Effect of Planting Distance and Fertilizer Level on the Mineral Content of the Leaf of two Varieties of *Carica papaya* L[1].

Agripino Pérez López[2]

ABSTRACT

Ten-month-old papaya plants of variety P.R. 6-65 contained significantly more N, P, K and Ca, lower K and Mg in blades, than plants of variety P.R. 7-65, and equal content of Mn. The petioles in variety P.R. 7-65 had significantly more Mn and K, but less Mg and Ca than those of variety P.R. 6-65, and equal contents of N.

N in the blades in the two varieties at two planting distances decreased, while N in the petioles increased as the age of the plants increased.

The P content in the blades of plants of the two varieties and the two spacings decreased as the age of the plants increased, while in the petioles this reduction was significant only at the planting distance of 1.8 × 1.8 m. At the 1.2 × 1.2 m planting distance, the P in the petioles of variety P.R. 6-65 was not significantly affected by the plant age, but in variety P.R. 7-65 P increased significantly with the age of the plant.

K in the blades and petioles of variety P.R. 6-65 at 10 and 23 months decreased significantly as the planting distance increased. In variety P.R. 7-65, similar results were found in 23-month-old plants but not in those 10 months old.

The Ca and Mn content in the blades and petioles were not affected by the planting distance or by the fertilizer supplied to the plants.

Mg in the blades of P.R. 7-65 decreased as the planting distance increased, and did not vary in variety P.R. 6-65; there was a significant interaction of fertilizer × distance. The significant second order interaction of fertilizer × distance × variety for the Mg content of the petioles suggests that the varieties responded differently to the fertilizer supplied at the two distances.

INTRODUCTION

Papaya nutrition has not been studied thoroughly in Puerto Rico. Cibes and Gastambide (1) reported deficiencies under controlled conditions, and several reports (2, 3, 4, 5) have been published by Pérez-López et al.

Limited yields of papaya in Puerto Rico are probably due to the lack of information about planting distances and nutrient requirements of the varieties. Therefore, this study was designed to determine the effect of two planting distances and two fertilizer levels on the N, P, K, Ca, Mg, and Mn content of blades and petioles of varieties P.R. 6-65 and P.R. 7-65.

MATERIALS AND METHODS

This paper follows previous publications (2, 6), in which location, soil type, rainfall, fertilization and orchard management are discussed.

[1] Manuscript submitted to Editorial Board March 31, 1981.

[2] Horticulturist and Horticulture Professor, Agric. Exp. Stn. Mayagüez Campus, Univ. P.R., Río Piedras, P.R.

The planting distances were 1.2 × 1.2 m and 1.8 × 1.8 m, and the fertilizer levels were 227 and 454 g/plant/month of a 15-15-15 commercial fertilizer. The varieties were P.R. 6-65 and P.R. 7-65. The treatments were initiated when the first flower opened in about 30% of the plants.

When the plants were 10 and 23 months old, four leaves per plot (blades and petioles separated as individual samples) were collected, washed and dried to a constant weight in a forced air oven at 70° C and analyzed for N, P, K, Ca, Mg, and Mn. Ca, Mg and Mn were analyzed only in plants 10 months old. All data were evaluated by Duncan's Multiple Range Test.

TABLE 1.—*Effect of planting distance and fertilizer level on the nitrogen content of blades and petioles of 10- and 23-month old plants of the P.R. 6-65 and P.R. 7-65 papaya varieties*

Planting distance	Leaf	Varieties					
		PR 6-65 Fertilizer level (g)		Mean	PR 7-65 Fertilizer level (g)		Mean
		227	454		227	454	
M		%	%	%	%	%	%
				10 months			
1.2 × 1.2	Blade	5.17	5.13	5.15a[1]	5.15a	5.02a	5.09b
	Petiole	1.25	1.13	1.19a	1.26	1.29	1.27a
1.8 × 1.8	Blade	5.24	5.30	5.27a	4.79	4.99	4.89b
	Petiole	1.14	1.20	1.17a	1.07	1.09	1.08b
				23 months			
1.2 × 1.2	Blade	3.56	3.72	3.64a	4.43	3.60	4.02a
	Petiole	1.29b	1.60a	1.45a	1.19	1.42	1.31a
1.8 × 1.8	Blade	3.40	3.62	3.51a	3.68	3.63	3.66a
	Petiole	1.21a	1.22a	1.21b	1.12	1.23	1.18b

[1] Means in rows and columns followed by the same letter do not differ significantly at 0.05 probability level.

