MANUAL FOR THE CONSTRUCTION AND OPERATION OF A NATURAL CASSAVA DRYING PLANT

BERNARDO OSPINA P.

RUPERT BEST

CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL (CIAT)

October 1984

CONTENTS

MANUAL FOR THE CONSTRUCTION AND OPERATION OF A NATURAL CASSAVA DRYING PLANT

I. INTRODUCTION

Cassava is one of the most traditional crops of the tropical regions of Latin America, and its production is primarily for human consumption. Cassava is very popular among low-income farmers since it can be grown at low cost and in addition is resistant to drought, grows easily on poor soils, and can be harvested over a long period of time.

As is common with most perishable agricultural products, the large volumes of cassava produced during the harvesting period saturate the demand in the market for fresh roots, resulting in price reductions and serious marketing problems to producers. The situation is aggravated by the high perishability of the roots which deteriorate rapidly after harvest. A solution to these problems consists in sun drying the roots to obtain a product that can be stored during long periods of time without deterioration problems and that can be used in the preparation of balanced animal feed. This market shows a growing demand for dry cassava to be used as a substitute for sorghum and other cereals whose levels of local production do not meet the requirements of the feed industries.

Cassava drying is a simple process that can be done by the farmers themselves, allowing them to use the land and labor more efficiently, and offering them the opportunity to promote the formation and consolidation of associative or cooperative production, processing, and marketing groups. The establishment of an agroindustry based on cassava production will help create an alternate market through which farmers can commercialize important volumes of their annual production surpluses.

II. CONSTRUCTION OF THE PLANT

This section details the main aspects to be considered in constructing the minimum infrastructure of a 500-m^2 drying floor plant with a capacity to produce approximately 6 tons of dry cassava per week, as well as the characteristics of the equipment, implements, and tools required.

1. Infrastructure

The infrastructure for a drying plant includes the drying floor, the chipping area, and the storehouse. Following is a description of the steps involved in the construction of these elements and Annex 1 presents the corresponding designs and costs.

1.1 Drying floor

The drying floor is the area where fresh cassava chips are exposed to solar radiation. It must be constructed as inexpensive as possible to maximize the resources available in the region. A resistant, smooth surface that will not crack is necessary in order that the rakes can easily spread, turn, and gather the cassava chips.

Organization

Coordination of the construction of the drying floor is specific for each region, depending on the type of organization existing among the farmers. A mason with experience can generally be found in the area and he can direct the work team, if possible including members of the farmers' association. In other areas, it is possible to build the drying floor with the help of certain state institutions whose instructors and apprentices come to the area and construct the installations together with the farmers.

Location

The place to build the drying area must be carefully selected. Among the characteristics to be considered in selecting the site are: equidistant location with respect to the areas supplying the raw material; away from trees, buildings, or other obstacles that reduce natural ventilation and shadow the drying floor during day hours; availability of water resources and electricity; and good roads.

Demarkation and land clearing

Once the size of the area to be constructed has been defined, the land is demarked taking into account the natural slope of the area since it is advisable that the drying floor have some inclination to allow rain water to drain.

It is advisable to use a motorgrader for land clearing, having care not to go very deep since this would imply additional filling and would increase costs considerably.

Levelling and surfacing

Levelling consists basically in assuring that the area demarked have no promontories or higher-altitude zones which would make construction of the floor difficult; this is achieved with the motorgrader. Surfacing seeks to maximize compactness of the land; this operation is carried out after land clearing. Consecutive passes of the motorgrader achieve this effect, but it can also be done manually. When the soil in the chosen area is very clayey and shows a tendency to crack during the summer periods, a layer of soil must be applied over all the area before surfacing. It is advisable to examine the soil texture to help precise its characteristics.

Foundation

A foundation must be layed along the perimeter of the demarked area to serve as support for the drying floor. First, a 20 to 30-cm wide and 30 to 40-cm deep ditch is excavated along the perimeter to construct the footing by casting concrete or by using concrete blocks.

