PACLOBUTRAZOL EFFECTS ON CACAO SEEDLINGS[1]

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ABSTRACT - The effects of paclobutrazol (2RS, 3RS) - 1-(4-Chlorophenyl) - 4,4-dimethyl-2-(1H, 2, 4-triazol-1-yl)-pentan-3-ol), ICI PP333 on the morphological characteristics of cacao (*Theobroma cacao* L.) seedlings were evaluated under greenhouse conditions. The experimental design was a complete randomized design with five treatments and 10 replications. Applications of 5, 15, 45, and 90 ppm of PP333 were made directly to the soil in which 5-months old 'Catongo' cacao seedlings were grown in 5,0 kg poliethylene bags. Plant height was the parameter more affected by the action of PP333. The height reduction by the highest rates was 32% with respect to control plants. The 15 ppm application reduced height by 17% and the 5 ppm did not statistically differ from the control. With the exception of the 90 ppm treatment which significantly reduced stem diameter, the other treatments were not statistically different from the control. Individual leaf area, in the two higher doses, was significantly lower than the control, 0, 5, and 15 ppm treatments, by approximately 28%. Total dry weight of plants at the highest rate of PP333 were 21% lower than the control seedlings. Root, stem, and leaf dry weight for the 90 ppm seedlings were 32, 17 and 22% lower than control plants, respectively. The highest dose changed the partitioning of photosynthates, decreasing the root/shoot ratio which was significantly lower.

Index terms: growth regulators, *Theobroma cacao*, partitioning.

EFEITOS DO PACLOBUTRAZOL EM PLÂNTULAS DE CACAU

RESUMO - O efeito do paclobutrazol (2RS, 3RS)-1-(4-Clorofenil) - 4,4-dimetil - 2 - (1H, 2,4 - triazol-1-il) - pentan-3-ol), ICI PP333 nas características morfológicas de plântulas de cacau (*Theobroma cacao* L.) foi avaliado sob condições de casa de vegetação. O delineamento experimental utilizado foi o inteiramente casualizado com cinco tratamentos e dez repetições. O experimento consistiu na aplicação de 0, 5, 15, 45, e 90 ppm de PP333 em plântulas de cacau "Catongo" de 5 meses de idade crescendo em sacos de polietileno com 5 kg de solo. A altura da planta foi o parâmetro mais afetado pela ação do PP333. As maiores dosagens reduziram a altura em 32% em relação ao tratamento testemunha. A dosagem de 15 ppm reduziu o crescimento em 17% e a de 5 ppm não diferiu estatisticamente do controle. A exceção de 90 ppm, que reduziu significativamente o diâmetro do caule em 15%, não se verificaram diferenças significativas nos outros tratamentos em relação a testemunha. A área de cada folha, nas duas maiores dosagens, foi significativamente menor em relação aos tratamentos 0, 5 e 15 ppm. As dosagens maiores decresceram, aproximadamente, 28% a área das folhas. A dosagem de 90 ppm diminuiu o peso da matéria seca total em 21% em relação ao controle. Os pesos da matéria seca da raiz, caule e folhas a 90 ppm foram 32%, 27% e 22% menores, respectivamente, em relação às mesmas partes das plântulas testemunha. A dosagem maior do produto modificou a partição dinâmica de assimilados, decrescendo a razão peso seco da matéria seca da raiz/peso seco da matéria seca parte aérea, que foi significativamente menor em relação aos outros tratamentos.

Termos para indexação: reguladores de crescimento, *Theobroma cacao*, distribuição de assimilados.

