International Starch Institute

CASSAVA PLANTATION

TM29-2e

INTRODUCTION

"Farming in the Tropics and the Temperate Zone may seem as two worlds, but below the differences plant physiology and farmers thinking are very much alike ".

Large scale farming of cassava for industrial starch manufacture is not common practice. Even in Thailand - the largest cassava starch producer - large-scale farming is rare and outgrowers supply most factories. In Africa only one cassava plantation for starch manufacture is known. Although large-scale farming is practiced here and there, only little is published and the knowledge level is low. When Dr. A. M. Coccia, FAO Rome visited International Starch Institute the industrialization of farming and the lack of knowledge was on the agenda and we got the incentive to form a team gathering information[1].

FARMING IN THE TEMPERATE ZONE[1]?

The principles and procedures applied in farming of starch of different origin and on different location extend the knowledge pool.

INDUSTRIAL VARIETIES. In the temperate zone only one growth season is possible and potatoes - another tuber - replace the cassava. Which knowledge may be transferred to cassava? First of all the temperate zone farmer will never grow ware potatoes (potatoes for food) as a starch crop. Ware potatoes are selected for taste and cooking performance - actually the European Commission has enforced a starch table against the use of ware potatoes in starch manufacture. The farmer

Information has been gathered from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, The International Section of The Danish Farmers Advisory Services, The Ministry of Agriculture, Ghana and The Thai Tapioca Flour Industries Association. A certified farmer and a farm mechanizing specialist - both with hands-on experience from setting up and running a 1000 ha plantation in Africa - team up with International Starch Institute.

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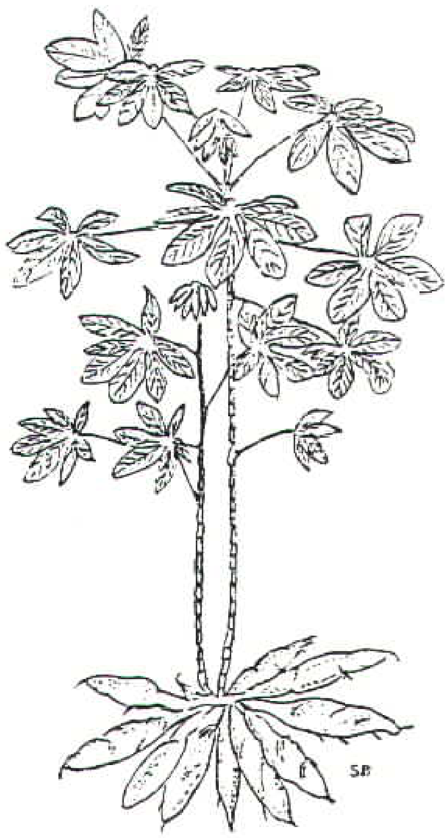
will instead choose an industrial cultivar tested for high starch yield.

DISEASE RESISTANCE. Resistance to certain diseases is preferred. Resistance is not absolute, but means savings on the spraying costs and makes the crop less vulnerable to an attack.

MATURITY CONTROL. To adapt to factory needs both early and late varieties are grown in order to lengthen the starch production campaign.



DISEASE-FREE SEED. Most important The farmer will only plant approved disease-free seed potatoes.

A few farmers have specialized in protective aseptic measures and grow disease-free seed potatoes in class "A" - this means that they start their crop with seed material propagated on a breeding station.

Next level is growing class "B" material in some larger scale and with seed from a class "A" farmer and so on until a level is reached able to supply disease-free seed material to the whole industry. Both authorities and farmers organisation have strong means to enforce these basic rules.

CROP ROTATION. Control of diseases is by far the most important key to profitable starch farming - so important, that a farmer will never grow potatoes after potatoes, but will have three full years in between with another crop. During the three years suspension of potato growing various diseases bound to potatoes become distinct. He will also be careful to keep distance between fields. Legislation ensures that potato growing in certain areas may be banned, if a farmer is not in control of his crop. This applies even in private gardens.

"Today Satellite Positioning, GPS controls the fertilizer spreader taking input from harvest and soil analysis. The GPS program optimizes the farmer's profit instead of yield - and what's good to the farmer also pleases the environment".

