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Pruning Techniques for *Jatropha curcas* L. to Increase Seed Yield Production

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Abstract

In this study, the effects of different pruning heights and number of branches left were evaluated to determine the most effective pruning height and optimum number of branches to be left after branch thinning to increase seed yield production of *Jatropha curcas*. The experiment, which was conducted at the MMSU Experimental Station from 2009-2011, was laid-out in Split plot design and was replicated three times. The treatments were as follows: Factor A – (Pruning height) A_1 – No pruning; A_2 – 50 cm; A_3 – 60 cm; and A_4 – 70 cm and Factor B (number of branches left) B_1 – 8 branches; B_2 – 10 branches; and B_3 – 12 branches.

The main effects of pruning height were significant in all the parameters tested. *J. curcas* with 0.70cm pruning height consistently produced the most number of branchlets (42.44), inflorescence plant^{-1} (78.33), fruit cluster^{-1} (7.11), as well as total fruits plant^{-1} (533.44), seed yield plant^{-1} (0.86kg), and seed yield ha^{-1} 2161.47kg). This was comparable in plants with 0.60cm pruning height on the number of branchlets, number of inflorescence plant^{-1}, total number of fruits plant^{-1}, seed yield plant^{-1}, and seed yield ha^{-1}. The shortest period (8 days) to initiate flower buds was observed from the unpruned plants, however, they had the least results in all the other parameters.

Likewise, significant main effect of the number of branches left after branch thinning was noted in all the parameters except on the number of days prior to flower bud initiation. *J. curcas* with 12 branches consistently exhibited the most number of branchlets (42.33), number of inflorescence plant^{-1} (74.92), fruit cluster^{-1} (6.01), total fruits plant^{-1} (467.92), seed yield plant^{-1} (0.71kg), and seed yield ha^{-1} (1782kg). Similar trends, however, were noted in plants with 10 branches in terms of the number of branchlets, number of inflorescence, and seed yield ha^{-1}. No interaction effect of pruning height and number of branches left was observed in all the other parameters tested.

Keywords: *branchlets, branch thinning, fruit cluster^{-1}, inflorescence, top-pruning*

Introduction

The Philippines is experiencing an energy crisis due to the unstable and high cost of petroleum products. To address this problem, government agencies have been urged to look into potential alternative energy sources such as plants. Many green plants are rich sources of energy, which are worth more than petroleum. Many of these are forest and fruit trees, which can be found growing abundantly in the natural forests and plantations (Diaz, 1997).

One of the potential sources of biodiesel is *J. curcas*, commonly known as

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Tubang bakod. It is a non-food source with its seeds yielding up to 30-38% crude oil that can be processed into biodiesel (Mendoza *et al*, 2007). It was also found that the glycerin, which is one of the by-products during biodiesel oil extraction can be used in soap making. According to the old folks, the various parts such as bark and leaves have been traditionally used in curing sprain, muscle pains, and fractures. Large-scale plantations of *J. curcas* could help sequester carbon dioxide through a process known as carbon farming (Becker *et al*, 2013). *J. curcas* can be grown in any type of soil even in low fertility, marginal areas, on field borders, along fences or canals. However, like other crops, it requires optimum management practices to produce a more favorable environment for growth, fruit, and seed production.

One of the most important cultural practices that may affect growth and seed and oil yield of *J. curcas* is top-cutting or pruning. However, pruning of branches requires skill or technique to achieve success. According to reviewed literature, pruning of live branches decreases the photosynthetic activity of the plant. The removal of vegetative growth reduces both stored and manufactured carbohydrates in the leaves, which could accumulate higher level of nitrogen that stimulates vegetative growth at the expense of reproductive growth (Cutler, 2000). Improper pruning could also restrict the flow of essential nutrients needed for growth, leading to defoliation and eventually death.

On the other hand, the number of branches left after branch thinning is also equally important in influencing the growth and form of plants. The bushy characteristics of *J. curcas* tend to have a shading effect, thus, only few branches develop inflorescence (Samsam, 2010). According to Kramer and Kozlowski (1978), carbohydrate supply is an important factor that could affect flower bud initiation. Thus, reducing the number of branches could increase light intensity and enhance the manufacture of carbohydrate.

