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Original Research Article

A Study on the Impact of Spacing over the Growth of *Jatropha curcas* L. - A Biofuel Alternative

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A B S T R A C T

Considering the lack of scientific knowledge and the practical difficulties in cultivation of *Jatropha* as a biofuel alternative, a field work has been conducted for a period of three years since Jan 2009 at Krishna district of Andhra Pradesh, selecting various block and boundary plantations of *Jatropha* of 1 to 1½ years old, to evaluate the assumed sustainability of *Jatropha* cultivation under varied environmental conditions. The spacing in the block plantation was maintained as 3x3m, 2x2m, at various study sites and 3m and 2m, in boundary plantations where *Jatropha* it was grown in a single row as fence along the four boundaries of mango garden. High plant densities were maintained at the control site since the plants were grown with spacings of 1x1m and 1.5x1.5m, each in 0.5 acres, in order to compare the growth of the plant with other plantations. The physical growths as well as phenology were observed by recording quarterly observations. Results revealed that the block plantations could show considerably good percentages even at the minimal spacing (1x1m) when compared to the boundary spacing. In the block spacings the least flowering was recorded as 40% and highest (72%) at control site (1x1m and 1.5x1.5m) even though it was more dense. This was because of the supplementation of nutrients from outside and also the regular watering by drip which helped to absorb the required nutrients from the soil and thus to overcome the crowding effect. The above results revealed that spacing alone will not have much influence over the growth and the productivity of the plant. 2x2m spacing seems to be ideal in block plantations without supplementing the nutrients and with the addition of nutrients yield was high even at the minimum spacing. In boundary plantations 3m distance with regular watering is ideal to increase the yield.

Keywords

Jatropha, Andhra Pradesh, Spacing, crowding effect

Introduction

Increasing the fossil fuel prices and increasing Green House gas emissions are the main reasons to find new and renewable energy alternatives for the coming years (FAO, 2008). In addition fossil fuel consumption will have severe impacts on natural ecosystems in many ways such as environmentally, economically and socially. This is the reason to search for the alternatives which are renewable, environmentally friendly and economically feasible. Since bio fuels can be produced from a diverse set of crops like, sugar crops, starchy crops and oil crops each country is adopting a strategy that exploits the comparative advantages it holds in certain crops. For example, the sugar cane and maize are the main feed stock for ethanol in

Brazil and US respectively, while the Malaysia is from oil palm. The Government of India (GoI) has launched a National Mission on Biofuels, the main strategy of which has been to promote Jatropha curcas: a plant that bears non-edible oil seeds that can be used to produce biodiesel, mostly on waste lands. Apart from reducing the dependence on imported fuels, the mission aims to generate several other benefits like employment generation for the rural poor, regeneration of waste lands, reduction of emissions from energy use. Twelve districts from the state of Andhra Pradesh were proposed for Jatropha cultivation under the Demonstration phase of the National Mission on Biodiesel and the present study was carried out at Krishna District, which was one among the twelve proposed.

Jatropha curcas (Linnaeus), usually referred as "JATROPHA" is a deciduous monoecious tall bush or small tree up to 6 m height with soft wood (Ranjan, 2009). It belongs to the family Euphorbiaceae of the sub family Crotonoideae and there are more than 200 different names for its great significance to man and the various possibilities of its uses. There are approximately 170 known species of the plant (Dehgan, 1984) out of which only 17 are seen in India.

Non-palatability, suitability to various climatic and soil conditions, easy propagation, faster growth rate and perennial nature are the other preferable characteristics for the selection of the species J. curcas as a potential bio fuel crop (Takeda, 1982; Martin and Mayeux, 1984, 1985; Jones and Miller, 1991, Harika *et al.*, 2012). In India, it can be seen in almost all the states and is generally grown as a live fence for the agricultural fields. It can also be grown in waste lands or degraded lands to reclaim them. Many investigations are going on to know the impacts of fertilizers, spacing, water availability etc., over the growth of Jatropha. The objective of the present study was to record the growth consistency of *J. curcas L*. and the impact of supplementation nutrients over growth, flowering, fruiting and seed output and thus to find out the suitable conditions for its successful cultivation.

Materials and Methods

The present study has been started in Jan-2009 and carried out for a period of 3 years, in two selected Jatropha plantations of one year old from Krishna district of Andhra Pradesh viz., Rajavaram and Chandarlapadu. Krishna district was located between 16º 10 N and 81º 08 E. The average temperature of the region was 45ºC in summer and 21º C in winter and the average rainfall was 1028 mm/yr.