RESULTS AND DISCUSSION

Since the content of most of the elements studied in these experiments was not affected as the fertilizer level was increased, the 227 g/plant/month of the same 15-15-15 commercial fertilizer should be ample to grow papaya spaced 1.8 × 1.8 m, the best spacing as confirmed in a previous report (2).

NITROGEN

Table 1 shows the N content of blades and petioles of plants 10 and 23 months old. In both 10- and 23-month old plants the petioles of plants planted 1.8 × 1.8 m apart had significantly lower N content than those planted 1.2 × 1.2 m. The table also shows that in 10-month-old plants, N

content of the blade in variety P.R. 6-65 was significantly higher (5.21) than that of variety P.R. 7-65, which was 4.99 (table 2). When the plants of both varieties were 23 months old, those fertilized with 454 g of fertilizer and planted at 1.2 × 1.2 m had significantly more N than those planted at 1.8 × 1.8 m and fertilized with 227 g of fertilizer.

Table 1 also shows that the N content of the blades, when the plants were 10 months old, was five times higher than that of the petioles, and that as the plant's age increased from 10 to 23 months, the N content of the blade decreased while that of the petioles increased.

Table 2 shows that the N content of the petioles in the 10-month-old plants of P.R. 6-65 and P.R. 7-65 was about equal and that the N content of the blade was significantly higher in P.R. 6-65 than in the blade of P.R. 7-65. In both varieties the blade N content was five times higher than that of the petioles.

TABLE 2.—*Blade and petiole element content of 10-month-old plants of the P.R. 6-65 and P.R. 7-65 papaya varieties*

Variety	Elements					
	N	P	K	Ca	Mg	Mn
	%	%	%	%	%	*p/m*
			Blade			
P.R. 6-65	5.21a[1]	0.42a	2.66b	3.00a	1.13b	129a
P.R. 7-65	4.99b	0.39b	2.95a	2.56b	1.24a	152a
			Petiole			
P.R. 6-65	1.18a	0.17a	2.35b	2.76a	0.71a	59b
P.R. 7-65	1.18a	0.15a	3.20a	2.23b	0.65b	73a

[1] See table 1.

PHOSPHORUS

Table 3 shows that the P content of the blades and petioles in 10-month old plants planted 1.8 × 1.8 m was significantly higher than that of plants of the same age planted 1.2 × 1.2. This tendency disappeared when these same plants were 23 months old.

At 10 months there were no significant differences in P content of blades and petioles, respectively of the two varieties. At 23 months old the P content of the petiole of variety P.R. 7-65 was affected significantly only by the planting distance; i.e., plants at 1.2 × 1.2 m contained significantly more P than those planted at 1.8 × 1.8 m.

Table 2 also shows that in 10-month-old plants, the P content of the petioles in the two varieties was about equal, but the P content of the blades of variety P.R. 6-65 was significantly higher than that of variety P.R. 7-65. In both varieties, the P content of the blade was twice that of the petioles.

POTASSIUM

Table 4 shows that variety P.R. 6-65 10 and 23 months old, contained significantly lower K in the petioles than P.R. 7-65. For the blade content, this was not the case, since the interaction between fertilizer × variety was significant for the P content of the blades in the 23-month old plants. In the 10-month old plants, blade K content was higher in a highly significant way in variety P.R. 7-65 than in P.R. 6-65.

In 23-month-old plants of the two varieties the K content of blades and petioles of plants planted 1.2 × 1.2 m was higher in a highly significant way than the K content in those planted 1.8 × 1.8 m.

The interactions between variety × distance, and variety × fertilizer were highly significant only on blades of 10- and 23-month-old plants.

