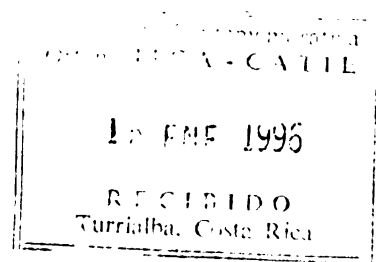


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**YIELD PERFORMANCE**  
**OF YAM BEAN (*Pachyrhizus erosus* (L.) Urban)**  
**AS A RESULT OF DIFFERENT PLANTING DISTANCES**

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## INTRODUCTION

Since 1989 CATIE has conducted a number of evaluation studies of the yield performance of different yam bean (*Pachyrhizus erosus* (L.) Urban) accessions. Large differences in yield between the different accessions tested have been recorded. The tuber yields obtained in the initial trials were quite low, i.e. below 10 t ha<sup>-1</sup>. This was primarily due the large planting distances used, 1-2 plants m<sup>-2</sup>; however, with a gradual increase in planting density, the tuber yield also increased (Morera, 1992; Mora and Morera, 1994).

The recommended planting distances vary considerably, depending on the length of the growth period, the tuberous root size desired, and the day length at the time of planting (Heredia Z., 1985; Sahadevan, 1987). In order to obtain yam bean tubers of marketable size in Mexico, Díaz A. (1978 & 1979) and Heredia Z. (1985) recommended to plant in double rows on ridges with a distance of 0.92 m between ridges, a distance between rows of 0.25 m, and placing a seed every 0.2 m within each row, i.e. 85 470 plants ha<sup>-1</sup> or 8.5 plants m<sup>-2</sup>. To obtain yam beans of a smaller size, so-called “small cone”, they recommend to plant on ridges 0.76 m apart with a distance between the rows of 0.2-0.25 m placing a seed every 0.15 m within rows, i.e. 135 364 plants ha<sup>-1</sup> or 13.5 plants m<sup>-2</sup>. In India the applied distances are usually 0.3-0.4 m between plants and 0.6-0.75 m between rows or ±42 300 plants ha<sup>-1</sup>. In the Philippines, the distance commonly used is 0.1 m between plants and 0.15-0.2 m between rows, 571 428 plants ha<sup>-1</sup>, although experiments in this country have shown that the production of tuberous roots doubled using a distance of 0.15 x 0.15 m, 444 444 plants ha<sup>-1</sup> (Kay, 1973). Like in other root and tuber crops, a maximum plant density must exist, above which yield may be large, but with reduced size and quality of the product. Hence, in order to determine the optimal plant density

without a reduction in root quality under local conditions in Costa Rica evaluations of different plant densities have been completed.

The purpose of the present investigation was to study and evaluate the yield performance quantitatively and qualitatively of three genotypes/accessions of yam bean (*P. erosus*) under three different planting distances.

## MATERIALS AND METHODS

The experiment was conducted at Cabiria, CATIE (Turrialba, Costa Rica). It consisted of evaluating the effect of three planting distances and three *P. erosus* accessions. A factor 3 squared experiment was laid out in a randomised plot design divided by three replications. The evaluated factors were as follows: accessions (3 levels) in the main plots and distances (3 levels) in the sub-plots. The following accessions were used: EC032 originally from Kantunil, State of Yucatan, Mexico; EC509 from San Juan, Province of Cartago, Costa Rica and EC534 from the State of Nayarit, Mexico. The distances used were 0.75 m between the ridges with double rows 0.25 m apart, and 0.1 m, 0.15 m and 0.2 m between plants. This resulted in planting densities of 266 667 plants ha<sup>-1</sup> at a distance of 0.1 m within row, 177 778 plants ha<sup>-1</sup> at 0.15 m, and 133 333 plants ha<sup>-1</sup> at a distance of 0.2 m.

At harvest the tuberous roots were classified in two groups according to size and weight: small sized with weights lower than 0.3 kg and medium sized for tuber weighing between 0.3-0.6 kg.

## RESULTS AND DISCUSSION

In accordance with the analysis of variance highly significant differences were found (1% level) between planting distances for the three variables and weight of tuberous roots of small size and for the total number of tuberous roots. Significant difference (5% level) was recorded between the three distances for the total weight of tubers as well as between accessions for the total number of tubers. Furthermore, significant difference was obtained for the interaction between accessions and distances in the variable number of tubers of small size and for the total number of tubers. Regarding the small tuber size, the accession with the highest average number of tubers was accession number EC032 (132 400 tubers ha<sup>-1</sup>) followed by accession number EC509 with a similar quantity (131 300 tuber ha<sup>-1</sup>); EC534 had a lower number of tubers per hectare, i.e. 117 900 ha<sup>-1</sup>, but the highest tuber yield (17.7t ha<sup>-1</sup>) although not significantly different from the two other accessions. For each accession, it was observed that the number of tubers and the fresh weight yield (t ha<sup>-1</sup>) increased with reduced distance, e.g. the accession number EC509 at the 0.1 m distance of between plants had the highest average number of tubers per hectare, i.e. 207 800 tubers ha<sup>-1</sup> (Fig. 1).

