MECHANIZATION OF YAM CULTIVATION IN THE IVORY COAST

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SUMMARY

Hand cultivation of yams in Ivory Coast requires 182-202 man-days of work per hectare. Mechanization of land preparation, planting and harvesting are all possible, using machinery specially developed by IRAT since 1968. The machines are described, figured and costed. Most of the machinery was made up by using components from other existing machines. The machines can all be matched to an MF165 or similar 60 h.p. tractor. Yams pose several special difficulties for all operations. An analysis of performance and the costs of yam production by both man power and machinery provide a basis on which decisions on the appropriateness of mechanization in any particular situation could be based.

RESUME

La culture manuelle d'igname en Côte-d'Ivoire nécessite 182-202 travailleurs par jour par hectare. L'utilisation d'engins appropriés mis au point par l'IRAT depuis 1968 rend possible la mécanisation de la préparation du sol, du semis et de la récolte. Les engins sont décrits, chiffrés et leurs coûts estimés. La plupart des engins ont été mis au point à partir des pièces tirées de machines déjà fabriquées. On peut adapter tous les engins à un tracteur MF165 ou analogue à 60 h. p. L'igname pose des problèmes spécifiques pour chaque opération. Une analyse de la performance et des coûts de la production manuelle et de la production mécanisée d'igname permet de determiner li'utilite de la mecanisation selon les cas en presence.

RESUMEN

Las labores de cultivo manuales para el ñame en la Costa de Ivory, require de 182-202 día-hombre por hectárea. La preparación del terreno, mecanizadamente, la siembra y la cosecha son todas posibles desde 1968, utilizando maquinaria especialmente desarrollada por el IRAT. Se describen las máquinas, sus características y sus costos. La mayor parte de la maquinaria se desarrolló utilizando componentes de otras máquinas ya existentes. Todas estas máquinas pueden ser tiradas por un tractor MF 165 u otro similar de 60 h.p. El ñame posee dificultades especiales para todas las operaciones. Las decisiones sobre lo apropiado de la mecanización de ñame, en cualquier situacion particular, podrían basarse en un análisis del comportamiento del cultivo y costos de producción tanto manual como mecanizadamente.

INTRODUCTION

Present status of yams in Ivory Coast

In Ivory Coast, yams are grown in the savanna that extends to the north of forested area and to the east of the Bandama River. During 1969, 209,000 hectares of yam were cultivated and produced 1,520,000 tons. Yields vary from about 7.5 to 9 t/ha. During 1965, the average consumption in Ivory Coast was 171.2 kg per person per year. Consumption for 1980 is projected at 149.3 kg per person per year. At present yams are grown with traditional methods in a shifting cultivation system and all the work is manual. Yam comes first in crop sequence on cleared savanna or forest. Cropping is on mounds and there are up to 1000 of these per hectare. Labour inputs are as follows: making of mounds, 50-60 days; preparation and sowing of setts, 12 days; weeding, 80 days; harvesting, 40-50 days. This makes a total of 182-202 days work per hectare.

Objectives for crop improvement

More and more of the main food crops in Ivory Coast are now produced in modern agricultural systems. These systems increasingly involve mechanization and yam has been excluded from these modern systems because it is grown entirely with hand labour.

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Considering the importance of yams as food crop, it would be desirable to bring them into modernized farming, and for this to occur, a method for mechanizing its production must be developed. To achieve this involves solving three problems that IRAT in the Ivory Coast has been studying since 1968.

The first two will be only briefly discussed. These are: Adaptation of farming practices: in order to get maximum production in a modern farming system it is necessary to arrive at a crop rotation which takes into account the economic value of crops at particular times, and the capability for intensive use of the land available.

Adaptation of the crop itself: attempting to adapt yam to mechanization encounters several problems. Yams tend to produce roots of a wide variety of sizes and shapes and are reproduced from tubers which need to be retained from the previous harvest. The three major operations requiring a special mechanized solution are ridging, planting and harvesting. Other farming operations can be carried out using standard methods. Yam mechanization has previously been studied by I.G. Campbell[1], James (not consulted). Warren[5] and IRAT in the West Indies.

RESEARCH ON THE MECHANIZATION OF YAMS

Choice of equipment

The selection of equipment for this study was obtained with a view to making ridges with a profile comparable to the traditional system, i.e. 45-60 cm high, being able to plant setts of irregular and large size, which might also be carrying a delicate bud or shoot, and being able to recover fragile tubers at harvest from deep underground.