The whole Jatropha curcas plantations under study were categorized as Block plantations and Boundary plantations. Block plantations were raised in 1-20 acres at different study areas whereas, the boundary plantations were raised in a single row as fencing on border of the mango garden. Block plantations were maintained at (5 acres), Nandigama (50 acres) and Chandarlapadu (1 acre) stations while it was grown as boundary plantation at Morusumilli, Kuntamukkala, Pulluru and Nekkalam stations.

The spacing in the block plantation was maintained as 3x3m, 2x2m, at various study sites and 3m and 2m, in boundary plantations where Jatropha it was grown in a single row as fence along the four boundaries of mango garden. High plant densities were maintained at the control site since the plants were grown with spacing of 1x1m and 1.5x1.5m, each in 0.5 acres, in

order to compare the growth of the plant with other plantations.

The spacing between individual plants was maintained as 3x3m, 2x2m, 1x1m and 1.5x1.5m at the three Boundary stations. The spacing viz, 3x3m were maintained at Rajavaram in 5 acres and at Nandigama in 30 acres. Another plantation with a spacing of 2x2m was raised at Nandigama in 20 acres. Two types of spacing were maintained at Chandarlapadu viz., 1x1m and 1.5x1.5m in 0.5 acres each. Two different spacing were maintained in all the four boundary plantations as 3m at three field stations (viz., Kuntamukkala, Morusumilli and Pulluru) and 2m at the other station viz., Nekkalam. By a general practice of arboriculture, pruning was also undertaken in all block plantations. The physical growth parameters such as height (ft), girth (inches) and number of branches were measured once in three months in all the plantations. Phenological parameters such as flowering, fruiting and seed output were also recorded once in three months.

Results and Discussion

In the first year of plantation there was a difference in the height of the plant among these filed stations at different spacings. Difference of 1 ft height was observed before pruning at 1x1m and 1.5x1.5m spacings, followed by 3m distance boundary crop (Kuntamukkala). In the later stages there was a remarkable difference in the height in case of block and boundary plantations. The block plantations showed a height of above 14.5ft except Rajavaram plantation (9.5ft) whereas the maximum height reported at the boundary crops was 12.5ft.

In case of girth and number of branches per tree also similar results were obtained. the spacing of 3x3m, 2x2m, 1x1m and 1.5x1.5m (Block plantations) except Rajavaram reported a mean girth over 10.5 inches (Rajavaram 8.3 inches only). Boundary plantations could show a height mean girth of 9.6 inches (range of 8.5-9.6 inches). In case of number of branches also, the block plantation spacings were having an average of 30 branches except Rajavaram (20) whereas the boundary spacings have a range of 22-29.

In the four boundary plantations except Kuntamukkala station flowering was recorded below 45% (least -30% at Pulluru and highest 43.6% at Nekkalam). In the block spacings the flowering was recorded in between 40% and 72%, least at Rajavaram (40%) and highest (72%) at control site (1x1m and 1.5x1.5m). Similar trend was observed in case of fruiting and seed output percentages. The block plantations could show considerably good percentages even at the minimal spacing (1x1m) when compared to the boundary spacings. The highest percentages could be achieved at the control site even though it was more densed. This was because of the supplementation of nutrients from outside and also the regular watering by drip. These have helped to absorb the required nutrients from the soil and thus to overcome the spacing effect. Rajavaram, though it was a block plantation with 3x3m spacing could not show remarkable increase in the growth and phenology. The reason was irregularity in the availability of nutrients and water, since it was a rain fed plantation (Table-1).

Spacing between the plants has major impact on soil properties. Thus plant density is influencing the growth and seed output of the plant. Achten, (2010) reported that a narrow spacing will lead to fast canopy closure which results in higher water and light competition and lower fruit: biomass

ratio in the mature stadium. When planting *Jatropha* for live-fencing or hedges for soil conservation a dense biomass is needed and close spacing is appropriate. When the aim of the plantation is oil production, seedlings should be planted wide enough to ensure high seed yields in the mature stage, but close enough to avoid unacceptable loss of photosynthetic capacity in the juvenile stage. Thus, optimum spacing can only be recommended after at least 5 years consecutive growth and yield observations and this in different environmental conditions and using different provenances.

