Yield Potential Of Indonesian Jatropha New Variety (Jet-1 Agribun) Under Rainfed Condition

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Abstract.
Jet-1 Agribun is one of the Indonesian Jatropha new varieties suitable for rainfed areas with a high yield of dry seed and oil content. The field trial was conducted at Asembagus Experimental Station in Situbondo, East Java from February to December 2019 and aimed to observe the potential of Jatropha Jet-1 Agribun under rainfed conditions. Observation on seed yield and growth components of Jatropha plantation was also made in two and three years old Jet-1 Agribun. Results of the observation showed that Jet-1 Agribun in the first year produced seed 471.8 kg/ha. A two-year-old plant produced a dry seed of 3,958.7 kg/ha. Three-year-old plants after pruning produced dry seed 910.95 kg/ha and 916.04 kg/ha at 1 m x 1 m and 2 m x 2 m, respectively, indicating that wider spacing is more allowable for cropping with food crops until the canopy closes. Development of Jatropha should be integrated with food crops or other crops through intercropping systems, by using the land around the plants until the canopy closes.

Keywords*: Culture technique, Jatropha, new variety and yield potential.*

I. INTRODUCTION

Globally the availability of fossil energy is predicted to be limited in the next few years, so it is necessary to find alternative renewable energy sources. *Jatropha curcas* L. is one of the potential oil crops for bio-fuel, especially bio-diesel, and has been promoted as an alternative to fossil fuel and can grow on marginal and arid land from 0 up to 500 m above sea level, tolerates drought conditions (Abobatta, 2019). Jatropha as a biofuel crop (non-edible oil), has high oil content ranging from 38.7-45.8% (Jonas et al., 2020). The Jatropha seed yield can reach 4,100 – 6,750 kg/ha/year in the third year after planting when cultivated with optimum conditions in Asembagus, the eastern part of East Java, Indonesia (Purwati et al., 2018). The average seed yield of Jatropha globally was 2,218±148 kg/ha/year and was affected by genetic diversity, age of the plant and plant density, cultivation practices, and soil fertility (Lama et al., 2018). Jatropha has multipurpose and several advantages with a minimum requirement of water, that can be used as a living fence to control soil degradation in arid regions.Jatropha as an oily seed plant has been intensively studied in 2005 as an alternative to renewable energy resources. Investigation of new and renewable energy including biofuel development in Indonesia was initially started in the 1980s. Currently, biodiesel from palm oil is a feasible option in bio-fuel applications in Indonesia where it forces the application of a certain amount of biodiesel blended into petrodiesel which currently existed in B20.

Research in Jatropha breeding and cultivation techniques has been concentrated to produce new varieties and cultivation technology. The use of new varieties with high-yielding seed yield and oil content will increase the seed yield till an economically feasible seed yield is achieved. Yi et al., (2014) improved Jatropha seed productivity through mass selection breeding which will lead to better economics for Jatropha plantation.Indonesia through ISFCRI has improved Jatropha's new varieties with high seed yields. Two new varieties Jet-1 Agribun and Jet-2 Agribun were released by the Indonesian Ministry of Agriculture in 2017 with a potential yield ranging from 2.33-2.64 t/ha/year with an oil content of 35.80-37.44%. Jet-1 Agribun was resulted from domestication (exploration from the dry areas in East Nusa Tenggara), while Jet-2 Agribun produced by hybridization between accession Lampung and SP-117. One of these accessions came

from Lampung province, Sumatera island which has a wet area and climate. The material used in this study was Jet-1 Agribun representing the genotype adapted in the research site. This study aimed to observe the potential yield of Jatropha Jet-1 Agribun under rainfed conditions in Indonesia.