FERTILIZING. Fertilizing industrial potatoes and ware potatoes differs. The composition of fertilizer may be in favour of starch formation or against it and optimal composition is linked to the pH and type of soil. Therefore soil classifications are extended with regular soil analysis made down to small patches. The harvested quantity is continuously monitored during the passage of the field and the data is saved along with the satellite positioning, which now is accurate to less than two centimetres. The harvesting data and the soil data is fed into a computer controlling the fertilizer spreader and a program is optimising profit - not tonnage.

TIMING. All farming operations are governed by the plants and the weather - not by the farmer and his wish - meaning that seeds are planted at the most optimal time and not when the farmer has the time or find it convenient. So it is with weeding, irrigation and diseases control. From the advisory service centre the farmer gets day by day the required information and advice and when the time has come, he may run the tractor from early morning to midnight. During high season tractors with artificial light is a common sight in the landscape.

Some farmers invest in light and temperature controlled seed stores and take the seed through special temperature and light programs two months in advance to prepare the seed for growth and then plant when the outdoor light and temperature are optimal and give the seed a kick start.

RESEARCH AND BREEDING. Farmers association run their own research and breeding stations. They also run their own advisory services. The breeding stations and the advisory services is in Denmark - as probably the only country in the world - paid by the farmers themselves and not by the government. Costly operations, but it pays and may be one of the explanations to the successful starch farming in Denmark - 75% of the potato crop is processed into starch and the Danes produce more starch per head than any other nation.

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Subsoiler

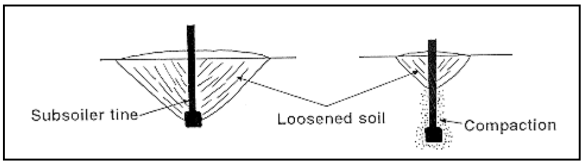
DIFFERENCES. Tropical research stations confirm that the above procedures apply for cassava tubers as well, but only in regions with a large and long-standing starch production, yield of starch is in focus.

PREPARATION FOR PLANTING.

LAND CLEARING. As a one-time operation land clearing is contracted. Road builders use the type of equipment and a cost[2] of 350 USD/ha is estimated.

SUBSOILING. The soil has to been loosened by deep treatment by a subsoiler with tines and/or by deep ploughing based on test runs.

Loosening is necessary for more reasons. (1) It provide loose soil for ridging (2) rain is soaked and provides a reservoir of water for the plants (3) reduces mud by soaking away



water with improved support for tractors and (4) minimizes drain off of water.

Several factors need to be considered. The soil moisture content needs to be in the optimum range. The depth and interval between tines should be chosen after examining the effects of a test run. If the soil is too wet, the subsoiler will not lift and crack the soil but will instead tend to create more compaction. If the soil is too dry, large blocks of soil will be lifted but not cracked.

For each combination of implement type and soil conditions, a particular depth (critical depth) exists for which subsoiling is most effective. When a subsoiler is operated at the

Seven furrow reversible mould plough.

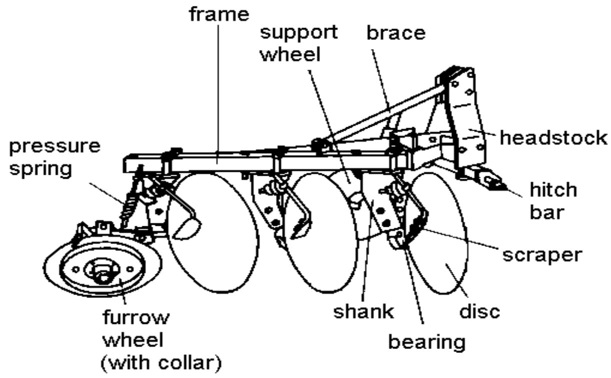
[2] Ministry of Agriculture, Accra, January 1, 2001.
1 US Dollar = 7,000.00 Ghanaian Cedi;
1 Acre (imp) = 0.4046842 ha

critical depth, a crescent-shaped pattern of soil disturbance is created. If, however, the implement is operated below its critical depth, the amount of soil loosening is much smaller and soil around the passage of the tines can be compacted. Vibrating depth-seeking tines may overcome some traditional problems of subsoiling. The depth of subsoiling should be such that a crescent-shaped disturbance is achieved. This can be gauged by digging a number of holes after test runs.

