CARIBBEAN FOOD CROPS SOCIETY

42

Forty Second
Annual Meeting 2006

Carolina, Puerto Rico

Vol. XLII – Number 2

PROCEEDINGS

OF THE

42th ANNUAL MEETING

Caribbean Food Crops Society
42th Annual Meeting

July 9 – 15, 2006

Intercontinental Hotel
Carolina, Puerto Rico

"Food Safety and Value Added Production and Marketing in Tropical Crops"

Edited
by
Héctor L. Santiago and Wanda I. Lugo

Published by the Caribbean Food Crops Society

New fertigation recommendations for cassava in a non-traditional production system

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) is well adapted to low fertility soils and tolerates long periods of low soil moisture. Although the area dedicated to cassava production has decreased dramatically in recent years, it is still traditionally planted in the central mountainous regions and in well-drained Oxisols in the northwestern part of Puerto Rico. As with other root crops, there is an increasing tendency to switch production to the southern semiarid coast of Puerto Rico. In this region soils are fertile with high cation exchange capacity, rainfall is low, and farmers commonly utilize microirrigation and fertigation for crop production. Fertilizer recommendations for Cassava production are based on studies conducted decades ago in low pH, low fertility Ultisols without microirrigation. A cassava fertilizer-production trial (cultivar 'Serrallés') was established at the Lajas Agricultural Experiment Substation during 2002 in a Fraternidad clay (Typic Haplusterts). The conventional recommended fertilization rate (275-50-250-60 kg/ha of N, P_2O_5, K_2O, and MgO, respectively) was compared with the same rate via fertigation. Three additional fertigation rates were tested which were a reduced N treatment (100-50-250 kg/ha, N, P_2O_5, K_2O), reduced K treatment (100-50-125 kg/ha, N, P_2O_5, K_2O), and no K (100-50-0 kg/ha, N, P_2O_5, K_2O). Magnesium application was eliminated because of the high-soil test value observed in this soil. Fertigations were performed monthly with urea, phosphoric acid, and potassium chloride as the N, P, and K sources, respectively, whereas the conventional treatment was split applied at four and six months after planting. Mean total yields, average root weight, and number of roots/ha obtained seven months after planting were 7,229 kg/ha, 0.17 kg/root, and 42,929 roots/ha, respectively. There were significant differences among treatments. Reduced fertilizer applications can be recommended for cassava produced in these soils.

Key words: Cassava, Fertigation, Fertilization

RESUMEN

El cultivo de yuca (*Manihot esculenta* Crantz) está bien adaptado a condiciones de baja fertilidad y tolera periodos largos de baja humedad en el suelo. Aunque el área dedicada a la producción de yuca se ha reducido dramáticamente en años recientes, tradicionalmente se sigue sembrando en la región montañosa central y en Oxisoles de buen drenaje de la parte noroeste de Puerto Rico. Al igual que con otras raíces y tubérculos se ha observado una tendencia de mover su producción a la región

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semiárida del sur de Puerto Rico. En esta región los suelos son fértiles con una alta capacidad de intercambio catiónico, la precipitación pluvial es baja y comúnmente los agricultores utilizan microriego y fertigación. Las recomendaciones de fertilización para yuca están basadas en estudios realizadas décadas atrás en Ultisoles con baja fertilidad y pH, y sin microriego. Se estableció un experimento de fertilización en yuca (cultivar 'Serrallés') en la Subestación Experimental Agrícola de Lajas durante el 2002 en un suelo Fraternidad arcilloso (Typic Haplusterts). La cantidad de fertilización recomendada (275-50-250-60 kg/ha de N, P_2O_5, K_2O, and MgO, respectivamente) se comparó con la misma cantidad vía fertigación. Se probaron tres dosis de fertigación adicionales, las cuales eran un tratamiento reducido de N (100-50-250 kg/ha, N, P_2O_5, K_2O), un tratamiento reducido de K (100-50-125 kg/ha, N, P_2O_5, K_2O) y uno de ningún K (100-50-0 kg/ha, N, P_2O_5, K_2O). Las aplicaciones de magnesio se eliminaron debido al alto contenido de este elemento en estos suelos. Las fertigaciones se realizaron mensualmente usando urea, ácido fosfórico y cloruro de potasio como las fuentes de N, P y K, respectivamente. El tratamiento convencional fue dividido en aplicaciones a los dos y cuatro meses después de la siembra. El rendimiento total, peso promedio de raíces y el número de raíces/ha obtenido a los siete meses después de la siembra fue 7,229 kg/ha, 0.17 kg/raíz, y 42,929 raíces/ha, respectivamente. No se detectaron diferencias significativas entre tratamientos. Se puede recomendar aplicaciones reducidas de fertilizantes en esos suelos.