INTRODUCTION

Knowledge of the effects of exogenously applied plant growth regulators on morphological characteristics aids in understanding the action of these chemicals in plants. The experimental plant growth regulator, paclobutrazol (2RS, 3RS) - 1-(4-Chlorophenyl)-4, 4-dimethyl-2 (1H, 2, 4-triazol-1-yl) pentan-3-ol), ICI PP333 has been, reported to inhibit gibberellic acid biosynthesis in plants (Goldsmith et al., 1983; ICI Américas 1984) by inhibiting kaurene oxidase, a Cyt p-450 oxidase (Hartlet & Ellis 1973). Paclobutrazol retards growth of both monocotyledonus and dicotyledonous plants and also has been reported to increase yield in rice (Street et al. 1986), apples, pears, and several other fruits (ICI Américas 1984, Raese & Burts 1983, Swietlik & Miller 1983, Williams 1984a, b, Williams & Edgerton 1983), decrease vegetative growth (Cambiachi et al. 1983; Stang & Weis 1984), change the assimilate partitioning (N'Diaye 1980, Quinlan 1980), influence branching and stimulate flowering (Stinchcombe et al. 1984, Edgerton & Hoffman 1965), fruiting (Martin & Dabek 1988, Martin et al. 1987), and improve fruit quality (Green 1982). Since most of these investigations have been done with crops other than cacao (*Theobroma cacao* L.), it was deemed necessary to obtain physiological information with promissing growth regulators. The objective of this experiment was to evaluate the

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effects of paclobutrazol on morphological characteristics of cacao seedlings.

MATERIALS AND METHODS

Catongo cacao seedlings were planted Nov 6, 1985, in 5.0 kg soil containers and grown under greenhouse conditions. After five months, 50 homogenous plants were chosen for PP333 application. The seedlings were at the seventh leaf flush, approximately 76 cm in height and 10.3 mm in stem diameter. Paclobutrazol was applied April 7, 1986, at doses of 0, 5, 15, 45, and 90 ppm dissolved in 2 liters of water which were poured directly to the soil.

Height and diameter were measured weekly during 98 days on six plants until they began to jorquete when the experiment was terminated. The height was taken from the beginning of the root zone to the terminal bud, while the diameter was measured 2.0 cm below the cotyledonary leaves. At the end of the experiment four seedlings per treatment were harvested, separated into plant parts and dried at 75°C to constant weight. Test of homogeneity of slopes was performed to test differences between regression coefficients utilizing the General Linear Model procedure of the Statistical Analysis System Institute package (1982).

RESULTS AND DISCUSSION

The effect of PP333 on seedlings height became apparent after the fourth week of measurements. Cacao seedling in which 45 and 90 ppm of PP333 were applied maintained approximately constant height troughout the experimental period. However, plants in 0, 5 and 15 ppm treatments continued to increase in height until the end of the experiment (Fig. 1). The rate of increase for the 45 and 90 ppm was 13 and 26 times smaller, respectively, than the control, thus, doubling the dosage from 45 to 90 ppm decreased the rate of height increase by half (Table 1). At the last measurement, plants in these treatments were approximately 32% smaller than the control, while seedlings in which 5 and 15 ppm were applied were about 83% and 95% as high as the control plants (Fig. 1).

Plant diameter was also affected by PP333 application, although not as drastically as plant height. Only at about the sixth week of measurements were apreciable differences found at the highest PP333 dosage. The rate of diameter increase for the 90 ppm treatment was statistically different and approximately half of that of the other dosages (Table 1). The rate of diameter increase for the other dosages was not statistically different from each other according to the test of homogeneity of slopes. At the end of the experiment, plant diameter in the 90 ppm application was about 15% smaller than the diameter of plants in the other treatments.

At the end of the experimental period the final leaf number for the 45 ppm plants was significantly higher than those of the other treatments. Although total leaf area for this treatment was not significantly different from those of the control, 5 and 15 ppm treatments, the mean leaf area was