II. MATERIALS AND METHODS

A field trial was done in 2019 using Jet-1 Agribun (Indonesian Jatropha new variety) material. Jatropha Jet-1 Agribunwas planted in the dry area of the eastern part of East Java at Asembagus Experimental Station, Situbondo, Indonesia. The experiment consisted of three different plant ages: first-year, second-year, and three-year-old plants. The experimental unit included a total of 750 trees. The first-year-old plants were planted on April 25, 2019, at a spacing of 2 x 2 m. The existing two-year-old plants were planted on March 28, 2018, using stem cuttings with a planting space of 2 x 2 m, consisting of 600 plants. While the existing three-year-old plants were planted in June 2017, with two different planting spaces, i.e. 2 x 2 m and 1 x 1 m using stem cuttings. Each unit of planting space consisted of 500 plants and 1000 plants, respectively, and the plants had been pruned in May 2019 to a height of 60 cm above the ground.

Plant maintenance consisted of the application of fertilizer, irrigation, weeding, and pest management. The fertilizer used was 450 kg/ha NPK compound fertilizer (15% N -15% P_2O_5 -15% K_2O) and 100 kg/ha Urea. Urea was applied at the end of the rainy season. The amount of 75 kg/ha NPK compound fertilizer was applied every two months. Besides, 2.5 kg/hole of organic matter was applied before planting. Irrigation was applied every 20 days at the early stage after planting. Weeding was done four times a year using a hoe. Capsules or Jatropha fruits were selectively harvested when they have physiologically mature or when the color turned from green to yellow or brownish-yellow. The parameters observed were plant height, canopy width, number of flowers, inflorescence per bunch, and number of capsules per plant.

III. RESULTS AND DISCUSSION

Growth of Jet-1 Agribun

Jet-1 Agribun planted in April 2019 (first-year-old) has reached a plant height of 28.4 cm and a canopy width of 38.1 cm at the age of 2 months after planting (MAP). Plant height continued to increase to 104.85 cm at the age of 8 MAP and canopy width 118 cm by the end of December 2019 (Figure 1). The development of canopy width is faster than plant height from the age of 2-7 MAP as indicated by the wider canopy than height. The development of plant height and canopy width significantly increased in the period of 2-5 MAP, and from 5-7, MAP showed slow growth and was stagnant from 7-8 MAP.

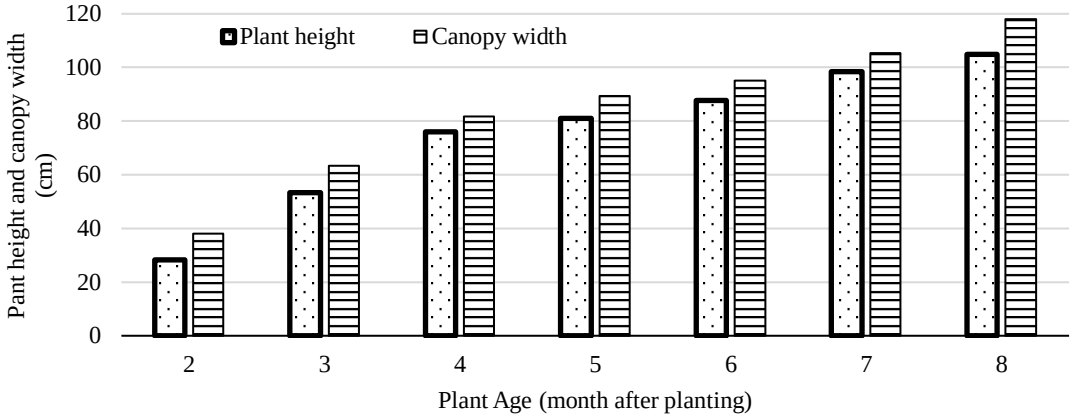

Fig 1.Plant height and canopy width of Jet-1 Agribun in the first year.

Second-year-old of Jet-1 Agribun was planted on 28 March 2018 and has been 21 months after planting by the end of December 2019. The plants have reached a height of 183.22 cm and a canopy width of 236.28 cm on average (Figure 2). Canopy width growth until the second year was higher than plant height. During the periods of 15-21 MAP, there were no significant increases in plant height and canopy width. This research supports Saadaoui et al., (2015), who observed the mean plant height and canopy circumference

after five years varied between 178-217 cm and 368-594 cm, respectively, on eight Jatropha accessions in Tunisia.

