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GROWTH RESPONSE AND SIZE VARIABILITY AS INFLUENCED BY INTRASPECIFIC COMPETITION IN *JATROPHA CURCAS* (L.) SEEDLINGS

*Japhet, W.S., Khadijah, A. and Samaila, J.

Department of Biological Sciences, Ahmadu Bello University, Zaria, Kaduna State, Nigeria

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ABSTRACT

Growth response and size variability were assessed in *Jatropha curcas* seedlings grown at two levels of intra-specific competition. Intra-specific competition was achieved by growing seedlings at high density (inter-plant distance 5x5 cm) for high level and at low density (inter-plant distance 20x20 cm) for low level of intra-specific competition. The results revealed that plants sown at high level of intra-specific competition showed significant increase in stem height, stem biomass and leave biomass compared with plants sown at low level of competition. Plants sown at high level of intra-specific competition had higher coefficient of variation at the first time of measurement/harvest, but at subsequent measurement/harvest their coefficient of variation was lower than those sown at low level of intra-specific competition. These results suggest that in response to reduced light availability, *Jatropha curcas* seedlings could be able to overcome the problem of light availability by investing in traits that would enhance their ability to intercept more light. This information is useful for any management plans aimed at seedling establishment of this species in the field.

Key words: Growth, Competition, Plant height, Size variability, Seedling establishment.

***Corresponding author:** wisdomjaphet@yahoo.com

INTRODUCTION

Jatropha curcas L. is a small tree belonging to the Family Euphorbiaceae. Although it originated in Central America, it can now be found throughout the Tropics, especially, in Asia and Africa (Openshaw, 2000). The plant is getting increasing attention because of the many benefits that could be derived from it. *Jatropha* produces oil which is presently getting worldwide importance as a biodiesel and could be a cleaner alternative to fossil fuel (Cerrate *et al.,* 2006; Ndong *et al.* 2009). In addition to its biodiesel potentials, the plant has a variety of other uses. For instance the roots and leaves can be incorporated into formulations for treatment of skin diseases (Henning, 2002), and the seed which are rich in Nitrogen has been reported to be an excellent plant nutrient source if detoxified (Makkar *et al.,*

1998). Many other parts of the plant have been found to have anticancer properties (Duke, 1983).

In spite of the importance of this species, there are only limited published data on its life history. For instance information on how the plants will response to intra-specific competition (high density) will be useful in predicting seedling establishment of the plant in the field. Appreciable amount of literatures have indicated that for seed producing plants, optimum yield could be achieved when there is some level of intra-specific competition (Weiner, 2003; Vegas and Sadras, 2003; Maddoni and Otegui, 2006). Therefore, ever since, there has been a growing consensus among researchers for sowing crops at high density (Weiner, 2003). Benefits of high crop density include; increases in ground cover for maximum yield (Weiner, 2003), suppression of weeds (Forcella *et al.,* 1992) enhanced light interception due to early canopy closure (Ottam and Welch, 1989; Andrade *et al.,* 2002).

High density could, however, lead to shading among individuals in a population, and plants have been reported to respond differently to this phenomenon. While some plants have been reported to respond to high density by exhibiting a plastic increase in ecologically important traits such as height (Ballare and Scopel, 1991), other studies have reported a decrease in similar traits (Lentz, 1998). Determining how *Jatropha curcas* will respond to intra-specific competition at the seedling stage may improve our present level of knowledge on factors influencing the establishment of this plant in the field. Our objective in this study was, therefore, to determine the effect of intra-specific competition on *Jatropha curcas* seedlings by manipulating the inter-planting distance among seedlings of this species in a garden experiment.

MATERIALS AND METHOD

A garden experiment was conducted in the Botanical Garden of the Department of Biological Sciences, Ahmadu Bello University Zaria in the 2011 wet season. The experiment compared *Jatropha* seedlings sown with high intra-specific competition (High density) and low intra-specific competition (Low density). Seedlings were first raised in the nursery in a screen house and later transplanted four weeks after sowing. Seedlings were transplanted in seed beds measuring 3x3m. Seedlings were spaced 5× 5 cm for high density treatment and 20×20 cm for the low density treatment. The treatment was laid in a completely randomized design with three replications for each treatment. Plots were watered when necessary to prevent water stress. Weeds and pest were adequately Controlled.

