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The influence of CO_3Cu on the growth of the *Duranta*

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Abstract: In this article, we present some research results whose objective was to analyze the growth of *Duranta* plants, under the influence of sprinkling foliage and CO_3Cu concentrations. The methodology followed a quantitative approach, field-type experimental design, data are taken during 30 days of cultivation, length of root, dry weight, and stem diameter and height are measured. The results show an increase of dry weight, harmonic growth of the root related to the height of the plant. It is concluded that a solution of 140 g of CO_3Cu liter of latex-1 generates increase in dry weight of *Duranta*.

1. Introduction

The *Duranta* is a plant that could be grow quickly from a short trunk but with many branches, the leaves are opposite in an elliptical shape and partly toothed. They multiply by many means of cuttings or seeds planting. To strengthen and shape the *Duranta* plant, its pruning should be moderate as well as its watering. The cultivation of shrubs used as plants in pot or garden requires a management where the volume / pot ratio is aesthetically harmonic, which arises from decreasing the volume of the container without affecting the quality of the plant [1]. *Duranta* is a shrub that reaches a size of 2 meters to 4 meters high, with thorns or frequently unarmed [2]. Its opposite leaves, simple, obovate-spatula shape to elliptical, 3.2 cm to 7 cm long and 1.5 cm to 3 cm wide, acute apex (to rounded), attenuated base, entire margin or with few irregular teeth in the upper half, glabrescent. The inflorescence in clusters of 5 cm to 22 cm in length, terminal and axillary. Sometimes presenting as panicles, frequently recurved or pendulous, bracteoles 3 mm to 4 mm long; corolla zygomorphic, more or less hypochlorite form, blue, lilac or white, with narrow tube 7 mm to 10 mm long, 5-lobed, unequal lobes 3 mm to 5 mm long; deuteous fruit, 4 Pyrenees, each with 2 seeds.

In its cultivation in a pot, when the radical system reaches the walls, morphological and physiological changes are produced that produce modifications to the aerial part (lower biomass gain and smaller diameter at neck height (DAC)) according [3]. For this purpose, authors [4] cite copper carbonate (CuCO_3) as a practical tool for root pruning, spiral reduction and ramification improvement. Population growth or population dynamics was one of the first attempts to mathematically model human population growth, thus analyzing the hypothesis where the growth rate of the population with constant birth and mortality rates [5] grows proportionally (two quantities u and v are proportional, then $u \propto v$, that is, one quantity is a multiple of another, then $u = kV$). For the case of the total population $P(t)$ of the country at any time t , the variation of the population with respect to time by the Equation (1):

$$\frac{dP}{dt} = kP, \text{ where } k \text{ constant of proportionality} \quad (1)$$



When looking for the equation that gives rise to the differential equation when deriving it with respect to time, the opposite operation is apply to the derivation, that is to say the integration, for which variables are separate obtaining the Equation (2) to Equation (4):

$$\int \frac{dP}{P} = \int k dt, \quad \text{Ln}|P| = kt + C \quad (2)$$

$$e^{\text{Ln}P} = e^{kt+C} = e^{kt}e^C \quad (3)$$

$$P(t) = e^{kt+C} = e^{kt}e^C \quad (4)$$

Is P_0 , the initial population quantity, i.e. in a time $t=0$ (see Equation (5)).

$$P(0) = e^{k*(0)}e^C = e^C = P_0 \quad (5)$$

$$P(t) = P_0e^{kt} \quad (6)$$

Equation (6), $P(t)$ is a general solution of the differential equation, in which a family of curves is observe according to the initial value P_0 k indicates the rate of variation of P with relation to, if the constant of proportionality k , y , $P(t)$ are positive, then $P'(t)$ is positive and $P(t)$ is increasing, in this case it is said that the problem is growth [6]. However, if K is negative, y , $P(t)$ is negative, then $P'(t)$ will be negative, which implies that $P(t)$ is decreasing, and the problem is of decrease.