Floor casting

The characteristics of the soil determine the dosification of the mixture to be used. Four materials are used: cement, sand, gravel or triturate, and water. The mixture of these four elements is known as concrete or plain concrete. Care must be taken that the sand is clean, this is, free of vegetative material or soil; likewise, the gravel must be free of earthy materials.

Different proportions are used in the preparation of concrete, but the dosis generally recommended is 1 part cement, 3 parts sand, and 5 parts gravel or triturate.

Concrete is used for footings, columns, beams, and floors. The mason's experience in other constructions in the area where the drying floor is going to be established is the best help to select the adequate proportions. Overall, a 1:2:3 mixture is recommended for clayey soils and a 1:3:5 mixture for sandy soils.

Table 1 shows the amounts required for constructing one cubic meter of concrete with different dosifications.

Table 1. Materials and amounts required for the construction of one square meter of concrete, according to dosification

Mixture or dosification	Cement kilos	Cement sacks	Sand m^3	Triturate m^3	Water Gallons	Water Liters
1:2:2	420	8 1/2	0.670	0.670	51	192
1:2:3	350	7	0.555	0.835	42	158
1:2:4	300	6	0.475	0.950	38	135
1:3:4	260	5 1/5	0.625	0.835	33	124
1:3:5	230	4 1/2	0.555	0.920	27	101
1:3:6	210	4 1/5	0.500	1.000	25	94

The following example explains the use of Table 1: A 1:3:5 dosification will be used to construct a drying floor with the following dimensions:

Length : 25 m

Width : 20 m

Depth : 8 cm

Procedure:

a) Multiply these dimensions to obtain cubic meters:

$$25 \times 20 \times 0.08 = 40 \ m^3$$

b) Find the 1:3:5 proportion in Table 1 and obtain the corresponding values:

Dosification	:	1:3:5
Cement	:	230 kg total (or 4.5 50-kg sacks)
Sand	:	0.555 m^3
Triturate	:	0.920 m^3
Water	:	101 liters

c. Multiply those amounts of materials by the value obtained in (a); the result is the amount of material necessary for casting the natural cassava drying floor.

Cement	:	4.5 x 40 = 180 sacks
Sand	:	0.555 x 40 = 22.2 m^3
Triturate	:	0.920 m^3 x 40 = 36.8 m^3
Water	:	101 liters x 40 = 4,040 liters

To assure that the concrete prepared always has the same characteristics, masons use a common recipient to measure all materials necessary for the concrete. For example, a 33 x 33 x 33 cm (length, width, height) wooden box can be used as reference. This box is big enough for a 50-kg sack of cement. Another unit of measurement commonly used by masons in rural areas is a tin can (a container used to pack oil). A sack of cement is the equivalent to two tin cans; thus a 1:3:5 mixture would be equal to:

2 cans cement

6 cans sand, and

10 cans triturate.

The mason uses his criteria to determine the amount of water necesarry in preparing the concrete. This can be a critical element in the construction of drying floors in areas where water is scarce.

During the two weeks following the construction of a concrete floor it is advisable to sprinkle water over the surface to contribute to the hardening of the floor.

Expansion Joints

It is advisable to lay out the area where the drying floor is going to be built in 2x2-m square areas. A separation should be left between each of these slabs as an expansion joint, reducing the risks of floor cracking. The expansion joint can be a piece of wood or triplex placed to separate two adyacent slabs. The separation must be narrow. When floor casting is finished, the expansion joints are removed and the openings are filled with a cement and sand mortar. Lampblack may be used to help highlight the separations between slabs.

This practice helps workers in managing the floor during the drying process since each slab has a 4-m^2 area, or the capacity to hold 48 kg of fresh cassava chips, which is approximately the carrying capacity of the wheelbarrows commonly used in this process. In other words, the load of a wheelbarrow of cassava chips will cover a 4-m^2 slab.

Iron

To reduce the risk that the concrete surface may crack, 1/2-inch, 20 to 30-cm-long iron rods are recommended. These pieces of iron act as binding elements between slabs and can be placed every 60 to 80 cm.