PLOUGHING. There is little difference between mouldboard and disc ploughs as regards of effect, maintenance, reliability, power requirements and total tillage costs.

Criteria	Disc plough	Mould board plough
inverting	medium	good
mixing	medium	hardly
crumbling	medium/good	medium
burying of long stubble	not completely	completely
plough sole compaction	little	by landside (heel) less by share
susceptibility for damage by roots and stones	little	more
possible fields of use	heavy, dry, stony soils forest soils	clean fields
durability	high	medium
weight	high	lower
draught requirement	high	high

MOULD PLOUGHING. The popular reversible mould plough allows ploughing from one end of a field. A multi-furrow mould plough may be adjusted to optimal width and a nominal capacity of 1 ha/h with a suitable 90 - 160 HP mover.

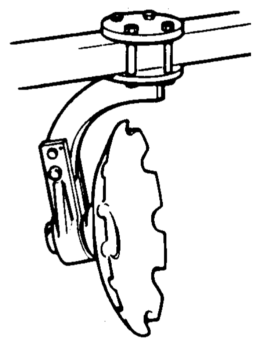


Disc Plough

Disc harrow.

DISC PLOUGHING. The disc plough is used for the following jobs:

primary tillage,
ploughing land containing stones and roots,
seedbed preparation,
deep tillage between rows of trees,
working in large amounts of plant residue,
ploughing in regions with a high risk of erosion,
ploughing on sticky waxy soils and soils which tend to form plough soles,
land clearance.



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Making plant furrows for planting by hand.

Ploughing is also a weed killer and is carried out shortly before planting.

HARROWING. The disc harrow plays, next to the disc plough, an important role in motorized tillage. Ploughing is followed by disc harrowing (disking) flattening the soil and preparing for ridging.

For both harrowing and ploughing chooses have to be made on the basis of test runs and information on actual soil structure[3].

Ridges

PLANTING

RIDGING. After ploughing and harrowing the cassava may be planted on the flat, on ridges, or in furrows. For furrows, make them 10 cm deep, and place the cuttings horizontally in the direction of the furrow. In areas where drainage is a problem, the land is heaped in ridges, and the cassava is planted on the crest. Ridging may be done before planting or after.

Because planting takes place in the most intensive seasons, it should be mechanized to reduce labor peek load. A pulled two or four-seater transplanter will do the job. A front toolbar mounted with ridging discs and roller-shares pulls up the soil and forms ridges with a 10 cm deep furrow at top. A spacing counter deposits start-fertilizers in spots and sounds a bell for synchronizing the manual planting operation. A rear toolbar with discs closes

[3] MOTORIZED SOIL TILLAGE IN WEST-AFRICA - A survey on the current use and consequences of tillage done with engine-driven machinery by Gert van der Meijden, Food and Agriculture Organization of the United Nations, FAO Regional Office for Africa, Accra, Ghana and Agricultural Engineering Branch, Agricultural Support Systems Division, FAO, Rome, Italy, May 1998.

and covers the sticks. Frequent job rotation is required due to the intensity of the work.

START FERTILIZER. Spot fertilizing placing a small portion of a start fertilizer (nitrogen) in the planting grove is cost effective. Sticks are planted in the grove close to the fertilizer but without risk of "singe off" by the fertilizer.

PLANTING. Plant the stems cuttings (1 per hole) in a horizontal position to a depth of 5-10 cm. The cuttings are properly placed and covered afterwards.

PLANT SPACING. Plant cuttings may be planted at a spacing of 1.2 x 0.8 m (~10,000 plants/ha) dependent on the cultivar. Cuttings planted in moist soil under favourable conditions produce sprouts and adventitious roots within a week. Expected germination is 100% with healthy planting material.

Two-seater transplanter available with all weather cap, furrow marker, electronic distance marker, spot fertilizer and boxes for sticks

STEM PREPARATION / NURSING. Healthy stem cuttings 15-20 cm long, taken from mature mid-plant sections (10-12 seed pieces per plant) are used and the cuttings are made just before planting. The stems are brought to the "nursery", where inspection for diseases and cutting take place. The sticks are given a preventive chemical treatment and stored until use. It may be a problem to get enough disease-free material from the production fields and separate raising of stick cultures have to be foreseen. Propagated seed from breeding stations have large variance and needs screening by test farming before reliable results can be achieved.