On rain fed waste lands, high density plantations at 2 ×1m or 1.5 ×1.5m accommodating 5000 or 4444 plants per hectare respectively, was desirable (Radich, 2004; Gubitz *et al.,* 1999). Planting distances of 2×2 M (2500 plant ha^{-1}), 2.5×2.5m (1600 plants ha^{-1}) or 3×3m (1111 plants ha^{-1}) are common practices. Adriaans *et al.,* (2006) suggested 3×3m spacing for better yield since more dense vegetation affects the seed yield. Planting distances of 2 × 2 m (2500 plants ha -1), 2.5 × 2.5 m (1600 plants ha -1) or 3 × 3 m (1111 plants ha -1) are common practice (Heller 1996).

It was noted that spacing of plants is a trade-off between biomass and fruit production. A narrow spacing will lead to fast canopy closure which results in higher water and light competition and lower fruit: biomass ratio in the mature stadium. The experimental results in the present study showed that difference in spacing had no significant effects on growth (e.g. girth of the plant, plant height, and number of branches per plant) of the physic nut (*Jatropha* curcas L.,) before pruning. But deviations could be observed after pruning in the physical growth as well as seed yield.

However, the physic nut tested at 1×1m, and 2 m x 2 m spacing tended give the highest mean values in all characteristics. The results showed that the physic nut plants tested at 1.5 m x 1.5 m spacing with the fertilization showed a better recovery in 1year after transplanting than the physic nut tested at wider spacings (2 m x 2 m and 3 m x 3 m). There was no specific variation found at different spacings. Variations were observed at the same spacing among different sites. It is evident that 2x2m is ideal for block plantation and with the fertilization the same growth was observed at 1x1m and 1.5x1.5m spacings.

Depending upon the number of branches per plant flowering, fruiting and seed yield were varied from one station to the other. In addition they were influenced by the nutrient and water supplementation. Among the boundary plantations more number of branches was identified at 3m spacing plantations when compared 2m. The height as well as girth was also more at 3m spacing. But phenological results did not show any such variation because similar results were obtained at both the spacings. Hence, spacing has no much influence in boundary plantations at 3m and 2m distances. It was also observed in low density plots (1×1m, 1.5×1.5m) that more percentage of yield was reported when compared to 2×2m, 3×3m plots. This was because of the addition the nutrients externally to overcome the competition for the nutrients. Similar results were found in another study on different spacings and fertilization by Ounchittikoun, (2005), Harika *et al.,* (2015) revealed that the physic nut plants fertilized with 187.5 kg/ha (30 kg/rai) of chemical fertilizer (15-15-15) at 1 m x 1 m spacing produced the highest seed yield (725.56 kg/ha or 116 kg/rai) in the first three years of plantation. These results were in conformity with those of Soudkeo (2005), Harika *et al.,* (2014) where in the preliminary study on *Jatropha* plantation that *Jatropha* cuttings tested at 1 m x 2 m

spacing with well management (e.g. irrigating channels, fertilization, and weed control) gave a satisfactory seed yield (1 kg seed/plant) in the first year of plantation. On contrary to the above all, Thachaleun *et al.*, (2006) reported that 12 external varieties together with 01 local species of physic nut treated with fertilization and chemical administration at 1 m x 1 m spacing showed lower seed yield. Another study revealed that both seedlings and cuttings tested at 1 m x 1 m spacing produced less than 625 kg/ha (100 kg/rai) of seed yield in the first year of plantation.

The present study confirms the same that *Jatropha* was successfully established in all the field stations but significant differences were found in the growth, flowering, fruiting and seed output which were influenced by various parameters like pH of the soil, watering schedule and the availability of the nutrients etc. Considering all the parameters, it was proved that spacing has limited influence on the plant growth and seed output. It is found that for *Jatropha* cultivation as a block plantation 1x1m spacing is ideal with fertilization and 2x2m without fertilization.

The above results revealed that spacing alone will not have much influence over the growth and the productivity of the plant. 2x2m spacing seems to be ideal in block plantations without supplementing the nutrients and with the addition of nutrients yield was high even at the minimum spacing. In boundary plantations 3m distance with regular watering is ideal to increase the yield.

