Growth, Yield, Nutrient Content and Fruit Quality of *Carica papaya* L. Under Controlled Conditions. II. Boron Effects[1]

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ABSTRACT

A sand culture greenhouse experiment was conducted with papaya, *Carica papaya* L., variety Blue Solo, to determine the effects of four levels of B in the nutrient solution (0.01, 0.05, 0.1 (control), and 1.5 p/m) on growth, fruiting and mineral content. B deficiency and B excess symptoms are described for leaves, petioles, central stems, and fruit. Mineral contents of leaves, petioles, and fruits are presented and discussed. Fruits receiving 0.05 p/m B in the nutrient solution were preferred. The critical level of B appears to be about 20 p/m in the petioles and leaves, whereas excess B occurred at about 70 and 300 p/m, respectively, for petioles and leaves. Quality components of the fruits are based on taste panel evaluation.

INTRODUCTION

The commercial papaya, *Carica papaya* L., is grown widely in the tropics and sub-tropics. Foliar studies on the nutrition of this plant have been made in Hawaii (2, 3, 4, 5, 6), and limited field tests and recommendations in Florida (17), Hawaii (10, 11) and India (18, 19). Nutrient deficiency symptoms and studies of the foliar N and P trends are available for a generic relative in Chile, known as the Mountain papaya *C. candamarcensis* Hook f. (9, 12, 13, 14), which is hardy in southern California but the fruits are of little commercial value (7). Cibes and Gaztambide (8) described the mineral deficiency symptoms displayed by this plant when grown under controlled conditions.

Objectives of this study were to determine the effects of different levels of B in greenhouse sand culture on growth, flowering, fruiting, fruit quality and mineral content of the leaves and fruit of *C. papaya*.

MATERIALS AND METHODS

This experiment was conducted simultaneously with a nitrogen experiment under the same greenhouse conditions and with the same materials and methods. The N and B effects (15) data were collected similarly on the same papaya plants and are reported in separate papers as Part I and

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II, respectively. The four levels of B (0.01, 0.05, 0.1 and 1.5 p/m) used in this study were replicated five times with female, hermaphroditic and male plants. Boron was supplied from boric acid.

RESULTS AND DISCUSSION

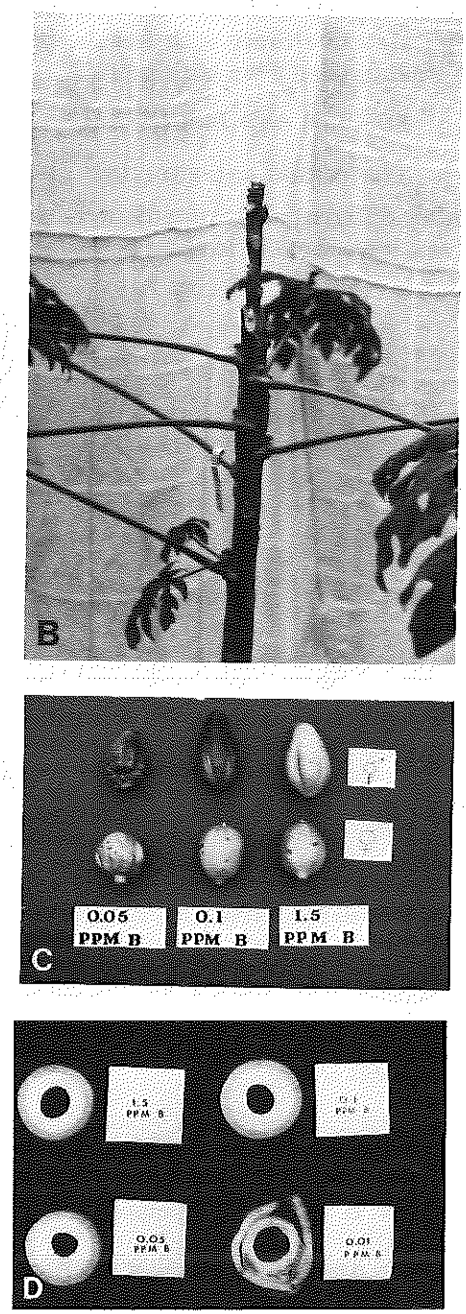
FLOWERING AND FRUITING

Within 20 days after differential treatments were initiated, the flower buds, regardless of sex, were the first to show deficiency symptoms in the

FIG. 1.—A. left to right, B levels from excess (1.5 p/m) to severely deficient (0.01 p/m); B. B-deficient terminal as shown in A at right; C. Fruits from hermaphroditic and female plants at low, normal and excess levels of B; D. Cross-section of papaya stems showing corkiness and cambial destruction at 0.01 p/m B; E. Abortion and dropping of male flowers (near center of picture) at the 0.01 B level; F. Yellowing and dropping of female flower buds at 0.01 p/m B; G. Right, leaf showing smaller size and tip burn due to B excess at 1.50 p/m; center, control; left, leaf from 0.01 p/m B.

lowest 0.01 p/m B dosis. A whitish exudation appeared on the youngest flower buds, which often fell before opening. Older flowers that were present before the first B deficiency symptoms appeared, eventually dropped within 50 days.

