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Spacing, Nitrogen and Potassium on Yield and Quality of Cabezona Pineapple[1]

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ABSTRACT

This study evaluates the effects of spacing, and of N and K_2O on Cabezona pineapple, a big fruit planted solely for the fresh market and grown in an Inceptisol at Lajas, Puerto Rico. Treatment differentials consisted of 3 spacings (30.5, 46 and 61 cm) between plants within the row, 61 cm between rows and 132 cm between double rows. Significant fruit yield increases occurred with treatment differentials. Up to 88.4 t/ha were obtained from plants spaced 30.5 cm and receiving 224 and 252 kg/ha of N and K_2O, respectively. Fruit weight increased as spacing increased. The mean values were 2.9, 3.4 and 3.9 kg for the 30.5, 46 and 61 cm spacings, respectively. The greater number (19,442 fruits/ha) of the largest marketable fresh fruits (about 3.6 kg each) were obtained from plots spaced 46 × 61 × 132 cm, with 336 kg N and 168 kg K_2O/ha. Close planting significantly reduced the number of slips per plant, values ranging from 2.7 to 8.7.

INTRODUCTION

Pineapple is one of the most important cash crops among the fruits of Puerto Rico. It contributed $6 million to the Island economy in 1979. Nevertheless, pineapple cultivation is not a simple process. It demands intensive work, in which every operation, from land preparation to the placing of the product in the hands of the consumer, must be properly managed.

The pineapple, a native of South America, probably was brought to Puerto Rico by the Caribs or the Arawaks (5). According to Salazar (13), Cabezona was the first pineapple variety to be cultivated to some extent in Puerto Rico. The planting of this triploid cultivar is restricted to the semiarid region of Lajas, on the hillsides of the Mariana soils (Inceptisols). Cabezona is a conical fruit usually weighing 3.0 to 7.0 kg. It is grown exclusively for the fresh market.

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The acreage in Cabezona is relatively small (61 ha) compared to that of other cultivars on the north coast of the Island (1,950 ha). Nevertheless, 54 small farmers receive their sole income from its cultivation. Sale prices have increased in the last few years; so growers have expanded their plantings. However, Cabezona pineapple is still planted in single rows, at a low plant density (11,960 p/ha); thus their yields are low (39.5 t/ha).

Research has been done on plant density and fertilizer requirements with other pineapple varieties in the northern coastal plain of Puerto Rico (10, 12, 14, 15). Furthermore, it is well known that spacing and manuring are among the most important agronomic practices in pineapple cultivation (1, 4, 9, 11, 16, 17). However, very little research has been conducted on agronomic practices regarding the Cabezona cultivar.

The present study was undertaken to determine the best spacing and fertilizer levels for Cabezona pineapple. The local consumers of fresh Cabezona prefer large fruits (at least 3.6 kg). Therefore, growers must increase yields without lowering fruit size below its commercial standard.

MATERIALS AND METHODS

A field experiment was planted October 1974 at Lajas Substation on a Mariana gravelly clay loam with an exchange capacity of 14 meq/100g of dry soil, pH 5.37, 58 p/m K, 1,097 p/m Ca, and 327 p/m Mg. Average annual rainfall is 1090 mm, with the wettest period from August to October, and the driest season from January to March. The experimental site was located at 40 m above sea level. A triple lattice design with three replications and 48 experimental plots (7.3 by 5.8 m; with 33,979; 22,528; 17,916 and 16,988 p/ha) was used to study the effect of spacing and of N-K_2O fertilizers on yield and quality of Cabezona pineapple.

Treatment differentials consisted of three spacings (30.5, 46 and 61 cm) between plants within the row, 61 and 132 cm between rows and double rows, respectively. Three levels of N and K_2O fertilizers were tested: (112, 224, 336 kg N; and 84, 168, 252 kg K_2O/ha). The above mentioned spacings were compared with the single row planting system (30.5 × 183 cm, where 101 and 67 kg/ha of N and K_2O were added, respectively).

