YIELD OF THREE CASTOR (*Ricinus communis* L.) HYBRID VARIETIES TREATED WITH DIFFERENT RATES OF FERTILIZER

I K. D. Jaya[1], I G. P. M. Aryana, B. B. Santoso, I W. Sudika
Energy Crops Centre, Faculty of Agriculture University of Mataram
Jl. Majapahit 62 Mataram 83125, Lombok INDONESIA Tel. (0370) 628129, Fax: (0370) 640189.
[1]Corresponding author: E-mail: ikdjaya@hotmail.com

ABSTRACT

The biggest challenge in growing energy crop of castor (*Ricinus communis* L.) as an industrial crop is to improve its daily productivity. Hybrid varieties have many been suggested as one of the ways to overcome the problem. This study aimed at testing yielding ability of three Chinese hybrid varieties of castor grown on dryland and treated with different rates of NPK (15-15-15) fertilizer. The varieties were Zhibo-5, Zhibo-7 and Zhibo-8 and the fertilizer rates were 0 g plant^{-1}, 125 g plant^{-1} and 250 g plant^{-1}. The experiment was conducted during the rainy season of 2010/2011, from February to May, 2011. There were 300 plants in each treatment and 10 plants from each treatment were taken as sample plants. The results show that most of the plants in zero fertilizer treatment failed to grow and those able to grow failed to produce panicle. Zhibo-5 treated with 250 g plant^{-1} of NPK fertilizer produced moderate number of panicles per plant but high in panicle length, panicle weight and number of fruit per plant. The highest seeds dry weight per plant (543.6 ± 92.8 g plant^{-1}) was also produced by Zhibo-5 treated with 250 g of fertilizer while the lowest (205.2 ± 92.1 g plant^{-1}) was also produced by the same variety treated with 125 g of fertilizer. The highest 1000 seeds weight (349.9 ± 29.6 g) was produced by Zhibo-7 treated with 250 g fertilizer and the lowest (252.7 ± 30.7 g) was in Zhibo-8 treated with 125 g fertilizer. In all, the three hybrid varieties require high input of fertilizer and may not as a good option to improve castor daily productivity.

Keywords: *energy crop, annual, productivity*

INTRODUCTION

Climate change has become a hot issue and government of all over the world has spent so much money to study this issue. Fossil fuels and coal burning for industries and transportation as well as high deforestation rate, that lead into high CO_2 concentration in the air, are considered as the main cause of the climate change. The use of renewable energies to replace fossil fuels uses in order to reduce CO_2 emission and to sustain the fossil fuels availability, has been intensified. One of the renewable energies is biofuel. Unfortunately, recent data shows that current world biofuels production is still low, less than 2% of the total demand (Zah and Rudy, 2009). In Indonesia, palm oil (*Elaeis guineensis*) and physic nut (*Jatropha curcas* L.) have long been utilized as feedstocks for biofuels. However, palm oil plantation in Indonesia has a bad record because of deforestation activities (Zhou and Thompson, 2009), while physic nut is considered as a high water foot print plant (Garbens-Leenes *et al.*, 2009).

One of the non-food crops that is catagorized as an energy crop as well as an industrial crop is castor (*Ricinus communis* L.). Castor oil was reported as a good source of biodiesel (Baldwin and Cossar, 2009; Barbosa *et al.*, 2010). Other uses of castor oil are as lubricans, plant-based paint, natural coating in chemical industries and cosmetics (Derksen *et al.*, 1995; Johnson Jr., 2007). Castor plant stem was also reported as a good source of particle board, even though the quality is not the best (Grigoriou and Ntalos, 2001). Based on that many uses, castor has been extensively grown as an industrial crop in countries like China, India and Brazil. In Indonesia, castor is mainly grown in East Java and West Nusa Tenggara. Considering the high demand of biofuels and the many uses of the castor oil, castor has a good future market.