On trees supplied with 0.05 p/m B many of the flowers had dropped 4 months after differential treatments. Also, fruits that had set were lumpy, misshapen and somewhat corky (fig. 1). No deficiency or other symptoms were noted on flowers or fruits on trees supplied with 0.10 or higher.


B
0.05
PPM B
0.1
PPM B
1.5
PPM B
C
D

GROWTH EFFECTS

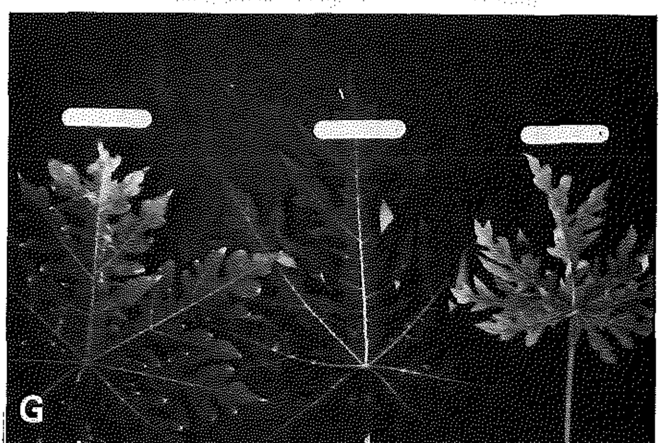
Shortly after flowering other deficiency symptoms began to appear. Ends of the petioles showed swelling with whitish exudation that dried and hardened (fig. 1). Terminal leaves down to the fifth and sixth leaf showed chlorosis. Eventually, no new leaves formed on plants supplied

with 0.01 p/m B, and the younger ones became distorted (fig. 2), coarse, brittle, stiff, and in some cases the center lobe was bent downward at a 90° angle due to splitting of the central vein. The younger leaves dropped prematurely. The terminal central stems cracked and showed internal corking (fig. 1).

Plants receiving 0.05 p/m B showed deficiency symptoms 6 months after differential treatments; leaves were fasciated, some dropped and the petioles were swollen and oozing at the tips, but total growth and yield of these trees were not significantly affected. No foliar symptoms were noted on control trees receiving 0.10 p/m B.

Forty-five days after differential treatments there were no differences in height of plants and number of nodes. When the experiment was terminated, 225 days later, there were differences in tree height (in cm): 132a, 150b, 150b and 157b; and number of nodes: 52a, 75b, 75b and 81b, respectively.

Plants at the lowest B dosis had thicker trunks at the base (5.6b, 5,15a, 5.1a, 5.0a in cm),[3] and thicker petioles at the blade base (5.7c, 5.4b, 5.2ab, 5.05a in cm, respectively). Number of leaves per plant were: 14a, 24b, 27b and 25b.



LEAF MINERAL CONTENTS

The B supply did not alter significantly the Fe, Cu and Al contents in either the blades or petioles. The N and P in the blades were slightly and irregularly altered by the B levels (table 1) while the Ca, Mg, and Zn accumulated in both the petioles and blades of plants at 0.01 p/m B. Mn accumulated only in the petioles at the 0.01 p/m level. Accumulation of these nutrients in the blades and/or petioles could have been due to failure of the 0.01 p/m B plants to use the nutrients in making any appreciable growth or to setting fruit.

Potassium in the blades showed little response to B supply, while K in

[3] Series of numbers refer, respectively to the levels of B, in the nutrient solution, ig.: 0.01, 0.05, 0.10 (Control), 1.5 p/m.