The soil was treated previous to planting the large slips (±400 g) with 100 gal/ha of D-D mixture (dichloropropane-dichloropropene)[4] and 9.4 liters/ha of Aldrin[5] (25% a.i.) to control nematodes and insects, respectively.

The fertilizer was applied in three equal amounts as sidedressing at

[4] Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

[5] At present Aldrin is not allowed for soil insect control in pineapple.

0.5, 4.5 and 8.5 months after planting. Besides the N-K_2O levels, all plots received P_2O_5 and MgO at the rates of 84 and 56 kg/ha, respectively. Ammonium sulfate (20.5% N), superphosphate (45% P_2O_5), potassium sulfate (50% K_2O) and magnesium sulfate (16.7% MgO) were used as the fertilizer materials.

D-leaf samples were taken twice for chemical analysis, one at 4.5 months after planting and another just before forcing time (12-mo-old plants). Flowering induction was achieved by pouring on the crown of each plant 50 to 100 ml of a solution of 25 g of calcium carbide in 10 liters of water in a closed container.

The experiment was harvested April 1976. Data on yield, growth characteristics and quality were recorded and statistically analyzed.

RESULTS AND DISCUSSION

FRUIT YIELD

Table 1 shows fruit weight, tonnage and number of the most preferable fruit sizes. Treatment differentials significantly influenced the mean fruit weight. Regardless of the amounts of N-K_2O fertilizer applied, the mean values were 2.93, 3.41 and 3.94 kg from plants spaced at 30.5, 46 and 61 cm within the row, respectively. Also, regardless of the spacing, fruit weights were 3.36, 3.42 and 3.51 kg for 112, 224, and 336 kg N/ha; and 3.29, 3.42 and 3.59 kg for 84, 168 and 252 kg K_2O/ha, respectively. Plants from the control plots (single rows at 30.5 × 183 cm, and fertilized with 101 and 67 kg of N and K_2O/ha) yielded large fruits (3.9 kg) but not as many as the plants in treatment no. 5 (table 1).

Cardinali (2), working with the Lagoa Santa cultivar, observed that the mean fruit weight was not significantly affected by planting densities between 10,000 to 30,000 plants/ha. Similar observations were made by Wang (20) with the Smooth Cayenne in Taiwan.

The mean fruit weight is an important characteristic in pineapple production, particularly for the Cabezona growers, because the local consumers of fresh Cabezona pineapple prefer large fruits (not less than 3.6 kg). Therefore, the pineapple plant should be well fed and properly spaced in order to maintain the size of the fruit at or above the 3.6 kg mark.

The highest number of large fruits (19,442 fruits/ha of not less than 3.6 kg) was obtained in plots with plants spaced 46 cm apart within the row, 61 and 132 cm between rows and double rows, respectively.

Fruit tonnage was also significantly affected by treatment differentials (table 1). The mean values varied from 55.24 tons/ha with plants spaced 61 cm within the row and supplied with 224 and 84 kg/ha of N-K_2O (treatment no. 15), to 88.41 tons with plants spaced 30.5 cm within the

row and fertilized with 224 and 252 kg/ha of N and K_2O (treatment no. 10).

Irrespectively of the N-K_2O treatments, mean values were 83.32, 66.23, 58.73 tons of fruits per hectare with plants spaced 30.5, 46 and 61 cm within the row, respectively. Furthermore, regardless of the spacing, the mean values were 66.78, 69.89, 70.68 tons of fruit for the 112, 224, 336 kg N/ha; and 65.34, 70.26, 71.01 tons for the 84, 168, 252 kg K_2O/ha, respectively. Plants from the check plots yielded 59.58 tons of fruit per hectare (treatment 16, table 1).