Patching and pointing

This is the final step in the construction of a drying floor; all possible surface cracks should be mended to avoid having areas where dry cassava dust can accumulate. The drying floor must be as smooth as possible.

1.2 Chipping area

The chipping area of a natural cassava drying plant is the place where the chipping machine is installed; it must have enough space for the chipping operators to move around easily and must accommodate the raw material to be processed. A 5 x 5-m area is considered adequate for 500 to 1000 m² drying-floor plants.

The chipping area must be roofed to protect workers from the sun and help avoid deterioration of equipment due to rains.

Location

To a certain extent the location of the chipping area is determined by the location of the drying floor. If access to the area surrounding the floor is easy on any side, the ideal location would be on the lower end to facilitate washing of the machine, which must be done each time it is used. If not possible, the chipping area must be located on the floor where the raw material is received. It must be built in the center of the side chosen to avoid cassava chips thrown by the machine to fall outside the drying floor.

Foundation

Since it is the place where the chipping machine is installed. the chipping area of a natural cassava drying plant will be subject to vibrations and supports greater raw material weight per unit area. Thus, a resistant floor, with cast footings or concrete blocks on a 40-cm wide excavation is considered adequate.

Levelling

It is advisable that the floor of the chipping area have difference in elevation to allow drainig of water used to wash the machine. This slope must be opposite to the direction of the slope of the drying floor so that water does not run off to the drying area.

Iron

For resistance to vibrations, the floor of the chipping area must be reinforced with 1/2-inch iron rods fastened to form a grid. A 15-cm thick floor with iron rods placed 5 and 10 cm apart is adequate.

Each rod must have a minimum of 5 cm of concrete coating to prevent oxidation and damage to its resistance.

Casting

Floor casting must be 15 to 30-cm deep, using a 1:3:5 mixture.

Roof

The chipping area must have a roof made of zinc or Eternit sheets or with materials typical of the region (palm tree leaves). Wooden posts are used in the four ends of the chipping area, on which a wooden rim is built to support the Eternit or palm tree leaves. The roof must have sufficient slope to allow rain water to drain without affecting the drying area.

1.3 Storehouse

The storehouse is one of the most important facilities of a natural cassava drying plant. It is used to store the dry cassava chips and the equipment and tools used in the process. The storehouse plays an additional role for the group of farmers since it becomes the meeting place for workshops, training courses, and other social activities.

The size of the storehouse is determined by the production capacity of the drying plant and the periodicity of dry cassava shipments. Approximately one cubic meter (1 m^3) of storehouse permits the storage of 500 kg of dry cassava; that is, a 140-m^3 storehouse (10 x 4 x 3.5 m) can house approximately 60 tons of dry cassava, or the production of a 500-m^2 drying floor during an 8-week period. If dispatches of dry cassava are done every 2 weeks, the storehouse will not have problems of congestion or defficient ventilation.

Location

The storehouse is built near the chipping area and the drying floor, trying to avoid uneven zones. The storehouse should be oriented with its longest side perpendicular to the north-south path of the sun to minimize exposure of the storehouse to direct sun rays.

Drainage must be adequate surrounding the storehouse to prevent humidity inside the storehouse. Likewise it must be located in such a way that it facilitates storing and shipment of dry cassava.

Excavation and foundation

A 30-cm deep and 20-cm wide excavation is recommended; this is filled with a 1:2:3 concrete mixture, reinforced with 3/8" iron rods placed 10 cm apart and having a 5-cm coating below and above. Iron straps (1 1/4") are placed every 20 cm, and are fastened with 16-gage soft wire. If the building is going to have columns, which is advisable when one of the walls of the storehouse is very long, the excavation at the location of the columns should be deeper.