Location and conditions of the study

The study has been carried out at IRAT-CI station in Bouake in cooperation with the Committee for Agricultural Machinery of Ivory Coast (COMACI) during the seasons of 1969-1970 and 1971[3]. A 60 H.P. Massey Ferguson 165 tractor was used for all trials. The trial plots were previously opened up by ploughing and harrowing.

METHODS

Mechanization of ridging

Two ridgers were tested. The first in 1969 and 1970, the other in 1971. A ridger with rigid stanchions was built using parts from various other pieces of machinery at the station. It comprises a double tool bar 2.45m wide and a set of disks 71 cm in diameter. (Figs 1 and 2) Adjustments can be made for the lateral displacement of disk-carrying stanchions to adjust the distance between disks and for the angle of presentation of the disks in one plane only. Satisfactory results were obtained with this first ridger, using the tractor in 3rd gear at 3.1 k/hr. and the space between the disks was adjusted to make ridges with a 1.25-1.30m base. The height then varied between 40-50cm.

There were some problems with this tool, including the irregular height and shape of the ridges, and especially that ridges produced with too sharp a profile tended to encourage erosion and rapid compaction. To remedy this it is desirable to be able to adjust leading edges of the disks in two planes instead of just one, and to be able to stabilize the ridger by preventing lateral movements. Thus we tried to obtain a ridger equipped with fully adjustable disks and circular coulters for stabilization. In 1971 we obtained such a ridger from Israel.

Description of the articulated stanchion ridger

The chassis comprised three tool bars, 2.55 wide, and two pairs of disks 71 cm in diameter (Fig. 1). The stanchions were composed of four articulating parts allowing for the adjustment of spacing, angle of presentation of the leading edge, deviation from the vertical plane and depth (Fig. 3). Two circular coulters mounted in front of the ridger disks provide the required stability. In performance the width of the work required (1.25m) did not allow the mounting of more than one pair of disks, and an attempt to use the ridging device with the concave side of the disks facing outside was unsatisfactory. The device for ridging finally adopted, taking advantage of the many possible adjustments, made it possible to get long parallel ridges with a rounded profile and having a 1.25m wide base and height of 45-50cm.