Su (16), found a highly significant interaction between spacings and fertilizer levels. He concluded that at least the 400-100-400 kg/ha rate of

TABLE 1.—*Effect of spacing and N-K_2O fertilizer on fruit yield of Cabezona pineapple grown on a Mariana gravelly clay loam*

No	Treatment					Fruit yield characteristics			
	Spacings between:			Fertilizer Levels		Mean fruit weight	Fruits per ha	Fruits[1] ≥3.6 kg	Fruits[2] ≥3.6 kg
	Plants	Rows	Beds	N	K_2O				
	cm	*cm*	*cm*	*kg/ha*	*kg/ha*	*kg*	*t*	*%*	*No*
1	30.5	61	132	224	168	3.06bcd	87.54a[3]	12.0	4,077
2	46.0	"	"	224	168	3.50abcd	69.33bc	83.7	18,856
3	61.0	"	"	224	168	3.59abc	63.10cd	92.7	15,748
4	30.5	"	"	336	168	2.97cd	83.93a	11.3	3,840
5	46.0	"	"	336	168	3.44abcd	68.50bc	86.3	19,442
6	61.0	"	"	336	168	4.12a	59.61cd	90.3	15,340
7	30.5	"	"	112	168	2.62d	78.31ab	10.3	3,500
8	46.0	"	"	112	168	3.32abcd	63.86cd	24.7	5,564
9	61.0	"	"	112	168	4.14a	58.17c	76.0	12,911
10	30.5	"	"	224	252	3.03bcd	88.41a	18.0	6,116
11	46.0	"	"	224	252	3.69abc	67.07cd	76.0	17,121
12	61.0	"	"	224	252	4.04a	57.55c	96.0	16,308
13	30.5	"	"	224	84	2.99cd	78.40ab	4.7	1,597
14	46.0	"	"	224	84	3.09bcd	62.38cd	61.0	13,742
15	61.0	"	"	224	84	3.80abc	55.24d	88.0	14,949
16	30.5	183[4]		101	67	3.90ab	59.58cd	63.7	11,412

[1] Based on five consecutive harvested fruits in each plot, which were weighed individually.
[2] An estimation of the number of fruits, if the whole plant density could possibly be harvested.
[3] Means followed by one or more letters in common do not significantly differ at the 5 per cent level by Duncan's multiple range test.
[4] Control: the double rows is the standard method of pineapple planting, but Cabezona is still planted in single rows.

N-$P_2$05 and K_2O is required in order to obtain large fruits of the Smooth Cayenne cultivar under Taiwan conditions. He also recommends the use of fertilizer materials per plant and not per unit area.

The commercial yields (39.5 tons/ha) obtained by the Cabezona growers in their single row system of planting might be improved by switching to the double row system and by using proper spacing and fertilizer practices to get higher fruit yield and at the same time more large fruits per unit area for the local fresh fruit market.

GROWTH CHARACTERISTICS

Table 2 shows slip and sucker production. It also shows the weight, length and width of the D-leaf. Treatment differentials significantly influenced the number of slips produced per plant, slip weight, number of suckers per plant and the length of the leaves. Regardless of the N-K_2O fertilizer, the mean values were 2.7, 5.5, 7.8 slips per plant in plants spaced 30.5, 46 and 61 cm within the row, respectively. A similar trend was observed by Su (16) in the Smooth Cayenne; both fertilizer level and spacing exerted a significant effect on the number of slips per plant. Furthermore, Collins (3) reports that the number of slips produced is a function of the variety and the cultural and environmental factors. This may be particularly important in the case of some pineapple varieties which seldom produce sufficient slips to expand the plantings.

The mean slip weight was significantly influenced. The mean values were 189, 251 and 356 g (removed from the plant 2 months after the harvest of the crop) for the 30.5, 46 and 61 cm spacings, respectively. The weight of the planting material is an important factor to be considered in pineapple growing. For example, it has been reported that fruit yield significantly increased as slip weight increased (8, 19).