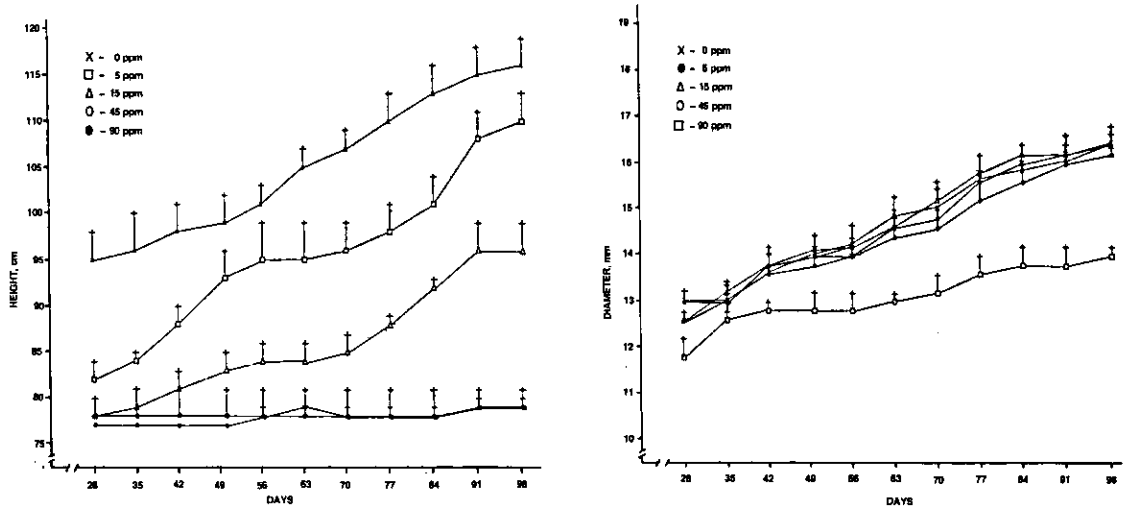

FIG. 1. Effect of different dosages of paclobutrazol on height (A) and stem diameter (B) of Catongo cacao seedlings.

significantly smaller than in those treatments and did not differ from the 90 ppm plants. Therefore, the higher dosages of paclobutrazol significantly decreased, by about 28%, the area of individual leaves (Table 2).

On the other hand, the highest paclobutrazol treatment decreased the dry weight of plant parts, and, therefore, total plant dry matter was 21% lower than that of control plants (Table 2). Root, stem and leaf dry weights, for the 90 ppm treatment, were approximately 32, 17, and 22% lower than the respective control parts. However, in terms of dry matter distribution within each treatment, the root percentage in the 90 ppm treatment was smaller than the other plant part percentages. However, stem and leaf percentages for the 90 ppm plants were similar to those of the other treatments. Therefore, the highest dosage of PP333 changed the partitioning of assimilates from root to shoot, decreasing the root/shoot ratio, which was significantly smaller (Table 2). Changes of the cacao assimilate partitioning from vegetative to reproductive parts would be one way to increase yield. Therefore, it can be hypothesized that the application of PP333 to adult plants arrest the development of sprouts (chupons) changing the partitioning of photosynthates which could then be used to set more pod, increasing, therefore, plant productivity.

CONCLUSIONS

1. The parameter more affected by the action of PP333 on 5 months cacao plants is plant height. Rates greater than 45 ppm pratically paralize growth, while 5 ppm or lower do not.

2. Stem diameter is decreased by the action of PP333 at concentrations equal or higher than 90 ppm.

3. Paclobutrazol rates higher than 45 ppm decrease individual leaf area.

4. The 90 ppm paclobutrazol rate decrease plant parts dry weight.

5. The highest dose of PP333 changed the partitioning of photosynthates from root to shoot significantly decreasing the root/shoot ratio.

TABLE 1. Linear regression parameters for height and diameter for Catongo cacao seedling treated with different dosages of paclobutrazol.

Concentration	Height		r^2	Diameter		r^2
	Intercept	Slope		Intercept	Slope	
ppm	cm	cm/d		mm	mm/d	
0	79.9	0.390	0.96	10.95	0.058	0.98
5	74.1	0.342	0.96	10.89	0.059	0.97
15	72.7	0.219	0.90	10.76	0.062	0.97
45	76.9	0.030	0.89	10.79	0.057	0.99
90	77.2	0.015	0.85	10.97	0.033	0.90

TABLE 2. Effects of paclobutrazol on mean final leaf number, total leaf area per plant, area per leaf, root (RDW), leaf (LDW), stem (SDW), and total (TDW) dry weights, and root-to-shoot ratio of Catongo cacao seedlings at the end of the experimental period.

Concentration	Final leaf number	Total area	Area per leaf	RDW	LDW	SDW	TDW	Root/shoot
ppm		cm^2		kg/planta				
0	38 b*	859 a	22 a	0.19 a	0.46 a	0.42 a	1.06 a	0.21 b
5	41 b	802 a	20 ab	0.18 a	0.40 ab	0.42 a	1.00 ab	0.22 ab
15	42 ab	767 a	18 bc	0.19 a	0.39 ab	0.40 a	0.98 ab	0.24 a
45	50 a	746 a	15 c	0.19 a	0.43 ab	0.42 a	1.04 a	0.22 a
90	37 b	599 b	16 c	0.13 b	0.36 b	0.35 b	0.84 b	0.19 c

* Treatments followed by the same letter within a column are not significantly different at the 0.05 level of probability according to Duncan's Multiple Range procedure.