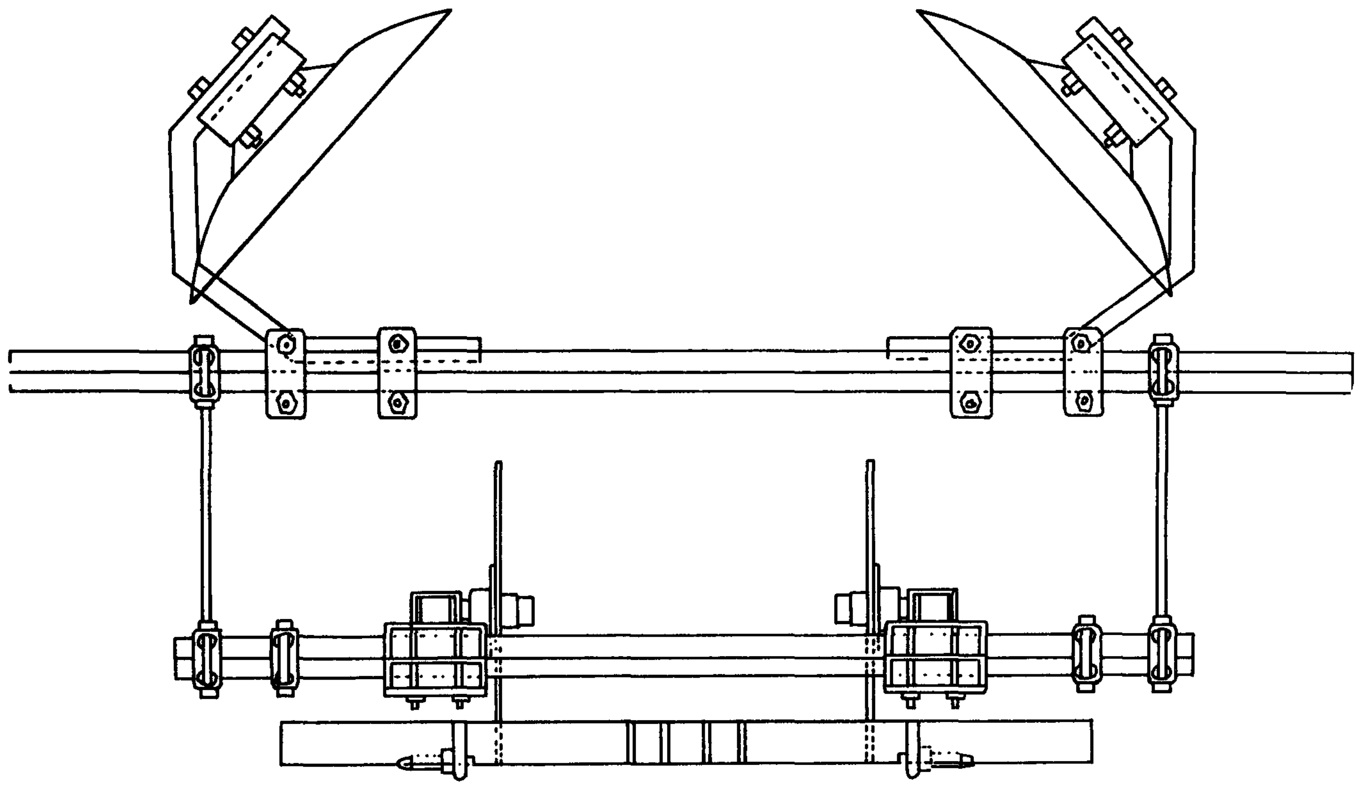


Figure 1. *Ridger, utilizing disks attached to a tool bar.*

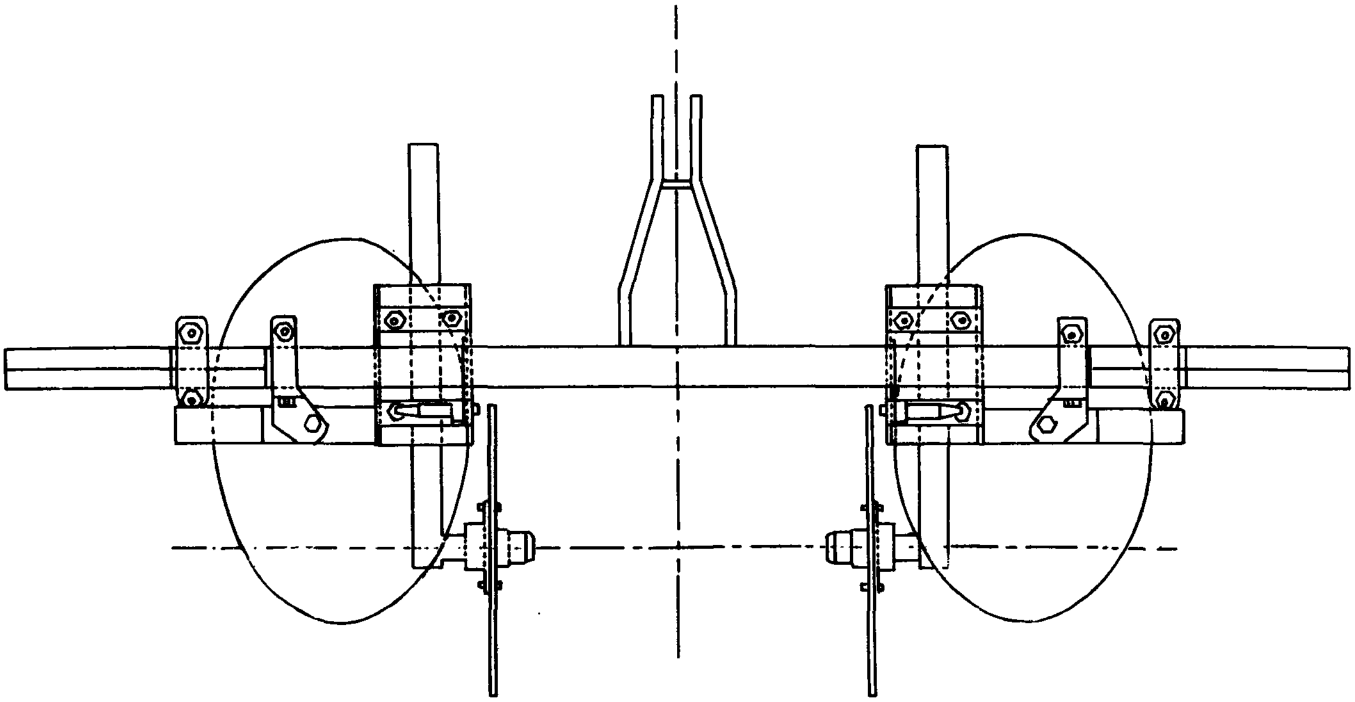


Figure 2. *Ridger, utilizing disks attached to a tool bar. Detail of attachment to the tool bar.*

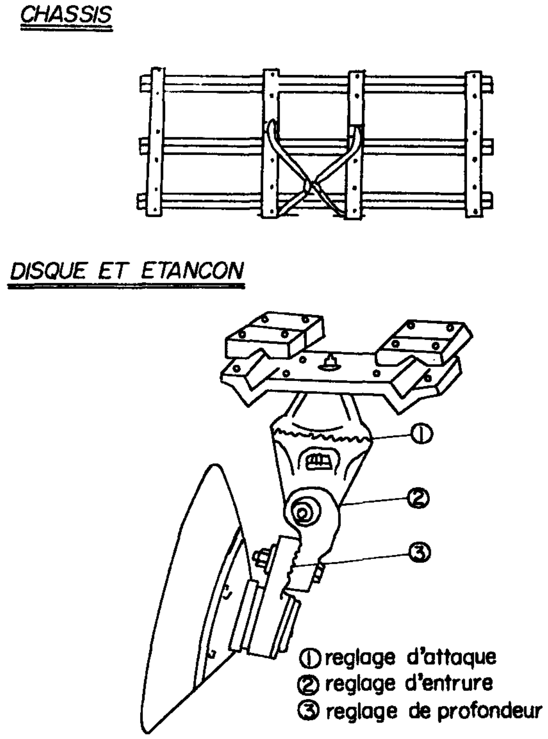


Figure 3. *Stanchions with capability of being adjusted for spacing, angle of cutting edge, deviation from vertical and depth.*

Economic aspects

Because the ridgers studies are no longer available commercially, the data are based on the costs of similar materials. The price can vary, according to the quality of the material, between 7,000-26,000 FF, from different manufacturers in France. In Ivory Coast a commercial firm has proposed to sell the ridger for 706,000 Francs CFA per unit. The rate of work for ridge forming ranged from 2¼-3½ hours per hectare, depending on the nature and the condition of the land.

Mechanization of the planting operation

The most convenient planter is one that uses a distribution system of bucket chains which are fed manually. A planter of this type selected in France, was greatly modified by the manufacturer at our request before being dispatched and met the following specifications: weight (after modifications), 360 kg; length. 