On the other hand, the analysis of growth in plants is a technique widely used nowadays and it is very useful to analyze the performance in terms of growth. The growth of a plant or one of its organs are studied by measuring variables such as length, volume, fresh or dry weight, among others, at successive intervals of time during the development period. By plotting the results of these measurements as a function of time, a sigmoid curve is obtained, and it is always possible to find a non-complex mathematical function that reproduces growth with considerable accuracy [7]. Some growth phases of organisms are usually in accordance with the exponential function.

Growth curves reflect the growth behavior of a plant in relation to time and are govern by external or environmental factors and internal factors of the plant that may have a genetic basis. The action and interaction of these factors allows the development of the plant, presenting an association between growth and performance factors [8]. The authors agree that growth constitutes an irreversible increase in the size of the plant, associated with an increase in dry weight, without neglecting, differentiation, or increased complexity of the plant, reserve the term growth for the quantitative aspects of development and the differentiation for the qualitative aspects of it. In reality, it is very difficult to isolate such processes on a higher floor due to their close interaction. When basic structural units are increase by cell division, they also increase their size, fresh weight, dry weight or volume.

2. Methodology

The research follows a descriptive study [9] *Duranta Adonis* plant. Propagated by seed were transplanted to containers of 512 cm³ of volumetric capacity and grown under greenhouse at a density of 90 plants per m² under greenhouse. Radiant and aerial growth parameters were measured in *Duranta* plants growing in pots of volume 512 cm³ according to hypothesis: sprinkling with BAP in *Duranta* plants, growing in pots increases the growth rate and post-nursery survival without modifying the partition rate [7]. The painting of the interior of pots with CO₃Cu increases the growth rate and survival without modifying the partition rate, the combined use of both treatments increases more significantly the growth rate and survival "post-nursery", without modifying the partition rate [10]. The experiment was elaborated in a medium temperature of 31 °C, with a range of 2.05 °C., Rainfall of 2507.7 mm per year, average relative humidity of 77.86% and 1346.6 hours of annual total solar brightness. At San José de Cúcuta city, with average temperature of 38 °C, with range of 13.15 °C, rainfall of 2853.7 mm per year,

average relative humidity of 71.45% and 1106.9 hours of annual total solar brightness. For 30 days the plants were cultivated, on days 1, 3 and 7 were made, sprays to the foliage with 5 ppm solution of 6-benzylaminopurine (BAP) [11]. The pots that corresponded to the treatments were painted inside with concentrations of $20 \text{ mg} \cdot \text{L}^{-1}$, $70 \text{ mg} \cdot \text{L}^{-1}$ and $140 \text{ mg} \cdot \text{L}^{-1}$ of latex-1, and dried in the sun for seven days. The application of CO_3Cu was by diluting the product in white latex for exterior, agitation until complete dilution, and painted with a brush. At the beginning of the trial, 50 plants were harvest to perform the initial measurement; 30 days after planting, 90% harvested.

The experiment was adjusted to a statistical design with three levels of copper in containers, and three levels of BAP application [9]. Treatments: CO_3Cu level: $20 \text{ mg} \cdot \text{L}$ of latex-1, $70 \text{ mg} \cdot \text{L}$ of latex-1, and $140 \text{ mg} \cdot \text{L}$ of latex-1. Level of 6-benzylaminopurine: one application ($5 \text{ mg} \cdot \text{L}^{-1}$), two applications ($10 \text{ mg} \cdot \text{L}^{-1}$) and three $15 \text{ mg} \cdot \text{L}^{-1}$. The data obtained and analyzed according to the completely randomized experimental design with five repetitions and six plants per experimental unit. Variance analysis performed on the variables evaluated, for the difference in means the Tuckey test was applied ($P \leq 0.05$).

3. Results

There are no factors limiting the growth of the plants in the containers. Is verify that at the beginning of the experiment with 95% reliability there are no significant differences between the variables. The analysis of characteristics physical of the substrate and of the grown soil to density of 0.41, solids dissolvent 63 ppm, space in total de 69%, space with air 32% in vol, capacity of container 40%, PH de 5.9, and characteristics chemical with conductivity electric of $182 (\mu\text{S} \cdot \text{c} \cdot \text{m}^{-1})$, matter organic de 40%. In Table 1, it is observed analysis of variance shows that the BAP produced significant effects on the root length, the partitioned dry weight, the DAC and the subsequent survival of the plants. The CO_3Cu produced significant effects on the partitioned dry weight and the DAC, but not on the subsequent survival.