Two weeks after transplanting, ten plants per replicate per treatment were tagged and their heights were measured every two weeks. Altogether, three height measurements were conducted. At the last measurement the following parameters were recorded: leave biomass, and stem

biomass. Leave biomass and stem biomass were obtained after oven drying the respective organ at 65 ^{o}C for 48 hrs.

Data obtained were subjected to one-way analysis of variance (ANOVA). Where analysis showed significant effect of treatment, differences in mean traits among treatment were assessed by the Bonferroni post hoc test. Coefficient of variation of height was performed to assess for size variability at all measurement times (Bendel *et al.,* 1989). Coefficient of variation was calculated as CV=100× Standard deviation of individual treatment means/grand mean of treatment means (Navas and Garnier, 2002). All analysis was conducted with the SPSS Statistical software version 17.0.

RESULTS

The effects of density on height, coefficient of variation, stem biomass and leaf biomass on *Jatropha curcas* seedlings are illustrated in figures 1-3. Plants sown at high density were taller than plants sown at low density at all measurement/harvest times (Figure 1). At the first time of measurement/harvest, the plants sown at high density had higher coefficient of variation for height compared with plants sown at low density (Figure 2). However, at subsequent times (second and third harvests), plants sown at high density had lower coefficient of variation compared with the plants sown at low density (Figure 2). Plants sown at high density had more stem biomass and leaf biomass compared with those sown at low density (Figure 3).

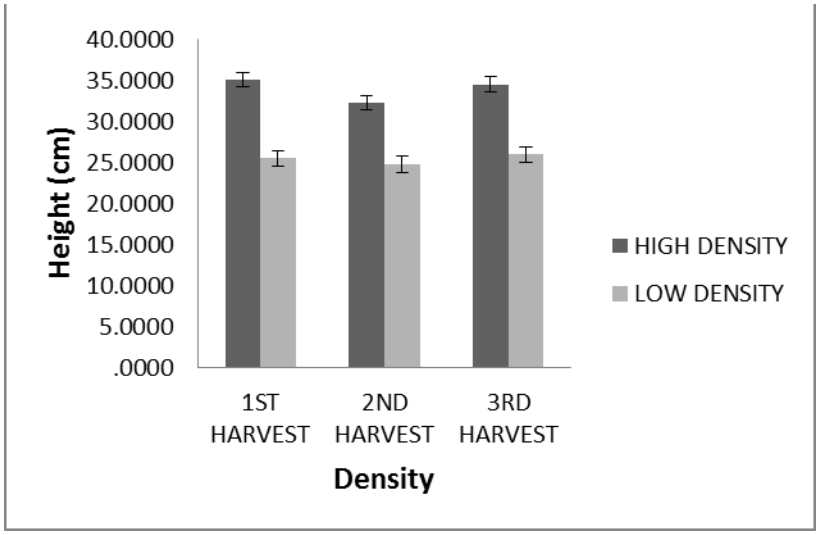

Figure 1: Height of *Jatropha curcas* seedlings in response to density at three harvest times. Bars are standard error bars.

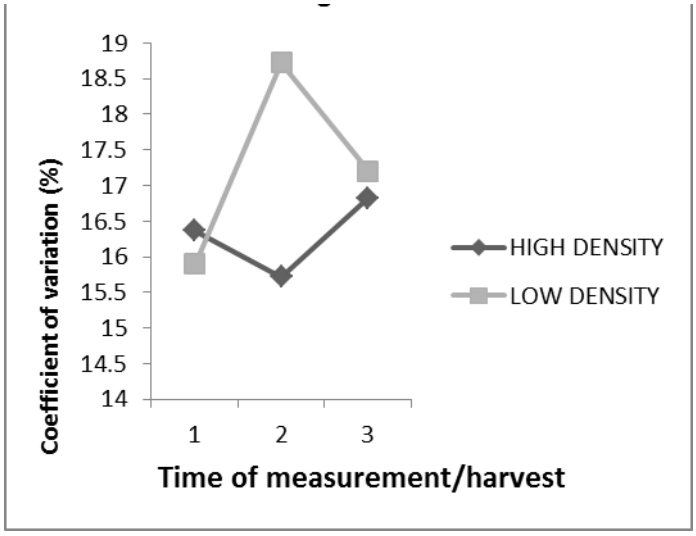

Figure 2: Coefficient of variation in *Jatropha curcas* seedlings in response to density at three harvest times.