Therefore, in order to balance vegetative and reproductive growth, appropriate pruning technique for *J. curcas* must be explored.

Generally, the study determined the effects of pruning and the number of branches left after branch thinning on the seed yield production of *J. curcas*. Specifically, it evaluated the effects of different pruning heights and number of branches left and their interaction effects on the branching, flowering, and fruiting characteristics and seed yield of *J. curcas*; and it determined the ideal pruning height and optimum number of branches to be left for increased seed yield production *of J. curcas*.

Methodology

The study was conducted at the MMSU Experimental Station from May 2009 up to December 2011. Two-year old *J. curcas* planted using a 2m x 2m space was used in

the study. The area is flat and a representative of a marginal area in Ilocos Norte. It was laid-out in a split plot design with three replications. The treatments include the following: Factor A - (Pruning height): A_1 - No pruning; A_2 - 50cm; A_3 - 60cm; and A_4 - 70cm and Factor B (number of branches left): B_1 - 8 branches; B_2 - 10 branches; and B_3 - 12 branches. Each experimental unit consisted of 16 sample plants with a total of 576 sample plants for the whole experiment.

Pruning of the *J. cucas* was conducted twice a year, before the onset of rainy days (June) and before the dry months (December). Slanting cut was done to the branches to avoid the retention of water that causes rotting on the cut portion. The height of pruning was measured from the ground level up to the point indicated in the treatments.

Moreover, branch thinning was done simultaneously with pruning. Inferior and crossing or rubbing and close branches were removed and only the wide branch angles (45, 60 and 90^o) were retained to readily allow the penetration of sunlight in between the remaining branches and to form a desired shape. The number of branches left was based on the treatments used in the study

Care and maintenance. Complete fertilizer (14-14-14) at a rate of 100g plant^{-1} was applied after top-pruning. Watering and weeding were done as the need arose. The cut weeds were placed as mulch to the experimental plants. The water sprouts of the test plants were removed to avoid competition in water, nutrient, and light of the remaining branches. Water sprouts are vigorous shoots arising from the trunk or bigger branches.

Data gathering procedure. The effects of the treatments were assessed based on the number of branchlets or secondary branches, number of days to flower bud initiation, number of inflorescence plant^{-1}, number of fruits cluster^{-1}, number of fruits produced plant^{-1}, seed yield plant^{-1} and seed yield ha^{-1}. The number of branchlets was counted one month after pruning (MAP). Data gathering of the other parameters related to flowering and fruiting characteristics was done weekly.

Data analysis. The data gathered were analyzed using analysis of variance (ANOVA) for split-plot design. Treatment means of parameters that showed significant results were compared using the Duncans's Multiple Range Test (DMRT) at 5% level of significance.

Results and Discussion

Branching characteristic

Number of branchlets produced. The effects of pruning height and the number of branches left on the branching characteristic of *J. curcas* are shown in Table 1.

Specifically, the average number of branchlets was significantly affected by the pruning height and the number of branches left after pruning *J. curcas*. Significant increase in the number of branchlets (42.44) was noted from *J. curcas* with 70 cm height. The result however, did not differ significantly from plants with 60 and 50cm pruning height with 41.00 and 37.78 branchlets, respectively. The number of branchlets produced by the unpruned plants had the least with 30.89 branchlets. The result implies that cutting or pruning branches of *J. curcas* facilitates the development of more branchlets or secondary branches regardless of the pruning height (50, 60 and 70cm) used. Likewise, pruning of the main stem branch stimulates growth of lateral buds (branching) below the cut. The removal of the apical tip and its suppressive hormone allows the dormant lateral bud to develop and produce new shoots (Wikepedia, retrieved 5/10/2011).

On the other hand, *J. curcas* with 12 branches significantly developed the highest number of branchlets (42.33) but did not differ from plants with 10 branches (38.33). Plants with eight branches significantly produced the least with 33.42 branchlets. The result implies that 10-12 branches plant^{-1} is ideal to encourage the development of more branchlets.

However, no significant interaction effect of pruning height and number of branches left was observed on the number of branchlets produced by *J. curcas*.