Most cator plants grown in Indonesia are perennial. There are three national variety available in Indonesia, namely Asembagus-22 (ASB-22), Asembagus-60 (ASB-60) and Asembagus-81 (ASB-81). The rests are mainly local variety, such as Beaq Amor, Klikit Kayangan and Gundul Bayan, that are mainly found on drylands Lombok. There are at least two basic problems in growing perennial castor varieties on drylands. The first problem is short period of rainy season. With this condition, the best plant productivity is limited only during the rainy season only and the rest of the year the castor plants tend to shed their leaves, and hence no yield is expected. The second problem is that this plant requires many harvests. Time lag between the first panicle harvest and the second and the third can be two weeks. This harvest practice costs a lot of labours that make perennial castor daily productivity is low. Castor varieties with shorter growing period (annual like) with high productivity is suggested to be grown on drylands to improve the

YIELD OF THREE CASTOR (*Ricinus communis* L.) HYBRID VARIETIES TREATED WITH DIFFERENT RATES OF FERTILIZER

I K. D. Jaya[1], I G. P. M. Aryana, B. B. Santoso, I W. Sudika
Energy Crops Centre, Faculty of Agriculture University of Mataram
Jl. Majapahit 62 Mataram 83125, Lombok INDONESIA Tel. (0370) 628129, Fax: (0370) 640189.
[1]Corresponding author: E-mail: ikdjaya@hotmail.com

ABSTRACT

The biggest challenge in growing energy crop of castor (*Ricinus communis* L.) as an industrial crop is to improve its daily productivity. Hybrid varieties have many been suggested as one of the ways to overcome the problem. This study aimed at testing yielding ability of three Chinese hybrid varieties of castor grown on dryland and treated with different rates of NPK (15-15-15) fertilizer. The varieties were Zhibo-5, Zhibo-7 and Zhibo-8 and the fertilizer rates were 0 g plant^{-1}, 125 g plant^{-1} and 250 g plant^{-1}. The experiment was conducted during the rainy season of 2010/2011, from February to May, 2011. There were 300 plants in each treatment and 10 plants from each treatment were taken as sample plants. The results show that most of the plants in zero fertilizer treatment failed to grow and those able to grow failed to produce panicle. Zhibo-5 treated with 250 g plant^{-1} of NPK fertilizer produced moderate number of panicles per plant but high in panicle length, panicle weight and number of fruit per plant. The highest seeds dry weight per plant (543.6 ± 92.8 g plant^{-1}) was also produced by Zhibo-5 treated with 250 g of fertilizer while the lowest (205.2 ± 92.1 g plant^{-1}) was also produced by the same variety treated with 125 g of fertilizer. The highest 1000 seeds weight (349.9 ± 29.6 g) was produced by Zhibo-7 treated with 250 g fertilizer and the lowest (252.7 ± 30.7 g) was in Zhibo-8 treated with 125 g fertilizer. In all, the three hybrid varieties require high input of fertilizer and may not as a good option to improve castor daily productivity.

Keywords: *energy crop, annual, productivity*

INTRODUCTION

Climate change has become a hot issue and government of all over the world has spent so much money to study this issue. Fossil fuels and coal burning for industries and transportation as well as high deforestation rate, that lead into high CO_2 concentration in the air, are considered as the main cause of the climate change. The use of renewable energies to replace fossil fuels uses in order to reduce CO_2 emission and to sustain the fossil fuels availability, has been intensified. One of the renewable energies is biofuel. Unfortunately, recent data shows that current world biofuels production is still low, less than 2% of the total demand (Zah and Rudy, 2009). In Indonesia, palm oil (*Elaeis guineensis*) and physic nut (*Jatropha curcas* L.) have long been utilized as feedstocks for biofuels. However, palm oil plantation in Indonesia has a bad record because of deforestation activities (Zhou and Thompson, 2009), while physic nut is considered as a high water foot print plant (Garbens-Leenes *et al.*, 2009).

One of the non-food crops that is catagorized as an energy crop as well as an industrial crop is castor (*Ricinus communis* L.). Castor oil was reported as a good source of biodiesel (Baldwin and Cossar, 2009; Barbosa *et al.*, 2010). Other uses of castor oil are as lubricans, plant-based paint, natural coating in chemical industries and cosmetics (Derksen *et al.*, 1995; Johnson Jr., 2007). Castor plant stem was also reported as a good source of particle board, even though the quality is not the best (Grigoriou and Ntalos, 2001). Based on that many uses, castor has been extensively grown as an industrial crop in countries like China, India and Brazil. In Indonesia, castor is mainly grown in East Java and West Nusa Tenggara. Considering the high demand of biofuels and the many uses of the castor oil, castor has a good future market.