Table 1. Analysis of variables.

Variables measure	Founding of variation	Adding of boards	Square medium	Fc	Ft
long root	BAP	759911.40000	82488.80000	29.7145	2.5702**
	CO_3Cu	5257.73000	3108.85000	1.5138	2.8671 NS
	BAP* CO_3Cu	63867.78000	4054.60000	2.0427	1.5975*
Weight dry air	BAP	7130.90000	7766.14000	34.6869	2.3142**
	CO_3Cu	3982.75000	1990.93000	8.8914	2.6709**
	BAP* CO_3Cu	3844.70000	0.24030	1.0701	1.5225 NS
weight dry radial	BAP	153943.78000	20493.20000	61.0337	2.4206**
	CO_3Cu	7097.00000	4050.37000	9.8728	4.9589**
	BAP* CO_3Cu	12563.46000	0.83100	2.3387	1.9929**
DAC	BAP	7.82058	0.91222	21.8210	2.7004**
	CO_3Cu	0.88360	0.44086	9.8532	4.6025**
	BAP* CO_3Cu	0.39574	0.02444	0.5452	1.6450 NS
Survivor	BAP	9.32310	0.99065	10.5735	3.7930**
	CO_3Cu	0.11760	0.05880	0.7875	3.2235 NS
	BAP* CO_3Cu	0.84105	0.05250	0.7035	1.8375 NS

In Table 2 it is observed the BAP* CO_3Cu interaction produced significant effects on root length and radial dry weight, changes in the partition are observed. Control plant shows greater spiraling of the root. Treatments with CO_3Cu do not avoid root spiraling, but supplied with the BAP shows shorter root length and absence of spirals.

The highest total biomass accumulation was observed in the treatments that combine BAP ($10 \text{ mg} \cdot \text{L}^{-1}$ and $15 \text{ mg} \cdot \text{L}^{-1}$) and Cu ($70 \text{ mg} \cdot \text{L}^{-1}$ and $140 \text{ mg} \cdot \text{L}^{-1}$) and is evidence of an increase in the growth rate (which produced an increase in reserves. which is why higher DACs were also observed). In Figure 1 it is observed the time vs stem length its relation and index of correlation between variables

when taking into account model 3x3 for $140 \text{ mg} \cdot \text{L}^{-1}$. the function that describes the growth of the plant obtained.

Table 2. Variance analysis of the effect of CO_3Cu and BAP on growth in *Duranta Adanis* pot in nursery.

Founding of variation		long of the root (cm)	Weight dry air (g)	weight dry radical (g)	DAC (mm)	survivor (%)	Coef. Part.
BAP	1 (5 mg-L^{-1})	9.01b	1.10	2.93	2.0010d	90a	0.375427
	2 (10 mg-L^{-1})	7.11bc	1.09	2.90	2.1431c	90a	0.375862
	3 (15 mg-L^{-1})	5.31cd	1.51	3.03	3.2219b	70b	0.498350
CO_3Cu	1 (20 mg-L^{-1})	9.89a	0.89	2.36	1.6414e	100a	0.377119
	2 (70 mg-L^{-1})	10.31a	1.40	3.71	1.5631e	93a	0.377358
	3 (140 mg-L^{-1})	10.04a	1.36	3.60	1.5834e	93a	0.377778
Interaction BAP* CO_3Cu	1 x 1	7.771b	1.43	4.37	1.9791d	98a	0.327231
	1 x 2	7.46b	1.67	4.56	1.9849d	90a	0.366228
	1 x 3	7.33bc	1.85	4.80	1.9512d	100a	0.385417
	2 x 1	6.86bc	1.54	4.50	2.1576c	90ab	0.342222
	2 x 2	6.60c	1.68	4.78	2.1518c	92ab	0.351464
	2 x 3	6.51c	1.91	4.92	2.1837c	98a	0.388211
	3 x 1	6.11d	1.82	4.67	4.0407b	100b	0.389722
	3 x 2	6.18d	1.85	5.17	4.0741b	100b	0.357834
	3 x 3	6.08d	2.01	5.65	4.0729a	100b	0.355752
	T	10.23a	0.89	2.36	1.8514e	100a	0.377119

