THE NEW TECHNOLOGY FOR CASSAVA PRODUCTION *

Abelardo Castro-M. **

*Paper presented at a workshop on pre-release testing of agricultural technology, held at CIAT, on March 19-21, 1979.

**International Cooperation and Cultural Practices Specialist, CIAT Cassava Program.

THE NEW TECHNOLOGY FOR CASSAVA PRODUCTION *

Abelardo Castro-M. **

*Paper presented at a workshop on pre-release testing of agricultural technology, held at CIAT, on March 19-21, 1979.

**International Cooperation and Cultural Practices Specialist, CIAT Cassava Program.

THE NEW TECHNOLOGY FOR CASSAVA PRODUCTION

ABELARDO CASTRO MERINO

ABSTRACT

Cassava is a low priority crop in agricultural development policies in most Latin American countries, imparing active research, extension and policies in those countries.

However, the Cassava Research Program at CIAT has generated the low cost technology that can increase yields in most of Latin America.

This technology package consists of the visual selection of the planting material; chemical treatment (fungicides + insecticides + micronutrients) of the selected cuttings; proper management of cuttings - cut rectangularly at 20 cm, with 5 to 7 nodes, planted vertically at 10 cm depth, and reducing storage to a minimum; the use of high yielding adapted varieties.

Regarding soil management, plant on ridges on heavy textured soils with more than 1.200 mm rainfall per year. Avoid planting on wet soils.

Fertilize cassava when grown on Oxisols and Vertisols with half a ton of dolomitic lime, one ton/ha of 10-20-20 + 20S + 10 Zn complete fertilizer or similar. In other soils, fertilize to replace nutrients extracted in the final product.

Control weeds timely. Avoid use of insecticides and use varieties tolerant to pests. Plan the planting to avoid disease attack. Rotate or fallow to break pest cycles.

Mechanical aids to assist harvesting are available. Fresh root storage is possible. Techniques developed are being improved.

THE NEW TECHNOLOGY FOR CASSAVA PRODUCTION *

ABELARDO CASTRO MERINO **

INTRODUCTION

Cassava has consistently remained a low priority in agricultural development policies in most Latin American countries, imparing active research, extension and policies in those countries.

The establishment of cassava research programs at CIAT has generated the low cost technology that can substantially increase yields in much of Latin America.

A new technique must promise quite substantial increase in yield, or reduction in costs, to be acceptable to most farmers. Only the promise of quite large additional returns can overcome the wise conservatism of farmers in the light of yield risk and uncertainty.

Present practices for cassava production in Colombia and Latin America

Diaz and Pinstrup-A (1977) surveyed five cassava growing areas of Colombia. The agro-climatic characteristics and cultural practices used are summarized in Table 1. Prominent practices found are lack of stake selection and treatment, no herbicide use, high percentage of replanting,

---

* Paper presented at a workshop on pre-release testing of agricultural technology, held at CIAT, on March 19-21, 1979.

** International Cooperation and Cultural Practices Specialist, CIAT Cassava Program.

very few farmers plant on ridges, low yields with wide yield ranges per region and only Region II showing a high yield potential of more than 50 ton per ha. Regarding soil texture, the bulk of cassava (60%) is grown in medium textured soils.

Grouping the farmers in small, medium and large operators in each region, shows that yields are similar for all size of farmers, except in Region II where small growers produce about 50 percent the yield of the medium and large farmers. Characteristics of the planting material are similar for all size of farmer. Planting density is similar to all levels and regions, except Region V which uses a lower planting density (Table 2).

Regarding soil type grown to cassava, there is no difference between small, medium and large cassava growers (Table 3).

Personal communication with 37 Latin American Agronomists (January, 1979) in charge of research and extension in cassava production, representing eleven countries, suggests that the present average yield of about 12 ton/ha they report can be substantially increased by the use of improved cultural practices and new varieties.

Agro-climatic characteristics and agronomic practices reported are summarized in Table 4. A wide range of yields, rainfall and elevation above sea level are found. Planting on the flat is a predominant practice; planting density is extremely variable and lower for cassava in association than in monoculture. Soil fertility under cassava, as reported, is rather of medium and low than high fertility. Very few farmers use fertilizers, chemicals or machinery.

The new technology for cassava production

Increased agricultural production comes from new techniques or methods put into practice on farms. The technology of farming means the way it is done. The sources of new technology may be other farmers, other regions, research. Research is a careful and diligent search for the most productive methods now used by individual farmers, or purposeful experimentation to develop really new materials and practices that can make agriculture more productive (Mosher, 1966).

Soils and fertilizer requirements for cassava production

The farmer cannot change the soil he has available. The best he can do is to manage it properly to get maximum economic yield.

Both, the ability of cassava to yield well on acid, low phosphorus, vast infertile soils (Oxisols and Ultisols) of Latin America and its response to fertilizer is well documented (Fig.1, Fig.2, CIAT 1976, 1977, 1978; Howeler, 1978; Howeler and Cock, 1978). The low phosphorus content of these soils appears to be a main limiting factor for cassava production. Also, cassava extracts about 100 kg K_2O for each 25 tons of roots. The soil may become exhausted of potassium if cassava is grown continuously without adequate fertilization (Howeler, 1978).

a. In summary, for the acid, infertile, presently underutilized soils, fertilize with:

   - 500 kg/ha of dolomitic limestone
   - 1,000 kg/ha of complete fertilizer like 10-20-20 + 20 S + 10 Zn or similar. A residual effect of the fertilizer applied to second and possible third year is expected.

b. For other soils, apply nutrientes as removed in the final product (Table 5), not to increase yields but to maintain soil fertility and yield.

As a soil management practice, rotation with other crops is recommended to maintain soil fertility and to avoid the incidence of pest problems.

Regarding soil texture, cassava should not be planted on wet soils. If the soils are heavy textured and rainfall is greater than 1200 mm per year or there may exist water logging conditions at any stage during the growth cycle, plant on ridges and provide surface drainage channels. Planting on ridges together with other practices such as rotation, reduced root rotting from as high as 80 percent to practically zero level in the Caicedonia area of Colombia where rainfall is about 1200 mm per year and soils have deficient surface drainage (Oliveros et al,1975).

Effect of cassava residue on cassava yield

Cassava residue after two continuous cassava crop can reduce germination of cuttings up to 20 percent more as compared to the residue-free plots. Also, higher root rot incidence on the plots with residue can decrease yields up to 30 percent less as compared to the residue-free plots (Table 6, CIAT 1978).

It is recommended :

a. the use of crop following or rotation practices with gramineae, or,

b. elimiante the cassava plant residue.

Variety selection

Variety is the single most important factor of the new cassava technology. Varieties with low potential yield low (Fig. 3).

New cultivars should be tested continuously to identify those with better yield, quality and acceptance by a given community. To assure yield stability, the introduced varieties must be tested for three years before being recommended to farmers.

