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SHORT NOTE

REGRESSION EQUATIONS FOR PLANT HEIGHT ESTIMATION IN CASHEW TREES[1]

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ABSTRACT

Measuring plant height in trees is not an easy task; however, their canopy diameter can be evaluated more easily. Thus, estimating plant height based on the tree canopy diameter is an appealing idea. This work aimed to obtain regression equations to estimate plant height, based on the mean canopy diameter of an early-dwarf cashew tree clone (CP 076) and a clonal population, irrigated and propagated by layering (rooting). The population consisted of clones from five different matrices. Plant height and diameter were measured quarterly from March/1990 through June/1996. The distance from ground level to the highest point of the canopy was considered as plant height. The mean value of diameters measured in the North-South and East-West directions were considered as the canopy diameter. The equations to estimate plant height (h), based on the canopy diameter (d) of clone CP 076 and of the Clonal Population were $h = 0.5167\ d$ and $h = 65.3277 + 0.3756\ d$, respectively.

Key words: *Anacardium occidentale*, clone, early-dwarf cashew tree.

RESUMO

EQUAÇÕES DE REGRESSÃO PARA ESTIMAÇÃO DA ALTURA DO CAJUEIRO

Nas árvores pode não ser muito fácil medir a altura da planta, mas o diâmetro da copa pode ser avaliado com mais facilidade. Assim, é desejável a estimação da altura da planta a partir do diâmetro da copa. O trabalho teve como objetivo obter equações de

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regressão para estimar a altura da planta, a partir do diâmetro médio da copa, de um clone (CP 076) e de uma população clonal de cajueiro anão precoce, irrigados e propagados por alporquia. A população foi constituída por clones de cinco matrizes diferentes. Utilizou-se o delineamento de blocos ao acaso com três repetições. A altura da planta e o diâmetro da copa foram medidos trimestralmente, de março/1990 a junho/1996. Como altura da planta, considerou-se a distância do nível do solo ao ponto mais alto da copa. Como diâmetro da copa considerou-se a média dos diâmetros medidos nas direções norte-sul e leste-oeste. As equações para estimação da altura da planta (a), a partir do diâmetro (d) da copa do clone CP 076 e da População Clonal são $a = 0{,}5167\ d$ e $a = 65{,}3277 + 0{,}3756\ d$, respectivamente.

Palavras-chave: *Anacardium occidentale*, clone, cajueiro anão precoce.

Evaluating plant height is an interesting methodology because it is associated with vigor, phytomass yield (*2*), and other traits such as lodging, in the case of annual crops. In the case of trees, it is also interesting to measure their canopy diameter, which will give an indication of the spacing that should be adopted for different crops. In trees, measuring plant height is not an easy task; however, their canopy diameter can be evaluated more easily. Thus, estimating plant height based on the tree's canopy diameter is an appealing idea (*1*).

The objective of this work was to obtain regression equations to estimate plant height, based on the mean canopy diameter of an early-dwarf cashew tree clone and a clonal population, propagated by layering (rooting) under drip irrigation conditions.

Material and methods. The trial was performed in an area at Universidade Federal do Ceará (UFC), located in the municipality of Caucaia, Ceará, at 3°41' S latitude and 35°43' W longitude. This region has two well defined seasons: a rainy season, which occurs from January to July, with maximum rainfall in March and April, and a dry season, from August to December, with sporadic rainfall. According to Universidade Federal do Ceará (*3*), the mean precipitation is 1642 mm. The mean air temperature, based on data collected during 30 years, ranges from 23.5°C to 30.2°C, with a compensated mean of 26.7°C. The mean annual relative humidity is 79%. The predominant climate in the region, according to Köppen's classification, falls into the AW' class (tropical rainy), or, according to Gaussen's classification, it is a 4eTH (tropical hot with an attenuated drought). During the experimental period, the mean temperature and relative humidity ranged from 26.3 to 27.2 °C and from 69 to 82%, respectively. The annual radiation ranged from 124,335 to 159,471 cal/cm^2, while the annual precipitation ranged from 1183 to 3045 mm. The soil was classified as a sandy Abruptic Red-Yellow Argisol with a weak plinthic

A horizon. The soil analysis indicated pH + 5.1, 1.0 ppm P, 0.49% C, 0.04% N and, expressed as meq/100g: 0.40 Ca^{++}, 0.40 Mg^{++}, 0.22 K^{+}, 0.06 Na^{+}, 0.80 H^{+} and 0.10 Al^{+++}.