Three-year-old of Jet-1 Agribun had been pruned in May 2019. When the plant was seven months after pruning showed a plant height of 143.65 cm and a canopy of 197.8 cm with wider spacing of 2x 2 m by the end of December 2019 (Figure 3). The canopy width was narrower (162.05 cm) in a 1x1 m plant spacing, and the plant canopy started to intercept 2 months after pruning. Plant height and canopy width are lower at narrow spacing. With a spacing of 2x2 m (2500 plants/ha), it is easier for plant maintenance and it requires less planting material and fertilizer than narrow spacing (10.000 plants/ha). Tjeuw et al. (2015) found pruning reduced plant height leading to reduced seed yield of up to 75%, seed yield was highly correlated with plant height and the number of productive branches. Moreover, pruning the trees reaching > 1.75 m height at the 3-4-year-old can stimulate additional branching to increase seed production and maintain the trees at a convenient height for harvesting (Everson et al., 2013). Pruning from ground level and for primary branches can increase seed yield but depend upon specific genotypes (Rao et al., 2017).

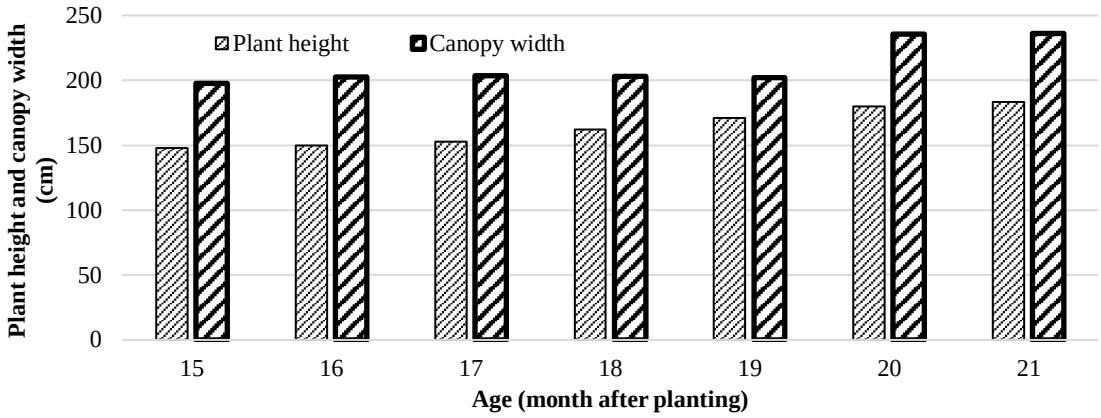

Fig 2.Development of plant height and canopy width of JET-1 Agribun Year II

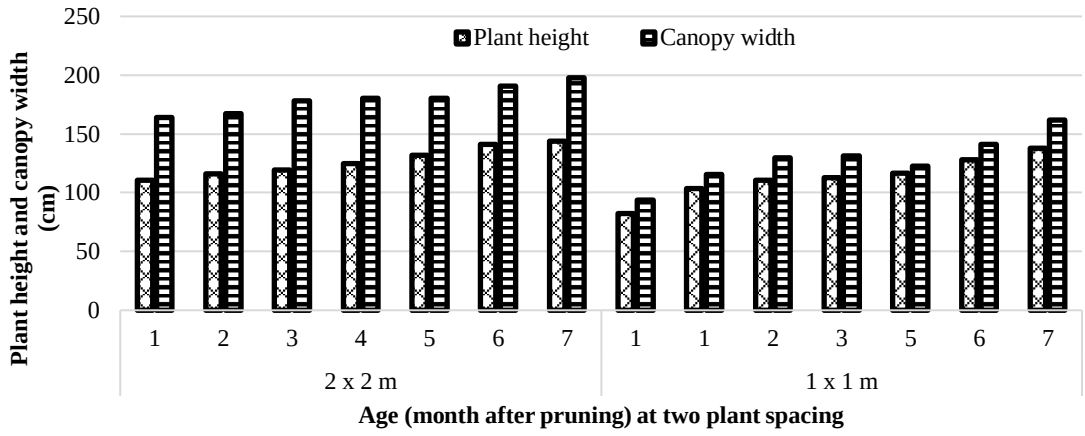

Fig 3.Growth of plant height and canopy width of the JET-1 Agribun after pruning at two plant spacing

