MECHANIZATION OF CASSAVA PRODUCTION IN COLOMBIA

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ABSTRACT

Advances obtained in Colombia in recent years in the development of cassava varieties with high yielding potential have helped to improve the competitiveness of the crop, and are facilitating its insertion in different markets, especially those related to the production of balanced feed for animals, as well as other industrial uses such us starch and adhesives.

To compete in these markets, production costs for cassava have to be maintained as low as possible. The cassava crop demands a high quantity of hand labor, especially in the activities of planting and harvesting. In countries such us Brazil and Thailand, important advances have been made in the development of mechanized systems for cassava production. In Colombia, CLAYUCA has been working to adapt some mechanical planters and harvesters for cassava that were originally developed in Brazil.

The two cassava planter prototypes that CLAYUCA has tested in Colombia have the capacity to plant two or three rows. The three-row model can plant 9.2 ha per day using four workers (3 planting and 1 tractor driver); the two-row model can plant 6.2 ha per day using three workers (2 planters and 1 tractor driver). There are eight working hours per day. These results compare very favorably with the results obtained with traditional cassava planting systems, in which the planting of one hectare requires at least 7 man-days. These two models of mechanical planters are a viable alternative for cassava farmers, but the minimum area needed to recover the investment costs is 30 ha. The two-row prototype was considered a best option considering that it allows variations in the distance between rows, distance between plants, the length of the stake as well as the depth of planting. One of the main advantages of the use of mechanical planters is the fact that the planting material can be harvested right before planting, thus improving the quality and avoiding the need to store stems for long periods.

For the harvesters, the two models tested by CLAYUCA can harvest 1.2 tonnes per man per day, which is very good compared with traditional harvesting systems in which at least 20 to 25 man-days/ha are required to harvest around 12 to 15 tonnes. The use of the semi-mechanized system, in which the roots are pulled out of the soil, and the workers later detach the roots from the stem, allows to increase the efficiency from around 500 kg to nearly 1 tonne of roots harvested per person per day.

In the Valle del Cauca region of Colombia, the introduction of mechanized planting is allowing farmers to reduce production costs of planting to up to 15.6% in comparison to traditional manual planting. With respect to harvest, the introduction of the harvesting machine is allowing reductions in production costs of around 18.5%. The combination of both practices is giving a total reduction in direct costs of nearly 20%.

INTRODUCTION

With the current trend towards economic globalization, agricultural sectors in developing countries such us Colombia, have to face strong competition from imported agricultural products, coming from developed countries in which a complex scheme of subsidies is used to support agricultural activities. Consumers have the choice of using alternative, imported, cheaper products, thus creating marketing problems for local farmers.

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Under these conditions, farmers critically need to have access to cost-reducing technologies that help them to enhance and maintain competitiveness for the crops they produce.

Cassava in Colombia is a good example to illustrate this situation. During the last five years, with the steady growth presented by the poultry and animal balanced feeds sectors, a great demand has appeared for cassava as a source of energy in the balanced feeds. To be able to enter these growing markets, cassava has to compete with imported cereals, mainly maize, which is now reaching annual volumes of importation of around 2 million tonnes per year. Although some progress has been made in recent years with the development of new, higher yielding varieties of cassava, this is not enough to achieve a significant reduction of production costs and a greater competitiveness.

For cassava to be able to compete in growing markets such as the animal feed sector, production costs should be kept as low as possible. One of the most important components in the production costs of cassava is the high labor requirement, especially during planting and harvesting. In some countries such as Brazil, there have been important advances in the development of mechanized systems for cassava planting and harvesting, that have allowed farmers to reduce production costs. This paper reports on the preliminary experiences obtained in Colombia with the adaptation and evaluation of Brazilian prototype machinery for cassava planting and harvesting, under the specific conditions of some of the most important Colombian cassava growing regions.

The data presented in this paper were obtained during the implementation of a project financed by the Colombian Ministry of Agriculture and Rural Development, MARD. The grant was given to CLAYUCA (Latin American and Caribbean Consortium to Support Cassava Research and Development) and the experimental work, conducted in three of the main cassava growing regions of Colombia, served as the basis for two students of the Universidad del Valle to obtain their Bachelors Degree in Agricultural Engineering.

To facilitate the implementation of the project, CLAYUCA imported from Brazil two prototypes for cassava planting and two prototypes for cassava harvesting.

