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Effect of Nitrogen and Boron Application on *Carica papaya* L. I. Growth and Yield¹

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ABSTRACT

The experiment was carried on a Coto clay (an Oxisol). The effect of four levels of N (0, 57, 170 and 340 kg/ha) and four levels of B (0, 2.3, 4.5, 6.8 kg/ha) were determined using the P.R. 7-65 papaya variety. Treatments were initiated when the transplanted seedlings were three months old, and were repeated every six weeks. The information recorded showed the following results: Increments of N and B levels did not show a marked effect on plant height and stem diameter. Boron tended to be more effective than N in increasing stem height and diameter. The petiole fresh and dry weights increased linearly as the N and B levels were raised. The number and weight of fruits borne on female and hermaphroditic trees increased linearly as the N and B levels were raised. The results of the experiment showed that the papaya plant requires a high N and B fertilization rate.

INTRODUCTION

According to the Puerto Rico Department of Agriculture (1) in Puerto Rico there is a demand for 1,250 metric tons of papaya fruits per year. This supply is not being produced, although it is possible to produce 36 metric tons of fruit per acre (11). This lack of supply could be attributed, among other things, to the lack of research information on the response of this crop to fertilizer levels.

Except for a few reports (6, 8), the information on papaya nutrition both in Puerto Rico and abroad is meager. Reports from Hawaii (2, 3, 4, 5) on the papaya fertilization are mainly applicable to the Solo variety. Since the varieties, soils, and climates may deviate the extrapolation of research findings, this experiment was conducted to determine the effects of different levels of N and B on the growth and yield of the P.R. 7-65 papaya variety.

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MATERIALS AND METHODS

This research was carried on a Coto clay (an Oxisol) at the Isabela Substation where the combined effect of four levels of N and four levels of B were studied on the P.R. 7-65 papaya variety.

Four to five seeds were sown on $9 \times 13 \times 30$ cm size black polyethylene bags filled with 1:1:1, Coto soil, sand and filtered press cake (cachaza). Before sowing, the filled bags were fumigated with methyl bromide in a concentration of 1.7 kg/m^3 . Seedlings were kept during 60 days in the nursery before transplanting.

Treatments, replicated four times were distributed in a 4×4 factorial experimental design as shown in table 1. Each experimental plot consisted of eight plants spaced $2 \text{ m} \times 2 \text{ m}$, equivalent to 2,640 plants per hectare.

During the first 3 months after transplanting the plants were managed and fertilized with N, P, and K according to recommendations (11).

From there on, the experimental treatments were initiated as shown in the following tabulation:

<i>Treatments</i>	<i>Nitrogen kg/ha</i>	<i>Boron kg/ha</i>
N ₁ B ₁	00	00
N ₂ B ₁	57	00
N ₃ B ₁	170	00
N ₄ B ₁	340	00
N ₁ B ₂	00	2.3
N ₂ B ₂	57	2.3
N ₃ B ₂	170	2.3
N ₄ B ₂	340	2.3
N ₁ B ₃	00	4.5
N ₂ B ₃	57	4.5
N ₃ B ₃	170	4.5
N ₄ B ₃	340	4.5
N ₁ B ₄	00	6.8
N ₂ B ₄	57	6.8
N ₃ B ₄	170	6.8
N ₄ B ₄	340	6.8

All plots were fertilized every 6 weeks at a rate of 222 kg/ha of P₂ O₅ and K₂O. Nitrogen was applied as urea, P₂O₅ as triple superphosphate, K₂O as KCl and B as Na₂B₄O₇.

Before the initiation of the treatments there was no statistical difference in plant size.

The experiment was terminated when the plants were 9 months old (counting from sowing date). The following data was recorded: stem diameter 15 cm above ground; plant height from the ground to the terminal bud; number and weight of green fruits in each female and hermaphroditic plant; fresh and dry weight of four petioles per plot. The healthiest leaf between the 9th and 13th, counting basipetally, was selected for sampling and the petioles were used for nutrient content determinations.

All data recorded were statistically analyzed (12).