Columns

Columns are the most important element in the construction of a storehouse since they receive and transmit the building's weight to the floor. It is advisable to build a column every 3 to 4 linear m of wall. Once the columns are located, a 1.0-m deep, 60 x 60-cm hole is excavated at the base. The first 20 cm are filled with a 1:2:3 concrete mixture, placing over this a 3/8"-iron rod grid with the rods 20 cm apart from each other. This grid serves as a bonding point for the iron rods forming the structure of the column. A 25-cm square lattice is formed, and a 3/8"-rod is placed at each end fastening these with 1/4" iron straps, placed every 25 cm. An 18-gage soft wire is used to fasten the rods to the frames. The excavation is then filled with concrete up to 50 cm, to form the footing on which the column will rest. At this point, a wooden form is used to cast the column with a 1:2:3 concrete mixture. This operation is conducted after building the walls.

Walls

Walls are built using cement blocks or bricks. Each square meter of wall requires about 25 units of 38 x 19 x 9 cm cement blocks, or 50 units of bricks. The bricks or blocks are bound with a 1:3 mixture (1 part cement and 3 parts sand). If one of the storehouse walls is very long, requiring a central column, it is advisable when placing the 1/4" iron frames every 3 rows of blocks or bricks, to cut 1-meter long pieces of iron in such a way that 30 to 40 cm of the rods stick out on each side of the column. These pieces of iron fasten the wall to the column. To reduce heat transfer by sun radiation it is advisable to paint the walls with a light color to reflect part of the radiation. The inside surface of the walls must be smooth to prevent accumulation of leftovers, facilitate cleaning, and avoid interstices which enhance insect survival.

Lower fastening beam

This beam fastens the columns together. It is casted in reinforced concrete, immediately after the footing. A 3/8"-iron rod is used with frames or straps of 1/4" rods, placed 25 cm apart. A wooden form is used to cast the beam with a 2:2:3 concrete mixture.

Upper fastening beam

This beam also fastens columns together and serves as support for the wooden structure on which the roof is built. It is constructed immediately above the upper edge of the storehouse door, using concrete reinforced with 3/8" rods and 1/4" straps placed every 25 cm. Generally, various rows of concrete blocks or bricks are placed on top of the upper fastening beam.

Roof

The roof is the final step in the construction of the storehouse. Wooden beams are used to assemble a supporting template on which

Eternit or zinc sheets are placed. The roof can also be built using materials typical of the region. A peak roof with an adequate drop is advisable to drain rain water. The roof must have eaves to protect the walls from direct moisture and in addition, to provide shadow to the walls, thus reducing higher temperatures due to solar radiation.

Doors and windows

Doors and windows in a storehouse play an important ventilation function. Windows can be substituted by rows of oraft blocks, which can reduce costs, especially in regions where wood is expensive. In humid regions this uncontrolled ventilation can contribute to moistening the stored product. A storehouse must be ventilated only when necessary.

Flour

The floor inside the storehouse should be as smooth as possible; therefore, a not very thick slab should be castec. Wooden stowages are placed over the slab to support the dry cassava sacks. These stowages separate the stored product from the floor preventing that the increase in humidity due to the capillary nature of the concrete affect the lower part of the piles. They also allow that air circulation remove accumulated humidity.

Piles

The piles of dry cassava sacks should be assembled on the stowages. Jute or hemp sacks hold better and form more stable piles. It is necessary to leave control and/or transversal alleys for circulation of personnel and equipment and which favor the circulation of air. The stowages must be removed periodically to clean the floor and prevent contamination of the product.

Control of rodents

Rodents are enemies of stored products. They can produce damage by direct consumption, contamination of the product with their excrements, or by acting as vectors of an unlimited number of diseases.

The size of a rodent population depends on three main factors: available feed, water, and space for them to build their nests. Rodents prefer living where water is available; therefore it is advisable to control leaks and pools close to the storehouse. It is advisable to construct 2 to 3-m wide sidewalks around the storehouse; these should be free of obstacles.

1.4 Fencing the drying area

Once the construction of facilities has been finished and before starting up the natural cassava drying plant, the drying area must be isolated with a wire fence. This fence will prevent the access of animals that can cause problems by reducing yields and contaminating the end product.