A. MECHANIZED PLANTING OF CASSAVA

Prototypes for Mechanized Planting

1. Cassava Planter Model PC-20 (two rows)

The main technical characteristics of this prototype are (**Photo 1**):

- Distance between planting rows: adjustable from 85 to 95 cm
- Distance between plants in the row: adjustable from 40 to 100 cm
- Tractor potency requirements: 60-70 HP
- Hydraulic lifting system
- Automatic cutting of the stakes (saw controlled by the tire of the tractor)
- Storage capacity for chemical fertilizer: 150 kg
- Capacity for storage of cassava stems (2 sides): 1.5 m^3
- Planting depth control: available
- Output: 5 to 7 ha/day
- Labor requirement: two people plus tractor driver.

2. Cassava planter Model PMT-3 (three rows)

The main technical characteristics of this prototype are (**Photo 2**):

- Distance between planting rows: fixed, 1.0 meter
- Distance between plants in the row: fixed, 90 cm
- Tractor potency requirements: 60-70 HP
- Hydraulic lifting system
- Automatic cutting of the stakes (jaws system, cutting by pressure on the stem)
- Storage capacity for chemical fertilizer: 150 kg
- Capacity for storage of cassava stems (2 sides): 1.5 m^3
- Planting depth control: absent
- Output: 8 to 10 ha/day
- Labor requirement 3 people plus tractor driver.

Parameters Evaluated

The principal parameters evaluated during this project were:

Soil conditions

1. Chemical and physical characterization of the soils in the three regions in which the research was conducted
2. Moisture content and apparent density (to determine the degree of compaction of the soils)

Prototype operational performance

The variables measured to determine the performance of the two prototypes were:

1. Uniformity in depth of planting
2. Uniformity in size of the cassava stakes planted
3. Uniformity in plant spacing
4. Mechanical damage of the cassava stakes
5. Field performance
6. Labor costs

Results and Discussion

Tables 1 and **2** present the results obtained during the experimental work. Data presented for each site is the average of three repetitions. In each case, the parameter is expressed in terms of percentage, which indicates the results obtained measured against the condition predetermined for operation of the machine. For example, if the desired size of the stake is 20 cm, and the prototype is adjusted to produce stakes with this length, the result of the uniformity of size parameter indicates the efficiency of the machine to produce and plant stakes with this size.

Uniformity in spacing: This parameter depends on the mechanism of the prototype for feeding the cassava stems from which each stake is cut. It is also influenced by the degree of preparation of the soil. In general, it was observed that the two-row prototype performed better, with values around 92%. The advantage of this prototype is that it includes a device to discard those stakes that do not meet the pre-determined length of stake. Another advantage of this machine is that it allows the use of different planting distances. The three-row prototype does not include the device to control the length of the stake. All the stakes are cut the same size. In general, performance of this prototype was inferior, with values around 80% (**Photo 3**).

Table 1. Evaluation of the two-row cassava planter, model PC-20.

Parameter	Site 1	Site 2	Site 3	Average	Manual planting
Uniformity in spacing (%)	91.3	92.6	94.3	92.7	97.7
Uniformity in size of stakes (%)	98.0	97.3	98.0	97.7	98.3
Uniformity in planting depth (%)	94.5	96.6	96.6	95.9	
Mechanical damage of the stakes (%)	10.0	10.0	9.6	10.0	0
Performance (ha/hour)	0.42	0.39	0.38	0.39	0.02
Performance (ha/day)[1)]	6.72	6.24	6.08	6.34	0.32[2)]

[1)] Assuming 8 hours of work; includes only the workers operating the machine
[2)] In the case of manual planting , the performance value is estimated assuming the same number of workers that operate the planting machine

Table 2. Evaluation of the three-row cassava planter, model PCT-3.

Parameter	Site 1	Site 2	Site 3	Average	Manual planting
Uniformity in spacing (%)	74.0	77.0	87.3	79.4	98.1
Uniformity in size of stakes (%)	96.1	96.1	95.6	95.9	98.6
Uniformity in planting depth (%)	95.6	96.6	97.6	96.6	
Mechanical damage of the stakes (%)	36.6	25.0	22.3	27.9	0.0
Performance (ha/hour)	0.37	0.42	0.36	0.38	0.02
Performance (ha/day)[1)]	8.88	10.08	8.64	9.20	0.48[2)]

[1)] and [2)] as under Table 1

Uniformity in size of stakes: This parameter is independent of the stage of preparation of the soil but plays a very important role in assuring high germination percentages. It is well known that the length of the stake and the number of nodes have a clear effect on germination of cassava stakes. The two-row prototype gave a good performance of 97.7% when used to produce stakes with length of 15 cm (**Photo 4**). With the three-row prototype the results were slightly lower, around 95.9%, and the size of the stake obtained was only 11 cm, which could be too short if the variety planted does not have a large number of nodes.