Management of planting material

a. Selection and treatment of cuttings.

It is necessary to plant good cassava seed in order to obtain high yields. In order to obtain good seed, the following factors should be considered (Lozano et al, 1977; Cock et al, 1978; CIAT, 1978).

1. Good *quality* seed comes from a variety with good germinating capacity. The part of the stem selected for the cutting should be of sufficient maturity (between 6 an 18 months old), have 5 to 7 nodes, measure at least 20 cm in length, and have a diameter of more than one half the maximum thickness of the stem of the variety planted.

   Cuttings from the lowest (oldest) part of the vigorous plants are not recommended.

   Obtain and use cuttings from the upper and middle part of vigorous varieties for higher yields (Table 7).

2. Care should be taken to prevent mechanical damage to the cuttings during their preparation, transportation and planting. The cuts should be even and transverse.

3. Propagating material should not be introduced from Africa mosaic-infected regions to clean areas
4. Propagating material should not be introduced from regions where there is cassava bacterial blight or superelongation. When these diseases are present in a region, sources of planting material should be taken only from those plantations that remain disease free during the rainy season. If there is no such material available, material free of bacterial blight should be produced and the cuttings treated with fungicides that will eradicate the causal agent of superelongation (Vitigran or Difolatan and Orthocide).
5. Cuttings should not be taken from plants that present symptoms of virosis or mycoplasmosis. All such plants should be rogued and burned.
6. All cuttings should be checked carefully a.d. any piece of stem that shows signs of localized pathogens (localized epidermal canker or pith rotting) and insect damage (galleries or tunnels, epidermal wounds) should be destroyed.
7. Cuttings should be treated with fungicides and insecticides (Table 8) as soon as they are cut from the plant and before storage. Storage should be reduced to a minimum. Whenever possible, use new, freshly cut stakes.
8. Major effects of stake treatment are:
   a) Desinfection
   b) Protection
   c) Increasing length of storage

d) Enhancing rate of germination, rooting and initial growth.

9. Cuttings should not be planted in soil infested with insects (white grubs, termites, cutworms) without applying insecticides around the cuttings or in the soil.

10. Planting should be done when the soil has a good moisture level and not during the drying season. Good agricultural practices should be used, preparing the soil well before planting.

11. If upon harvesting, there is a lack of uniformity in production and more than 5 percent root rot, cassava should be rotated with Gramineae for a period of no less than six months.

b. Depth of planting.

Stakes should be planted vertically. Buring them 10-20 or 30 cm deep, does not affect yield or harvest index (Cock et al, 1978). Due to ease of planting and harvesting, vertically planted cuttings should be buried 10 cm.

c. Length of cuttings.

Cuttings 20 cm long, when carefully selected and treated give higher yields than cuttings either 40 or 60 cm long (Table 9).

d. Cutting angle of the cuttings

Rectangular or slanted cutting of the cuttings does not affect yields, however, roots are more uniformily distributed in the rectangular cut cuttings suggesting that this system is best (CIAT, 1978).

e. Planting position.

Cuttings of ten varieties were planted vertically, inclined and horizontally at different dates. The germination of vertically planted

cuttings was always highest, the advantage being greatest when rainfall in the first 30 days was least (Table 10). In a trial taken to final yield germination was greatest in vertical treatments and yield was significantly increased (Table 11, CIAT, 1978).

The rate of emergence of shoots was greater in vertically and inclined than in horizontal planting (Fig. 4). Lodging is also less in vertical planting. Consequently, vertical planting is recommended.

From the above results it is recommended that well selected and treated cuttings, cut rectangularly at 20 cm long with 5 to 7 nodes, coming from the upper and middle part of one-year old vigorous plants should be vertically planted at 10 cm depth. Following these practices maximum yields can be obtained.

Storage of planting material

Cuttings should be used fresh and storage should be avoided. However, storage of cuttings is a normal practice among cassava growers. Under these conditions, heavy losses occur due to poor germination, rotting and slow initial plant vigor, because of:

a. Dehydration of the stake
b. Microbial or insect attack
c. Germination during storage which wastes available nutrients.

If planting material must be stored, dip-treatment with Malathion, Orthocide and Bavistin (Table 8b) is recommended.

For no storage, the cuttings can be treated with the formulation as shown in Table 8a, due to the lower cost.

Planting density

Different cultivars have different growth habits, and this is further affected by agro-climatic conditions. Growth affects total root yield and commercial root yield (Fig.5). According to final use, optimum planting density must be determined for each region, but should be from 10 to 15.000 plants per hectare.

Planting pattern

Root yield is not significantly affected by square (1 x 1 m) or rectangular (2 x 0.5 m) planting. Planting density and adapted cultivar are the important factors to assure high yield. This is an important factor to use the machinery available. Using wider row spacing may enable easier cultural control of weeds, allow easier harvesting of mixed crops and allow bands of uncultivated land to be left between rows thus enhancing erosion control (Fig. 6).

Weed control

The slow initial growth of cassava enhances weed competition, which may reduce root yield by 80 percent (Doll and Piedrahita, 1976).

Timely and properly distributed, manual weeding is recommended (Table 12). Chemical weed control immediately after planting, integrated with later manual weedings or additional chemical control, is an alternative where labor is scarce (Table 13).

Pest management

Cassava, being a long cycle crop (7 to 18 months) provides all the

alternatives to be attacked by pests. For the same reason, any chemical control would have to be repeated over and over again. Also, cassava has a tremendous ability to reduce growth rate under stress conditions, to recuperate and form new leaves and with time, to yield well. Consequently, do not spray to control pests.

Management of pests is by:

a. the use of resistant-tolerant cultivars
b. using clean, selected and treated planting material
c. by erradicating diseased plants or fields if necessary
d. planting late in the rainy season, to escape disease attacks

Certain insects like hornworm (Erinnyis ello) cannot be controlled by resistant varieties. Consequently, the use of biological control installing and releasing nest of the wasp, Polistes sp., Thricogramma sp., or by spraying with Dipel, which is the bacteria Bacillus Thuringiensis that attacks the worm without affecting the benefic fauna, is recommended

Harvesting

Harvesting is a back-breaking operation in cassava production. However, mechanical aids have been developed to assist labor. Two of these have been evaluated at CIAT with promising results. The data is shown in Table 14 (CIAT, 1978).

Cassava root storage

Cassava roots shelf life is very short. Within 48 hours after harvest, generally either physiological or microbial deterioration occurs. Extended shelf life to 20 or more days can be achieved by:

a. Leaving harvested roots attached to the stem. In this manner, they will deteriorate more slowly than those that have been detached.

b. Prunning. Root deterioration is reduced from almost 100 percent to less than 20 percent, depending on the variety (Fig.7, Lozano et al, 1978), when the plants are pruned 25 cm aboveground and the roots are left in the ground for up to 20 days, before harvesting.

c. Plant pruning plus dipping the roots in a fungicide mixture (Figure 8), further prevents rotting up to 20 days of storage.

d. Storage in bags. Fresh root can be preserved up to 20 days if dipped in a fungicide solution and stored in polyethylene-lined paper bags (Fig.8).