The average number of the medium sized tubers demonstrated that the accession EC534 was inferior in number of tubers per hectare and yield when compared to accessions EC509 and EC032, but the differences were not statistically significant. It was observed that accession EC032 had the highest number of medium sized tubers per hectare, but with a lower yield than accession EC509 (Fig. 2). Although the differences were not significant the highest tuber yields of accessions EC032 and EC534 were obtained at the planting distance of 0.15 m.

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Concerning the average total number of tuberous roots per hectare, regardless of planting distance, it was found that accessions EC032 and EC509 had a higher amount than accession EC534 surpassing this latter accession by 38 200 and 30 600 tubers ha<sup>-1</sup>, respectively (Fig. 3).

The averages total yields for all three accessions were very similar to the lowest value recorded, i.e. 27.9 t ha<sup>-1</sup> for accession EC534; the recorded yield of EC509 was 31.8 t ha<sup>-1</sup> a little higher than EC032 with 31.6 t ha<sup>-1</sup>. although this last accession had a higher number of tuberous roots; this indicates that the weight per tuber is higher in EC509. From these results, it can be concluded that accessions with equal fresh weight yield per hectare may vary considerably in tuber size; an important characteristic when breeding/selecting towards a specific ideotype. Similarly, as demonstrated for the small sized tubers, the tendency for the total number of tubers harvested per hectare there appear to be a decrease in the number of tubers produced when increasing the sowing distance (Fig. 3).

In Fig. 4 the recorded averages of small and medium sized tubers and total yields are compared with each sowing distance. The weight and number of tubers of small size were higher when decreasing the planting distance, demonstrating that the smaller the distance the greater the competition between plants thus resulting in higher quantities of small sized tubers. There are no significant differences for the medium sized tubers between planting distances, but the opposite tendency does exist, e.g. a lower number and a lower tuber weight as a result of a smaller planting distance. It can be concluded, as with the previous calculation, that the tubers grow and develop better at larger distances (lower plant density) due to reduced competition between plants. By comparing the total number of small sized tubers produced with the number

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of medium sized, it can be observed that the variation is high according to the three different distances, but the same situation does not apply to the yield, where the highest number of medium sized tubers were produced at the 0.2 m distance. There was a significant difference between planting distances with respect to total number of tubers produced. At the 0.1 m distance the total number of tubers produced is superior by 84 900 tubers when compared to the distance of 0.15 m and by 100 000 tubers when compared to the 0.2 m distance. The total yields do not show these significant differences between planting distances they do vary statistically between 0.1 m and 0.2 m (Fig. 4). In this Figure it is seen that the totals, both the number of tubers and the yields, are influenced primarily by the values of the small sized tuber variable. The variation in the total number of tubers is a function of the number of plants per hectare, as related to each sowing density. It can be expected that a higher plant density will result in a larger production of tuberous roots, considering that each *P. erosus* plant in general is mono-tuberous. However, at low plant densities the occasional multi-tuberous plant has been observed in the field, but usually these tubers are of a very irregular size and shape. As seen in tab. 1. the lowest plant density tested, 0.2 m or 133 333 plants ha<sup>-1</sup>, did not appear to be sufficiently low to induce the growth of multiple tubers as the number of tubers harvested in none of the plots exceeded the number of seeds sown. The number of tubers harvested in the plots with the lowest plant density (0.2 m) was closest to the original plant density, i.e. 83.3-96.7%. That the plots with the 0.15 m distance had the lowest harvest percentage in comparison with the originally plant density cannot be explained.

The high yields obtained at narrow planting distances (high plant density) are not necessarily the best alternative, because the yield size is a result of a high number of small sized

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tubers of no commercial value, as is demonstrated in the experiment with the high quantity of tubers weighing less than 200 g at the 0.1 m distance. Although the optimal commercial size of yam bean tuber is linked to the consumer preference and thus not clearly defined, the preferred size on the US-market according to Fukuda and Paull (1994) is 0.34-1.1 kg, however, in South East Asia the optimal tuber size is 0.15-0.5 kg “onion sized” (pers. observ.).