2. Equipment

The minimum necessary equipment for the operation of a natural cassava drying plant is:

2.1 Weighing scale

This scale is used to weigh fresh and dry cassava. It must have a 500 kg capacity.

2.2 Chipping machine

The commonly used chipping machine model is called the Thailand type. This machine is built with materials easily found in the market and is basically composed of a general supporting structure, a feeding bin, and a chipping disk. Under normal operating conditions it can chip 2-3 tons of fresh cassava per hour. A construction guide of the machine with instructions, list of parts, and designs is available in the Utilization Section, Cassava Program, Centro Internacional de Agricultura Tropical, Apartado Aéreo 6713, Cali, Colombia.

2.3 Motor (gasoline or electric)

This is probably the most important piece of equipment of a natural cassava drying plant. A system of pulleys and belts sets the chipping machine in operation. Its installation, operation, and maintenance require special and intensive training of the farmers. Mechanical problems in the motor can interfere with plant activities resulting in economic losses to the farmers.

Under ideal operating conditions, a natural cassava drying plant should have two motors: a gasoline and an electric motor.

Annex 3 presents the most important aspects for the maintenance of a gasoline motor.

3. Implements and tools

The necessary implements and tools for the operation of a natural cassava drying plant are:

3.1 Wheelbarrows

These are used to transport the cassava chips and for gathering the dry product. Generally they have a 50 kg capacity. The number of wheelbarrows required depends on the size of the installations. Generally, a natural cassava drying plant having a 500-m² concrete floor needs four wheelbarrows.

3.2 Rakes and collectors

These are wooden implements; the rake is used to spread and turn over the chips periodically to guarantee uniform and faster drying. Dry chips are gathered with a wide shovel having a 1.5-m long handle and a rectangular flat part finishing in edge (1.2 m long and 0.40 wide) (Figure 1). Metallic shovels are also used to pack the dry cassava chips.

FIGURE 1. Wooden rake (A) to spread and turn over the cassava chips and wooden shovel (B) to collect the dry chips.

3.3 Plastic tent

The tent is used to protect the product during the rainy period. The tent is scarcely used during the dry period but becomes very important during the rainy period because rains generally last only a few hours and cassava can continue to be dried afterwards. A natural cassava drying plant having good tents can operate partially during winter. A 250-m^2 tent is advisable for a 500-m^2 concrete floor plant.

3.4 Sacks

The best sacks to pack the cassava chips are made of hemp or jute. A cassava drying plant must have an adequate number of sacks to avoid bulk storing of dry cassava. Sacks are also necessary to buy the fresh roots.

3.5 Other

Among the additional elements necessary in a natural cassava drying plant are:

a) Set of tools

One 1/2" x 3/4" open-end wrench

One 1/2" x 3/4" groove wrench

One 8" expansion wrench

One set of Allen wrenches

b) Half-round file for sharpening the disk

c) Tool for fixing holes in the chipping disk

d) Tank and funnel for gasoline and oil for the motor

Annex 1, Table A4 summarizes the costs to establish a 500-m² drying floor plant.

III. PLANT OPERATION

1. Organizational aspects

The efficient operation of a natural cassava drying plant requires organization on the part of the farmer or group of farmers owning the plant. It is fundamental to have a manager, who must work permanently during the processing period. He is the person responsible of plant operations and must be dynamic and respected by the rest of the farmers. He is in charge of organizing the work teams, supplying the raw materials on time, and controlling the quality of the end product. The other fundamental person in the organization of a natural cassava drying plant is the treasurer, who is in charge of making payments and collecting dues.

One of the most important functions of the plant manager is related with the supply of raw materials. A drying plant normally operates during the dry season of the year and its facilities must be used intensively during that period. For example, a drying plant located in a region that allows for 20 weeks annually of natural cassava drying, must process a minimum of 60 lots per year. With lower processing levels, annual operation costs will be higher and profits lower. In addition to having the plant process an adequate number of lots per year, it is very important that plant facilities be used each time at maximum capacity in terms of optimum load of fresh chips per square meter of drying floor. Achieving these two objectives guarantees the overall efficiency of a drying plant.