Most cator plants grown in Indonesia are perennial. There are three national variety available in Indonesia, namely Asembagus-22 (ASB-22), Asembagus-60 (ASB-60) and Asembagus-81 (ASB-81). The rests are mainly local variety, such as Beaq Amor, Klikit Kayangan and Gundul Bayan, that are mainly found on drylands Lombok. There are at least two basic problems in growing perennial castor varieties on drylands. The first problem is short period of rainy season. With this condition, the best plant productivity is limited only during the rainy season only and the rest of the year the castor plants tend to shed their leaves, and hence no yield is expected. The second problem is that this plant requires many harvests. Time lag between the first panicle harvest and the second and the third can be two weeks. This harvest practice costs a lot of labours that make perennial castor daily productivity is low. Castor varieties with shorter growing period (annual like) with high productivity is suggested to be grown on drylands to improve the

plant daily productivity (Anjani, 2010).

Some annual castor hybrid varieties have been developed in China, such as Zhibo-5, Zhibo-7, Zhibo-8. The adaptability of these hybrid varieties on dryland of Pringgabaya, Lombok has been reported by Jaya and Hadi (2010). In that study, all the hybrid varieties were given 240 g of NPK (15-15-15) fertilizer per plant. That dosage is considered as high, and since the castor population was 4.444 plants Ha^{-1}, in 1 Ha was applied more than 1 ton of fertilizer. Considering the price of NPK fertilizer is IDR 115.000 per 50 kg, the cost of fertilizer only will be around IDR 2.500.000 per hectare, which is way too expensive. The purpose of this study is to test and to explore yielding ability of three Chinese castor hybrid varieties that treated with different rates of fertilizer. The results of this study are expected to be used as guidelines in choosing annual hybrid castor variety that has high daily productivity.

MATERIALS AND METHOD

An experiment was conducted during the rainy season of 2010/2011, from February to May, 2011 in Akar-akar, North Lombok, at elevation of around 12 m above sea level. Soil texture was sandy loam with 0.09% N, 815 ppm of P, 0.74 me/100 g of K and soil pH 6.5. Three Chinese castor hybrid varieties were grown and fertilized with NPK (15-15-15) at three different rates, 0 g, 125 g and 250 g per plant. Spacing was 1.5 m x 1.5 m and planting holes of 30 cm x 30 cm x 30 cm of length, width and depth were made for each plant. Each planting holes received 1 kg of chiken manure and 4 g of Furadan 3G that had been mixed with the soil. Sowing was done on February 14, 2011 and no other treatment was given to the growing plants. Each treatment plot had 300 plants and 10 plants from each treatment were selected as sample plants for measurements. Parameters measured were panicles number, panicles length, panicles weight, number of fruits, seeds dry weight and weight of 1000 seeds. All the collected data were analyzed using One-Way Analysis of Variance in Minitab.

RESULTS AND DISCUSSION

Total rainfall during the experimental period was 900 mm with 40 days of rain. This ammount of rain is considered as high because usually the total rain at the experimental site was about 700 mm. Since there was sufficient rain that created enough moisture in the soil until the end of the experimental period, all the plants in the fertilized treatments grew and yielded well. Those plants in the unfertilized plots, for all the three hybrid varieties, failed to grow and to yield. More than 90% of the plants died at about flowering stage and the rest, produced one panicle only with a very small number of fruits and the seeds inside the fruits were empty. This fact shows that hybrid varieties, especially castor hybrid varieties from China, need high input of fertilizer to grow and to yield.

Zhibo-8 was harvested the earliest at 85 days after sowing (DAS), followed by Zhibo-7 at 90 DAS and the last was Zhibo-5. All the three varieties expressed their genetics as annual varieties on dryland tropics as what they performed in their country of origin, Guandong, China, which is catagorized as sub-tropical region. These results can be used as a guideline in choosing castor hybrid varieties to be grown in drylands areas in Indonesia that have short period of rainy season.