Yield components and seed yield

In the first year after 110 days, a 25% population of Jatropha Jet-1 Agribun started producing seeds 2.12 g/plant and 1.15 capsules/plant on average. Later after 120 days about 80% of the plant population increased producing seeds to 10.67 g/plant with an average of 5.85 capsules/plant (Table 1). The number of harvested capsules continued to increase with plant age through inflorescence development and new branches. Cañadas-López et al., (2018) also observed three months after planting that the Jatropha began to produce fruits, and the maximum seed production occurred at a four-year-old plantation depending on the accessions in Manabi-Ecuador with the average seed yield of 314.02±63.19 g/plant/year. Cañadas-López et al., (2017) reported variation in the seed yield of Jatropha (0.28-0.30 kg/tree/year) from the highest-yielding accession in Ecuador.

Table 1. Dry seed yield and yield components of JET-1Agribun at 110-120 days after planting

Harvest Age (DAP)	The percentage of the plant population starts yielding	The average number of inflorescence/ plant	The average number of harvested capsules/plant	Dry seed yield (g/plant)
110	25	0.15	1.15	2.12
120	80	1.05	5.85	10,67

Seed yield up to December 2019 (8 MAP) reached 471.8 kg/ha and the number of harvested capsules was 127 capsules/plant (Table 2). The seed yield and capsules formed will increase along with the age. Purwati et al. (2015) reported average seed yield for three years (no-pruning) in Asembagus for HS-49/NTT (released as Jet-1 Agribun) was 1531.34 kg/ha/year. Everson et al. (2013) stated the seed yield in the first year from March to July 2007 was lower, i.e. 89.9 kg/ha due to a competition of weeds and grass in the early establishment phase.

Table 2. Seed yield and harvested capsules of JET 1 Agribun in the first year

Plant age	Seed yield (kg/ha)	Harvested capsules/plant
The year I (8 months)	471.8	127.23

During the dry season, there was no significant rainfall at Asembagus from April to November 2018, and from May to November 2019 so irrigation was necessary to meet the water needs of plants. Plants received 184.6 mm of rainfall from planting to December 2018, and 256.2 mm in 2019 (Figure 4). The annual rainfall in 2018 was 510.8 mm, and 594.84 mm in 2019. Asembagus, located in the eastern part of East Java represents a very dry area in East Java. Moseki et al. (2019) estimated the total Jatropha evapotranspiration rate (ETc) was 955.4 mm/growing season under semiarid conditions in Bostwana. The daily evapotranspiration rate of Jatropha was 3-4 mm/day on clear-hot days in South Africa (Everson et al., 2013). The total rainfall in the experimental site was much lower than Jatropha ETc which needs supplemental irrigation to meet the plant requirement. Cañadas-López et al., (2017) stated that the seed yield of Jatropha was not affected by annual rainfall, and variation in seed production was mainly affected by agronomic practices. Everson et al., (2013) identified that Jatropha of two to four year old were conservative water users. Vaknin et al., (2018) stated that the seed and oil yield of Jatropha increased at irrigation mid-level (60% ETp).