The technology on root storage at present shows cooking quality problems and an evaluation on toxicity due to the chemical treatment. These factors are being studied.

CONCLUSIONS

Yields can be more than double by use of new varieties, simple cultural practices, and low cost inputs, such as:

1. Visual selection of the planting material
2. Chemical treatment (Fungicides + insecticides + micronutrients) of the selected cuttings.
3. Proper management of the cuttings, cut rectangularly at 20 cm, with 5 to 7 nodes, planted vertically at 10 cm depth, and reducing storage to a minimum
4. Planting on ridges when soils are heavy textured and rainfall more than 1200 mm per year.
5. Timely weed control
6. Use of high yielding varieties, tolerant to pests.
7 If grown in the acid, infertile Ultisols and Oxisols, fertilizing with half a ton per hectare of dolomitic lime and one ton per hectare of 10-20-20 + 10 Zn + 20 S complete fertilizer or similar. In other soils, replace nutrients extracted in the final product.
8. Proper planting date to escape disease or insect attack.
9. Avoidance of insectice use
10. Harvesting can be mechanized
11. Fresh root storage techniques being developed increase shelf life significantly

LITERATURE CITED

1. CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL. 1977. Annual Report 1976, p B57 - B66.

2. CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL. 1978. Annual Report 1977, p. C53 - C61.

3. CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL. 1979. Annual Report 1978, (in press).

4. COCK, J.H., CASTRO, M.A., and TORO, J.C. 1978. Agronomic implications of mechanical harvesting. In Cassava harvesting and Processing. Proceedings, CIAT, Cali, Colombia. p 60-65.

5. DIAZ, R.O., and PINSTRUP-ANDERSON, Per. 1977. Descripción Agroeconómica del Proceso de Producción de Yuca en Colombia. Centro Internacional de Agricultura Tropical, CIAT, Cali, Apartado aéreo 67-13, Colombia.

6. DOLL, J.D. and PIEDRAHITA, W.C. 1976. Métodos de Control de Malezas en Yuca. Centro Internacional de Agricultura Tropical, Serie ES-21, 12p.

7. HOWELER, R.H. 1978. The Mineral Nutrition and Fertilization of Cassava. In: Cassava Production Course, Book I, Preliminary draft, CIAT, Cali, Colombia. p. 267-312.

8. HOWELER, R.H., and COCK, J.H. 1978. The Ability of Cassava to Grow on Poor Soils. In: Crop Tolerance to Suboptimal Land Conditions. American Society of Agronomy, Special Publication.

9. LOZANO, J.C., COCK? J.H., and CASTAÑO, J. 1978. Nuevos Avances en el Almacenamiento de Yuca. Fitopatología Colombiana, Vol. 7 (1): 2-14.

10. LOZANO, J.C., TORO, J.C., CASTRO, A., and BELLOTTI, A.C. 1977. Production of Cassava Planting Material. CIAT, Series GE-17. 28 p.

11. MOSHER, A.T. 1966. Getting Agriculture Moving. F.A. Praeger, Publishers. p. 191.

12. OLIVEROS, B., LOZANO, J.C. and BOOTH, R.H. 1975. A Phytophthora Root Rot of Cassava in Colombia. Plant Disease Reported 58 (8): 703 - 705.

Table 1. AGROCLIMATIC CHARACTERISTICS AND CULTURAL PRACTICES OF FIVE CASSAVA GROWING AREAS IN COLOMBIA (after Díaz and Pinstrup-A., 1977).

Characteristics and Practices	Regions I	II	III	IV	V
Temperature C°	22	22	26	27	30
Stake selection	No	No	No	No	No
Stake treatment	No	No	No	No	No
Planting density plants/ha	12.000	9.800	12.400	12.100	7.400
Replanting % of farmers	30%	42%	17%	46%	57%
Planting on ridges %	1.6%	14.1%	0%	1.8%	0%
Use of herbicides	No	No	No	No	No
No. of weeding per crop	1-4	1-6	1-5	1-7	1-7
Horizontal Planting	98.4	85.9	100.0	98.2	100.0
Yield ton/ha	4.7	11.6	3.0	6.3	4.0
Yield range ton/ha	0.1-15	0.5-52	0.5-15	0.4-18	0.3-10

Table 2. YIELD, STAKE CHARACTERISTICS AND PLANTING DENSITY IN FIVE CASSAVA GROWING AREAS OF COLOMBIA (after Díaz and Pinstrup-A., 1977).

Region	Size of Farmer	Yield Ton/ha	Stake Characteristics*		Plants/ha planted
I	Small	4.5	Age (days)**	18	11.600
	Medium	4.0	Length (cm)	17	12.800
	Large	5.7	Buds (No.)	10	10.000
II	Small	7.9	Age (days)	14	11.500
	Medium	12.8	Length (cm)	18	9.300
	Large	14.2	Buds (No.)	10	9.400
III	Small	2.8	Age (days)	12	13.300
	Medium	2.7	Length (cm)	18	11.900
	Large	3.5	Buds (No.)	10	11.900
IV	Small	5.9	Age (days)	14	12.100
	Medium	7.4	Length (cm)	19	12.900
	Large	5.7	Buds (No.)	10	11.600
V	Small	3.0	Age (days)	17	6.900
	Medium	4.2	Length (cm)	26	8.100
	Large	4.8	Buds (No.)	14	7.400
Average	Small	4.8	Age (days)	15	11.080
	Medium	6.2	Length (cm)	19	11.000
	Large	6.7	Buds (No.)	11	10.000

* For all size of farmers.

** From harvesting (cutting) to planting.

Table 3. SOIL TYPE GROWN TO CASSAVA BY SMALL, MEDIUM AND LARGE FARMERS IN COLOMBIA (after Díaz and Pinstrup-A.,).

	Size of farmer			
Soil texture	0.1 - 1.99 ha	2 - 9.99 ha	10 ha or more	TOTAL
		%		%
Clay	16	16	15	16
Loam	46	50	37	44
Silt	18	20	22	20
Sand	20	14	26	20

Table 4. CULTURAL PRACTICES IN CASSAVA PRODUCTION IN ELEVEN LATIN AMERICAN COUNTRIES - AVERAGE OF THIRTY SEVEN REPORTS (Castro, 1979, Personal Communication).