INTRODUCTION

Cassava (*Manihot esculenta* Crantz) is well adapted to low fertility soils and tolerates long periods of low soil moisture. Although the area dedicated to cassava production has decreased dramatically in recent years, the crop is still traditionally planted in the central mountainous regions and in well-drained Oxisols in the northwestern part of Puerto Rico (Badillo, 1984; Badillo-Feliciano and Lugo-López, 1975). Fertilizer recommendations for cassava production are based on studies conducted in low pH, low fertility Ultisols under rainfed conditions or supplemental sprinkler irrigation. Irizarry and Rivera (1983) reported a nutrient uptake of 204-12-222-86-33 kg/ha for N, P, K, Ca, and Mg, respectively, for cultivar 'Llanera' harvested at 10 months after planting on a Corozal clay. They recommended a fertilization rate of 272-32-249-50 (kg/ha de N, P_2O_5, K_2O, and MgO, respectively), assuming nutrient losses of 50, 20, and 25% for N, P_2O_5, K_2O and MgO, respectively. This recommendation was made, even though no significant difference was detected in yields when comparing 0, 500, and 1000 kg/ha of 10-5-20-3 split applied at one and four months after planting. Cultivar 'Serrallés' yielded 6,903 kg/ha and 4,931 kg/ha of marketable roots in a Coto and Corozal clay, respectively. Marketable yield tended to be larger when cassava was harvested nine months after planting, but no significant differences were detected when compared with cassava harvested seven and 11 months after planting (González-Vélez and Cardona, 2002). In a cassava variety trial conducted at Corozal 'Serrallés' fertilized with 1,000 kg/ha of 15-2.2-12.4-3 applied one and four months after planting and harvested 12 months after planting yielded 22,225 kg/ha. The highest yield was produced by the cultivar CM 3380 with 41,238 kg/ha (Goenaga et al., 2002). In a tillage experiment conducted at Lajas, 'Serrallés' cultivar was submitted to four tillage treatments and three

conventional fertilizer rates (0, X, and 2X recommended rate). In that experiment total yield obtained nine months after planting was 20,040 kg/ha for the conventional tillage treatment whereas the no-till treatment produced a total yield of 6,780 kg/ha (Lugo-Mercado et al., 1992).

An increasing tendency of producing cassava in the southern semiarid coast of Puerto Rico is observed. In this region, soils are fertile with high cation exchange capacity and low rainfall, and farmers commonly utilize microirrigation and fertigation for crop production. No fertilization rate study has been done under such conditions. The hypothesis tested in this study is that reduced fertilizer levels can be recommended for cassava grown under semiarid conditions where the use of fertigation reduces nutrient losses compared with conventional fertilization, with no yield reductions.

MATERIALS AND METHODS

The study was conducted at the Lajas Agricultural Experiment Substation of the University of Puerto Rico (18 02'N and 67 04' W). The soil at the experimental site is classified as Fraternidad clay, (fine, smectitic, isohyperthermic, Typic Haplusterts) (Beinroth et al., 2003). Soil and climatic conditions registered during the trial are in Tables 1 and 2.

The soil was plowed and disked twice. Cassava stems (cultivar 'Serrallés') were planted on 11 February 2002 on 1 m wide beds. Stem cuttings were spaced 0.76 m apart and 1.83 m among rows. The experimental plots consisted of three rows 7.62 m long. To ensure adequate soil water content in the field, a drip irrigation system consisting of 5.08 cm polyethylene sub-mains and drip laterals with drippers spaced 20 cm apart was installed.

The experiment consisted of five fertilization rates arranged in a randomized complete block design with four replications. The conventional recommended fertilization rate (275-50-250-60 kg/ha of N, P_2O_5, K_2O, and MgO, respectively) applied as granular fertilizer was compared with the same rate applied via fertigation (Estación Experimental Agrícola, 1997). Three additional fertigation rates were tested; a reduced N treatment (100-50-250 kg/ha, N-P_2O_5-K_2O), reduced K treatment (100-50-125 kg/ha, N-P_2O_5-K_2O), and no K (100-50-0 kg/ha, N-P_2O_5-K_2O). Magnesium application was eliminated on the later treatments due to high-soil test value observed in these soils (Table 2). Fifty percent of conventional fertilizer was applied in bands two months after planting (11 April 2002) and the remaining 50% four months after planting (10 June 2002). Fertigations were performed monthly with urea, phosphoric acid, and potassium chloride as the N, P, and K sources, respectively (Table 3). Hand weeding was performed as needed. Variables measured were total yield (TY), total root number (TRN), and average root weight. Yield was determined in the middle row of the plot. The number of harvested plants per plot varied from five to 15 thus the number of harvested plants per plot was utilized as covariate to account for the variation caused on response variables. The data were analyzed with ANOVA and LSD for means separation (SAS Institute, 2002).