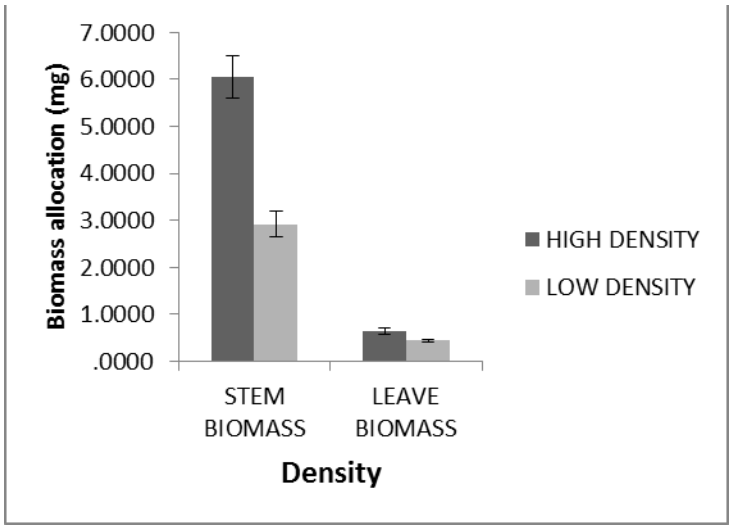

Figure 3: Biomass allocation pattern in response to density in *Jatropha curcas* seedlings at final developmental stage. Bars are standard error bars.

DISCUSSION

Plant height was significantly affected by density at all measurement times (Figure 1). At all measurement times, plants sown at high level of intra-specific competition (high density) were significantly taller than those

sown at low level of intra-specific competition (low density). For plants growing at high density, light will be limiting due to shading amongst individuals (Ballare *et al.,* 1997), and plant usually respond by showing plastic increase in height to place their leaves in a better position for light interception (Weiner and Fishman, 1994; Ballare *et al.,* 1997), a phenomenon that have been referred to as "foraging". This was precisely what was observed in this study (Figure 1). At all the three measurement times' plants sown at high density were significantly taller than plants sown at low density. Competition for light leads to size variability amongst individual due to the one- sided competition of light resource that's unilaterally supplied (Weiner, 1990; Schwining and Weiner, 1998). Size variability is defined as the occurrence of many small individuals and very few large individuals in a plant population (Weiner and Solbrig, 1984; Weiner, 1990). The few large individual dominates by acquiring a disproportionate larger share of the resource such as light which is unilaterally supplied (Weiner 1990; Schwining and Weiner, 1998). Appreciable amount of literature have reported that plastic increase in height in response to high density could reduce the incidence of size variability (Schwining and Weiner, 1998). Similar observation was made in this study. Plants sown at high density had higher coefficient of variability compared with plants sown at low density at the first measurement, but at subsequent measurements, the plants sown at higher density had lower coefficient of variation compared with the plants sown at low density. This suggests that the light foraging response exhibited throughout the course of growth and development by the plants sown at high density might have reduced the extent of size variability among individuals. Size variability is usually assessed using a measure of size inequality among members of a plant population, such as the coefficient of variation (Bendel *et al.,* 1989).

Most studies of plant behavior or strategies have based their conclusions on observations recorded at the final development stage (e.g. Wang *et al.,* 2006; Japhet *et al.,* 2009). This potentially underplays information on plant strategies that could be exhibited by the plant at earlier stages (Ryser and Eek, 2000). In this study, we performed three sequential height measurements to follow the fate of individuals so as to give us better information of a plant's ability to respond to changes in the environment and the kind of strategy involved.

Plants sown at high density had significantly more stem biomass and leave biomass compared with plants sown at low density (Figure 3). For plant growing at high density light will be limiting due to shading (Ballaré and Scopel 1997). Therefore an increase in leave biomass and stem biomass would ameliorate the negative effect of shading because of increase in whole plant photosynthesis (Ballaré and Scopel 1997).

In summary, this study has shown that seedling of *Jatropha curcas* will exhibit plasticity in growth in environment of variable resource availability, and this information would be useful for any project aimed at large multiplication of the seedlings of this species.

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REFERENCES

Andrade, F.H., Calvino, P., Cirilo, A. and Barbeiri, P. (2002). Yield response to narrow rows depends on increased radiation interception. *Agronomy Journal*, 94: 975-980

Ballaré, C.L. and Scopel, A.L. (1991). PhotoControl of stem elongation in plant neighborhoods: effects of photon fluence rate under natural conditions of radiation. *Plant Cell Environment,* 14:57-65

Ballaré, C.L. and Scopel A.L. (1997). Phytochrome signaling in plants canopies: testing its population-level implications with photoreceptor mutants of *Arabidopsis*. *Functional Ecology,* 11:441-450

Bendel, R. B., Higgins, S. Steberg, J. E. and Pyke, D. A. (1989). Comparison of skewness coefficient, coefficient of variation, and Gini coefficient as inequality measures within populations. *Oecologia,* 78:394–400.