The number of small sized tubers per hectare and total number of tubers per hectare recorded is a result of the interaction between accessions and distances (Fig. 5). The variation in total number of tubers between the planting distances tested is different for each accession. Accordingly, the difference in performance between accessions varied as a result of the planting distance; this may well be a consequence of environmental and genetic variation between genotypic characters for shape and size of the tuberous roots. In Fig. 5 it is seen that in the case of total number of tuberous roots the interaction is due to the difference in the magnitude of the response to the planting distance. It is quite possible to identify accessions with the same total yield at any given plant density, but with a significant variation in the percentage of small sized tubers according to planting distance; therefore, it is important to clarify the optimal planting distance for each accession in order to obtain tubers of the commercially preferred size and quality.

The average weights per root of the three accessions and the three distances, respectively are shown in Figs. 6 and 7. The highest average value for both small and medium sized tubers (and total average weight per tuber) is accession EC534 (Fig. 6). However, this accession had the lowest total number of tuberous roots and yields (Fig. 3). Accession EC032,

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which had the highest total number of tubers, also had both the lowest weight per medium sized tuber and the total average weight per tuber.

It is probable that highest individual tuber weight may be obtained at the 0.2 m distance (133 333 plants ha<sup>-1</sup>); however, in this experiment the highest average weight per tuber was obtained at the 0.15 m distance (Fig. 7). There is no simple explanation of this effect; however, it is usual that the larger the distance between plants the higher the competition by weeds due to less and slower ground coverage by the crop, this obviously has a negative effects on the vegetative development of the plant including the tuberous roots.

### CONCLUSION

The existence of differences between accessions for the total production of tuberous roots was demonstrated. Also that interaction between accessions, planting distances and the resulting number of small sized tubers and total number of tubers exists. It may therefore be concluded that it is necessary to evaluate the optimal distance for each accession in order to obtain optimal tuber size and quality.

A negative correlation was found between planting distances and number and weight of both the small sized tubers and the total figures. The planting distance of 0.1 m (266 667 plants ha<sup>-1</sup>) does not appear optimal for any of the three accessions evaluated, because of the production of a high number of small sized tuberous roots and a relatively low average weight per tuber. It will thus be important in future experiments to evaluate the yield performance with a separation of tuber sizes as the accessions with similar weights may differ in number of small sized tubers. It is necessary to examine the capacity and/or characteristics of each genotype to



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produce small sized tubers at large planting distances/ low plant densities, i.e. irrespective of the influence of planting distance.

Further studies are needed using other genotypes, other planting distances in rows and different spacings between ridges; i.e. maintaining the same plant density and vary the distance between plants.

The future development of the yam bean in Costa Rica and other countries of the Central America will depend on the knowledge of the individual accessions available and of the total contribution of an appropriate agronomic management.

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Table 1.

Distance within row (cm)	Plant density (plants ha <sup>-1</sup> )	Accession EC032		Accession EC509		Accession EC534	
		Total no. tubers ha <sup>-1</sup>	% plants ha <sup>-1</sup>	Total no. tubers ha <sup>-1</sup>	% plants ha <sup>-1</sup>	Total no. tubers ha <sup>-1</sup>	% plants ha <sup>-1</sup>
10	266 667	245 600	92.1%	237 800	89.2%	183 300	68.7%
15	177 778	153 100	86.1%	140 200	78.9%	168 900	66.7%
20	133 333	128 900	96.7%	126 700	95.0%	118 500	83.3%