Even though treatment differentials showed significant effects on the number of suckers per plant (table 2), the plot mean was less than one sucker per plant. Nevertheless, this observation is not very important for the Cabezona growers, because they do not harvest a second crop.

Wee (21), working with the Singapore Spanish pineapple, observed a drop of 54% in sucker production by increasing plant density from 28,700 to 104,400 plants/ha.

Table 2 shows the significance of treatment differentials on length of the D-leaf; it also shows no significant effect on the dry weight and on the mid-width of the leaves. Leaf weights varied from 15.4 to 18.1 g. Cabezona pineapple normally produces very large leaves, because it is a triploid with 75 chromosomes in the somatic cells (3). Leaf length increased as plant density increased. Similar observations were made by Wee (21) with the Singapore Spanish. Nevertheless, Su (16) observed no effect of spacing on the length and number of leaves per plant of the Smooth Cayenne variety.

The leaf area was not determined, but according to Tay and Tan (18), the estimation of leaf area is important in agronomic studies. They have worked out a linear regression equation for estimation of leaf area in the Singapore Spanish cultivar.

NUTRITIONAL STATUS OF THE PLANT

Table 3 shows the nutrient contents of the D-leaf of 12-mo-old plants. Treatment differentials significantly influenced the leaf nutrient compo-

TABLE 2.—*Effect of spacing and N-K_2O fertilizer on growth characteristics of Cabezona pineapple grown on a Mariana gravelly clay loam*

No	Treatment					Growth characteristics					
	Spacing between:			Fertilizer levels		Slips per plant	Mean slip weight	Suckers per plant	D-leaf weight[1]	D-leaf length	D-leaf width
	Plants	Rows	Beds	N	K_2O						
	cm	*cm*	*cm*	*kg/ha*	*kg/ha*	*No*	*g*	*No*	*g*	*cm*	*cm*
1	30.5	61	132	224	168	3.18g[2]	114de	.39c	16.7	128a	7.8
2	46.0	"	"	224	168	5.90de	323ab	.36c	18.0	120abc	8.1
3	61.0	"	"	224	168	9.61a	341ab	.75bc	17.0	115c	8.0
4	30.5	"	"	336	168	2.85g	104de	.58bc	18.1	125ab	8.0
5	46.0	"	"	336	168	5.97de	206cd	.60bc	16.7	119abc	7.9
6	61.0	"	"	336	168	7.75abcd	383ab	.66bc	18.1	113cd	8.0
7	30.5	"	"	112	168	2.96g	92e	.57bc	15.5	116bc	7.5
8	46.0	"	"	112	168	4.31efg	172de	.67bc	14.5	110cd	7.5
9	61.0	"	"	112	168	6.34cde	392a	1.05b	14.2	105d	7.6
10	30.5	"	"	224	252	3.54fg	293abc	.67bc	17.1	128a	7.8
11	46.0	"	"	224	252	6.27cde	363ab	.65bc	15.4	115c	8.0
12	61.0	"	"	224	252	8.21abc	363ab	1.04b	16.3	111cd	8.0
13	30.5	"	"	224	84	0.91h	341ab	.52c	16.3	120abc	7.7
14	46.0	"	"	224	84	5.27ef	193cde	.37c	16.7	116c	7.7
15	61.0	"	"	224	84	7.41bcd	299abc	.72bc	16.3	111cd	8.1
16	30.5	183[3]		101	67	8.69ab	274bc	1.58a	17.2	112cd	7.8

[1] The most recently full-grown leaves from 12-mo-old plants; dry-basis (whole leaf).

[2] Means followed by one or more letters in common do not differ significantly at the 5% level by Duncan's multiple range test.

[3] Control: the double rows is the standard method of pineapple planting, but Cabezona is still planted in single rows.