Table.1 Comparative account of growth and seed output of Jatropha at different spacings

	Boundary Plantations				Block Plantations		
Spacing	3m	2m	3m	3m	3x3m	3x3m and 2x2m	1x1m and 1.5x1.5m
Nutrients applied	-	-	-	-	-	Gypsum	Gypsum, NPK and Super phosphate
Name of the plantation	Kuntamukkala	Nekkalam	Morusumilli	Pulluru	Rajavaram	Nandigama	Chandarlapadu
Mean Plant Height (ft)	11.1	10	12.5	11.9	9.5	15	14.5
Mean plant girth (Inches)	8.8	8.5	9.5	9.6	8.3	10.8	10.5
No. of Branches	22	23	29	25	20	30	30
Flowering (%)	60	43.6	30.5	30	40	69	72
Fruiting (%)	39	33.7	15.5	15	30	50.2	61.1
Seed Yield (%)	30	26	10.2	10	23.6	40	51.2

References

Achten, W.M.J., 2010. Sustainability evaluation of biodiesel from *Jatropha* curcas L., Katholieke Universiteit Leuven, Groep Wetenschap & Technologie, Arenberg Doctoraatsschool, W. de Croylaan 6, 3001 Heverlee, Belgie.

Adriaans, T., Jongh, J.D., Moers, P. and Rijssenbeek, W. 2006. 'Handbook on *Jatropha* Curcas'. Technical report, FACT Foundation.

Dehgan, B., 1984. Phylogenetic significance of interspecific hybridiza- tion in *Jatropha* (Euphorbiaceae). *Systematic Botany* 9, 467–478.

Food and Agriculture Organization of the United Nations, 2008. The state of food and agriculture -Biofuels: prospects, risks and opportunities FAO:http://www.fao.org /Waicent/Faoinfo/Agricult/AGP/AGPC/doc/Counprof/Madagascar/madagascareng.htm, accessed 15.04.2008.

Gubitz, G.M., Mittelbach, M. and Trabi, M. 1999. Exploitation of the tropical oil seed plant *Jatropha* curcas L. Bioresource Technology 67, 73-82.

Harika, D., A.V.V.S. Swamy, T.John Vijay, Potentiality of Jatropha curcas on large scale cultivation as a renewable biodiesel alternative, International Journal Of Environmental Sciences, 3(1), 2012, 393-397.

Harika, D., Swamy A.V.V.S, John Vijay T and Swetha D (2015). Impact of Availability of Nutrients over the Growth of Physic Nut, International Journal of Science, Technology & Management www.ijstm.com Volume No 04, Special Issue No. 01, ISSN (online): 2394-1537, P-1760-1764. IF-2.012

Harika, D., Swamy, A.V.V.S. and Subhashini, V. 2014. Studies on the impact of availability of water over the growth of Jatropha. *Life Sciences International Research Journal*, Pp. 443-447.

Heller, J., 1996. Physic nut - *Jatropha* curcas L. - Promoting the conservation and use of underutilized and neglected crops. PhD dissertation Institute of Plant Genetic and Crop Plant Research, Gatersleben, Germany & International Plant Genetic Resource Institute, Rome, Italy.

Jones, N., and Miller, J.H. 1991. *Jatropha* curcas : A multipurpose species for problematic sites. Land Resour. Ser., 1: 1-12.

Martin, G., and Mayeux, A. 1985. Curcas oil (*Jatropha* curcas. L.): a possible fuel. Agric. Trop., 9: 73-75.

Martin, G., and Mayeux, A. 1984. Reflections on oil crops as sources of energy: 2. Curcas oil (*Jatropha* curcas): A possible fuel. Oleagineux, 39(5): 283-287.

Ounchittikoun, Th., 2005. Physic nut – the energy crop for various utilizations. Bangkok: VASIRA CO., LTD.

Radich, A., 2004. "Biodiesel Performance Cost and Use, Energy Information Administration,http://www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html, (2008/ 02/12)

Ranjan, P., 2009. *Jatropha* Curcas and Its Potential Applications; A Compilation Paper on Plantation and Application of *Jatropha* Curcas,http://www.environmental expert.com/files/0/articles/73213/*Jatropha*.pdf

Soudkeo, N., 2005. Jatropha Plantation as a Large Plantation Field (Thai language). Journal of Natural Agriculture, 8, 36-41.

Takeda, Y., 1982. Development study on *Jatropha curcas* (sabu dum) oil as a substitute for diesel oil in Thailand. Interim Report of the Ministry of Agriculture. Thailand.

Thachaleun, Th., Sengthong, V, Sychai, O, Ounsisong, S, Phengon, D. and Satkeo, S. 2006. Studies on Growth and Yield of Physic nut (Thai language). Phrachomkoutraskrabang, 14(2), 17-21.