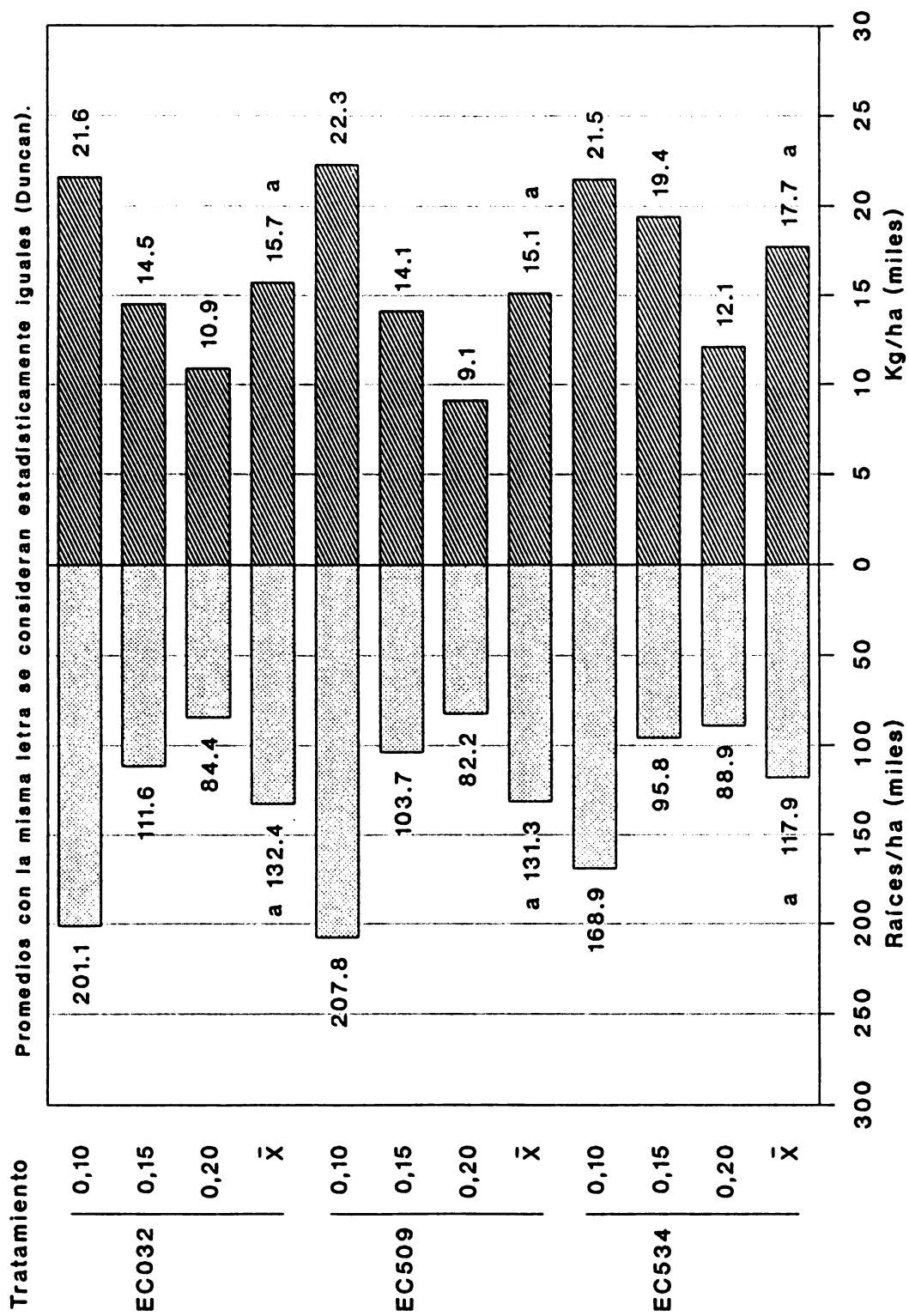


Figura 1. Rendimiento promedio para número y peso de raíces de tamaño pequeño de 3 introducciones de jícama y 3 distancias de siembra entre plantas. CATIE. 1995.