Uniformity in planting depth: This parameter did not present great differences between the two prototypes. The values obtained were around 96% for both machines. This parameter is important for its influence on the germination percentage. The depth of planting of the cassava stake is highly influenced by the type of preparation of the soil. If the area to be planted is not well prepared, the machine will be subjected to variations in the regulation of the depth of planting. This effect is minimized with the two-row planter, as this machine has a device to control the depth at which the stake is released (**Photo 5**).

Mechanical damage to the stake: Each of the two prototypes evaluated presented different degrees of damage to the cassava stakes. The differences occur as a consequence of the cutting device that each machine has. In the case of the two-row prototype, the cutting system is based on circular saws that function with the power take-off device of the tractor. The damage to the stake with this device is minimum, less than 10%. The three-row prototype gave a lower performance with respect to this parameter as the mechanical damage of the stake was around 28%. This is because the device for cutting the stakes is based on a jaws system that applies pressure on the stem to cut off the stakes with the desired length.

Efficiency of Performances: This parameter indicates the capacity of the prototypes to perform the task of planting the cassava stakes at the given distance between rows and between plants. The efficiency of the machine is affected by parameters such us soil conditions (land preparation and moisture content), capacity of the tractor, and abilities of the workers performing the task. **Tables 1** and **2** present the values obtained. The two-row prototype gave an output of 6.3 ha per day or roughly 0.8 ha per hour, using two persons and a working day of 8 hours. In the case of the three-row prototype, the output was 9.2 ha per day of 8 hours, using 3 workers. This corresponds to approximately 1.15 ha per hour. In both cases, this does not take into account the tractor driver. With the traditional planting system, by hand, a total of six workers are needed to plant one hectare in one day.

Economic impact: The two prototypes evaluated did not present significant differences in performance, although the economic importance of using them is very high. **Tables 3, 4** and **5** present the values calculated for the total cost of the planting operation using the two planters as well as with the traditional system, and its share of the total cost of production of one hectare of cassava.

Table 3. Costs of planting one hectare of cassava using the traditional method of manual planting in the Valle del Cauca, Colombia, in 2000.

Activity	Unit	Amount	Unit value (US$)	Total value (US$)
Cutting of stakes	Man-day	2	4.60	9.20
Treatment of stakes (chemicals)				6.10
Treatment of stakes	Man-day	0.5	4.60	2.30
Manual planting	Man-day	6	4.60	27.60
Re-planting	Man-day	1	4.60	4.60
Total costs of cassava planting (1 ha)				**49.80**
Totals costs of cassava production, 1 ha, US$				**566**
Percentage of total cost of production due to planting = 8.8%				
Estimated output = 1 ha/day				

The use of the two-row planter allows a reduction in the costs of planting of 51% in comparison with the traditional system. With the three-row prototype, the reduction in costs for the planting operation is of 55.6%. The three-row planter, when compared to the two-row prototype allows a further reduction of costs of 2.3 dollars per hectare.

Table 4. Costs of planting one hectare of cassava using the 2-row planter, Model PC-20, in the Valle del Cauca, Colombia, in 2000.

Activity	Unit	Amount	Unit value (US$)	Total value (US$)
Cutting and piling the stems	Man-day	3	4.60	13.80
Fixed and variable costs of planting machine	hour	1.28	4.14	5.30
Labor mechanical planting	Man-day	0.33	4.60	1.46
Labor tractor driver	Man-day	0.16	9.60	1.54
Replanting	Man-day	0.5	4.60	2.30
Total costs of cassava planting (1 ha)				**24.40**
Totals costs of cassava production, 1 ha, US$				**477**
Percentage of total cost of production due to planting = 5.1%				
Estimated output = 6.2 ha/day				

Table 5. Costs of cassava planting using the 3-row planter, Model PMT-3, in the Valle del Cauca, Colombia, in 2000.