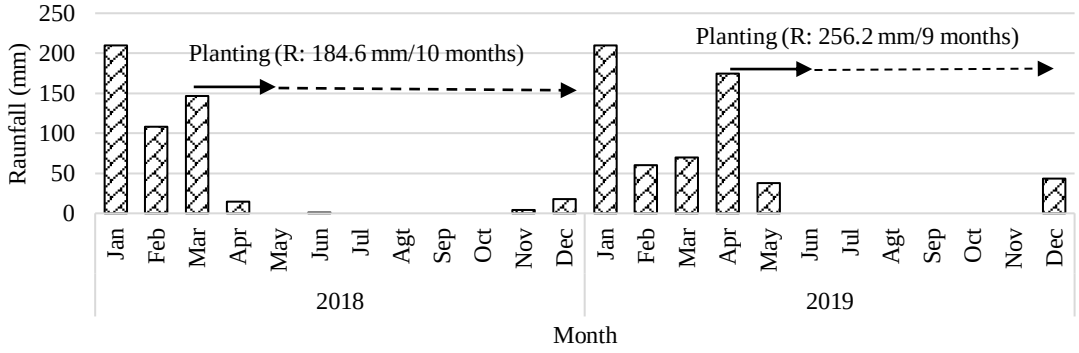

Fig 4. Rainfall distribution in Asembagus experimental station 2018-2019

In the second-year-old plants from January to December 2019, the plants produced 3,958.7 kg/ha of seed with a total number of harvested capsules of 839.97. The dry seed yield attained was higher than the yield description of JET-1 Agribun (2.33 t/ha/year). With the oil content of 37.44% (from the descriptor list), it showed that the oil yield of JET-1 Agribun was 1,482.14 l/ha/year. Seed yield and the number of capsules in two-year-old plants until December 2019, increased more than eight times compared to year I which reached a seed production of 471.8 kg/ha and 127 harvested capsules (Table 2). However, research development of high-yielding Jatropha varieties is still necessary to achieve the economic yield before they are implemented for a sustainable biofuel program as suggested by Kgathi et al. (2017) for the Jatropha project in Bostwana. In addition, agronomic and socio-economic research of Jatropha should be fully understood before developing on a large scale which maybe offers risk (Mmopelwa et al., 2017).

Improving yield and harvesting efficiency will increase economic performance in Jatropha (Van Eijck et al., 2012).The low seed yield in the first year is related to the low number of harvested capsules from June to December 2018. Jet-1 Agribun plants received 184.6 mm of rainfall in year I and 594.84 mm in year II until December 2019 (Figure 4). The water needs of plants in the first year were mostly supplied by irrigation while in the second year rainfall was during the rainy season of 2018/2019. The seed yield of Jatropha worldwide as reported by Lama et al. (2018) was 2218±148 kg/ha, depending on the age of the plant which was a linearly positive effect on seed yield, however, rainfall and plant density had quadratic effects on seed yield, and economically feasible at seed yield of 2500 kg/ha/year. Our findings revealed that the seed yield of a two-year-old plant achieved more than the economically feasible yield as seen in Table 3. Different management practices, climate, soil fertility, and genetic diversity are factors affecting the seed yield of Jatropha. The seed yield obtained from some Jatropha projects in the Sub-Saharan Africa regions were 0.86 t/ha in Kenya, 1.6 t/ha in Tanzania, 0.63 t/ha in Mali, and more than 1 kg/tree in Mozambique, their low seed yields were from young plantations (Jingura & Kamusoko, 2015).

Table 3. Seed production and harvested capsules of JET 1 Agribun at years I-II

Plant age	Seed yield (kg/ha)	Harvested capsules/plant
Year I	357.5	77.1
Year II	3958.7	839.9

The weight of 100 dry seeds from two-year-old plants at different harvest periods ranged from 68.28 to 69.40 g in January-March 2019, then decreased to 67.33-67.36 g in April-May 2019, then continued to decline from 65.76-66.18 g in June-July 2019 to 62.7-64.6 g in August – October 2019 and drop to 59.4-60.9 g in November-December along with decreasing rainfall which is shown in Figure 5. The average seed weight of Jet-1 Agribun was 65.41 g for 100 seeds, higher than reported by Heliyanto et al., (2020), an average of 100 seed weight was 60.101+0.330 g from different accessions in Indonesia. Makinde et al. (2020) categorized Jatropha seeds into large seeds with 71.79 g, medium seeds with 65.29 g, and small seeds with 50.51 g of 100 seeds, for use in the assessment of seedling vigor, dry matter yield, and oil content. Based on this seed weight category, the average seed weight obtained from this study was considered medium seed weight. Cañadas-López et al., (2018) & Wassner et al. (2016) obtained the linear regression up to 58.8-60.5 g and the quadratic beyond that point for the relationships between seed weight for 100 seeds and seed oil content. Wani et al. (2012) stated that there was a positive correlation (r=0.8) between 100 seed weight and oil yield. Therefore, higher seed weight in addition to high yield is an important characteristic of Jatropha resulting in higher Jatropha oil.