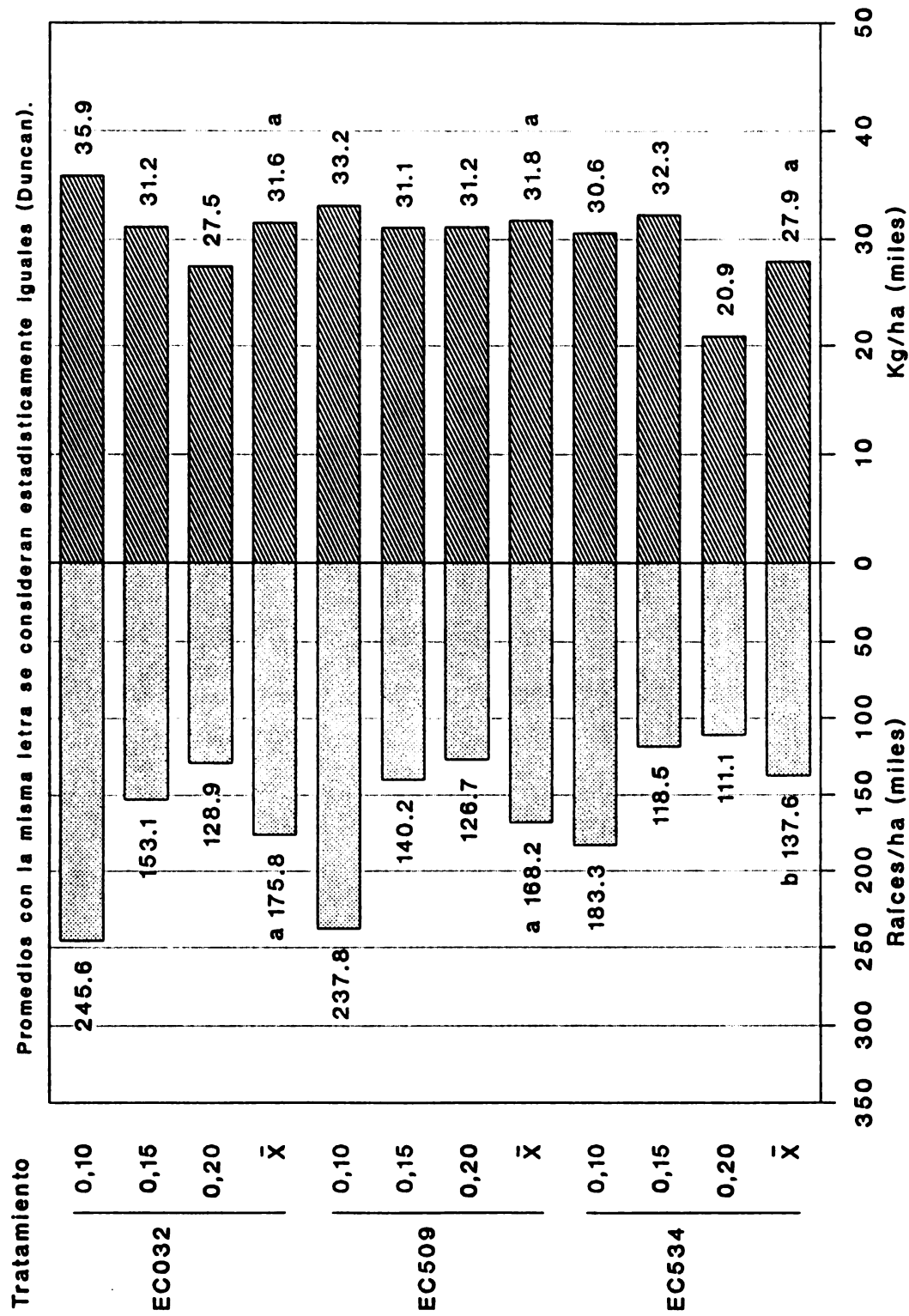


Figura 3. Rendimiento promedio para número y peso de raíces totales de 3 introducciones de jícama y 3 distancias de siembra entre plantas. CATIE. 1995.