Once the facilities have been constructed, small scale trials must be carried out in order to try out the equipment, familiarize farmers with the technology, and define an operational scheme for the plant, which adjusts itself to the conditions of the area.

2. Operation

Processing of a lot of fresh cassava includes the following steps:

Weighing the fresh cassava

Cassava is transported to the drying plant to be weighed; various sacks are placed on the scale at the same time to hasten this operation.

The plant manager is responsible for receiving only the amount of fresh cassava that the plant can process. For example, in a drying plant with a 500-m^2 patio it is not advisable to spread more than 6 tons per shift (12 kg/m²) since drying would slow down and the quality of the end product would be seriously reduced. Also, if more cassava is received than can be spread out on the drying floor, the unused roots will enter a deterioration process which is irreversible and which can convey serious economic losses to the enterprise. The manager must control the supply of raw materials to guarantee that the drying plant will have the supply of cassava needed at the right time (see Annex 2, Table A5). A practical standard is to never process cassava that has been harvested for more than two days.

Cassava chipping

The chipping machine can be easily handled by the farmers, but it is essential to perform certain check-outs and adjustments prior to chipping to guarantee the correct operation of the machine.

The most delicate part of the machine is the gasoline or electric motor. The group of farmers must select one or several persons to be in charge exclusively of operating the motor. It is necessary that these operators receive specific training on maintenance and repair of motors.

The oil and fuel level, the spark plug, and motor acceleration must be checked before initiating the chipping operation. Correct alignment between pulleys (driving and receiving) and adequate tension of the belts joining the pulleys must be checked. This is simplified by designing the supporting base of the motor in such a way that it facilitates lateral and longitudinal displacement of the motor. The machine must be operated empty to check-out the transmission mechanism and the equilibrium of the chipping disk. Adjustment on the shaft of the setscrews that fasten the chipping disk and the receiving pulley must be revised. Anchorage of the driving pulley to the shaft of the motor must also be revised. The cutting surfaces of the chipping disk must be very well sharpened.

Once this revision process has been carried out, the chipping activities can be started. Depending on the geometry of the resulting chips, adjustments can be made to the disk holes in order to increase or reduce the thickness of the chips. Under normal conditions a Thailand-type chipping machine with an 8-HP gasoline motor can process from 2 to 3 tons of fresh cassava per hour.

<u>Spreading out of chips</u>

The concrete floor is convered with a uniform layer of cassava chips, which are distributed over the drying area using a wheelbarrow and then a wooden rake to spread them out uniformly.

Some 10 to 12 kg of fresh cassava chips can be dried per square meter of drying floor; under normal climatic conditions this batch can be dried in 2 days. Larger batches delay drying and smaller loads reduce the drying efficiency of the plant.

Turning

In order to accelerate and achieve the uniform drying of the cassava chips, these must be turned over several times during the day (6 to 8 times). This operation is done with a wooden rake.

Collection

When the cassava chips reach an adequate level of humidity they are gathered and packed. The chips are dry enough when they crumble easily when pressed between the fingers. A wide wooden rake is used to gather the chips which are then packed in hemp or polyethylene sacks of approximately 40 to 50 kg per sack. The administrator must keep control of the processing of each lot, recording the amount of fresh cassava chipped and the amount of dry cassava collected (see Annex 2, Table A6).

Storage and marketing

Dry cassava is stored in the storehouse and shipment to clients is organized so there is no congestion in the storehouse. A natural cassava drying plant with a 500-m^2 floor can produce approximately 6 tons of dry cassava every 15 days. If shipments are done every 15 days, a 140-m^3 storehouse is adequate.

Dry cassava is purchased by companies that manufacture balanced animal feed. The product must be delivered at their processing plants and transportation of the dry cassava is on the account of the farmers. The dry cassava chips must meet certain quality standards (low contents of humidity, fiber, and ash; and high content of starch); one of the most important is the humidity content, which should not be greater than 14%. Also, if cassava is processed after more than two days of being harvested, fungi attacks can occur and in severe cases aflatoxins can be present, which make the product unusable.