During the dry season, the plants were watered by drip irrigation, with one dripper/plant (flow of 36 liters of water/hour). Irrigation was conducted by adopting the following watering shifts: 15 min/plant/day during the 1st year, 30 min/plant/day during the 2nd year, 45 min/plant/day during the 3rd year and 60 min/plant/day during all subsequent years. An analysis of the water utilized for irrigation indicated: EC 25 °C = 0.9 mmhos/cm; pH = 6.8, Ca^{++} = 1.7 meq/l; Mg^{++} = 3.5 meq/l; K^{+} = 0.3 meq/l; Na^{+} = 3.4 meq/l; Cl = 7.8 meq/l; CO^{2-} = 0.0 meq/l; HCO^{3-} = 1.2 meq/l; SO_4^{2-} = 0.0 meq/l; sodium adsorption ratio = 2.1 meq/l. All other management practices consisted of two hoeings and one mowing performed each year.

Two populations, obtained by layering, were planted in January 1990, in a randomized complete-block design with three replications. One of the populations was from the CP 076 clone, developed by Empresa de Pesquisa Agropecuária do Ceará (EPACE); the other was obtained by Universidade Federal do Ceará, consisting of clones from five different matrices, selected based on their fruit yield and quality. For simplification, the first population will be hereafter referred to as the CP 076 clone and the second as the Clonal Population. Each plot originally consisted of four plants grown at 6 m x 3 m spacing. This planting density was maintained until the third year (1990 to 1992). In 1992, plants had grown to an extent that caused mutual shading, making it necessary to eliminate one plant in each row, alternately. Thus, starting in the fourth year, the plants were grown at 6 m x 6 m spacing. The same design was still adopted, but with five replications.

Plant height and diameter were measured quarterly during the experimental period. The distance from ground level to the highest point of the crown was considered as plant height. The mean value of diameters measured in the North-South and East-West directions was considered as the crown diameter. The data were statistically analyzed according to recommendations by Zar (*4*).

Results and discussion. The changes in plant height and canopy diameter for the CP 076 clone and for the Clonal Population as a function of cultivation time can be found in Figure 1. From the time of planting at the permanent location until nine months later, plant height and mean canopy diameter were approximately equal for the clone and for the Clonal

Population. After that period, there were few differences between the clone and the population with regard to crown diameter or plant height, but canopy diameter was always greater than plant height.

For the CP 076 clone the fitted equation was $h = 20.1184 + 0.4837\ d$, with $R^2 = 0.90$, where h and d represent plant height and canopy diameter, in cm, respectively. The intercept coefficient was not significant, but the slope coefficient was significant at 1% probability. By excluding the intercept coefficient we were able to obtain the equation $h = 0.5167\ d$. For the Clonal Population the fitted equation was $h = 65.3277 + 0.3756\ d$, with $R^2 = 0.99$, where h and d represent plant height and canopy diameter, in cm, respectively. In this case, both the intercept and slope coefficients were significant at 1% probability.

The results obtained in our work are in agreement with some aspects observed by Salam and Abdurazak (*1*), during a two-year period, in a similar study conducted with 18 cultivars, planted with three replications. The authors fitted regression equations for the crop when it was 11 and 13 years old. For the first period, the fitted equation was $a = 5.0851 + 0.1843\ d$, and only the intercept coefficient was significant. At 13 years after planting, the equation obtained was $a = 2.0117 + 0.5455\ d$, and both coefficients were significant. In both these equations, a and d are measured in meters. According to those authors, the importance of the intercept coefficient decreases as the plant grows, while the slope coefficient becomes more important. In other words, in young trees, crown diameter is less related to tree height, but it depends more heavily on the intercept coefficient. In mature trees this coefficient is not very important. From the data obtained in this research it can be seen that the importance of the intercept coefficient being present in the equation that relates cashew tree height to crown diameter may depend rather on the population of plants being studied than on plant age. In the CP 076 clone the slope coefficient was not significant, contrary to the Clonal Population, even though the plants in both groups were the same age. In addition, the time at which evaluation is performed must also be important, as, incidentally, was observed by Salam and Abdurazak (*1*). It must be pointed out, however, that those authors evaluated "normal" size cashew trees, while in this study we evaluated dwarf cashew trees. In addition, the local environmental conditions were obviously different.