Table 1. Effect of pruning height and number of branches left after branch thinning on the number of branchlets developed by the *J. curcas* (average of 2 years).

TREATMENT	NUMBER OF BRANCHLETS PRODUCED PLANT^{-1}
Pruning Height	**
No pruning	30.89 [b]
50 cm	37.78 [a]
60 cm	41.00 [a]
70 cm	42.44 [a]
CV (A) (%)	11.30
Number of Branches Left	**
8 branches	33.42 [b]
10 branches	38.33 [a]
12 branches	42.33 [a]
CV (B) (%)	4.20
A x B	ns

** - significant at 1% level of significance CV- coefficient of variation
ns - not significant
Means marked by a common letter within a factor are not significantly different at 5% level using DMRT.

Flowering characteristics

Number of days to flower bud initiation. Significant main effect of pruning height was observed on the number of days to flower bud initiation of *J. curcas* (Table 2). The unpruned *J. curcas* significantly produced flower bud earlier (8 days) compared to the plants with 50, 60 and 70cm pruning height that took 39.11, 38.89, and 38.56 DAP, respectively.

The result implies that the early initiation of flower bud of the unpruned *J. curcas* was due to the presence of stored carbohydrates that stimulate the earlier initiation of flower buds. This was substantiated by the statement of Kramer and Kozlowski (1978), that pruning of live branches decreases the amount of photosynthetic surface and the carbohydrate which they produce during photosynthesis is utilized via respiration during vegetative growth. They further stressed that flower bud initiation only starts when the concentration of carbohydrate is relatively high including some environmental factors, which are known to affect initiation of buds.

On the contrary, no significant effect on the number of branches left was noted on the number of days to bud initiation. Numerically, however, the days to flower initiation took 30.75 to 31.50 DAP. Moreover, no interaction effect of pruning height and number of branches left was noted on the number of days to flower bud initiation of *J. curcas*.

Table 2. Effects of different pruning height and number of branches left after branch thinning on the flowering characteristics of *J. curcas* (average of 2 years).

TREATMENT	FLOWERING CHARACTERISTIC	
	Number of Days to Flower Bud Initiation (DAP)	Number of Inflorescence Plant^{-1}
Pruning Height	**	**
No pruning	8.00 $_{b}$	54.67 ^{b}
50 cm	39.11 $_{a}$	70.22 ^{a}
60 cm	38.89 $_{a}$	73.33 ^{a}
70 cm	38.56 $_{a}$	78.33 ^{a}
CV (A) (%)	15.10	11.80
Number of Branches Left	ns	**
8 branches	31.50	62.17 ^{b}
10 branches	30.75	70.33 ^{a}
12 branches	31.17	74.92 ^{a}
CV (B) (%)	9.80	8.80
A x B	ns	ns

** - significant at 1% level of significance
ns - not significant
DAP - days after pruning
CV - coefficient of variation

In a column, means marked by a common letter within a factor are not significantly different at 5% level using DMRT.

Number of inflorescence plant^{-1}. The main effect of pruning height in the number of inflorescence plant^{-1} was significant at 1% level of significance (Table 2). The highest count of inflorescence plant^{-1} was noted from *J. curcas* with 70cm pruning height (78.33), however, this was comparable with plants having 60 and 50cm pruning height with 73.33 and 70.22 inflorescence, respectively. The unpruned *J. curcas* plants had the lowest count of inflorescence plant^{-1} of 54.67. The development of new branchlets might have increased the photosynthetic surface and carbohydrates that stimulated the production of more inflorescence.

On the other hand, the number of inflorescence plant^{-1} was also significantly affected by the number of branches left. *J. curcas* with 10-12 branches encouraged the development of more inflorescence with comparative results of 70.33 and 74.92, respectively, higher than those plants with eight branches of 62.17 inflorescence plant^{-1}. Furthermore, flower initiation to fruit set development took 24-30 days. This result implies that leaving 10-12 branches is ideal for producing more inflorescence.

Nevertheless, there was no interaction effect of pruning height and number of branches left on the number of inflorescence plant^{-1} of *J.curcas*.