Activity	Unit	Amount	Unit value (US$)	Total value (US$)
Cutting and piling the stems	Man-day	3	4.60	13.80
Fixed and variable costs of planting machine	hour	0.87	3.94	3.43
Labor mechanical planting	Man-day	0.33	4.60	1.52
Labor tractor driver	Man-day	0.11	9.60	1.06
Replanting	Man-day	0.5	4.60	2.30
Total costs of cassava planting (1 ha)				**22.11**
Totals costs of cassava production, 1 ha, US$				**471**
Percentage of total cost of production due to planting = 4.7%				
Estimated output = 6.2 ha/day				

B. SEMI-MECHANIZED HARVESTING OF CASSAVA

CLAYUCA has also conducted research on the adaptation and evaluation of semi-mechanized harvesting systems for cassava. This activity is important due to the excessive cost of manual harvesting, which demands approximately 25-35 man-days per hectare. CLAYUCA imported two prototypes developed in Brazil and conducted some evaluation of the performance of the prototypes under the specific conditions of some of the main cassava growing regions of Colombia.

Prototypes for Mechanized Harvesting

1. Cassava Harvester Model P 900 (two rows)

The main technical characteristics of this prototype are (**Photo 6**):.

- Weight: 200 kg
- Output: 5 to 8 ha/day (8 hours)

- Working capacity: harvests two rows at the same time with cassava planting distances between rows of 80 to 100 cm
- Includes front cutting disk that facilitates the work
- Soil disturbance is minimum, leaving the cassava plant at the same site
- Works on soils in which it is not possible to harvest cassava manually
- Requires cutting of the cassava stems prior to the operation (at 20-40 cm height)

Parameters evaluated

The principal parameters evaluated were:

- Performance with each harvesting method (ha harvested per day)
- Root losses (% whole roots, % cut roots and % buried roots)
- Labor use (ha harvested per man per day and tonnes of roots harvested per man per day)

Results and Discussion

Table 6 presents the results obtained during the evaluation of the prototype. Values presented are the average of several repetitions and trials.

Table 6. Operating conditions of the cassava harvester Model P 900.

Parameter	Value
Operational speed	7 km/hour
Working depth	30-40 cm
Tractor power requirements	90 hp
Working width, maximum	2.4 meters
Performance	1.1 ha/hour

The main effect of the use of the harvester is the improvement in the efficiency of labor. Under the traditional system, in which the cassava roots are harvested by hand, a good performance for a worker is around 500 kg roots/day. With the use of the harvester Model P 900 CLAYUCA has been able to measure the harvest of around 1,100 kg roots/day. In more developed cassava production systems, such us those found in South Brazil, a good performance using mechanical harvesters is around 1,500 kg roots harvested/day.

***Economic impact*:** The importance of the use of mechanical harvesters is in the reduction in the number of workers that are needed to harvest a cassava field. **Tables 7** and **8** present the results obtained during the evaluation of the prototype and its comparison with the manual harvest system. It can be observed that the introduction of the harvester prototype allows a reduction in labor cost for harvesting of 53%, which results in a reduction of 43% of the cost of harvest, and a reduction of 12% of the total production costs.

Table 7. Costs per ha of manual harvesting of cassava in the Valle del Cauca, Colombia[1)] in 2000.

Activity	Unit	Amount	Unit value (US$)	Total value (US$)
Labor (harvesters)	Man-day	30	4.60	138.00
Packing	Sacs	180	0.04	7.20
Others	Roll			2.50
Total harvest costs				**147.70**
Total costs of cassava production per ha				**566**
Harvest costs as % of total costs: 26.1				

[1)] For a production of 12 t/ha

Table 8. Costs per ha of semi-mechanized harvesting of cassava in the Calle del Cauca, Colombia in 2000.

Activity	Unit	Amount	Unit value (US$)	Total value (US$)
Labor (harvesters)	Man-day	14	4.60	64.40
Packing	Sacs	180	0.04	7.20
Fixed and variable costs of harvester (per ha)				9.50
Labor tractor driver				1.20
Others	Roll			2.50
Total harvest costs				**84.80**
Total costs of cassava production per ha				**498**
Harvest costs as % of total costs: 17.1				

The economic impact of introducing mechanized planting and harvesting of cassava can also be assessed considering the different technological options that are available for farmers to increase their productivity and competitiveness. In case of Colombia, the cassava farmers have to compete with imported cereals, mainly maize and to do that the cost per tonne of cassava has to be as low as possible to become attractive for the processing plants that transform the fresh roots into dry chips or cassava flour that is later sold to the animal feed companies. **Figure 1** presents some data obtained by CLAYUCA that compares the impact of the different technological options available to farmers. It can be seen that the cost per tonne of fresh cassava roots under traditional production systems is US$ 29.4, and that by introducing higher yielding varieties farmers are able to reduce this cost to US$ 25.4, a 13.6% reduction. However, this price is still too high for cassava processing plants. The second option available is the introduction of mechanized planting. If the farmer maintains the traditional varieties, the reduction obtained in costs is slightly lower than the reduction obtained with the improved varieties. Furthermore, the introduction of mechanized planting and harvesting, maintaining the traditional varieties, allows farmers to reduce the cost per tonne of cassava to US$ 21.2, a very significant reduction of 27.9%. At this level, cassava starts to be very competitive with imported cereals. The ideal situation is when the farmers have access to improved varieties, and mechanized planting and harvesting is introduced. This whole technology package helps farmers to bring the production cost per tonne of cassava to US$ 17.5, a very competitive price for the crop to enter different markets. It means a 40.5 % reduction in production costs compared with traditional production systems.