TABLE 3.—*Effect of planting distance and fertilizer level on the phosphorus content of blades and petioles of 10- and 23-month old plants of P.R. 6-65 and P.R. 7-65 papaya varieties*

Planting distance	Leaf	Varieties					
		P.R. 6-65 Fertilizer level (g)		Mean	P.R. 7-65 Fertiilizer level (g)		Mean
		227	454		227	454	
M		%	%	%	%	%	%
				10 months			
1.2 × 1.2	Blade	0.39	0.41	0.40b[1]	0.37	0.37	0.37b
	Petiole	0.15	0.16	0.16b	0.13	0.13	0.13b
1.8 × 1.8	Blade	0.42	0.44	0.43a	0.39	0.49	0.40a
	Petiole	0.17	0.21	0.19a	0.18	0.16	0.17a
				23 months			
1.2 × 1.2	Blade	0.34	0.36	0.35a	0.36	0.35	0.35b
	Petiole	0.15	0.16	0.16a	0.15	0.16	0.16a
1.8 × 1.8	Blade	0.32	0.36	0.34a	0.39	0.35	0.37a
	Petiole	0.15	0.15	0.15a	0.14	0.14	0.14b

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

These interactions may have been significant because P.R. 7-65 is an early variety, while P.R. 6-65 is a late one. Therefore, they responded differently to the amount of fertilizer applied.

Since no significant differences were attributed to fertilizer amounts, 227 g or 454 g, no more than 227 g/plant/month should be applied.

Table 2 shows that at 10 months P.R. 7-65 contained significantly more K in the blades and petioles than P.R. 6-65. In P.R. 7-65 differences between the K content of blades and petioles were nonsignificant.

CALCIUM

Tables 2 and 4 show that variety P.R. 6-65 contained more Ca in a highly significant way in blade and petiole than variety P.R. 7-65, and

that the fertilizer level and planting distance did not affect significantly the Ca content of these plant tissues in 10-month-old plants. Both tables show that there is not a great difference between the Ca content of blades and petioles in either variety.

MAGNESIUM

Table 5 shows that variety P.R. 6-65 had a significantly lower Mg content in the blade and a higher content in the petiole than P.R. 7-65. This table also shows that the Mg content of the blades of plants planted 1.2 × 1.2 m was higher in a highly significant way than that of the plants planted 1.8 × 1.8 m. However, there was no difference in the Mg content of the petioles.

The interactions between fertilizer × distance and fertilizer × distance × variety were significant, indicating that Mg content is affected by the variables studied in this experiment.

TABLE 4.—*Effect of planting distance and fertilizer level on the potassium content of blades and petioles of 10- and 23-month old plants of the P.R. 6-65 and P.R. 7-65 papaya varieties*

Planting distance	Leaf	Varieties					
		P.R. 6-65 Fertilizer level (g)		Mean	P.R. 7-65 Fertilizer level (g)		Mean
		227	454		227	454	
M		%	%	%	%	%	%
				10 months			
1.2 × 1.2	Blade	2.65	2.76	2.71a[1]	2.67	3.01	2.84b
	Petiole	2.27	2.59	2.43a	2.98	3.19	3.09a
1.8 × 1.8	Blade	2.50	2.45	2.48b	3.19	2.92	3.06a
	Petiole	2.02	2.51	2.27a	3.64	2.99	3.32a
				23 months			
1.2 × 1.2	Blade	2.72	3.07	2.99a	3.17	2.71	2.94a
	Petiole	2.27	2.80	2.54a	3.50	3.27	3.39a
1.8 × 1.8	Blade	1.90	2.34	2.12b	2.58	2.48	2.53b
	Petiole	1.52	1.26	1.39b	2.44	1.96	2.20b

[1] See table 1.

Table 2 shows that the 10-month-old plants of variety P.R. 6-65 contained significantly less Mg in the blades and more in the petiole than those of P.R. 7-65, and that the Mg content in the blades of both varieties was twice that of the petioles.

MANGANESE

Table 5 shows that Mn content of blades and petioles in neither P.R. 6-65 nor P.R. 7-65 was affected by planting distance and fertilizer levels. It also shows that the Mn content of the petiole of variety P.R. 7-65 was significantly lower than that of variety P.R. 6-65.

Tables 2 and 5 also show that the Mn in the blades of the two varieties did not differ significantly and that the blades in both varieties contained twice as much as the petioles.