If only pathogen-free stock is introduced into new plantings, disease damage can be greatly reduced. Infected stem cuttings can be rendered pathogen-free, if rooted from stem tips[4].

Because a pathogen-free stock is the single most important profitability factor and the screening of planting material cannot be mechanized, nursing is by far the most labor intensive operation, but it is well suitable for casual day-laborers.

[4] Details of the appropriate procedures for preparation of planting stock can be obtained by contacting the Florida Cooperative Extension Service

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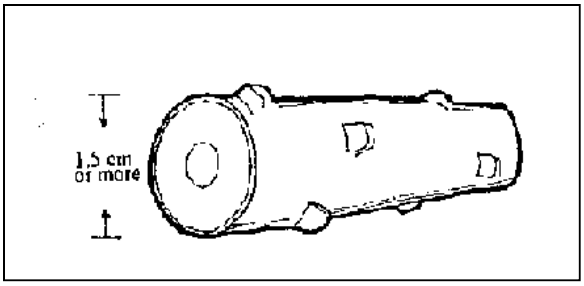

Boom Sprayer

PLANTING SEASONS. Planting is possible at any time of the year, where supplemental irrigation is available. Without artificial irrigation planting is a seasonal event only taking place in the rainy seasons - the earlier the better - and preferably at the very start of the rain. This will give the sticks the best possible growing conditions and allow the plants in some regions to grow through two rainy seasons before harvest.

The tropics have one or often two rainy seasons. The distribution and the intensity of the rain varies from region to region[5]. In West Africa planting may take place March/April to May and again in August to September. Planting in heavy and regular rain should be avoided.

CULTIVATION.

FERTILIZING. Until harvest the plants have to be looked after. When the stick gets a foot-hold, it is time for topping up the start fertilizer with a potassium-containing com-pound to push starch formation. The fertilizer may be banded at one or both sides of the rows by the use of a fertilizer spreader, but too much fertilizer soaks away or is just utilized by the weed. In stead we again prefer spot fertilizing placing a small amount of fer-tilizer near each plant - "bottle top method".

Fertilizer applications should be made only as a supplement to the nutrients already found in the soil at planting time, but in principle artificial fertilizer replaces the nutrients removed at harvest.

WEEDING. Weeds are controlled for the first 2 to 3 months. Weeds are best controlled through a proper crop rotation scheme and with proper pre-planting cultivation to prevent germination of weeds. Pre-emergence herbicides are very effective to control weeds

[5] In Thailand, cassava is planted either November to January (late rain crop) or February to April (early rain crop. Harvest is either during the early or late rain period, when roots are about 10-12 month old. However, in practice, harvesting is either delayed or advanced, a descision based on prevailing root price.

in cassava. Weeding is recommended at 4-5 weeks after planting and at 8 weeks after planting until crop ground cover is complete.

Spaying with pesticides, fungicides and insecticides is done twice. Some chemicals may be combined in one spray. A large boom sprayer may make first spray. For second - or a third as required - we suggest a mist sprayer with a range of up to 12 m. It just requires driving paths at intervals (omitting a row of plants). The driving path is needed anyway

Mist Sprayer

and by mist spraying damage to plants is negligible.

Mechanical weeding is possible at the very start using an interrow cultivator, but chemicals do the job.

PLOUGHING.

Immediately before planting the fields are ploughed and harrowed so the soil is easy and loose for the ridging. After a fallow period it may even be necessary to cut down weeds with a slasher in advance of ploughing. After harvest the fields are ploughed again.

HARVESTING.

MATURITY. Cassava can be harvested more or less whenever it is needed beginning about 7 Months After Planting (MAP). The early cultivars types mature at about 6 MAP. The greatest yields are achieved at about 9-12 MAP. Prolonged maturity periods turn the tubers fibrous and starch yield is bad. Harvest may be suspended in late rainy season due to low starch content and "green" starch with small granules. It may also be suspended during heavy rain making fields impassable[6].

[6] In Thailand it is common practice to suspend harvest 2 - 4 month a year.

Hydraulic truck body handles container at will.