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REFERENCES

CAMBIACHI, D.; BIGUZZI, M.; TORELLI, G. PP333 - cherry - the effects of some plant growth regulators to keep black the growth of young cherry trees. **L'informatore Agrario.** 1 Dec. 1983. p.28231.

EDGERTON, L.J. & HOFFMAN, M.B. Some physiological responses of apple to N-dimethyl aminosuccinamic acid and other growth regulators. **Am. Soc. Hort. Sci. Proc., 86**:28, 1965.

GOLDSMITH, I.R.; HOOD, K.A.; MACMILLAN, J. **Inhibition of gibberellic acid biosynthesis in Gibberella fujikurol.** s.n.t. Presented at S.C.I. Symposium on Errosterol Biosynthesis Inhibitors. Reading, U.K., March 20-24, 1983.

GREEN, D.W. Effects of PP333 and its analogs on vegetative growth and fruit quality of Delicious apples. **Hort. Sci., 17**:3-46, 1982.

HARTLET, M.R. & ELLIS, R.J. Ribonucleic acid biosynthesis in chloroplasts. **Biochem. J., 134**:249-62, 1973.

ICI AMERICAS INC. Clipper-growth retardant. **Technical Bulletin,** Mar. 1984.

MARTIN, P.J. & DABEK, A.J. Effects of paclobutrazol on the vegetative growth and flowering of young clone trees. **Trop. Agric.,** Trinidad, 65(1):25-8, 1988.

MARTIN, C.G.; YOSHIKAWA, F.; LA RUE, J.M. Effects of Soil application of paclobutrazol on vegetative growth, pruning time, flowering, yield, and quality of 'Flavor crest' Peach. **J. Am. Soc. Hort. Sci., 112**(6):915-21, 1987.

N'DIAYE, O. **Physiological aspects of peanuts (*Arachis hipogeas* L.) yield as affectded by Diaminizide.** s.l., Univ. of Florida, 1980. 173p. Tese Ph.D.

QUINLAN, J.D. Recent development in the chemical control of tree growth. **Acta Hort., 114**:144, 1980.

RAESE, T.J. & BURTS, E.C. Increased yield and suppression of shoot growth and mite population of "d'Anjou" pear trees with nitrogen and paclobutrazol. **Hortscience, 18**:212-4, 1983.

STANG, E.J. & WEIS, G.G. Influence of paclobutrazol plant growth regulator on strawberry plant growth, fruiting, and runner supression. **Hortscience, 19**(5):643-5, 1984.

STATISTICAL ANALYSIS SYSTEM INSTITUTE, Cary, EUA: **SAS user's guide:** Raleigh, 1982.

STINCHCOMBE, G.R.; COPAS, E.; WILLIAMS, R.R.; ARNOLD, G. The effect of paclobutrazol and daminozide on the growth and yield of apple trees. **J. Hort. Sci., 59**(3):323-27, 1984.

STREET, J.E.; JORDAN, J.A.; EBELHAR, M.W.; BROYKIN, D.L. **Agron. J., 78**:288-91, 1986.

SWIETLIK, D. & MILLER, S.S. The effects of paclobutrazol on growth and response to water stress of apple seedling. **J. Am. Soc. Hort. Sci., 108**:1076-80, 1983.

WILLIAMS, M.W. Use of bioregulators to control vegetative growth of fruit trees and improve fruiting efficiency. In: ORY, R.L. & FITTINGS, F.R. ed. **Bioregulators, chemistry, and uses.** Washington, American Chemical Society, 1984a. p.93-9. (American Chemical Society, Symposium Séries 257)

WILLIAMS, M.W. Use of bioregulators to control vegetative growth of fruit and improve fruiting efficiency. **Acta Hort., 146**:97-104, 1984b.

WILLIAMS, M.V. & EDGERTON, L.J. Vegetative growth control of apple and pear trees with ICI PP333 (paclobutrazol) a chemical analog of bayleton. **Acta Hort., 137**:111-16, 1983.