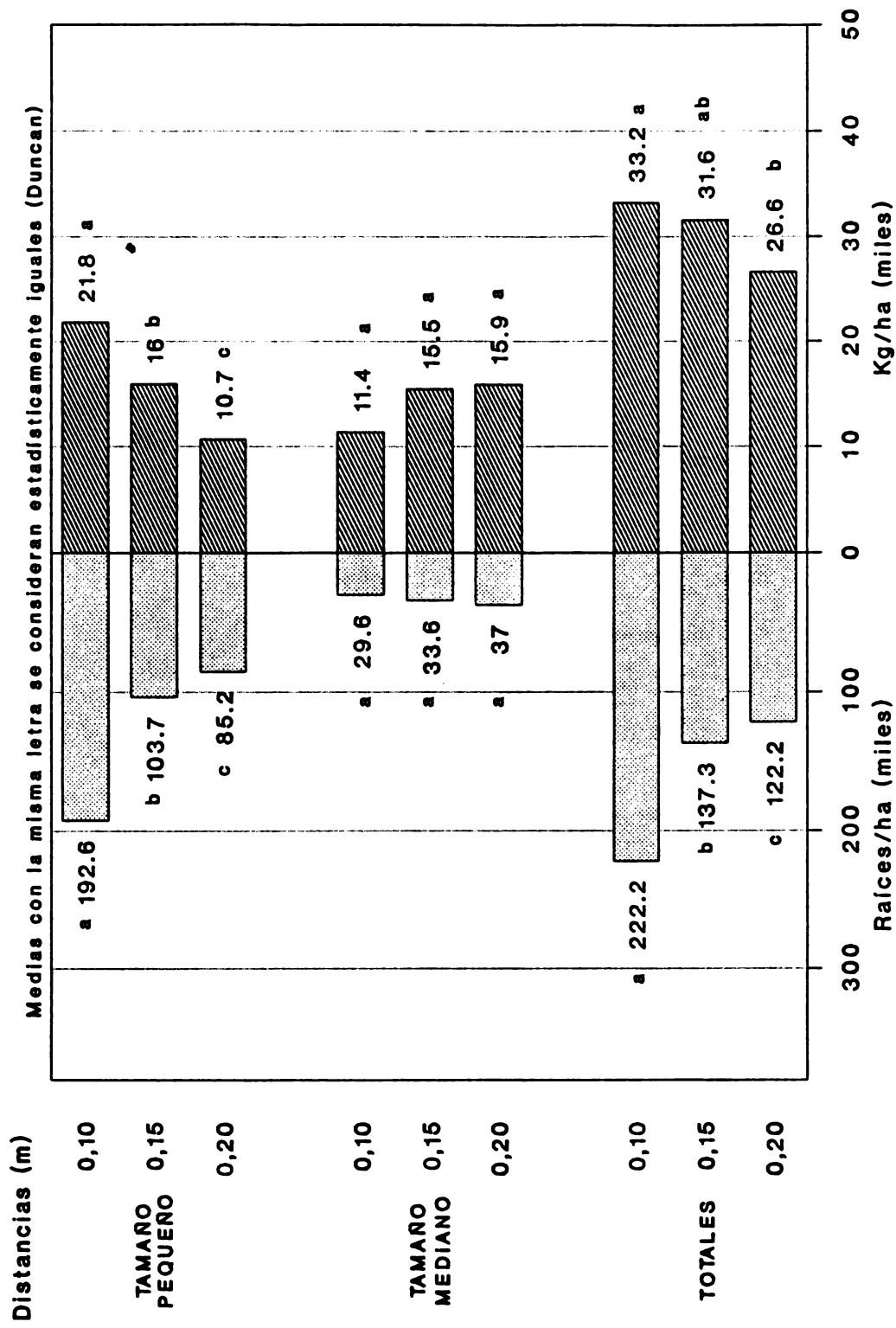
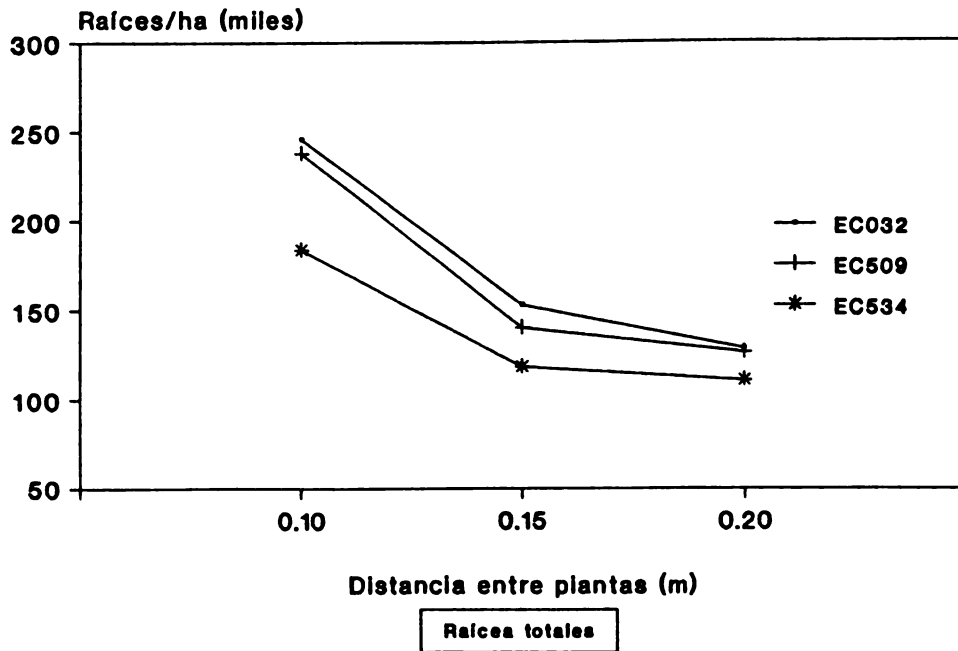