1.55 m; width, 1.37 m. The metallic frame and wheels, mounted on extended stanchions, were able to straddle the ridges. Sett distribution was by a fourteen cup chain of 18 x 12 x 10 cm running over sprockets. The furrow was opened by a breasted share equipped with mould boards. The setts are covered over by the action of two sets of concave disks of 45 and 55 cm diameter respectively (Figures 4 and 5).

Adjustments can be made to the depth of planting by raising or lowering the wheel stanchions in the frame. The wheel base can be varied from 1m to 1.20m. The plant population can be adjusted by use of a set of five interchangeable sprockets so as to allow spacing from 58 to 101 cm. The disks for covering the setts can be adjusted by swivelling.

Performance of the planter

With the tractor track reduced to 1.32 m, a single ridge can be straddled without damaging adjacent ridges. A forward speed of operation of 2.62 km/h in the second lowest gear of the tractor was used. One tractor driver and three men operated the planter.

After initial trials some modifications appeared necessary to improve the efficiency of the machine. This was made and the planting operation was then performed well.

Economic aspects

The material cost from the manufacturer was 2,580 FF or 3,309 FF delivered Abidjan. The modifications cost a further 1,600 FF. The planter can operate at the rate of 5 hours 10 minutes per hectare (manual planting takes 10 man-days per hectare).