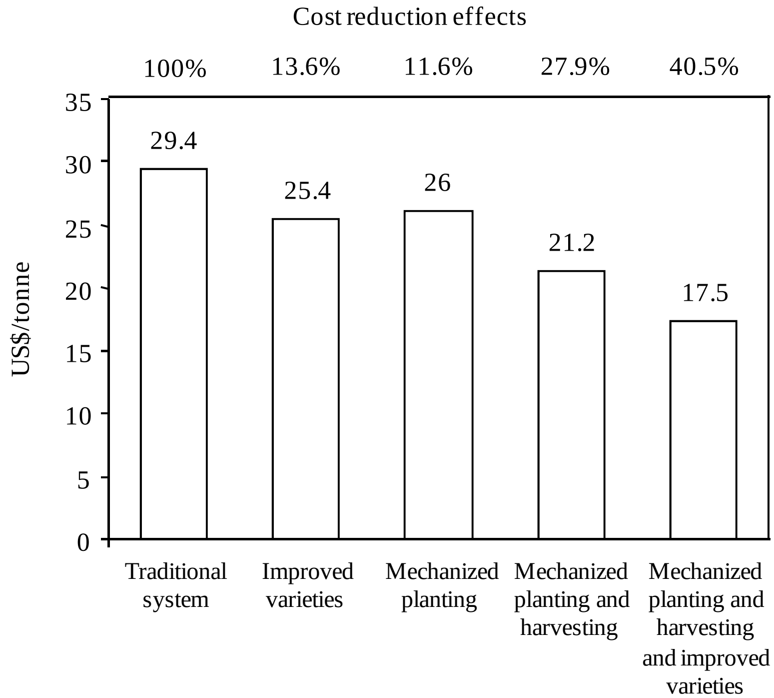

Figure 1. Cost reduction effects on cassava production due to different technology options.

CONCLUSIONS

1. The introduction of mechanized cassava planting and harvesting is a practice that has great potential to reduce the costs of labor, thus contributing to an increase in the competitiveness of the crop
2. The cost of the prototypes, around 3,500 US$ for the planter and around 1,500 US$ for the harvester, FOB Brazil, is affordable. Farmers' groups organized in the form of machinery rings can easily acquire and administrate these prototypes so that their cassava production can be done at lower costs and with improved competitiveness.
3. Operation of the planting and harvesting prototypes is simple and farmers can easily use them.
4. Farm workers that have to do the heavy work of digging cassava roots by hand, work more comfortably and improve their performance when they are allowed to use the harvester.
5. The discussion against the use of harvester prototypes arguing that it will to replace hand labor needs to be taken in the specific context. In many cases, where there is potential to stimulate commercial planting of cassava, investors will not move into

cassava production unless assured that production costs will be competitive. Mechanization of planting and harvesting becomes in these cases, a *sine qua non* condition. If the size of the unit is very small, as in the case of small-scale cassava farming systems, the adoption by farmers of mechanized planting and harvesting will be negligible.

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Photo 1. Two-row cassava planter, Model PC-20.

Photo 2. Three-row cassava planter, Model PMT-3.

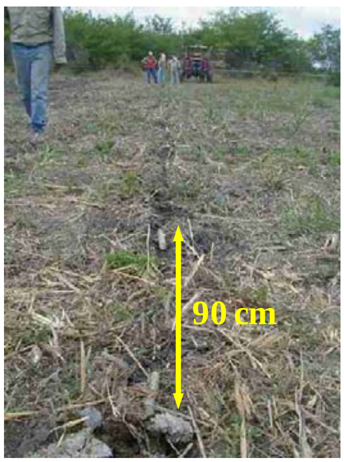

Photo 3. Distance between plants with mechanized planting.

Photo 4. Distance of cassava stakes with mechanized planting.

Photo 5. Spring device to control planting depth of the cassava stake.

Photo 6. Cassava harvester, Model P 900.