TABLE 3.—*The effects of spacing and N-K_2O fertilizer on leaf nutrient content of Cabezona pineapple grown on a Mariana gravely clay loam*

No	Treatment Spacing between:			Fertilizer levels		Level of indicated nutrient on:						
						4.5-mo-old-plants[1]		12-mo-old plants				
	Plants	Rows	Beds	N	K_2O	N	K	N	P	K	Ca	Mg
	cm	*cm*	*cm*	*kg/ha*	*kg/ha*	%	%	%	%	%	%	%
1	30.5	61	132	224	168	1.24d[2]	2.79bcd	1.45cde	.18bcd	2.45cde	.33ab	.41bc
2	46.0	"	"	224	168	1.46abcd	2.98abc	1.51cde	.25abc	2.74abcd	.28b	.37c
3	61.0	"	"	224	168	1.63a	2.97abc	1.68bc	.22abcd	3.03ab	.38a	.50a
4	30.5	"	"	336	168	1.52abc	2.86bcd	1.57c	.20abcd	2.27de	.33ab	.40bc
5	46.0	"	"	336	168	1.53ab	2.81bcd	1.93a	.26ab	2.72abcd	.32ab	.46ab
6	61.0	"	"	336	168	1.55ab	2.86bcd	1.87ab	.17abcd	2.66abcd	.34ab	.46ab
7	30.5	"	"	112	168	1.28cd	2.82bcd	1.31e	.26a	2.56bcde	.33ab	.41bc
8	46.0	"	"	112	168	1.39abcd	2.88bcd	1.33de	.20abcd	2.11e	.38a	.43abc
9	61.0	"	"	112	168	1.45abcd	2.95bc	1.57cd	.20abcd	3.04ab	.34ab	.46ab
10	30.5	"	"	224	252	1.35bcd	2.88bcd	1.48cde	.19abcd	2.84abc	.33ab	.39bc
11	46.0	"	"	224	252	1.48abcd	3.10ab	1.53cde	.25abc	2.91abc	.28ab	.37bc
12	61.0	"	"	224	252	1.47abcd	3.27a	1.62c	.24abc	3.14a	.26b	.39bc
13	30.5	"	"	224	84	1.38abcd	2.56d	1.52cde	.15d	2.06e	.38a	.45abc
14	46.0	"	"	224	84	1.62a	2.67cd	1.57c	.23abc	2.57bcde	.38a	.45abc
15	61.0	"	"	224	84	1.47abcd	2.82bcd	1.67bc	.20abcd	2.50bcde	.34ab	.40bc
16	30.5	183[3]		101	67	1.34bcd	2.82bcd	1.47cde	.20abcd	2.63abcd	.29ab	.40bc

[1] From the most recently full-grown leaves, dry-basis (whole leaf).

[2] Means followed by one or more letters in common do not differ significantly at the 5% level by Duncan's multiple range test.

[3] Control: the double rows is the standard method of pineapple planting, but Cabezona is still planted in single row.

nents. The general mean values were 1.57% N, 0.21% P, 2.64% K, 0.33% Ca and 0.42% Mg. Nevertheless, the authors cannot say whether the growth or fruit yield had been adversely affected, because there was no reference point available of the best nutrient indices for the Cabezona pineapple.

On the north coast of Puerto Rico, the leaf nutrient levels for the Red Spanish cultivar considered to be appropriate for good crops are the following: 1.5–2.0% N, 0.1–0.2% P, not less than 3.0% K, 0.3% Ca, and not less than 0.22% Mg. Since there were no significant differences in the mean weight of the D-leaf, it is suggested that the nutrient levels were not limiting the growth of the experimental plants. Thus, the information compiled in table 3 will serve as a reference point for further agronomic studies with Cabezona pineapple.

FRUIT QUALITY CHARACTERISTICS

None of the treatment differentials showed a significant effect upon the total acidity, total solids in solution or pH of the juice of half mature fruits (¼ yellow). The mean values were total acidity, 391 mg (expressed as mg of citric acid per 100 ml of juice), Brix 11.73; and pH, 3.90. Similar results were obtained with the Red Spanish pineapple (6).