Fruiting Characteristics

Fruit cluster^{-1}. Table 3 shows that the fruiting characteristics of *J. curcas* were significantly affected by pruning height and number of branches left at 1% level of significance. *J. curcas* with 70cm pruning height consistently produced the highest number of fruits cluster^{-1} (7.11). This was followed by plants with 60 and 50cm pruning height with 6.11 and 5.56, respectively. The least number of fruits cluster^{-1} was noted from the unpruned plants (3.22).

Likewise, the number of fruits cluster^{-1} was significantly affected by the number of branches left at 1% level of significance (Table 3). The highest number of fruits cluster^{-1} (6.01) was produced from *J. curcas* with 12 branches. This was followed by plants with ten branches (5.49) while the least was noted from plants with eight branches (4.99). No interaction effect of pruning height and number of branches left was also noted on the fruits cluster^{-1} of *J. curcas*.

Total number of fruits produced plant^{-1}. The total number of fruits produced plant^{-1} of *J, curcas* was likewise significantly affected by pruning height and number of branches left at 1% level of significance. The highest number of fruits plant^{-1} was produced from *J. curcas* with 70cm pruning height (553.44), however, this is comparable with plants having 60cm pruning height (467.00). The lowest number of fruits (178.33) was produced from the unpruned *J. curcas*.

Similarly, significant effect of the number of branches left was noted on the total number of fruits produced plant^{-1} of *J. curcas*. The highest number of fruits plant^{-1} was produced by plants with 12 branches. This was followed by *J. curcas* with ten branches (402.58) while the least was noted in plants with eight branches (331.50).

Table 3. Effects of pruning height and number of branches left after branch thinning on the fruiting characteristics of *J. curcas* (average of 2 years).

TREATMENT	FRUITING CHARACTERISTIC	
	Fruit Cluster^{-1}	Total Number of Fruits Produced Plant^{-1}
Pruning Height	**	**
No pruning	3.22 ^{c}	178.33 ^{c}
50 cm	5.56 ^{b}	403.89 ^{b}
60 cm	6.11 ^{b}	467.00 ^{ab}
70 cm	7.11 ^{a}	553.44 ^{a}
CV (A) (%)	14.90	25.60
Number of Branches Left	**	**
8 branches	4.99 ^{c}	331.50 ^{c}
10 branches	5.49 ^{b}	402.58 ^{b}
12 branches	6.01 ^{a}	467.92 ^{a}
CV (B) (%)	8.00	14.80
A x B	ns	ns

** - highly significant at 1% level of significance CV – coefficient of variation
ns – not significant
In a column, means marked by a common letter within a factor are not significantly different at 5% level using DMRT.

This could be supported by the initial results obtained in the number of branchlets and inflorescence produced and fruits cluster^{-1} wherein *J. curcas* plants with 0.70cm pruning height and with 12 branches obtained the highest. The result implies that following an ideal pruning height and leaving an optimum number of branches enhance the development of vigorous branchlets and promote the development of more inflorescence and fruits. However, improper or severe pruning could retard growth and reduce the number of fruits formed due to the reduced photosynthetic surface (Kramer and Kozlowski, 1978).

Meanwhile, the combined effect of pruning height and number of branches left on the fruiting characteristics of Jatropha was not significant.

Seed Yield

Seed yield plant^{-1} and seed yield ha^{-1}. The seed yield of *J. curcas* was also significantly affected by the pruning height and the number of branches left after branch thinning (Table 4). The effects of the treatments on the seed yield plant^{-1} and seed yield ha^{-1} followed the same trend. *J. curcas* with 0.70cm pruning height consistently exhibited the highest seed yield plant^{-1} (0.86kg) and seed yield ha^{-1} (2161.47kg). The result, however, is comparable to plants with 60cm pruning height (0.70 and 1745.93kg, respectively). This was followed by plants pruned at 50cm height while the lowest were noted from the unpruned plants.

Table 4. Effect of pruning height and number of branches left after branch thinning on the seed yield (kg) of *J. curcas* (average of 2 years).