TOPPING. Plant tops are cut at 50 cm from the soil surface 1-2 weeks prior to harvest. Sticks from the top are collected and brought to the factory for further examination and preparation. The rest is collected and moved to a fallow field, where it is burned or chopped. A bio-chopper may be used to turn the top into silage for feed. The silage may be mixed with pulp from cassava processing.

LIFTING. Next operation is lifting of tubers mechanically by a special heavy-duty harvester. A working team following the harvester cut the stems and loads the tubers into trailers. When a trailer is full, a mover takes it to the feeder road and brings back an empty one.

Plant lifter with depth-seeking shaking system. Available for one or two rows.

LIFTING. Apart from earlier trials conducted in the 1960s a mechanized cassava harvester developed at the University of Leipzig, Germany has - as the first - been tested for adaptation in Ghana by the Department of Agricultural Engineering of the Kwame Nkrumah University of Science and Technology, Kumasi. The development has however been halted because lack of a market.

In South Africa a modified potato harvester has been applied. A most attractive design comprises a depth seeking shaking system in a heavy-duty version and an arrangement with a manufacturer has been made in that respect.

POST HARVEST.

LAYING FALLOW / CROP ROTATION. After harvest the fields have to be ploughed. The fields have anyway to wait for rain before planting and may be laid fallow or cultivated with a cover / catch crop. Which to choose depends on the time of the year, because also the cover crop needs water and time to germinate and grow. Alternate crops with

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different cycle enables better fitting to the varying cassava intervals. Because the overall plantation economy depends on alternate crops as well as on cassava, it is important to have land available for optimizing both crops[7].

DISEASE PREVENTION. Bacterial blight, caused by the bacterium *Xanthomonus campestris* pv. *manihotis,* has perhaps caused more damage on a worldwide basis than any other disease of cassava.

This potentially devastating disease can be managed quite well through the adoption of a series of integrated control measures. Crop rotation is an important control. Infected crop debris should be incorporated promptly into soil, where the bacteria die rapidly: six months is sufficient to prevent pathogen carry-over. Weeds should be controlled because *X. campestris* pv. *manihotis* can survive on the leaves and in the rootzone of some weeds.

[7] In a South African plantation a four-year cycle with three cassava crops followed by two alternate crops is applied.

ORGANIZATION

WORKING SHIFTS. Mechanical operations are done in shifts to utilize the costly equipment. The evening shift does only mechanical jobs and use artificial light from tractor generator. Last shift takes the tractor and tools to the factory workshop, where the driver check, grease etc and have the equipment inspected and cleared for a new days job by a mechanic, so break down in the field is avoided[8]. In high season work by hand is done from dawn to sunset.

PLANNING. The planning of farm operation may be done and displayed on a wallboard. One way to display is shown in the graph and for simplicity the plantation is divided in 18 plots - serial numbered - each covering roots for one month of operation. I real life the plots are subdivided to smaller fields covering down to one days harvest.

A year-plan for each plot is worked out for the running year plus one full year.

[8] As an example: Working night hours during harvesting is common practice in Denmark but a Danish farmer does not need to work in shift. In high season he works, eat and sleep - nothing else. Use of casual laborers is also used in high season - be it picking strawberries in June or grapes in France etc.

A month-plan is worked out covering activity in each plot for the running month plus one full month ahead.

A week-plan is worked out for the activities plot-wise one full week ahead.

A plan for the coming day is fine-tuned and daily communicated to everybody.

A combination of early and late maturing cultivars takes advantage of the various growing periods due to the rolling harvest.

PLANTATION / OUTGROVERS.

MECHANIZATION. Mechanized cassava processing is a fairly well established activity and a prerequisite to hold production cost in check. Mechanized cassava processing is often not a viable venture for outgrowers when compared with traditional manual farming, which are underprised because traditional processors rely on family labor, which is not perceived as cost.

To process cassava starch profitable starch plants have to be sited at very high cassava producing areas, where raw material costs are low and production has to be at a very high capacity.