Wee (21) observed an increase in total acidity as plant density increased. He suggests that the shading effect under dense growing could be involved. Montenegro (9) also reports that nitrogen increments reduced the sugar (Brix) and the acidity of the juice in Pearl pineapple, grown in Piracicaba, Brazil. On the other hand, potash fertilizer increased ° Brix and acidity.

The authors have found no published data on juice quality characteristics of the Cabezona pineapple to compare with the mean values obtained in this trial. Nevertheless, Cabezona juice quality is very different from that of the Red Spanish and Smooth Cayenne varieties grown in the Oxisols of the northern coastal plains of Puerto Rico (6, 7).

The experimental results show that the double row system of planting will be a better agronomic practice for the Cabezona growers under Lajas conditions. The 46, 61 and 132 cm spacings of plants, rows, and double rows, respectively (22,500 plants/ha), with 336 kg N and 252 kg K_2O/ha, was the best combination from the point of view of the number of large fruits produced per unit area. Nevertheless, further studies along this line of research should be performed with Cabezona pineapple in the Lajas area or in other areas where eventually the Cabezona cultivar may be grown.

RESUMEN

Con el fin de estudiar el efecto del sistema de siembra y los incrementos de los abonos nitrogenados y potásicos sobre la producción de

piña Cabezona, se realizó una prueba en un suelo Mariana, típico de la zona piñera de Lajas. Se compararon tres densidades de siembra (30.5, 46 y 61 cm entre plantas en la hilera, 61 cm entre hileras y 132 cm entre cada par de hileras dobles; tres niveles de nitrógeno (112, 224 y 336 kg N/ha) y tres niveles de potasa (84, 168 y 252 kg K_2O/ha).

Las 15 combinaciones mencionadas en las tablas se compararon con el sistema de siembra de piña Cabezona en escala comercial (hileras sencillas con las plantas espaciadas 30.5 cm en la hilera y 183 cm entre hileras), que son las que reciben nitrógeno y potasa a razón de 101 y 67 kg/ha, respectivamente.

Se tomaron muestras de la hoja "D" a los 12 meses después de la siembra. También se tomaron datos de la producción de frutas, material de propagación y valores de calidad del jugo de la fruta (grados Brix, pH y acidez total).

Los resultados fueron los siguientes:

La producción de fruta aumentó significativamente con la densidad y la cantidad de abono. El valor máximo de producción, 88.41 tons/ha, correspondió a las distancias de 30.5, 46 y 132 cm entre plantas, hileras e hileras dobles, respectivamente; a cuyas plantas se les aplicó nitrógeno y potasa a razón de 224 y 252 kg/ha, respectivamente.

En cuanto al peso de la fruta, los valores medios fueron 2.9, 3.4, y 3.9 kg, que correspondieron respectivamente a las distancias de 30.5, 46 y 61 cm entre plantas en la hilera. El mayor número de fruta por área unitaria del tamaño preferido para el mercado en fresco de piña Cabezona (no menos de 3.6 kg), se logró con plantas sembradas a 46 × 61 × 132 × cm entre plantas, hileras e hileras dobles, respectivamente, las cuales recibieron 336 kg N y 168 kg K_2O/ha.

La producción de hijuelos fue afectada por los tratamientos. Los valores medios fluctuaron entre 2.7 y 8.7 hijuelos por planta. A mayor distancia de siembra mayor el número y el peso de los hijuelos por planta.

Los tratamientos estudiados no afectaron en una forma significativa las características de calidad. Los valores medios fueron grados Brix 11.73, pH 3.90, y acidez total 391 mg/100 ml de jugo.

Los resultados del ensayo demuestran que los productores de piña Cabezona pueden mejorar sus rendimientos mediante la adopción del sistema de siembra de la doble hilera, combinando apropiadamente las distancias de siembra con los fertilizantes.

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