All the varieties were affected significantly by fertilizer application rates. NPK fertilizer with higher rate (250 g $plant^{-1}$), gave better result in all three varieties for all parameters, followed by the lower rate (125 g $plant^{-1}$). In term of number of panicles per plant, Zhibo-8 produced the highest and the lowest was in Zhibo-5 (Table 1). Earlier, Jaya and Hadi (2010) reported that when these three varieties of castor were grown in a less rainfall condition, such as in Pringgabaya, East Lombok, Zhibo-7 produced the highest number of panicles (14 panicles), followed by Zhibo-8 (10 panicles) and the lowest was Zhibo-5 (9.4 panicles). In the experiment that was reported earlier, the plants were given the same NPK fertilizer but the dosage was 240 g $plant^{-1}$. This data shows that panicles number produced by both Zhibo-5 and Zhibo-8 are unstable and varied with environment conditions. Panicles number produced by Zhibo-7, on the other hand, were relatively constant in both locations showing that this variety is the most adapted on drylands Lombok conditions.

Table 1. Average number of panicles per plant, average length of panicles per plant and average weight o dry panicles per plant of the three hybrid varieties at two different levels of fertilizer rate

Treatments	Panicles number/plant (± SE)	Panicles length (cm)/plant (± SE)	Panicles weight (g) /plant (± SE)
Zhibo-5 + 125 g NPK	6.4 ± 1.96	42.0 ± 10.34	485.5 ± 286.7
Zhibo-5 + 250 g NPK	13.9 ± 3.78	45.5 ± 5.22	1601.4 ± 563.8
Zhibo-7 + 125 g NPK	9.6 ± 3.56	34.6 ± 5.56	811.8 ± 207.7
Zhibo-7 + 250 g NPK	15.0 ± 4.71	36.7 ± 8.14	1211.3 ± 391.4
Zhibo-8 + 125 g NPK	12.6 ± 5.82	38.3 ± 10.25	1161.6 ± 526.8
Zhibo-8 + 250 g NPK	16.3 ± 8.28	39.3 ± 6.21	1383,0 ± 673.0
P (5%)	0.000	0.048	0.000

The highest panicles number in Zhibo-8 was not followed by the highest in panicles length and panicles weight. The highest panicles length and panicles weight were produced by Zhibo-5 (Table 1). Looking at the panicles length data, the statistical analysis results show that there was a significant effect of fertilizer rate in all varieties. However, the average values of panicles length in both fertilizer rate in each of the variety treated, show not much different. This indicates that fertilizer has little effect on panicles length as compared to the effect of fertilizer on panicles number. Great effect of fertilizer was also shown in panicles weight data, especially in Zhibo-5 and Zhibo-7. Doubling fertilizer rate in Zhibo-5 resulted in more than triple of panicle weight, but not in other varieties. This data shows that among the three varieties, Zhibo-5 is the most responsive to fertilizer treatment.

Table 2. Average number of fruits per plant, average seeds dry weight per plant and weight of 1000 seeds of the three castor hybrid varieties treated with different rates of NPK fertilizer

Treatments	Fruits number/plant (± SE)	Seeds dry weight (g) /plant (± SE)	Weight of 1000 seeds (± SE)
Zhibo-5 + 125 g NPK	293.8 ± 98.00	205.2 ± 92.1	280.2 ± 18.07
Zhibo-5 + 250 g NPK	757.3 ± 170.60	543.6 ± 92.8	307.1 ± 5.35
Zhibo-7 + 125 g NPK	362.1 ± 82.9	266.7 ± 71.2	296.0 ± 14.06
Zhibo-7 + 250 g NPK	393.8 ± 105.3	315.0 ± 84.0	349.9 ± 29.63
Zhibo-8 + 125 g NPK	542.0 ± 199.0	358.3 ± 168.1	252.7 ± 30.68
Zhibo-8 + 250 g NPK	549.7 ± 264.4	360.1 ± 179.7	289.9 ± 11.58
P (5%)	0.000	0.000	0.000

The highest panicles weight in Zhibo-5, that was treated with 250 g plant^{-1} NPK fertilizer, resulted in the highest number of fruits per plant and the highest dry seeds weight per plant (Table 2). Fruits number data also show that NPK fertilizer rate has a great effect only in Zhibo-5, while in the other two varieties, fertilizer rate seems to have a very little influence. This data show that for Zhibo-7 and Zhibo-8, a fertilizer rate of 125 g plant^{-1} of NPK is the most economical in producing number of fruits, but not in Zhibo-5. Data in Table 2 also show that Zhibo-5 is the most responsive to fertilizer application, where doubling the dosage of NPK fertilizer resulted more than double in seeds dry weight. In Zhibo-7, doubling the rate of NPK fertilizer resulted only 18% increased in seeds dry weight while in Zhibo-8, no increase was recorded. With this kind of yield, Zhibo-5 will produce approximately 2.4 ton Ha^{-1} of dry seeds. Current price of 1 kg of castor dry seeds in Lombok is IDR 4.000, which means that from 1 Ha, a farmer can receive IDR 9.600.000 bruto.