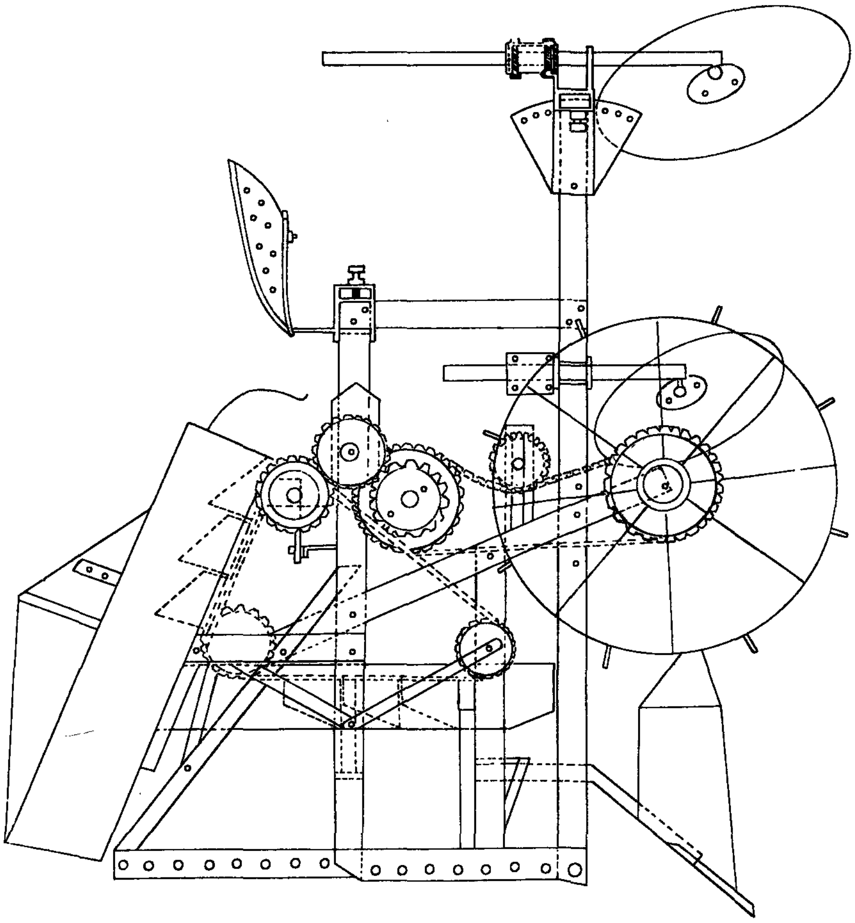


Figure 4. *A modified planter for yams.*

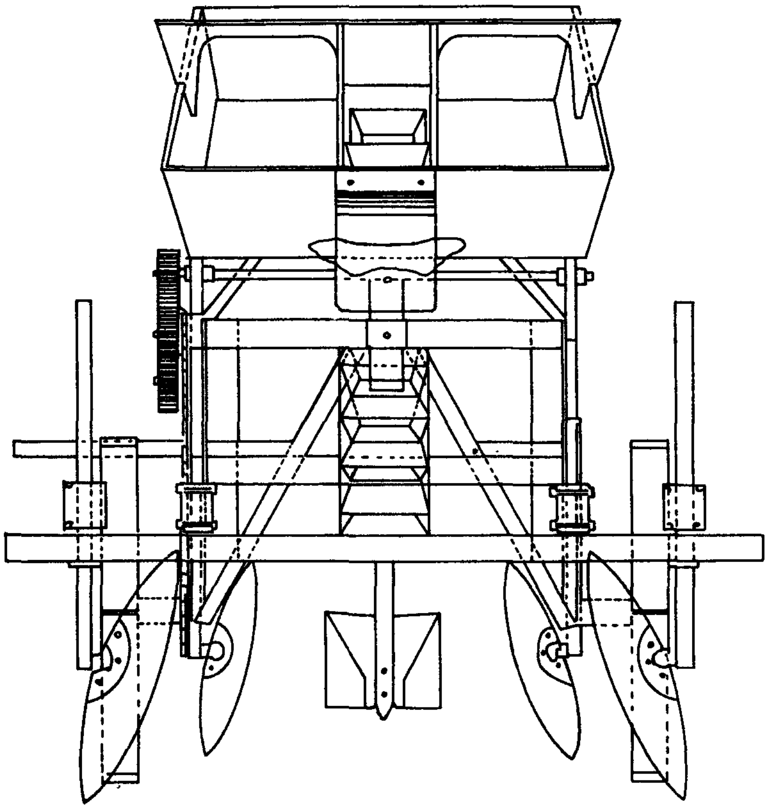


Figure 5. *Overhead view of the planter.*

Mechanization of harvesting

The harvester has to be strongly built but nevertheless should not subject the tubers to rough handling.