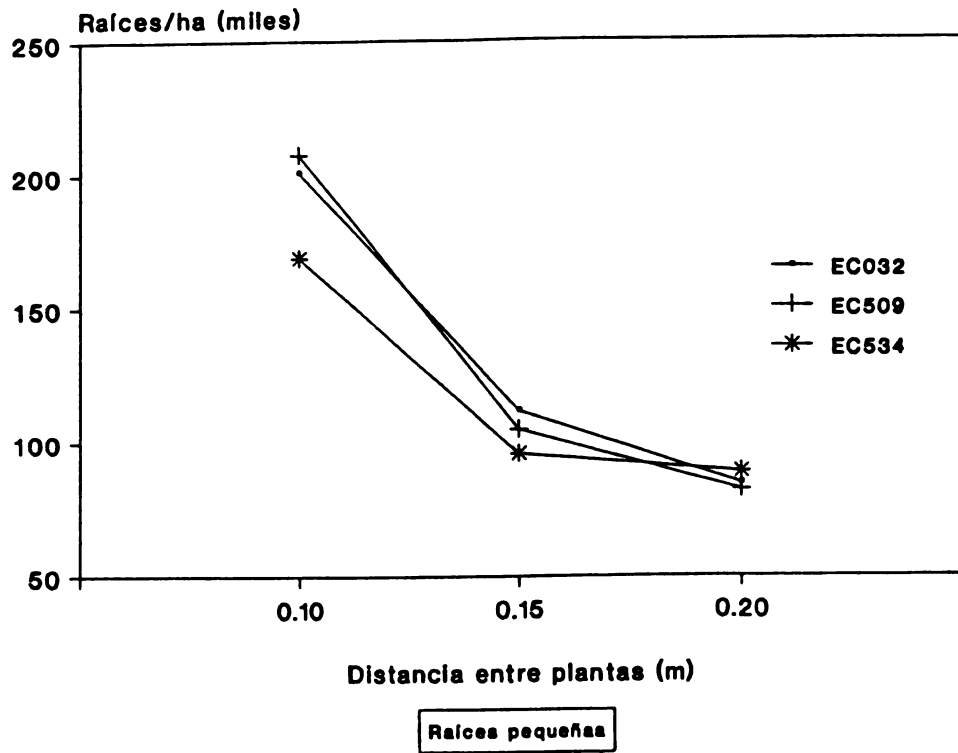