The manager must keep control of the amount of dry cassava dispatched in each shipment (see Annex 2, Table A7).

3. Yield (conversion factor)

The conversion factor of fresh cassava into dry cassava is a fundamental parameter in determining the economic profitability of a natural cassava drying plant.

The quality of the processed cassava (dry matter content) determines to a large extent the final yield of the process. This aspect is difficult to control by the farmers although controls can be established upon receival of the raw material at the plant; the purchasing price for low-quality varieties can be reduced. A conversion factor between 2.4 and 2.6 tons of fresh cassava to produce one ton of dry cassava is considered satisfactory.

Farmer's training also has incidence on the conversion factor achieved in the drying plant. Farmers with experience in drying will not allow overdrying of the product below the accepted levels. Likewise, cassava stored with an excess of humidity can suffer deterioration to the point of having to discard it, thus increasing the conversion factor and reducing utilities.

IV. DETERMINING THE DIMENSIONS OF THE PLANT

To determine the appropriate dimensions of a cassava drying plant using concrete floors involves considerations on production of cassava roots, climatic conditions of the zone, and projections of dry cassava production.

(i) Cassava production in the area

Production of cassava in the area of influence of the project is indicative of the surplusses which will be marketed, part of which will be the raw material for the drying plant.

(ii) Climatic conditions of the zone of influence of the project

Natural drying of cassava is carried out during the summer season when rains are scarce or inexistant. The number of summer months in the region must be estimated to determine the number of weeks per year when natural drying can be expected.

(iii) Amount of dry cassava to be produced

The amount of dry cassava to be produced depends on the length of the dry season and the demand for the product. If only a few months are available and large amounts of dry cassava are required, the drying plant facilities must have a good processing capacity. If the dry period is long the drying plant must operate below capacity to produce the same amount of dry cassava.

An example can better illustrate points a, b, and c. Example. A natural cassava drying plant is to be established in an area with five summer months. In the area, drying of a 12-kg/m² load of cassava chips generally takes 2 days. The capacity of a natural cassava drying plant with 500 m² of concrete floor is to be determined:

The process is assumed to operate three times per week during 16 weeks (80% of the time available).

$$16 \text{ weeks} \times \frac{3 \text{ lots}}{\text{week}} \times \frac{500 \text{ m}^2}{\text{lot}} \times \frac{12 \text{ kg}}{\text{m}^2} = 288 \text{ t fresh cassava}$$

Assuming a 40% yield, the plant would be in capacity to produce 115 tons of dry cassava per year. Similarly, a drying plant with 1000 m² of concrete floor would be in capacity to produce 230 tons of dry cassava per year.

The final decision on the size of the facilities will depend on the resources available and the organizational and administrative capacity of the farmer or group of farmers owning the plant. It is advisable to operate medium-sized plants during the first year and, based on results, determine to expand the processing capacity during the second year.

Table 2 presents different combinations of drying area, drying period, and production capacity for 500-, 1000-, and 2000-m^2 drying plants (12 kg/m^2 loads and 40% yield are assumed; that is, 2.5 tons of fresh cassava to obtain 1.0 tons of dry cassava).

Table 2. Relation between plant size, period of plant operation, and production capacity.

Drying floor area (m^2)	No. of weeks available/year	Annual production (ton) fresh cassava	dry cassava
	12	216	87
500	16	288	115
	20	360	144
	12	432	174
1000	16	576	230
	20	720	288
	12	864	348
2000	16	1152	460
	20	1440	576

ANNEX 1

DRAWINGS AND INFRASTRUCTURE COSTS OF A NATURAL CASSAVA DRYING PLANT

Drawing 1. Concrete floor.

NOTE: The floor must have a minimum slope of 1%, or that of the natural slope of the land.

1/2" x 0.50-m long pieces of iron, placed through the expansion joints.