	VARIABLE	AVERAGE	RANGE
1.	a) Yield of the area represented - ton/ha	12	4.0 - 18
	b) Yield of the country total - ton/ha	11	7.0 - 31
2.	Rainfall - mm/year	1.629	540 - 4.475
2.	Elevation - mase	340	0 - 1.600
4.	Planting on the flat - %	69	-
5.	Planting on ridges - %	19	-
6.	Storage of stakes - days	34	7 - 150
7.	Germination on stakes - %	81	60 - 95
8.	Plants/ha (monoculture)	11.330	3.000 - 25.000
9.	Plants/ha (intercropping)	8.880	4.000 - 18.000
10.	Manual weeding - Number	2.6	1 - 5
11.	Planting position	Horizontal = 54%	Slanted= 40% Vertical = 5%

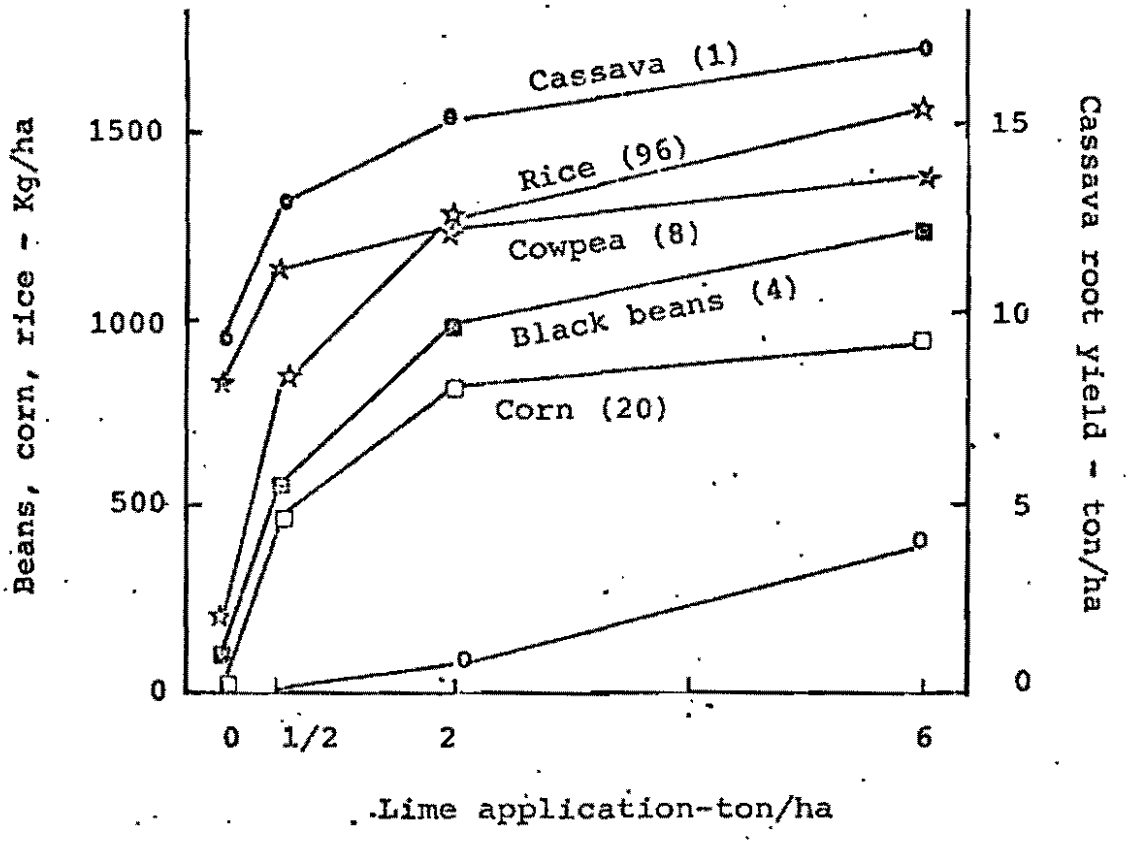


Figure 1.- The response of six food crops to the application of lime at Carimagua. Numbers in parenthesis indicate the number of cultivars tested.

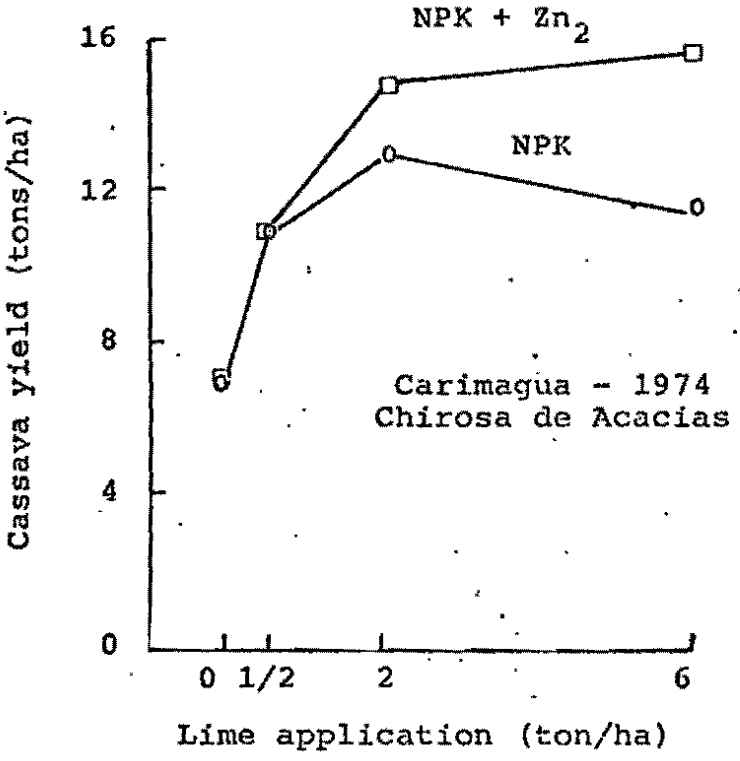


Figure 2.- Cassava response to liming, with and without the application of 20 kg Zn/ha at Carimagua.

Table 5. THE AMOUNT OF NUTRIENTS EXTRACTED PER TON OF HARVESTED CASSAVA ROOTS (after Howeler, 1978).

Plant Part	N	P	K	Ca	Mg
			kg/ton		
ROOTS					
Average	2.14	0.46	3.50	0.69	0.39
Range	0.7 - 6.85	0.19 - 0.77	1.60 - 5.08	0.36 - 1.00	0.05 - 1.08
TOTAL PLANT					
Average	6.95	1.26	6.67	2.87	0.99
Range	1.93 - 20.10	0.56 - 2.40	4.69 - 9.04	0.84 - 9.90	0.46 - 2.20

Table 6.- EFFECT OF PLANT RESIDUE FROM A PREVIOUS CASSAVA CROP ON GERMINATION, ROOT ROT AND YIELD UNDER CIAT'S CONDITIONS. (after Lozano. CIAT 1978).

Variety	Condition of the plots	Germination (%)	Root rot (%)	Yield (t/ha)	Yield reduction %
	residue-free*	84.4	2.1	27.5	
M Col 22					17.0
	with residues	73.4	3.5	22.8	
	residue -free	70.3	4.4	28.8	
CMC 84					32.0
	with residues	50.0	6.1	19.4	

* Residue-free was a plot in which cassava plant debris had been removed.