Figura 4. Promedio de rendimiento por tamaño de raíces y totales para las 3 distancias de siembra de jícama. CATIE. 1995.



**Figura 5. Efecto de la distancia de siembra sobre el número de raíces pequeñas y totales en 3 introducciones de jícama. CATIE. 1995.**

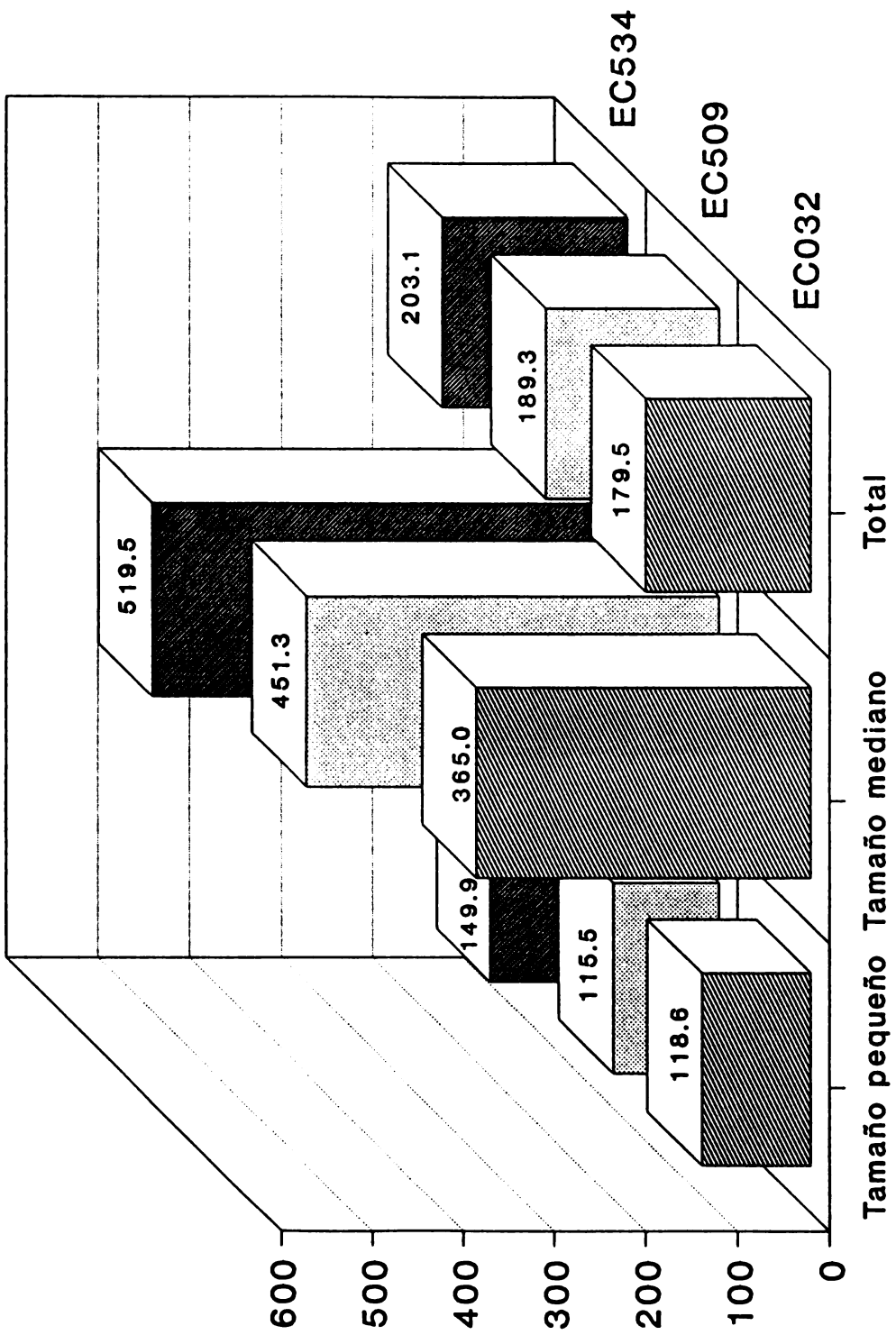


Figura 6. Peso promedio por raíz de 3 introducciones de jícama. CATIE. 1995.



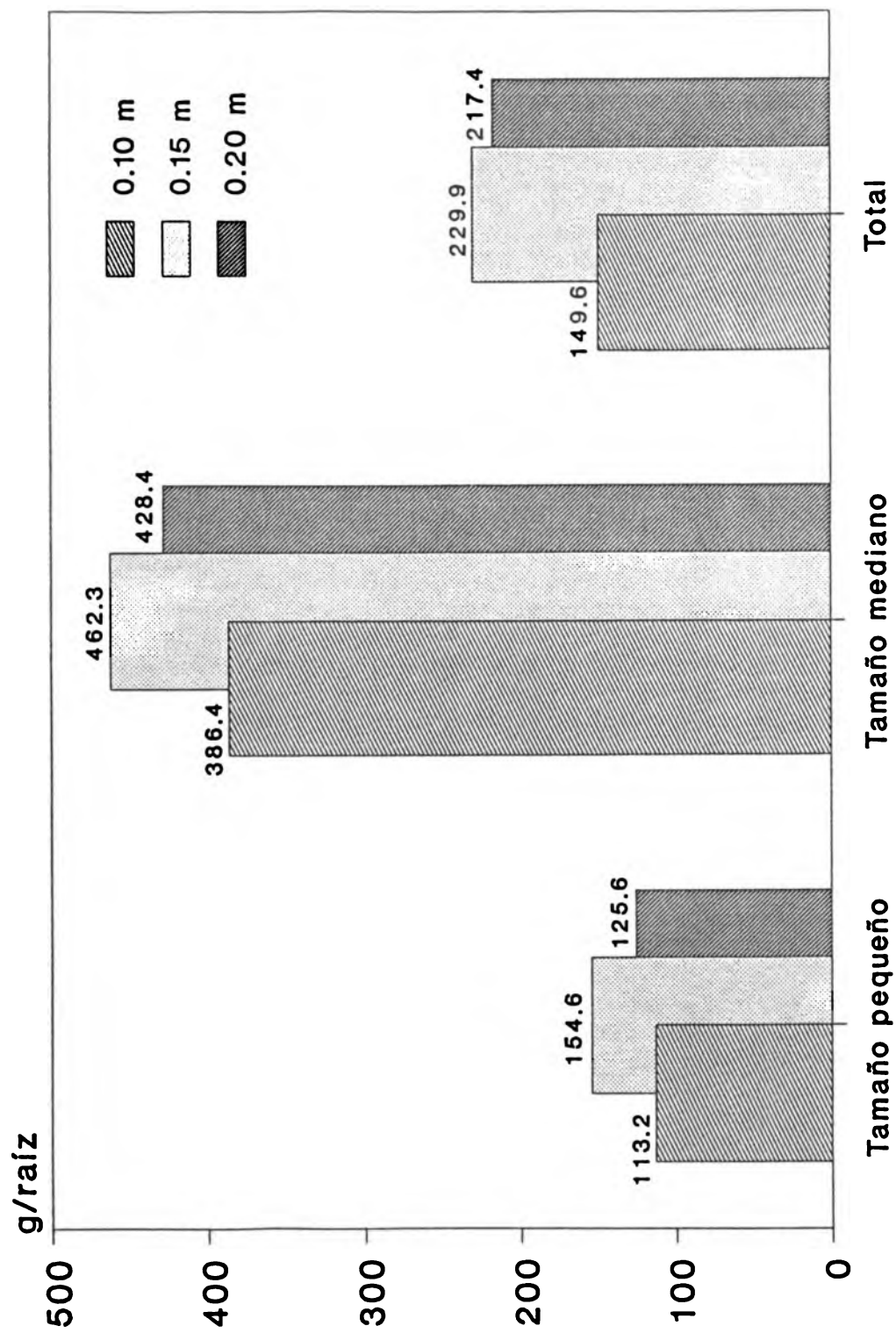


Figura 7. Peso promedio por raíz para las 3 distancias de siembra de jícama. CATIE. 1995.