TREATMENT	SEED YIELD PLANT^{-1} (kg)	SEED YIELD HA^{-1} (kg)
Pruning Height	**	**
No pruning	0.27 ^{c}	679.03 ^{c}
50cm	0.61 ^{b}	1531.72 ^{b}
60cm	0.70 ^{ab}	1745.93 ^{ab}
70cm	0.86 ^{a}	2161.47 ^{a}
CV (A) (%)	25.70	25.70
Branch Thinning	**	**
Branches reduced to 8	0.52 ^{c}	1296.25 ^{b}
Branches reduced to 10	0.60 ^{b}	1507.71 ^{ab}
Branches reduced to 12	0.71 ^{a}	1782.66 ^{a}
CV (B) (%)	14.40	14.40
A x B	ns	ns

** - significant at 1% level ns- not significant

In a column, means marked by a common letter within a factor are not significantly different at 5% level using DMRT.

On the other hand, seed yield plant^{-1} and seed yield ha^{-1} were also increased when the number of branches left after thinning was 12 branches, which produced 0.71kg and 1782.66kg, respectively. However, this was comparable to *J. curcas* with 10 branches in terms of seed yield ha^{-1} with 1507.71kg. *J. curcas* with eight branches had the lowest seed yield plant^{-1} (0.52kg) and seed yield ha^{-1} (1296.25kg). The higher yield obtained from plants pruned 0.70cm height with 12 branches was substantiated by more branches, which eventually developed more inflorescence and fruits.

On the other hand, there was no significant interaction effect of pruning height and number of branches left on the seed yield plant^{-1} and seed yield ha^{-1} of *J. curcas*.

Conclusions and Recommendations

The pruning height and number of branches left after branch thinning of *J. curcas* significantly affected all the parameters tested except on the number of days to flower bud initiation wherein the main effect of branch thinning was not significant. Branches that were pruned 0.70 m above the ground consistently exhibited the highest number of branchlets (42.44), number of inflorescence (78.33), fruits cluster^{-1} (7.11), total number of fruits (533.44), seed yield plant^{-1} (0.86kg), and seed yield ha^{-1} (2161.47kg). Nonetheless, the result was comparable with plants having branches pruned 0.60 cm above the ground on the number of branchlets (41.00), number of inflorescence plant^{-1} (70.22), total number of fruits plant^{-1} (467.00), seed yield plant^{-1} (0.70kg), and seed yield ha^{-1} (1745.93kg). Although the unpruned plants had the

shortest period to flower bud initiation (8.00 days) after pruning, they obtained the least in all the other parameters tested.

On the other hand, plants with 12 branches consistently exhibited superior growth because it developed the highest number of branchlets (42.33), number of inflorescence plant^{-1} (74.92), fruit cluster^{-1} (6.01), total fruits plant^{-1} (467.92), seed yield plant^{-1} (0.71kg), and seed yield ha^{-1} (1782kg). The result, however, is comparable with plants having 10 branches on the number of branchlets (38.33), number of inflorescence (70.33), and seed yield ha^{-1} (1507.71kg).

One of the important cultural techniques to increase the production of *J. curcas* seed for biodiesel production is to control the growth by means of pruning. This is important to create a favorable condition that balances vegetative and reproductive growth. Increasing the vegetative parts by pruning would increase the photosynthetic surface for the production of carbohydrates essential in flower formation and fruit development. Although pruning requires labor, the expenses incurred can be compensated by the higher quantity of seeds derived. Harvesting of *J. curcas* fruits can also be facilitated by pruning. The technology is simple and can be easily understood and adopted by stakeholders and entrepreneurs. Thus, the application of appropriate techniques in pruning and provision of adequate nutrition, water, and sunlight could ensure the continuous supply of *J. curcas* seed for biodiesel production. Greater production of biodiesel would mean greater utilization and value adding of local resources, lesser dependence on imported fuels, and better economy.

It was found that pruning height and number of branches left after branch thinning are important components of *J. curcas* production system. Pruning height of 70cm above the ground with 12 branches left after branch thinning must be included as a standard operation procedure for *J. curcas* plantation particularly in the second year to promote the development of more branchlets, inflorescence, and fruits as well as ensure continuous seed supply for biodiesel production.

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