The manufacturer made no modification before delivery to the machine which we chose. The specification of the machine is: weight, 340 kg; length, 1.50 m; and width 1.40 m. The body is manufactured from steel tubing. The working parts comprise two U-shaped stanchions carrying the ploughshares and the frame for the shaking riddle. These parts oscillate around pivots. By means of a set of rod-drives the ploughshares and the riddle are caused to reciprocate by power supplied by the tractor's power take-off. (Figs. 6 and 7).

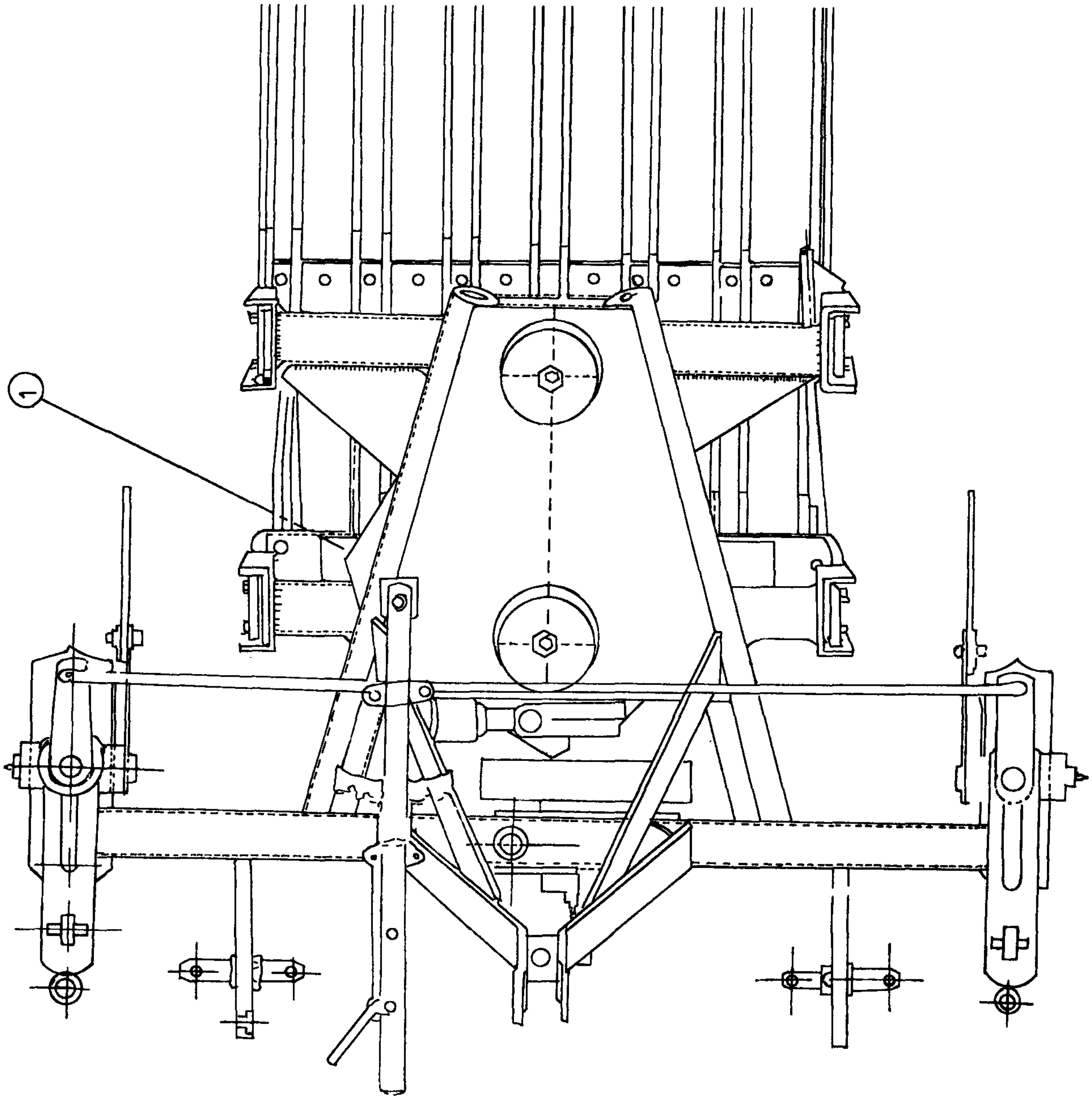
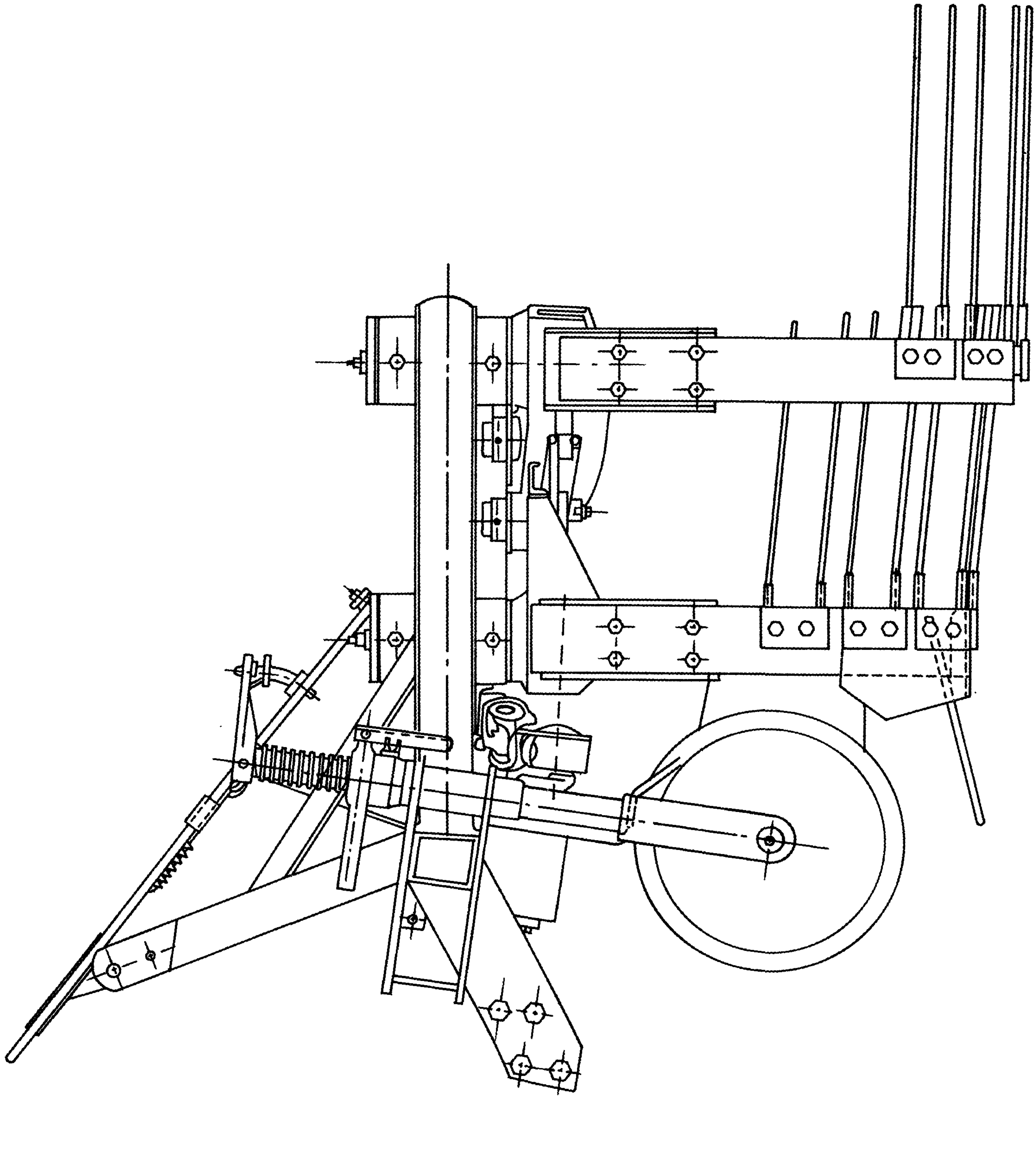


Figure 6. *Harvesting machine, overhead view.*



Adjustments and operation

Depth is adjustable to within a height of 25 cm., and the speed of shaking depends upon the r.p.m. of the power drive. The lifter is operated in the 2nd lowest gear with 1,500 r.p.m. as a minimum and requires 1 tractor driver, 1 man controlling the lifter (optional) and 4 men collecting and moving tubers aside before the tractor returns on its next round.

