26.2	16.6	20.3	6.2
Average of location/season*	153.3^{bc}	422.9^{ab}	476.9^{a}	217.1^{b}	455.8^{a}	29.8^{c}	100.8^{bc}	46.8^{c}	139.7^{bc}	85.4^{c}	
Average of both location*			345.3^{a}					80.5^{b}			
CV on both location (%)			6.20					6.20			

Note: (*) The number which followed by similar small capital at the same column is not significantly different (P ≥ 0.05) based on HSD test at 5% of error; CV: Coefficient of Variance.

Table 4. The average of seeds dry weight of *J. curcas* Linn. plant (kg/ha/year) in each year from both locations (North Lombok and Pasuruan) for five years of planting (2012–2016).

	Seeds dry weight										Average of genotype for 5 years
	North Lombok year					Pasuruan year					
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	
CV of location/season (%)	29.3	26.2	5.6	7.10	22.6	14.7	22.7	21.3	4.3	22.5	7.47
Average of location/season*	147.3^{bc}	276.8^{b}	181.3^{bc}	391.8^{ab}	824.7^{a}	37.2^{d}	204.8^{bc}	96.8^{c}	293.4^{b}	159.6^{bc}	
Average of both location*			364.37^{a}					158.35^{b}			
CV total (%)			7.47					7.47			

Notes: (*) The number which followed by similar small capital at the same column is not significantly different (P > 0.05) based on HSD test at 5% of error; CV: Coefficient of Variance.

Table 5. The average of 100 seeds dry weight of *Jatropha curcas* Linn (g) from both locations (North Lombok and Pasuruan).

	100 seeds dry weight										Average of genotype for 5 years
	North Lombok year					Pasuruan year					
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	
CV/season (%)	4.6	4.2	4.5	4.2	11.7	6.5	3.3	5.5	3.2	5.9	5.9
Average of location/season*	63.6^{bc}	71.7^{ab}	57.9^{c}	77.1^{a}	70.4^{ab}	67.7^{b}	67.1^{b}	68.2^{ab}	69.7^{ab}	67.4^{b}	
Average of both location*			68.2^{a}					68.0^{a}			
CV total of location (%)			5.9					5.9			

Notes: (*) The number which followed by similar small capital at the same column is not significantly different (P > 0.05) based on HSD test at 5% of error; CV: Coefficient of Variance.

During the five years period of planting, the average of seeds dry weight from North Lombok was 364.37 kg/ha/year and it was higher than Pasuruan (158.35 kg/ha/year). However, the average of the 100 seeds dry weight was not different ($P > 0.05$) at both locations (Tables 4 and 5).

The interaction between plant genotype and the environment is occurring due to the alterations of the plant that responds to its environment [10]. Therefore, the selection of *J. curcas* genotypes that have the best on seeds dry weight, the breeders must choose the genotype that suitable for a specific environment and the other genotypes for different environments. This is steps can be done by comparing the average yield of the seeds in each location. In addition, the seeds production of the plant every year in each location need to be assessable to obtain the potential and trends of the seed production from year to year as the basis for selecting the best genotype.

The level of a production plant is highly dependent on the environmental conditions such as genotype that was planted and a type of genotype [11]. There are several factors that affect the production level of *J. curcas* and the most dominant factors are the altitude and rainfall per year. Rainfall is the most important factor in the planting of *J. curcas*. The rainfall level that suitable for *J. curcas* plant growing is around 300–1000 mm/year [12].

Table 6. The average of seed oil of Jatropha curcas Linn (% dry weight) at both locations (North Lombok and Pasuruan) for five years of planting (2012–2016).

	Seed oil content										Average of genotype for 5 years
	North Lombok year					Pasuruan year					
	2012	2013	2014	2015	2016	2012	2013	2014	2015	2016	
CV/season (%)	2.2	10.1	9.9	9.0	17.7	2.8	6.6	3.1	12.7	9.3	8.9
Average of location/season*	35.1^{b}	28.5^{bc}	27.8^{c}	32.0^{bc}	30.2^{bc}	35.2^{b}	54.0^{a}	30.7^{bc}	26.6^{c}	30.9^{bc}	
Average of both location*			30.7^{b}					35.5^{a}			
CV total of location (%)			8.9					8.9			

Notes: (*) The number which followed by similar small capital at the same column is not significantly different (P > 0.05) based on HSD test at 5% of error; CV: Coefficient of Variance.

The average of seed oil content from Pasuruan, East Java was 35.5% of dry weight higher than North Lombok, West Nusa Tenggara (30.7% of dry weight) (Table 6). In general, a plant that has broad adaptability, it will stable on production [13]. Hence, the plant that has a broad adaptability character will able to grow in different environmental conditions [14]. If the plant genotype has an adaptability, which is similar in productivity on a various growing environment, it is defined as the static of stability, but if the adaptability followed by changed on an environmental index it is defined as the dynamic stability [15].

4. Conclusions

This study indicated that JCUMM5, JCUMM7 and JCUMM18 seeds production in dry weight/year was potential to be developed as promising *J.curcas* genotypes for dry land area, although compare to IP3A and IP3P as a control genotypes that has been released by Ministry of Agriculture of Indonesia as the promising genotypes. The JCUMM18 and the North Lombok location has a higher number on fruit bunches, the fruits number and seeds dry weight comparing than in Pasuruan. However, Pasuruan has higher on seed oil content than North Lombok. Therefore in the future we can develop the four genotypes of *J. curcas* for dry land utilization and the *J.curcas* genotypes that has been produced hopefully can support the sustainability of biodiesel production especially in the tropical region

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