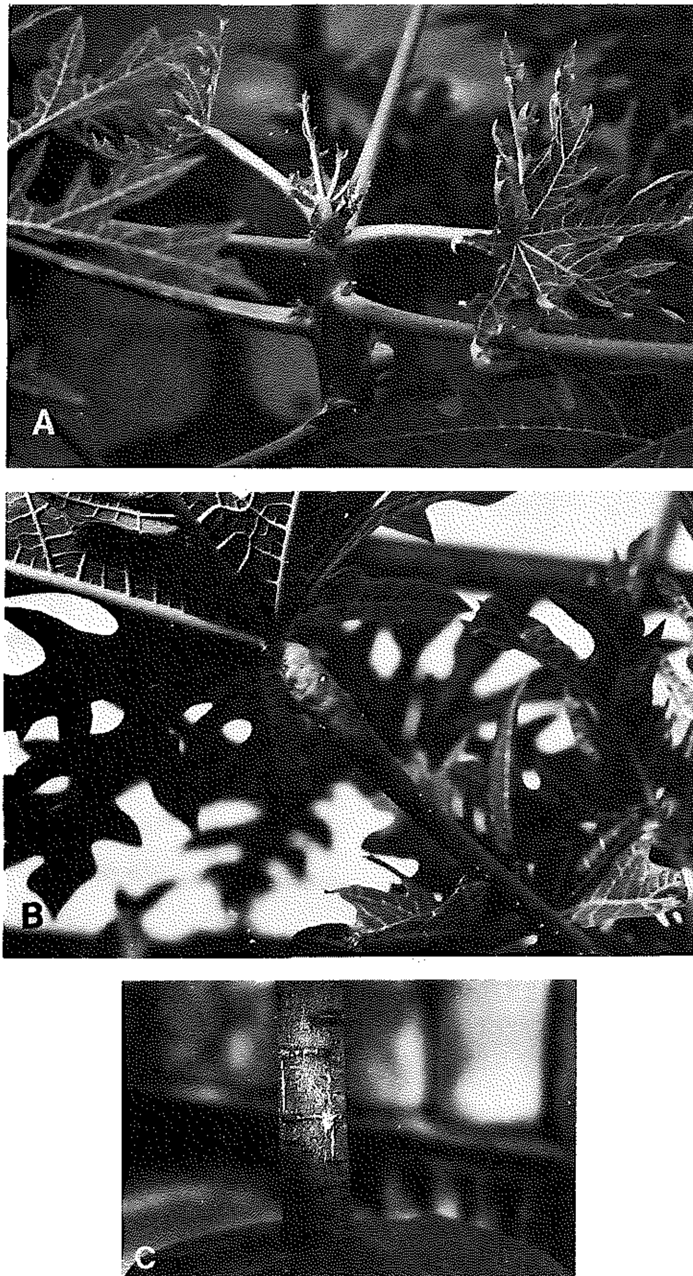


FIG. 2.—B deficiency at 0.01 p/m in the nutrient solution appeared early in the experiment showing: a) distortion of the top leaves; b) swelling of the petiole at the leaf blade attachment; c) splitting of the trunk near its base.

TABLE 1.—*Influence of B levels of mineral content of blades and petioles of papaya trees at 45, 105 and 225 days after treatment*

B level	Nutrient content							
	N	P	K	Ca	Mg	Mn	B	Zn
p/m	%	%	%	%	%	*p/m*	*p/m*	*p/m*
				Blades				
				45 days				
0.01	4.24a[1]	0.63ab	4.31a	1.35a	0.38a	41a	10a	48a
0.05	4.62ab	0.55a	4.32a	1.41a	0.34a	51b	18b	49a
0.10	4.66ab	0.55a	4.32a	1.56a	0.40a	53b	37c	50a
1.50	4.80b	0.73b	4.19a	1.46a	0.32a	57b	300d	42a
				105 days				
0.01	4.49a	0.73a	5.28a	2.15a	0.72b	53a	16a	45b
0.05	4.53a	0.73a	5.08a	1.91a	0.38a	57ab	29b	34a
0.10	4.63a	0.68a	5.13a	2.02a	0.40a	64b	39c	32a
1.50	4.72a	1.06b	5.00a	1.89a	0.33a	78c	300d	41ab
				225 days				
0.01	3.46a	0.68b	2.99a	3.17b	0.85b	38a	15a	60b
0.05	3.83a	0.70b	4.06b	1.38a	0.29a	50b	14a	44a
0.10	4.05a	0.52a	3.81b	1.50a	0.35a	50b	24b	54ab
1.50	3.88a	0.64b	3.94b	1.49a	0.32a	57b	300c	50a
				Petioles				
				45 days				
0.01	2.59b	0.68a	6.17a	1.31a	0.99a	32b	9a	26b
0.05	1.80a	0.64a	6.14a	1.21a	1.08a	18a	16a	13a
0.10	2.10ab	0.62a	7.05b	1.59a	1.05a	17a	25b	16a
1.50	2.23ab	0.73a	7.20b	1.41a	1.00a	16a	48c	16a
				105 days				
0.01	2.69b	0.97c	6.64ab	2.32b	1.42b	66b	26a	46b
0.05	1.77a	0.52a	6.51ab	1.84ab	1.91a	33a	27a	14a
0.10	2.21ab	0.61a	6.03a	2.33b	1.22a	29a	37b	14a
1.50	1.97a	0.80b	7.01b	1.78a	1.12a	32a	107c	18a
				225 days				
0.01	1.84b	0.70b	3.02a	3.45b	1.54b	61b	12a	27b
0.05	1.23a	0.51a	4.14b	1.45a	0.86a	20a	14a	10a
0.10	1.09a	0.48a	3.74b	1.73a	0.95a	22a	22b	12a
1.50	1.33ab	0.56a	4.97c	1.58a	0.83a	25a	54c	12a