Performance of the lifter

The first trials were carried out under heavy and dry soil and it was apparent that the stanchions and original ploughshares were not strong enough. Modifications made included replacing of the stanchions and shares by stronger components, reducing the width of work from 1.30 m to 0.80 m, increasing the length of the stanchion to 0.60 m, and reducing the number of riddling rods to hasten separation.

Even after modifications to the lifter tubers were sometimes damaged by sifters and broke when harvested from heavy and dry ridges. It has become apparent that for use of the machine harvester the ridges must be quite straight, too deep planting must be avoided and the tops of the yam must be cut and removed before harvesting. Results of harvesting trials are presented in Table 1.

Economics of yam harvesting

The cost price of the unmodified machines from the manufacturer was 3,548 FF and the cost price delivered in Abidjan was 4,376 FF. The work rate of the lifter primarily depends very much on the condition of the land at harvest time, and varies between 5-7½ hours per hectare. In contrast, hand harvesting requires from 2-3 man days per hectare.

AN ECONOMIC STUDY OF A MECHANIZED CULTIVATION

Costs

The cost for a mechanized yam cultivation (Table 2) was determined first on one hectare of land with the cultivar N'za Sequela of *Dioscorea alata*. Data for depreciation of material, with the exception of tractors, are based on a study published by the Ministry of Agriculture in Ivory Coast[2] on identical material or on material of reasonably similar type and value. These have been used in calculating the operating cost of the machines. Land preparation was done with equipment usually used in mechanized cultivation. Data are provided for full costs in Table 2.

Profitability

For cultivar N'za Seguela yielding 12 tons per hectare the expected profit is as follows: estimated sale price, 10 F/kg; gross return, 120,000 francs C.F.A.; variable costs, 100,000 francs C.F.A.; gross margin, 20,000 francs C.F.A.; percent profit (in terms of gross return), 16.6%.

CONCLUSIONS

At the end of four years of experimentation with equipment designed to introduce mechanization of yam cropping, it appears that the solutions proposed would allow integration of this crop into modernized systems of land management.

The solutions proposed certainly are not the only possible ones and the machinery worked out can be further improved. However, using the equipment described, hand labour could be reduced by 70%.

REFERENCES

1. Campbell, L.G. (1967) Prospects for mechanization of yam growing. In *Yams.* Coursey, D.G. (Ed.). pp. 100-105.

2. Ministry of Agriculture, Ivory Coast (1969) Project for rural modernization of Brobo, Diabo.

3. Minagri – Comaci, Ministry of Agriculture, Ivory Coast. Annual Reports on Trials at Minagri, Comaci 1969-1970-1971.

4. Soitout, M. (1970) IRAT/West Indies (Guiana (1970) Mechanization of yam harvesting).

5. Warren, J.B. (1957) The design of a tractor-mounted lifter. Imperial College of Tropical Agriculture, Trinidad, West Indies.

TABLE 1

Harvesting of yams — yield and damage

	Yield t/ha	% of weight (harvest) intact tubers	broken tubers
1970			
Ouan Seguela	16.8	79.8	20.2
Krengle	9.5	57.5	42.5
1971			
N'za Seguela	12.3	91.2	8.8
Akandu	3.2	72.8	27.2
1972			
BB dato 20	8.4	91.9	8.9
N'za Seguela	10.0	96.4	3.6

TABLE 2

Statement of variable costs for mechanized cultivation per ha. (in Francs C.F.A.)

Operation	Machines	Chemicals and planting materials	Manpower	Total
Land preparation	10,143	14,327	-	24,470
Ridging	2,458	-	-	2,458
Planting	8,028	22,000	2,520	32,548
Maintenance: motorized	855	10,407	176	11,388
manual	-	4,282	7,560	11 842
Harvest	6,775	-	1.260	8,035
Loading, transport	8,320	-	1,764	10,084
Total	36,579	51,016	13,230	100,825