RESULTS AND DISCUSSION

Table 1 shows the effect of N and B levels on height and stem diameter of the papaya plants. Nitrogen levels did not affect plant height and stem

TABLE 1.—*Effect of nitrogen and boron levels on plant height and stem diameter of the papaya plant*

Boron levels (kg/ha)	Nitrogen level (kg/ha)			
	0	57	170	340
	<i>Height (m)</i>			
0.0	1.72de ¹	1.75cde	1.86abcd	1.67d
2.3	1.76cde	1.92abc	1.95abc	1.99a
4.5	1.87abcd	1.81abcd	1.90abcd	1.88abcd
6.8	1.89abcd	1.88abcd	1.95ab	1.80bcde
	<i>Diameter (cm)</i>			
0.0	4.1b	4.5ab	4.1b	4.6ab
2.3	4.8ab	4.7ab	4.3ab	4.7ab
4.5	4.9ab	5.4a	5.0ab	4.6ab
6.8	4.7ab	5.2ab	5.4a	5.2ab

¹ Means followed by one or more letters in common do not differ significantly at the 0.05 probability level.

diameter. On the other hand, B levels significantly increased stem diameter.

The smallest plants were those fertilized with 340 kg/ha N and no boron (1.67 m), while the tallest (1.99 m) were those with the same amount of nitrogen plus 2.3 kg/ha boron. The difference between these two treatments was highly significant. This result suggests that at least 2.3 kg/ha boron should be applied in the fertilizer in order to assure well developed papaya plants. Similar response of papaya to N and B were reported by the senior author (9, 10) when plants were grown under controlled conditions.

Figure 1 shows that fresh and dry weights of the petioles increased in direct proportion as the nitrogen and boron levels were incremented in

the fertilizer. This effect is more clearly shown in the fresh weight than in the dry weight. The fresh and dry weights of petioles from plants fertilized with 340 kg/ha of N plus either 0, 2.3 or 6.8 kg/ha of B were not significantly different and were lower than that from plants receiving the same amount of N and 4.5 kg/ha of B. This results was probably due to a 1% significant interaction between the N and B fertilizers.

The result indicating a consistent increase as the nitrogen was raised is in agreement with those of the senior author (9) for *C. papaya* and Godoy et al. (7) on *C. candamarcensis* who reported that the petiole fresh and dry weights were heavier as the application of this nutrient element was increased.

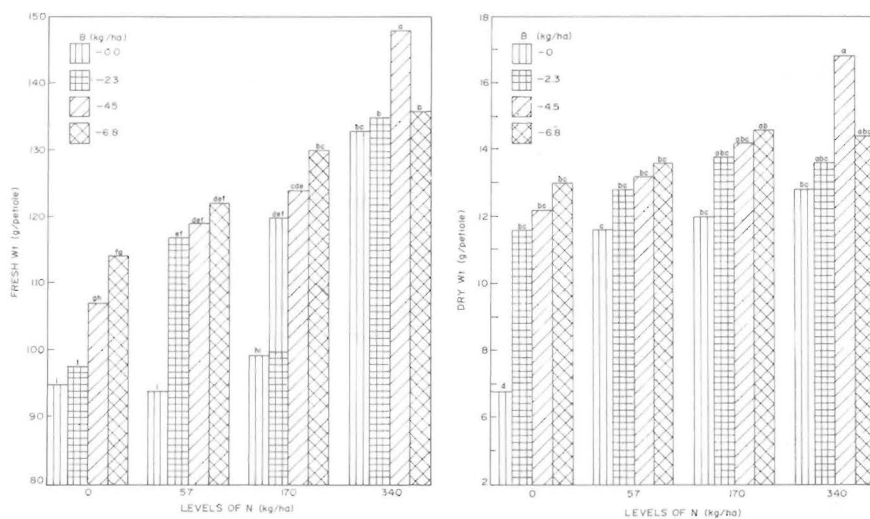


FIG. 1.—Effect of different nitrogen and boron levels on fresh (left) and dry (right) weights of petioles of the papaya plant.

Table 2 indicates that the mean weight of fruits per plant was not dramatically affected in female papaya plants as the B levels were increased and that hermaphroditic plants that were not supplied with B produced significantly lighter fruits than those of plants to which B was supplied at a rate of 4.5 or 6.8 kg/ha. No significant difference was found between the three B levels applied to hermaphroditic plants.

Similar results were observed when the data for both sexes was combined. Table 2 also shows that from 57 to 170 kg/ha of N was enough to increase significantly the fruit weight per plant and that there were nonsignificant differences between the three highest nitrogen levels supplied to both sexes of papaya plants.