RESUMEN

La producción de papaya en Puerto Rico es baja porque además del problema de enfermedades no hay suficiente información con respecto al abonamiento de este frutal.

TABLE 5.—*Effect of planting distance and fertilizer level on the calcium, magnesium and manganese content of blades and petioles of 10-month-old plants of P.R. 6-65 and P.R. 7-65 papaya varieties*

Planting distance	Leaf	Varieties					
		P.R. 6-65 Fertilizer level (g)		Mean	P.R. 7-65 Fertilizer level (g)		Mean
		227	454		227	454	
M		%	%	%	%	%	%
				Calcium			
1.2 × 1.2	Blade	2.93	3.08	2.92a[1]	2.70	2.53	2.62a
	Petiole	2.49	2.70	2.60a	1.99	2.04	2.02a
1.8 × 1.8	Blade	2.92	3.06	2.99a	2.49	2.52	2.51a
	Petiole	2.82	2.91	2.87a	2.82	2.08	2.45a
				Magnesium			
1.2 × 1.2	Blade	1.20	1.17	1.19a	1.42	1.35	1.39a
	Petiole	0.68	0.69	0.69a	0.72	0.62	0.67a
1.8 × 1.8	Blade	0.99	1.18	1.09b	1.00	1.21	1.11b
	Petiole	0.76	0.72	0.74a	0.59	0.67	0.63a
				Manganese			
		p/m	*p/m*	*p/m*	*p/m*	*p/m*	*p/m*
1.2 × 1.2	Blade	141	135	138a	123	175	149a
	Petiole	66	59	63a	61	76	68a
1.8 × 1.8	Blade	104	135	120a	132	177	154a
	Petiole	57	54	56a	70	84	77a

[1] See table 3.

En este estudio se usaron variedades de alta producción para comparar el efecto de dos densidades de siembra y dos niveles de abono 15-15-15 en el contenido en N, P, K, Ca, Mg y Mn de las láminas y pecíolos del papayo.

Plantas de la variedad P.R. 6-65 de 10 meses de edad contenían significativamente más N, P y Ca y menos K y Mg en las láminas e igual contenido de Mn que plantas de la misma edad de la variedad P.R. 7-65. Los pecíolos de la variedad P.R. 7-65 contenían significativamente más Mn y K y menos Mg y Ca, e igual porcentaje de P y N que la variedad P.R. 6-65.

Las plantas de 10 y 23 meses de edad de la variedad P.R. 6-65 sembradas a 1.2 × 1.2 m contenían significativamente más N en los

pecíolos, más K en la lámina y pecíolo y menos P en los pecíolos (plantas de 10 meses de edad) que las espaciadas a 1.8 × 1.8 m.

El N en la lámina de las dos variedades y en las dos densidades se redujo, mientras que en el pecíolo aumentó a mayor edad de los papayos.

El contenido en P de las láminas de las dos variedades en las dos densidades se redujo a mayor edad de las plantas, mientras que en el pecíolo esta reducción se observó solamente en las sembradas a 1.8 × 1.8 m. En las sembradas a 1.2 × 1.2 m, el P en los pecíolos de la variedad P.R. 6-65 no se afectó con la edad de la planta, pero en la P.R. 7-65 éste aumentó cuando era más vieja.

El contenido en K en las láminas y pecíolos de plantas de 10 y 23 meses de edad de la variedad P.R. 6-65 se redujo significativamente cuando se redujo la densidad de siembra. Hubo un efecto igual en plantas de la variedad P.R. 7-65 de 23 meses de edad y lo opuesto en las de 10 meses de esta misma variedad.

El contenido en Mg de la lámina de las plantas de la variedad P.R. 7-65 se redujo según se redujo la densidad de siembra pero no así en la variedad P.R. 6-65. En este caso, la interacción de abono × densidad fue significativa. Con respecto al contenido en Mg en el pecíolo, la interacción de abono × densidad × variedad fue significativa, lo cual sugiere que con respecto a este nutrimento los papayos respondieron diferentemente cuando se aplicaron los dos niveles de abono en las dos densidades de siembra.

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