Cerrate, S., Yan, F., Wang, Z., Coto, C., Sacakli, P. and Waldroup, P. W. (2006). Evaluation of Glycerin from Biodiesel Production as a Feed Ingredient for Broilers. *International Journal of Poultry Sci*ence, 5: 1001–1007.

Duke, J. A. (1983). *Jatropha curcas* L. Handbook of Energy Crops. Retrived 26th August 2011 fromhttp://www.hort.purdue.edu/newcrop /duke_energy/Jatropha_curcas.html.

Forcella, F., Westgate, M. E. and Warnes, D. D. (1992). Effect of row width on herbicide and cultivation requirements in row crops. *American Journal of Alternative Agriculture,* 7: 161-167

Henning, R. (2002). Using the Indigenous Knowledge of *Jatropha:* The Use of *Jatropha curcas* L. Oil as Raw Material and Fuel. *IK Notes* 47 (August): 1–4. Retrieved August 25th, 2011 from http://www.worldbank.org/afr/ik/iknt47.

Japhet, W., Zhou, D. and Ping, W. (2009). Variation in branch length in *Fagopyrum esculentum*: No evidence for true plasticity. *Botany*, 87:888-892.

Lentz, K.A. (1998). Effects of intraspecific competition and nutrient supply on the endangered Northeastern Bulrush, Scirpus ancistrochaetus Scuyler. *American Midland Naturalist,* 142:47-54.

Maddoni, G.A. and Otegui, M.E. (2006). Intraspecific competition in maize: Contribution of extreme plant hierarchy to grain yield, grain yield components and kernel composition. *Field Crop Research*, 97:155-156.

Makkar, H. P. S., Becker, K. and B. Schmook. (1998). Edible Provenances of *Jatropha curcas* L from Quintana Roo State of Mexico and Effect of Roasting on Antinutrient and Toxic Factors in Seeds. *Plant Foods Human Nutrition,* 52: 31–36.

Navas, M.L. and Garnier, E. (2002). Plasticity of whole plant and leaf traits in *Rubia peregrine* in response to light, nutrient and water availability. *Acta Oecologia,* 23:375-383.

Ndong, R., Montrejaud-Vignolesk, M., Saint Girons, O., Gabrielle, B., Pirot, R., Domergue, M. and Sablayrolles, C. (2009). Life Cycle Assessment of Biofuels from *Jatrophacurcas* in West Africa: A Field Study. *GCB Bioenergy,* 1 (3): 197–210.

Openshaw, K. (2000). A Review of *Jatropha curcas* L: An Oil Plant of Unfulfilled Promise. *Biomass Bioenergy,* 19: 1–15.

Ottman, M. J. and Welch, L F. (1989). Planting patterns and radiation interception, plant nutrient concentration, and yield in corn. *Agronomy Journal*, 81:167-174.

Ryser, P.and Eek, L. (2000). Consequences of phenotypic plasticity vs. interspecific differences in leaf and root traits for acquisition of above ground and below ground resources. *American Journal of Botany*, 87:402-411.

Schwinning, S. and Weiner, J. (1998). Mechanisms determining the degree of size asymmetry in competition among plants. *Oecologia*, 113:447-455.

Vega, C.R.C. and Sadras, V.O. (2003). Size dependent growth and development of inequality in Maize, Sunflower and Soybean. *Annals of Botany*, 91:795-805.

Wang, T., Zhou, D., Wang, P. and Zhang, H. (2006). Size-dependent reproductive effort in *Amaranthus retroflexus:* the influence of planting density and sowing date. *Canadian Journal of Botany*, 84: 485-492

Weiner, J. and Solbrig, O. T. (1984). The meaning and measurement of size hierarchies in Plant populations. *Oecologia*, 61:334–336.

Weiner, J. and Fishman, L. (1994). Competition and allometry in*Kochia scoporia*. *Annals of Botany*, 73: 263-271

Weiner J. (1990). Assymetric competition in plant populations. *Tree*, 5(11): 360-364

Weiner, J. (2003). Ecology the science of agriculture in the 21st century. *Journal of Agricultural Science*, 141: 371-377.