Table 1: Average climatic conditions registered during cassava growing season at Lajas, Puerto Rico.

Month 2002	Rain mm	Temperature, °C Maximum	Minimum	Solar Radiation $MJ/m^2/day$
February	23	30.5	16.1	20.45
March	68	31.6	17.2	20.68
April	171	30.5	18.8	20.04
May	55	31.1	20.5	20.20
June	70	32.7	21.6	19.60
July	33	33.8	20.5	20.05
August	134	33.3	21.6	20.52
September	71	32.7	21.1	19.08

Table 2: Soil test analysis at 15 cm depth for Fraternidad clay (Typic Haplusterts) measured at the experimental site at Lajas, Puerto Rico.

pH	organic matter %	Bray 1 mg/kg	K	Ca	Mg	CEC
			cmol/kg			
7.1	3.0	19	0.15	37.4	18.19	55.7

Table 3: Date of fertigation and percentage of total fertilizer for each treatment applied to cassava grown in a Vertisol under drip irrigation at Lajas, Puerto Rico, 2002.

Fertigation Date	Fertigation distribution, %
March 11	5
April 11	15
May 13	25
June 10	30
July 10	10
August 12	10
September 10	5

RESULTS AND DISCUSSION

Cassava was harvested on 10 September 2002. The number of plants harvested per plot was utilized as a covariate in the analysis of variance. The variation in harvested plants per plot (covariate) was not significant. No significant differences were detected for yield, average root weight, and number of roots per hectare among fertigation treatments (analysis not shown). Average yield produced by 'Serrallés' was 7,229 kg/ha (Table 4). These results agree with results reported by Lugo-Mercado et al. (1992) in the same soil, in which no significant differences were detected for cassava among fertilizer rates and tillage treatments. The total yield obtained herein was fairly larger than yield obtained by González-Vélez and Cardona (2002), but smaller than yield reported by Goenaga et al. (2002) both at Corozal, and lower than total yield reported for conventional tillage treatment at Lajas. It seems that 'Serrallés' has lower yields compared to other cultivars, such as CM 3311 or CM 3380. The average root number produced at Lajas in a Fraternidad clay was 42,929 roots/ha whereas Goenaga et al. (2002) reported 69,940 total roots/ha for the same cultivar harvested 12 month after planting at Corozal during 1998. The average total root number per plant was 5.5 at Lajas (Table 4). Gonzalez-Vélez and Cardona (2002) reported 2.8 and 1.5 marketable roots/plant for Isabela and Corozal, respectively.

Table 4: Effect of fertilization rates on roots per plant, root number, root average weight, and total yield of cassava (cultivar 'Serrallés') grown in a Vertisol under microirrigation at Lajas, Puerto Rico.

Fertilizer rate kg/ha of N-P_2O_5-K_2O-MgO	Roots per plant	Root number roots/ha	Root weight kg/root	Yield kg/ha
275-50-250-60 conventional	5.3	33,976	0.17	5,722
275-50-250-60 fertigation	5.7	46,870	0.15	7,352
100-50-250-0 fertigation	5.2	35,370	0.20	6,863
100-50-125-0 fertigation	5.2	42,688	0.16	6,594
100-50-0-0 fertigation	6.3	49,658	0.18	9,618
Mean	5.5	42,929	0.17	7,229

The application of the recommended fertilizer rate for cassava (275-50-250-60) did not increase cassava yield under drip irrigation conditions in the Lajas Valley region. The reduced N and P treatment (100-50-125-0 or 100-50-0-0) applied through fertigation produced as much as the recommended fertilizer rate, which has more than twice the amount of nutrients.

The lack of response for N and K applications and low yields observed on this soil could be caused by several factors. One possible explanation is that the cassava was harvested at seven months after planting. Another explanation could be that with the fertigation distribution used (Table 3), seventy five percent of fertilizer was applied though fertigation in the first four months after planting. In both situations, there was not enough time for the plant to respond to the nutrients applied. The application of fertilizers through the irrigation system reduces nutrient losses by volatilization or deep

percolation in cases of heavy rainfall. Cassava is a crop that tolerates dry conditions, but the use of drip irrigation enhances crop performance, maintains steady yields, and reduces the need for large application of fertilizers because of a more efficient application that reduces losses and confines nutrients close to the root zone. This could have contributed to plants being in active vegetative growth when harvested, without having accumulated sufficient biomass in the roots.

These results support the hypothesis that reduced nutrient applications can be recommended for cassava without jeopardizing productivity. A more detailed study is recommended by testing cassava response to fertigation rates, but should be done with a cultivar with higher yield potential than 'Serrallés'.

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