Table 3 shows the effect of nitrogen and boron levels on the mean number of fruits per plant. The table also shows that for both sexes the mean number of fruits per plant increased linearly as the B levels were raised. On the female plants, only those supplied with 6.8 kg/ha of B produced significantly more fruits than the check, while on the hermaphroditic plants no treatment was better than the check. This result suggests that the latter sex probably may require more B to set fruits than the former sex. The boron requirement for pollen germination and growth of fruit trees, and the recommendations of boron sprays to increase fruit set was established since 1950 (13).

TABLE 2.—Effect of nitrogen and boron levels on the weight (kg) of fruits per plant on female and hermaphroditic papaya plants

Boron levels (kg/ha)	Nitrogen levels (kg/ha)			
	0	57	170	340
	<i>Female</i>			
0.0	23.0d ¹	24.7cd	27.5abcd	26.9abcd
2.3	25.7abcd	25.2bcd	27.0abcd	29.8a
4.5	28.0abc	26.0abcd	29.9a	30.3a
6.8	24.2cd	28.0abc	30.2a	24.1cd
	<i>Hermaphroditic</i>			
0.0	12.8e	20.1a-bc	18.3cd	21.6abc
2.3	16.0de	18.9cd	19.1bcd	22.5abc
4.5	18.3cd	20.3abc	21.6abc	24.1a
6.8	20.5abc	19.7abc	23.3ab	20.2abc
	<i>Mean of both sexes</i>			
0.0	17.9f	22.4cde	22.9bcde	24.2abcde
2.3	20.8ef	22.0de	23.1bcde	26.1ab
4.5	23.1bcde	23.1bcde	25.7abc	27.2a
6.8	22.8bcde	23.9bcde	26.7a	22.1de

¹ Means followed by one or more letters do not differ significantly at the 0.05 probability level.

Table 3 also shows that N supplied at a rate between 57 and 170 kg/ha was enough to increase the number of fruits per female plant, and that 340 kg/ha of N was not enough to increase the number of fruits per plant on the hermaphroditic plants.

The interactions between N and B (tables 2 and 3) were highly significant. The interactions indicate that as the N level is increased, B should be added to the fertilizer. The senior author (9) reported that as the N increased in the nutrient solution the leaf B content was reduced.

RESUMEN

Un experimento en un suelo Coto arcilloso (un Oxisol) se llevó a cabo en la Subestación Experimental Agrícola de Isabela para determinar los

efectos de cuatro niveles (0, 57, 170 y 340 kg/ha) de N y cuatro (0, 2.3, 4.5 y 6.8 kg/ha) de B en el crecimiento y rendimiento del papayo P.R. 7-65. Estos niveles se compararon en un diseño factorial 4×4 . Los tratamientos se iniciaron cuando las plantas tenían 3 meses a partir del trasplante (5 meses desde el semillero). Desde el trasplante hasta el comienzo de los tratamientos, las plantas se abonaron con un análisis completo de N-P-K. Las cantidades de fósforo y potasio no se alteraron durante el experimento.

Se recolectaron los siguientes datos: altura y diámetro de las plantas. Aunque el boro tendió a ejercer un mayor efecto que el nitrógeno, los pesos verde y seco de los pecíolos aumentaron consistentemente a

TABLE 3.—Effect of nitrogen and boron levels on the mean number of fruits of female and hermaphroditic papaya plants

Boron levels (kg/ha)	Nitrogen levels (kg/ha)			
	0	57	170	340
	<i>Female</i>			
0.0	15f ¹	17ef	23abcd	18def
2.3	17def	24abc	26ab	23abcd
4.5	20cdef	25abc	25abc	27ab
6.8	21bcde	27ab	25abc	28a
	<i>Hermaphroditic</i>			
0.0	15cd	18bcd	13d	17bcd
2.3	16bcd	22abc	20abcd	21abc
4.5	22abc	22abc	22abc	22abc
6.8	21abc	24ab	27a	23abc
	<i>Mean of both sexes</i>			
0.0	15d	17cd	18cd	17cd
2.3	17d	23ab	23abc	22abc
4.5	21bcd	23ab	23ab	24ab
6.8	21abc	25a	26a	25a

¹ Means followed by one or more letters in common do not differ significantly at the 0.05 probability level.

medida que se aumentaron los niveles de nitrógeno y boro; el número y el peso de las frutas en las plantas hembras y hermafroditas aumentaron consistentemente pero en forma leve.

Los datos demuestran que entre 57 y 170 kg/ha de N y 4.5 kg/ha de B aplicados cada 6 semanas a un suelo Coto arcilloso (Oxisol) como el de Isabela es suficiente para obtener un buen crecimiento de las plantas y un buen rendimiento de frutas.

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