It can be therefore concluded that the equations for plant height estimation (h), based on canopy diameter (d) for the CP 076 clone and for the Clonal Population are $h = 0.5167\ d$ and $h = 65.3277 + 0.3756\ d$, respectively.

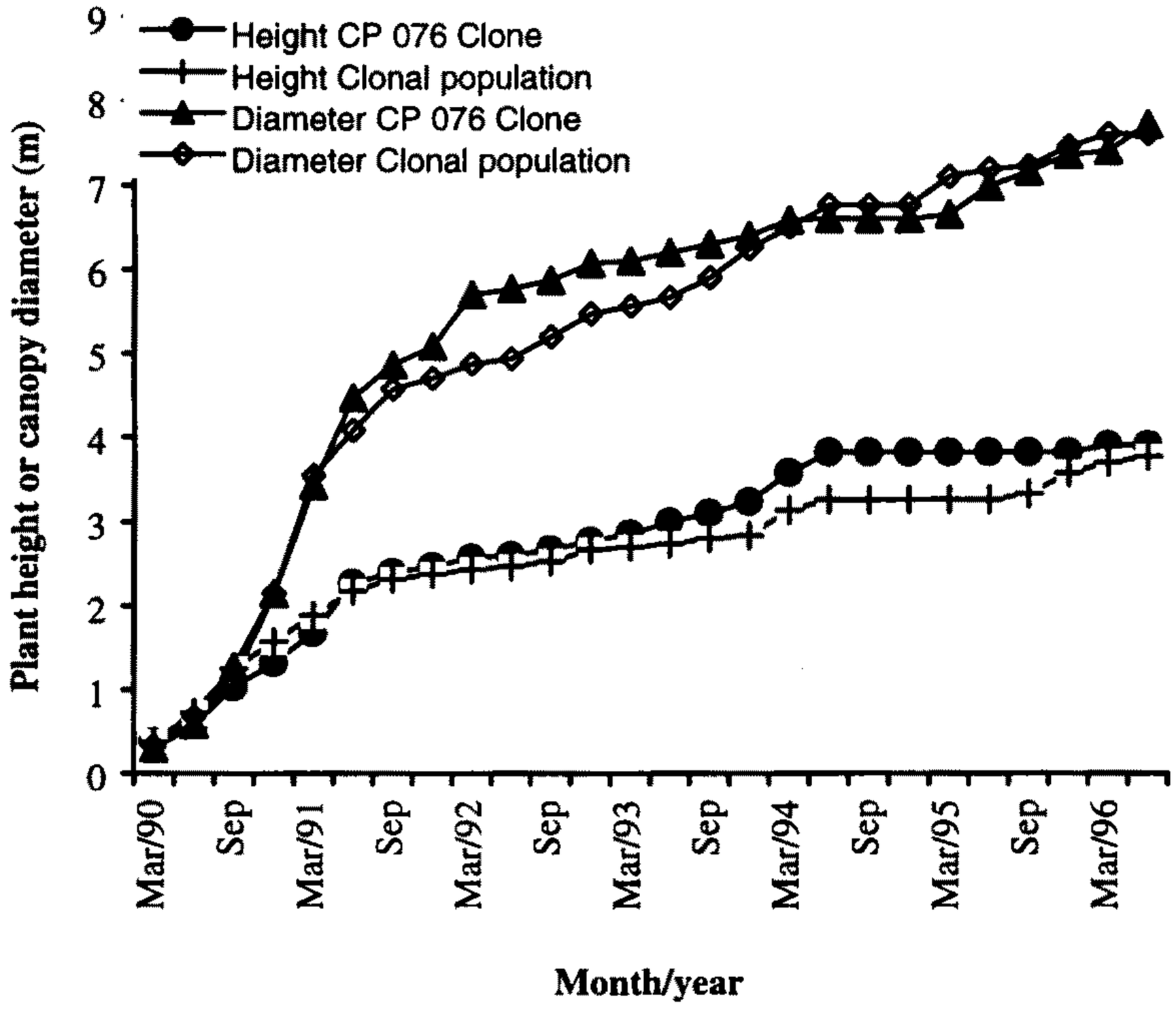

FIGURE 1 – Plant height and crown diameter for the CP 076 clone and for the Clonal Population of early-dwarf cashew trees, from March 1990 to March 1996.

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