Traditional manual farming operations[9]	**Man-days /ha**	**USD /ha**
Pre-planting operation	7½	7.50
Planting	12½	12.50
1. Weeding	12½	12.50
2. Weeding	10	10
Harvesting	25	250
Land rent		18
Seed		107
Tools		12
Operation excl. depreciation and interest		429,50

Operation excl. depreciation and interest.	15 t/ha	26.63 USD/t

Cassava farmers usually have neither capital or access to capital to enable them afford equipment. Traditional and small-scale cassava farmers also have limited mananagerial capabilities and training due to little formal education and this mitigates against the successful management of a cassava enterprise.

Plantation farming solves these problems by applying updated farming procedures and proper mechanization.

RAW MATERIAL SUPPLY SECURITY. The safe and regular supply of raw materials to a starch factory may be secured by farmer's ownership of the factory or by a plantation owned by the factory. Under seasonal peak load or other insufficiency of the plantation supplemental

[9] Crop Budget, Coastal Savannah, Ministry of Food and Agriculture, Ghana, January 2001.

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Operation Schedule. Plot size equivalent to one month of factory operation.		Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.	Plot No.
Year/Utilization		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
3. Year	Jan	5	5									H	E	9	9	9	9	5	5
100% utilization	Feb	6	6	P	P								H	E	10	10	10	6	6
	Mar	7	7	S	S	P	P	P	P					H	E	11	11	7	7
	Apr	8	8	W	W	S	S	S	S						H	E	12	8	8
	May	9	9	W	W	W	W	W	W							H	13	9	9
	Jun	10	10	F	F	W	W	W	W								E	10	10
	Jul	11	11	4	4	F	F	F	F	P	P	P	P				H	E	11
	Aug	12	12	5	5	4	4	4	4	S	S	S	S					H	E
	Sep	E	13	6	6	5	5	5	5	W	W	W	W						H
	Oct	H	14	7	7	6	6	6	6	W	W	W	W						
	Nov		E	8	8	7	7	7	7	F	F	F	F						
	Dec		H	E	9	8	8	8	8	4	4	4	4						

Legends:	
Harvest suspended	**Oct**
Ploughing and Harrowing	P
Harrowing	H
Start of Planting + 1. Fertilizing	S
Crop age month	8
Lay fallow	
Weeding, spray	W
2. Fertilizing	F
End of growth cycle: Harvest	E

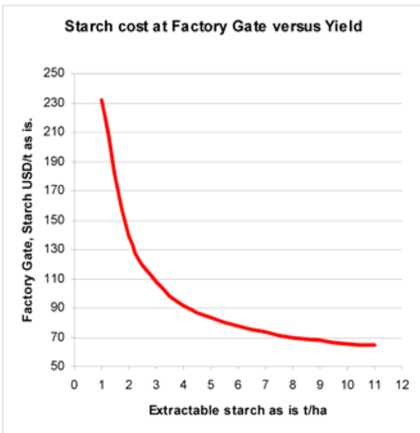
Plant on roots, Annual average ha:	54%
Plant on roots, Max ha:	67%
Plant on roots, Min ha:	39%
Laying fallow, Annual average ha:	46%
Laying fallow, Max ha:	33%
Laying fallow, Min ha:	61%

raw materials may be purchased from outgrowers.

PLANNING SCHEMES:

FIELD DISPOSITION. The following graph shows principle planning of main plots. In real life the main plots are subdivided and operation like ploughing, harrowing and planting are often done simultaneously. The graph is not related to any particular region and two month of suspended harvest is arbitrarily placed in May and October. A specific plan has to be worked out for each location based on local weather data.

WORK LOAD ESTIMATE: In addition to the scheduled jobs quite some odd jobs require labor. Graphical presentation of operations round the year and peak loads on a 1000 ha plantation:



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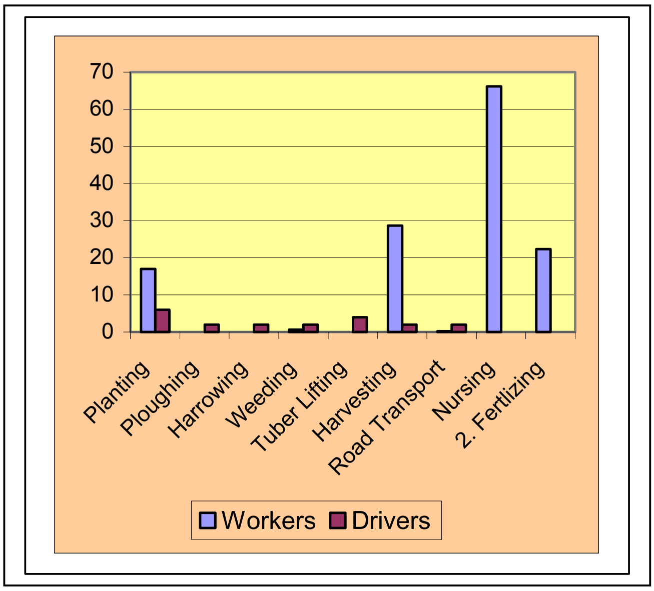

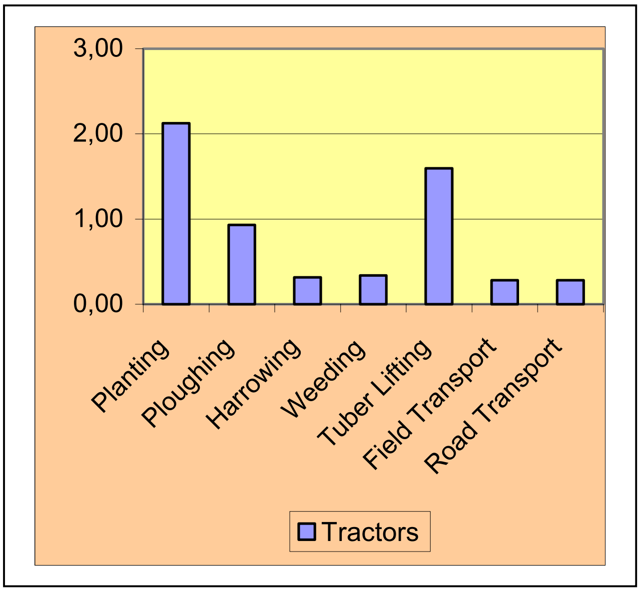

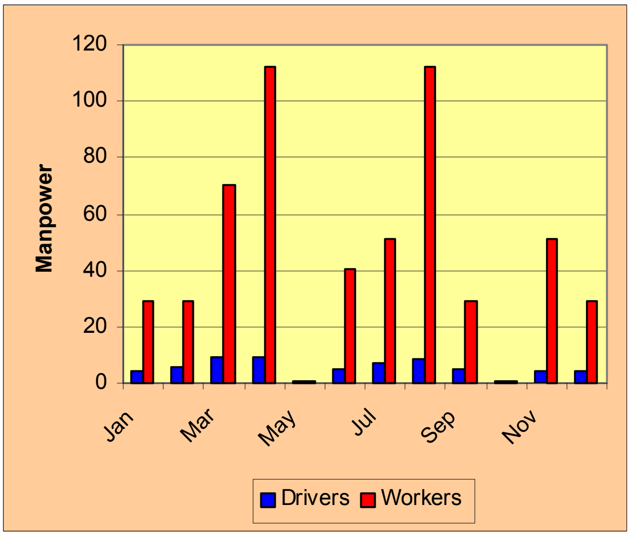

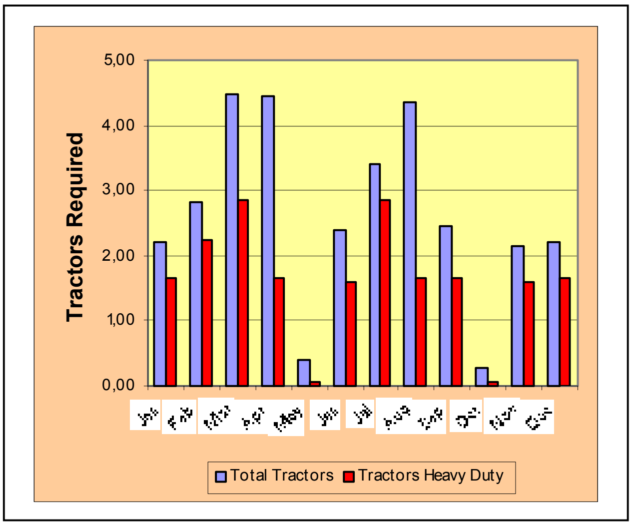

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