In term of weight of 1000 seeds, that shows the quality of seeds, Zhibo-7 treated with 250 g NPK fertilizer per tree produced the best result, followed by Zhibo-5 and Zhibo-8. Zhibo-7 was also the most responsive to the additional fertilizer rate applied, where doubling the fertilizer rate resulted in 17% increased in 1000 seeds weight, while in Zhibo-8 and Zhibo-5 were only 14% and 9%, respectively. The 17% increase in 1000 seeds weight in Zhibo-7 as caused by doubling the fertilizer rate should have

resulted in a very high yield. Unfortunately, the number of fruits per tree in Zhibo-7 variety was the lowest among the three varieties tested. More works are needed by breeders to improve the number of fruits per tree in Zhibo-7 since this variety is the most stable in producing number of panicles in different dryland environments in the island of Lombok.

CONCLUSION

The three castor hybrid varieties relay heavily on inorganic fertilizer of NPK in order to be able to grow and to yield well on dryland Lombok. The effect of fertilizer rates on some parameters were varies amongst the three varieties. In general, Zhibo-5 was the most responsive to the additional application of NPK fertilizer, especially in panicles weight, fruits weight and dry seeds weight parameters. In contrast to the other parameters, panicle length in each variety with 125 g and 250 g NPK per tree treatments showed not much different, even though statistically the fertilizer rate showed a significant effect. Overall, application of 250 g plant^{-1} of NPK only needed by Zhibo-5 to improve its yield while the other two varieties, 125 g plant^{-1} of NPK is considered as an optimum dosage.

REFERENCES

Anjani, K., 2010. Extra-early maturing germplasm for utilization in castor improvement. *Industrial Crops and Products* 31: 139-144.

Baldwin, B. S. and R. D. Cossar, 2009. Castor yield in response to planting date at four locations in the south-central United States. *Industrial Crops and Products* 3: 226-236.

Barbosa, D., T. M. Serra, S. M. Meneghetti, M. R. Meneghetti, 2010. Biodiesel production by ethanolysis of mixed castor and soybean oils. *Fuels* 89: 3791-3794.

Berksen, J. T. P., F. P. Cuperus, P. Kolster, 1995. Paint and coating from renewable sources. *Industrial Crops and Products* 3: 225-236.

Barbens-Leenes, W., A. Y. Hoekstra and T. H. van der Meer, 2009. The water footprint of bioenergy. *PNAS Early Edition 1-5*. www.pnas.org/cgi/doi/10.1073/pnas.0812619106

Grigoriou, A. H., and G. E. Ntalos, 2001. The potential use of *Ricinus communis* L. (Castor) stalks as a lignocellulosic resource for particleboards. *Industrial Crops and Products* 13: 209-218.

Inga, I K. D., F. Hadi, 2010. Exploring yield potential of three hybrid varieties of castor (*Ricinus communis* L.) grown on dryland. Poster. International Seminar on Economics, Culture and Environment. University of Mataram. 11 – 12 November 2010.

Johnson, Jr., W., 2007. Final report on the safety assessment of *Ricinus communis* (castor) seed oil, hydrogenated castor oil, glyceryl ricinoleate, glyceryl ricinoleate SE, ricinoleic acid, potassium ricinoleate, sodium ricinoleate, zinc ricinoleate, cetyl ricinoleate, ethyl ricinoleate, glycol ricinoleate, isopropyl ricinoleate, methyl ricinoleate, and octyldodecyl ricinoleate. *International Journal of Toxicology* 26 (Suppl. 3): 31-77.

Kaltschmitt, R. and T. F. Ruddy, 2009. International trade of biofuels: an introduction to the special issue. *Journal of Cleaner Production* 17: 51-53.

Yusuf, A. and E. Thompson, 2009. The development of biofuels in Asia. *Applied Energy* 86: S11-S20.

ACKNOWLEDGEMENT

Thank-you to PT. BetterEarth Green Energy (BEGE) – NTB for funding this research.