[1] Means in columns followed by the same letters do not differ significantly at the 0.05 level.

the petioles tended to increase with an increase in the supply of B, as has been noted in citrus (16).

Manganese in the blades increased with an increased supply of B, which indicates that the blade-Mn rather than petiole-Mn which showed no differences, may be the best index of the Mn status in the plant.

Boron in the blades and petioles increased with B supply (table 1). The average of the three samplings showed that toxicity symptoms were present (fig. 1) when the blades and petioles contained 300 and 70 p/m, respectively. Deficiency symptoms appeared when these tissues contained less than 20 p/m.

It was found that B deficiency affects the youngest leaves first, whereas excess B affects the lowest leaves first. Under our conditions B deficiency at 0.01 p/m supply was more harmful to growth and fruiting than excessive B at 1.5 p/m B. The data indicate that adequate growth and yield may be obtained when the levels of B in the blades and petioles are approximately 20 to 30 p/m. Muñoz et al. (13) have noted that the critical level of B in *C. candamarcensis* is between 20 and 30 p/m. B deficiency was found to be expressed similarly in all sexes in this study.

FRUIT MINERAL CONTENTS

The only significant differences in mineral content of the fruits were the higher P, Mg and B contents of trees receiving 1.5 p/m B vs those supplied with 0.05 and 0.10 p/m; e.g., for the 0.05, 0.10 and 1.5 p/m levels of B, the P contents in percent were 0.40a, 0.36a, 0.55b; for Mg in percent, 0.26a, 0.29a, and 0.36b; and for B in p/m, 12a, 19a, and 82b.

For commercial fruit production, fruits produced under controlled greenhouse conditions, do not seem to be the best index of the B status of the plant. In apple, however, Askew (1) found that the fruit rather than the leaves is a more sensitive index of B status of the tree.

FRUIT QUALITY

Only the ratio of total solids to titratable acidity increased significantly as the B supply was increased from 0.05 to 1.5 p/m (17.0, 21.3, 26.7, respectively with HSD of 7.2 at 1%). The other quality components, such as pH, soluble solids, titratable acidity and total solids were unaffected by B supply.

Fruits borne on plants receiving 0.05 p/m B were judged by the panel as slightly better in flavor than those receiving 0.10 p/m (control). The panel preferred the fruits having the lowest ratio of soluble solids to acids. Scores were 4.0 (slightly better than control); 1.4 (control); and 4.8, (slightly poorer than the control)—(HSD at 1% = 0.83).

RESUMEN

Un experimento se llevó a cabo en invernadero con *C. papaya* de la variedad "Blue Solo" para determinar el efecto de cuatro niveles de B (0.01, 0.05, 0.1 (control) y 1.5 ppm) en la solución nutritiva con respecto al crecimiento, fructificación y contenido de las hojas y frutas. Síntomas de carencia y toxicidad se describen para las hojas, pecíolos, tallo central y de frutas cosechadas en plantas hembra y hermafrodita. También se informa el contenido mineral de las hojas, pecíolos y frutas.

El nivel crítico de B en los pecíolos y hojas está cerca de 20 ppm,

mientras que el exceso para estos mismos órganos de la planta fue de 70 y 300 ppm, respectivamente. Las frutas se cataron para evaluar la calidad. De las plantas que recibieron 0.01, 0.05, 0.01 (control) y 1.5 ppm B en la solución nutritiva, los catadores prefirieron las frutas de las que recibieron 0.05 ppm.

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