Fig. 3.- RESULTADOS DE 4 AÑOS (4 CICLOS) DE PRUEBAS REGIONALES EN 8 LUGARES DE COLOMBIA POR DEBAJO DE 1300 METROS DE ALTURA

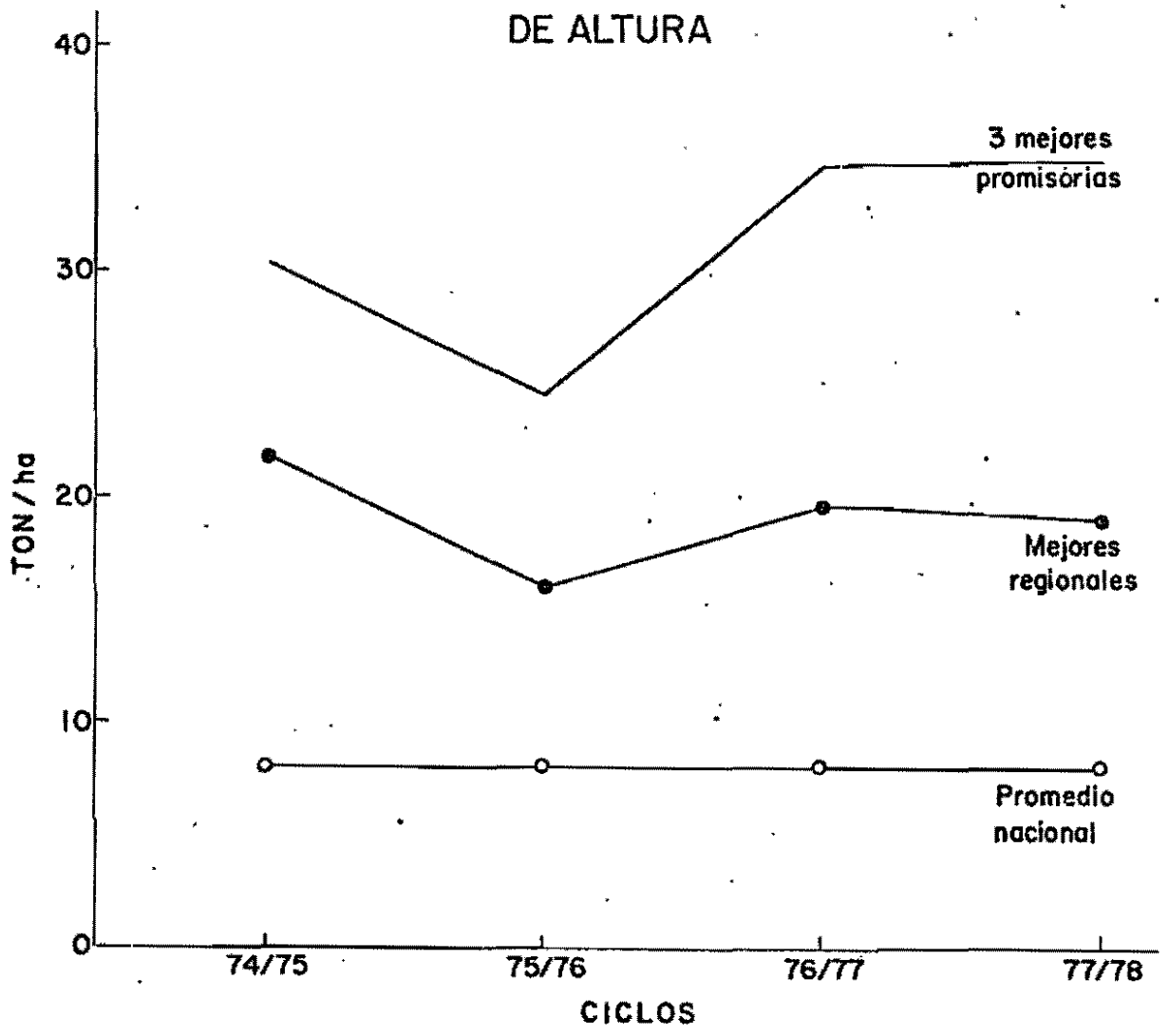


Table 7. EFFECT OF MATURITY OF STAKE ON YIELD, HARVEST INDEX AND GERMINATION OF CASSAVA. (CIAT, 1978).

Origin of stake	Fresh Roots Total	Fresh Roots Commercial	Harvest Index	Germination
	ton/ha			%
a) Variety M MEX 52, 1977				
Upper	18.5 a*	12.8 a	0.34 a	93.0
Middle	18.1 a	13.1 a	0.30 a	91.1
Lower	16.8 a	10.2 a	0.29 a	74.5
b) Variety M MEX 59, 1978				
Upper	17.4 a	12.0 a	0.35 a	93.6 b
Middle	11.8 b	6.2 b	0.26 b	96.9 a
Lower	12.5 b	6.4 b	0.26 b	98.5 a
c) Variety CMC 40, 1978				
Upper	28.8 a	26.3 a	0.49 a	100 a
Middle	31.5 a	27.9 a	0.50 a	100 a
Lower	26.4 b	22.5 b	0.44 a	100 a

* Means followed by the same letter are not significantly different at $P \leq 0.05$.

Table 8. COSTS OF TREATING CASSAVA CUTTINGS WITH CERTAIN PESTICIDES AND ZINC SULFATE

A) FOR SHORT TERM STORAGE

Product	Price/kg* US$	g/ha	Cost/ha* US$	Aggregate cost/ha
Dithane M-45	2.50	333.0	0.83	0.83
Manzate 80	2.50	187.5	0.47	1.30
Vitigran	1.85	300.0	0.56	1.86
Malathion E.C.	2.65	750.0	2.00	3.86
Zinc sulfate**	0.65	2.000.0	1.30	5.16
B) FOR LONG TERM STORAGE				
Orthocide 50	3.65	300	1.10	1.10
Bavistin 50	28.75	300	8.65	9.75
Malathion EC***	2.65	750	2.00	11.75

* Including 0.5 man-days.

** Use only when there is a deficiency of zinc.

*** Must be mixed with water before adding the fungicides.

Table 9.- EFFECT OF LENGTH OF STAKE ON ROOT YIELD AND HARVEST INDEX OF CASSAVA. CIAT, 1978.

Length of Stake	Root Yield		Germination	Harvest Index
	Total	Commercial		
cm	Ton/ha		%	
20	30.8 a	27.6 a	77.9 a	0.38 a
40	27.4 b	24.0 b	78.4 a	0.36 ab
60	27.5 b	23.9 b	77.0 a	0.34 b

Table 10. EFFECT OF PLANTING POSITION ON EMERGENCE OF CASSAVA (AVERAGE OF 10 VARIETIES). CIAT, 1978.