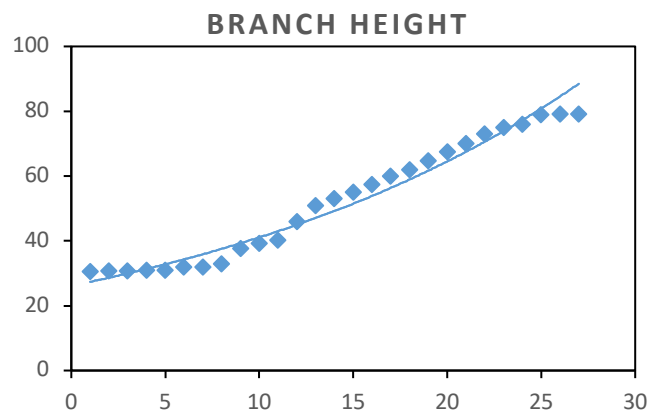


Figure 1. Plant growth data *Duranta* in thirty days.

Equation (7) that describes the growth variation of *Duranta* DAC to $R^2 = 0.951$ according to the change in time t was given by Equation (8).

$$h = 30.30 e^{0.004t} \quad (7)$$

$$\frac{dh}{dt} = 0.1212e^{0.004t} \quad (8)$$

For time initial: $h(0) = 30.3$ cm. For Time (1 day): $h(1) = 30.5$ cm = $\frac{5033}{5000}h(0)$. For this experiment, the increase in the measurement time was 0.66%. When comparing data, where $h(0) = c$, then, $\frac{5033}{5000}h(0) = h(0)e^k$, $e^k = \frac{5033}{5000}$ This is $k = \ln\left(\frac{5033}{5000}\right)$, $k = 0.0065$, and replacing the corresponding constants for any time t in Equation (6), one obtains Equation (9).

$$\text{Then } h(t) = h(0)e^{0.0065t} \quad (9)$$

4. Discussion

To perform the productivity analysis of a plant based on its growth, two principles are required: the measurement of existing plant material (P) and the measurement of the assimilative system of that material (A) in successive intervals of time [12]. In practice, the variables used constitute the total dry weight of the plant and the total leaf area of the plant. The leaf area is a variable that allows directly determine the productivity of any crop photosynthesis in the leaves fundamentally is perform. There are several methods for estimating it by using the dimensions of the leaf either fresh or dry weight [13]. State that the total production of dry matter depends mainly on the magnitude duration and efficiency of the photo synthetically active area or limbus of the leaves [14]. It also demonstrated that the production of dry matter in plants is a linear function of the interception of light; therefore, the increase of the leaf area increases the interception of light that results in an increase in the production of dry matter. Likewise, the maximum dry matter is obtained when the optimum leaf area is form in the shortest possible time.

The functional method uses the regression model for the adjustment of the primary data. It is a tool that facilitates the understanding of the growth process of the plant; nevertheless, it is necessary that in the adjustment of primary data by means of the model of regression [15] take into account the appropriate function to describe the process comparing the results of statistical analysis with various functions

5. Conclusions

CO₃Cu influenced in factors associate increase of dry weight and harmonic growth of the root related to the height of the plant. Combination of handlings with BAP (10 mg • L⁻¹ or 15 mg • L⁻¹) with CO₃Cu (70 mg • L⁻¹ or 140 mg • L⁻¹) generated an increase in dry weight and larger aerial part thus increasing the quality of the plants and the percentage of survival. The growth follows a logistic model for 0 < t < 30 days after the transplant.

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