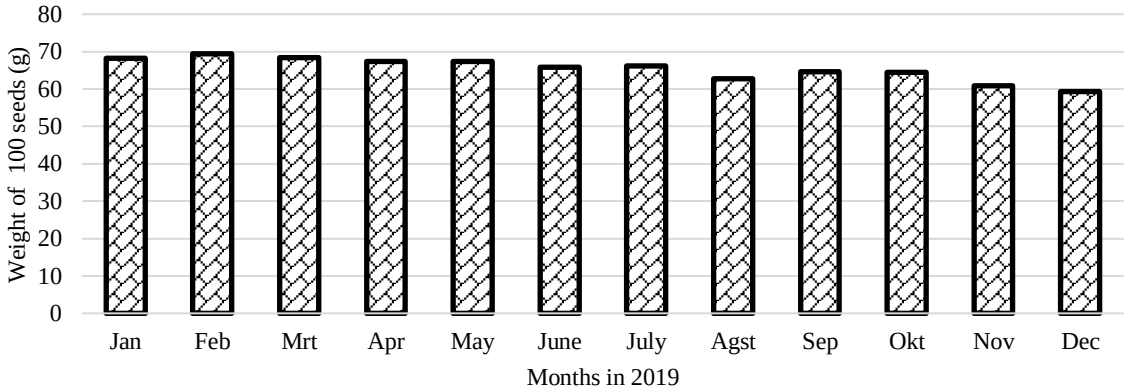

Fig 5.Weight of 100 dry seeds of Jet-1 Agribun in year II

The seed yield of three-year-old plants of Jet-1 Agribun at seven months after pruning (December 2019) was 910.95 kg/ha and 916.04 kg/ha obtained from 1x1 m and 2x2m, respectively (Table 4) which was more likely similar indicating that wider plant spacing was more allowable for the plant to capture light. The seed yield of Jatropha after pruning nearly doubled to the first-year seed yield and reduced to 76.86% than before pruning (full-year two). Tjeuw et al. (2015) found seed yield reduced to 75% after pruning. With wider spacing, the growers can use the land in between Jatropha plants with food crops in the intercropping system especially in the first year or after pruning until the canopy closes. (Joao et al. (2016) reported the

species in intercropping with *J. curcas* did not affect its vegetable development. *J. curcas* produced higher seed yield in intercropping with crop rotation systems in Brazil. Singh et al. (2019) suggested replacing the monoculture of Jatropha with intercrops between 3x3 m Jatropha plantations. The Monoculture of Jatropha is not economically feasible due to late fruiting and low yield. Intercropping between Jatropha and sweet basil – matricaria in India found highly ameliorative alternate land use for sodic soil. Moreover, intercropping can improve livelihood by giving some income to poor farmers who can not wait for such a long period without getting any income from their land.

Table 4. Seed yield and harvested capsules of JET 1 Agribun at different plant spacing at year III (after pruning)

Plant spacing	Seed yield (kg/ha)	Harvested capsules/plant
1 m x 1 m	910.9	213.7
2 m x 2 m	916.0	214.4

IV. CONCLUSIONS

The seed yield of one year old of Jet-1 Agribun was 471.8 kg/ha eight months after planting (April to December 2019). Jet-1 Agribun at year II had produced 3,958.7 kg/ha, eight times increased than the first-year yield. Plants three-year-old reached seed yield of 910.95kg/ha and 916.04 kg/ha at 1x1 m and 2x2 m, respectively, after pruning, indicating that wider spacing was more allowable for intercropping with food crops until the canopy closes.

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