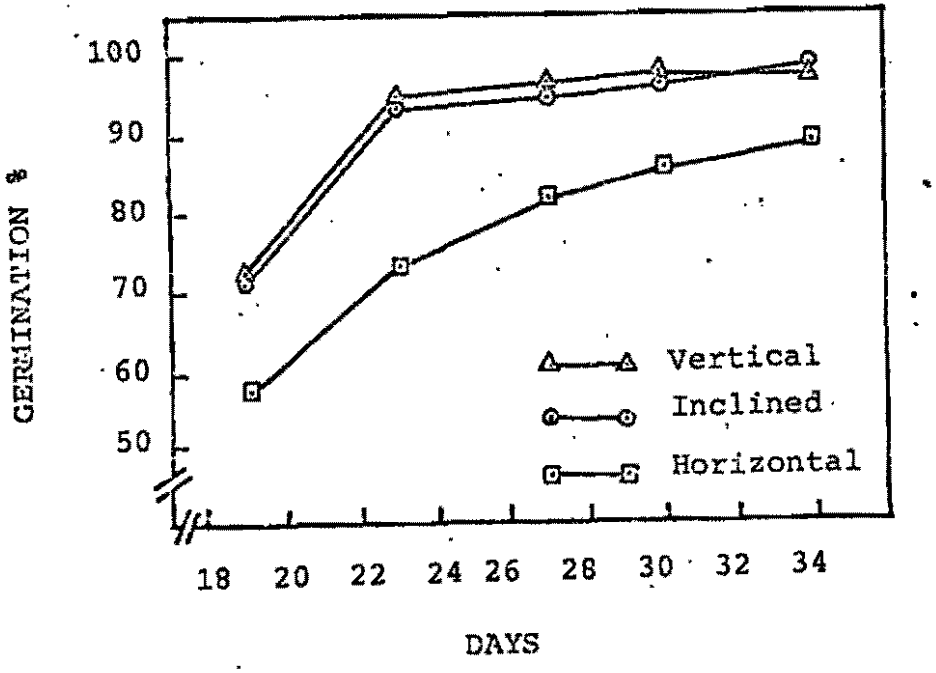
Planting date	Rainfall in first 30 days	Planting Position		
		Vertical	Inclined	Horizontal
		Emergence %		
March 29	215 mm	97.5	98.5	98.0
May 30	5 mm	100.0	100.0	91.5
July 29	25 mm	91.5	88.0	54.0
September 30	116 mm	99.0	96.0	95.0
	$\overline{X}$	97.0	95.6	84.6

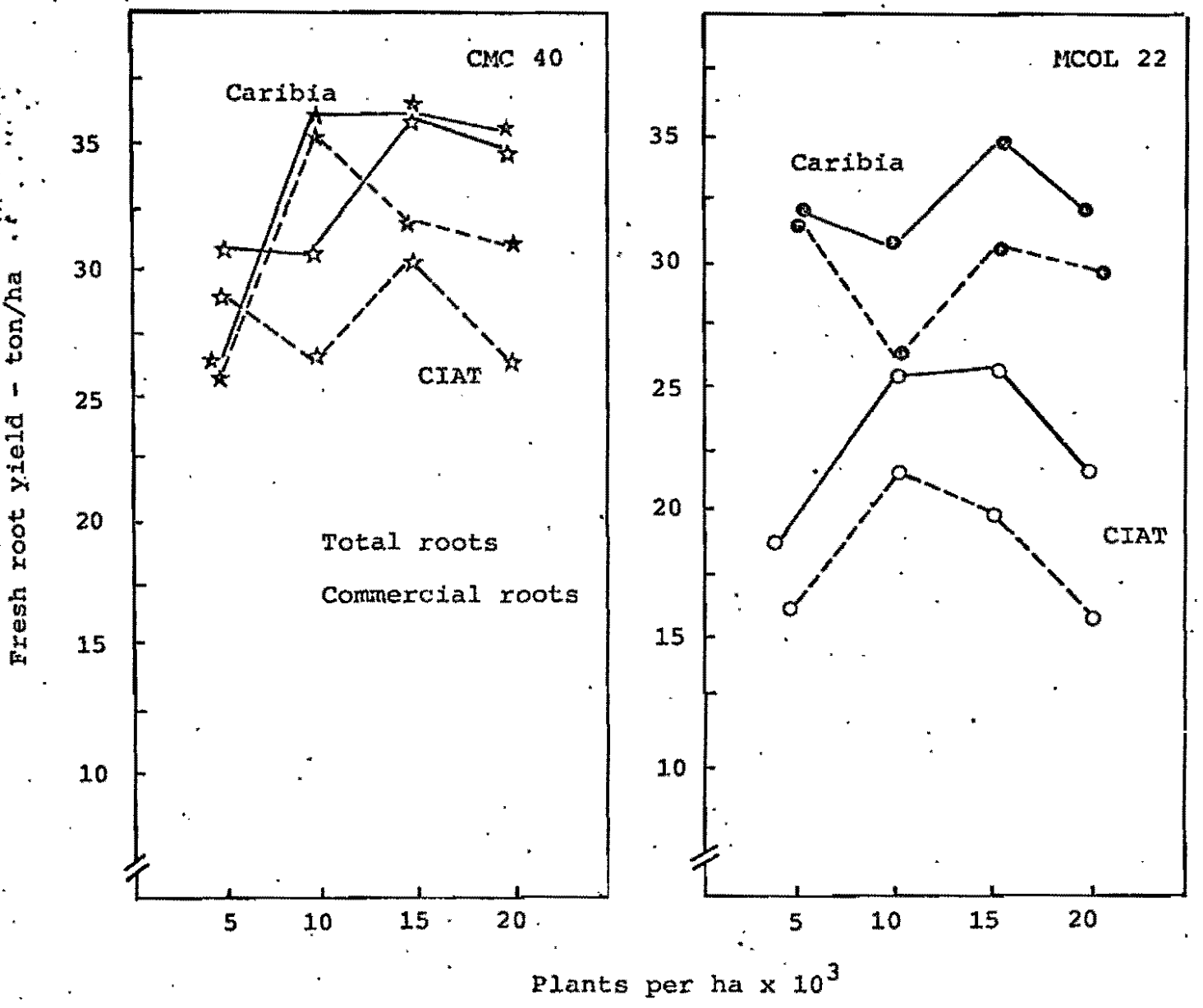
Table 11. EFFECT OF PLANTING POSITION ON ROOT YIELD AND HARVEST INDEX OF CASSAVA (AVERAGE OF TWO VARIETIES) CIAT, 1978.

Planting Position	Root Yield		Germination	Harvest Index
	Total	Commercial		
	Ton/ha		%	
Vertical	31.1 a*	27.4 a	89.2 a	0.36 a
Inclined	27.6 b	24.2 b	85.6 a	0.36 a
Horizontal	27.0 b	23.9 b	58.6 b	0.35 a

* Means within a column followed by the same letter are not significantly different ($P \leq 0.05$).

Figure 4.- Effect of planting position on germination and emergence rate of cassava. Average of 10 varieties and four planting seasons. CIAT, 1978.





Location	Temperature	Rainfall/year
Caribia	28°C	1.500 mm
CIAT	24°C	1.000 mm

Figure 5.- Effect of planting density and agro-climatic conditions on root yield of cassava.

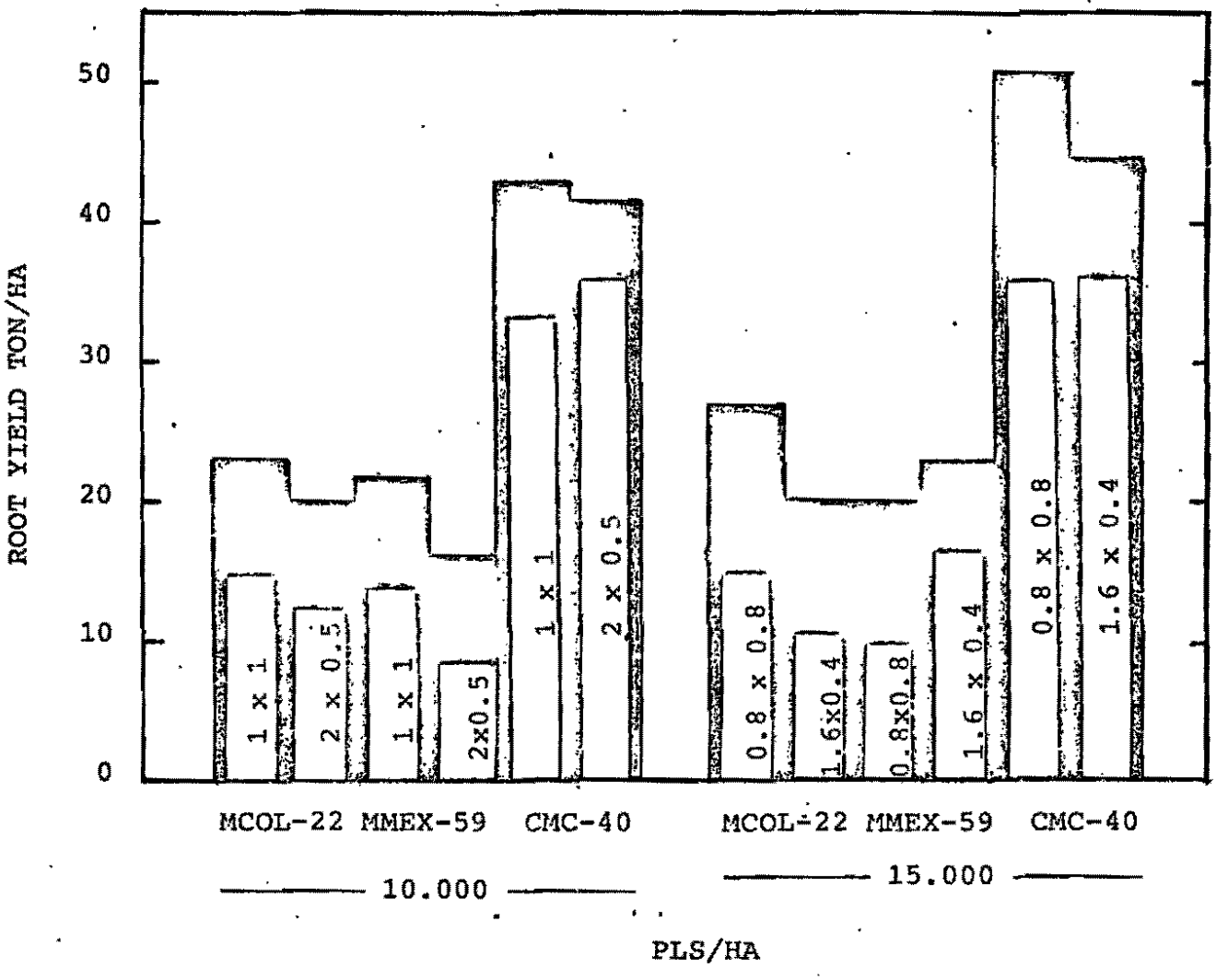


Figure 6.- Effects of square and rectangular planting patterns on root yield of three cassava varieties, planted at two densities. CIAT, 1978

Table 12. EFFECT OF WEEDING AND CHEMICAL WEED CONTROL ON ROOT YIELD OF CASSAVA (after Doll and Piedrahita, 1976)

Frequency of weeding (days)	Number of handweedings	Yield ton/ha	% of maxium yield
Chemical control	0	21.1	100
Check plot	0	1.4	7
15, 45	2	15.4	73
30, 60, 120	3	16.0	76

Table 13.- Chemical weed control recommendations for cassava.

Herbicide[1]	Rate (com. prod./ha)[2]	Time of application	Notes
Fluometuron (Cotoran)	4-5 kg	Pre[3]	Most annual weeds
Diuron (Karmex)	2-3 kg	Pre	Most annual weeds
Alachlor (Lazo)	4-6 liters	Pre	Excellent on grasses
Linuron (Afalon or Lorox)	2-3 kg	Pre	Most annual weeds
Fluometuron + Alachlor	2 kg + 2.5 liters	Pre	Tank mix
Diuron + Alachlor	1 kg + 2.5 liters	Pre	Tank mix
Trifluralin (Treflan)	2.5-3.5 liters	PPI[4]	Excellent on grasses
Butylate (Sutan)	5-6 liters	PPI	Controls grasses and sedges
Dalapon (Dowpon or Basfapon)	8 kg	Post[5]	Directed application
Paraquat (Gramoxone) + Diuron	2 liters + 2 kg	Post	Tank mix; directed application with a shield

[1] Name of commercial product given in parentheses.

[2] The lower rate is for lighter soils and the higher one for heavy textured soils.

[3] Pre = preemergence, before crops and weeds emerge.

[4] PPI = preplant incorporated; ridging after incorporation may reduce weed control.

[5] Post = postemergence; a surfactant should be added.

Table 14. LABOUR REQUIREMENTS FOR INDIVIDUAL OPERATIONS IN CASSAVA HARVESTING, WITH AND WITHOUT USING MECHANICAL AIDS. VARIETY "CHIROZA" HARVESTED AT ELEVEN MONTHS WITH 31 TON/HA FRESH ROOT YIELD. FIGURES ARE MEANS FROM PLANTING SYSTEMS AND POPULATION DENSITIES. CIAT-QUILICHAO, 1978 (after Leihner)

System	Cutting of stems h/ha/man	Lifting of roots h/ha/man	Separation roots from stem-classification* and packaging h/ha/man	Total harvest time h/ha/man	Amount harvested t/man/day**	%
Manual	25	44	204	273	0.90	100
With lifter	25	-	204	229	1.08	120

* Classification into commercial and noncommercial roots.

** Day of 8 hours.

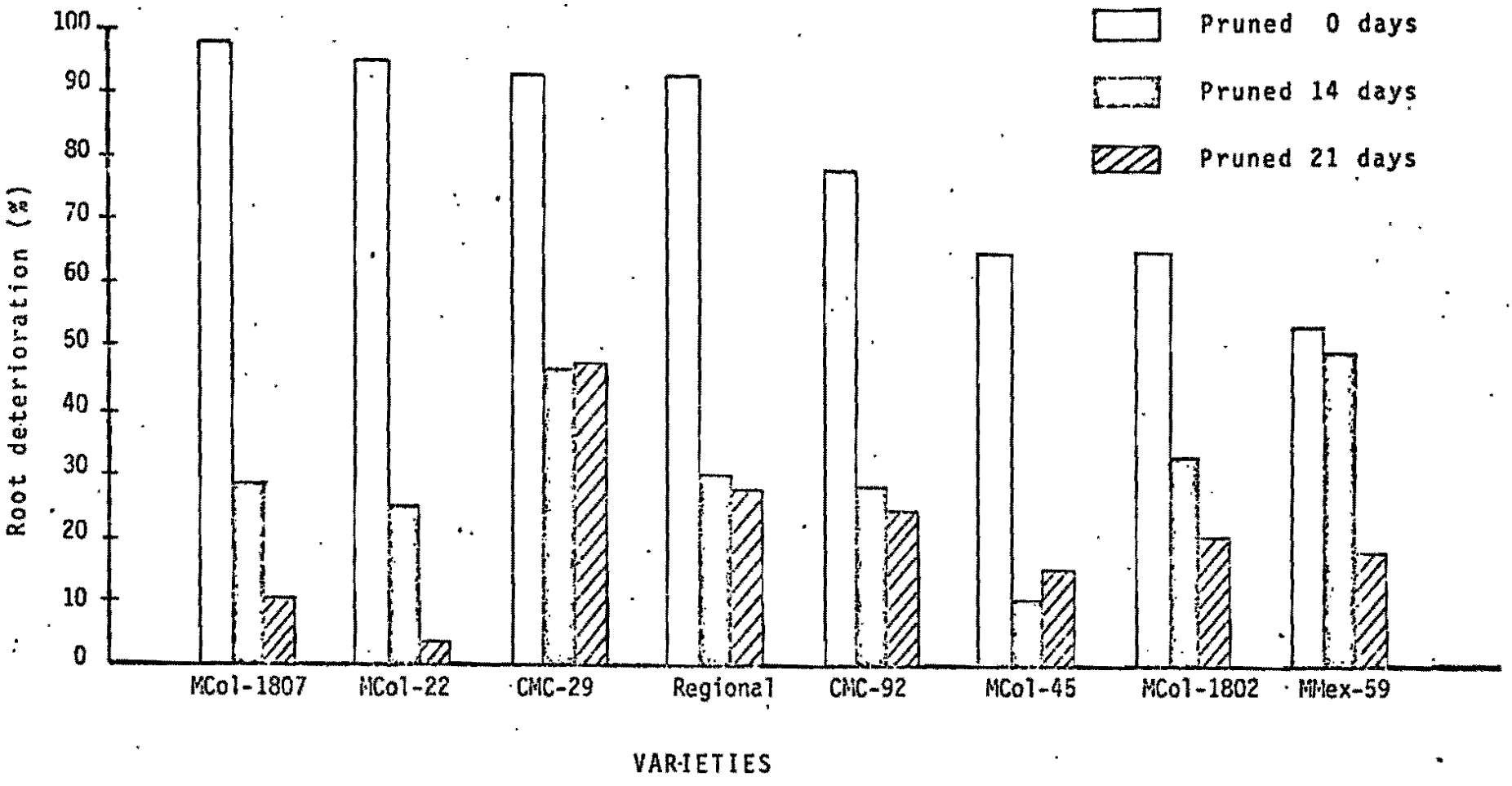
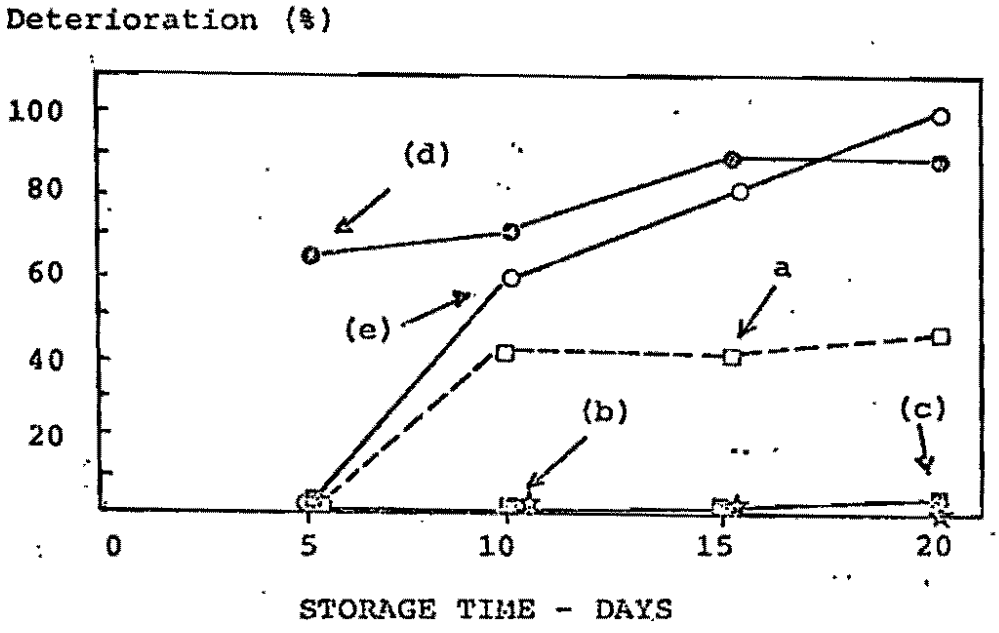


FIG. 7. Root deterioration of eight cassava varieties pruned 0, 14 and 21 days before harvesting and stored for 20 days (after Lozano, CIAT-1977).



a) □ Pruned 4 weeks

b) ☆ Pruned 3-4 weeks + maneb (4×10^3 ppm a.i.) + Sodium hypochlorite (2.5×10^4 ppm a.i.)

c) □ Maneb (8.000 ppm a.i.), roots in polyethylene-lined paper bags.

d) ● Control unpruned

e) ○ Control (unwrapped, untreated roots)

Figure 8.- Effect of a) plant pruning, b) pruning and chemical treatment and c) use of polyethylene bags and chemical treatment on prevention of root deterioration (after Lozano, CIAT 1977).