CHIPPING AREA 25 m²

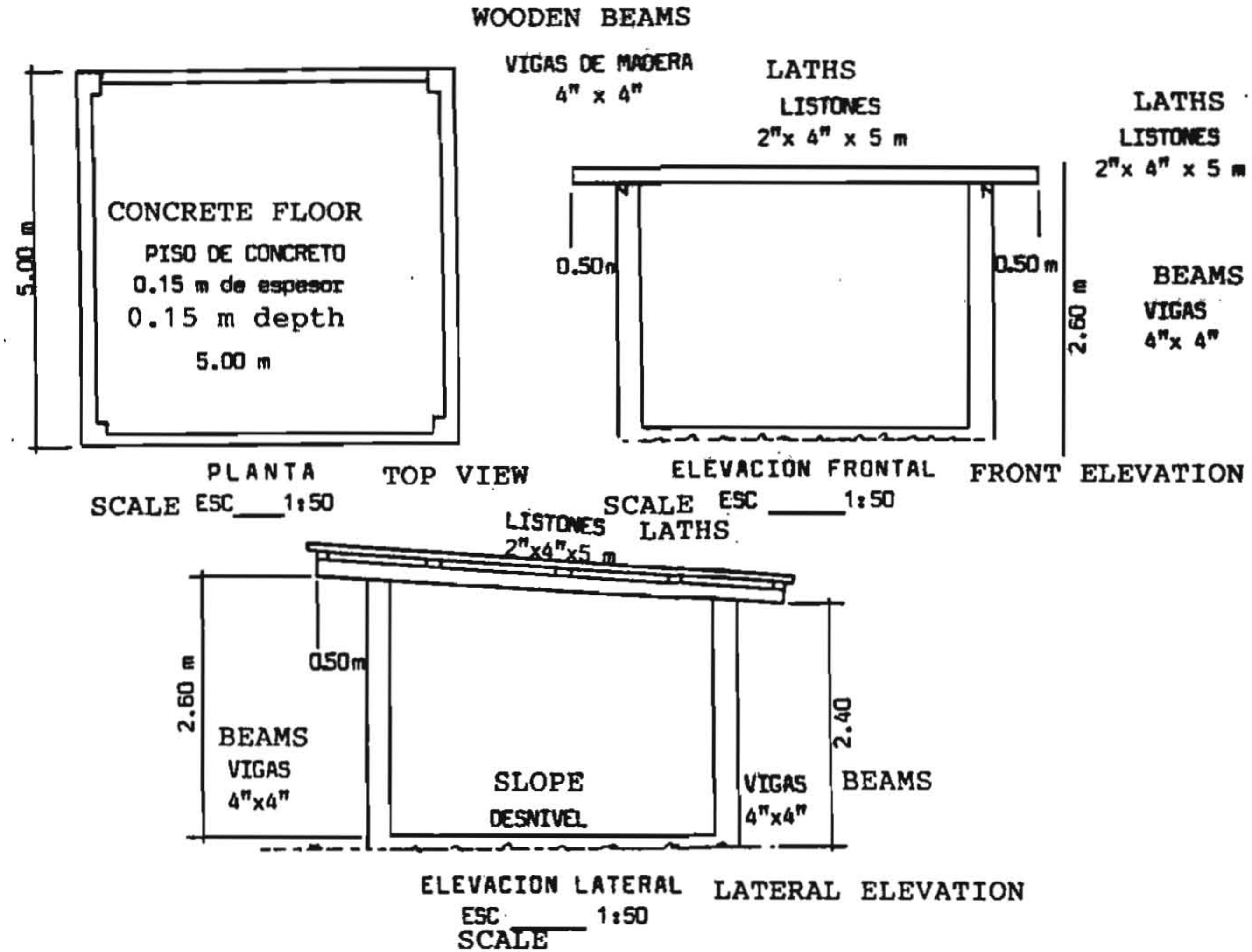
1% minimum

(See details in Page No. 2)

2 x 2-m slabs separated by expansion joints.

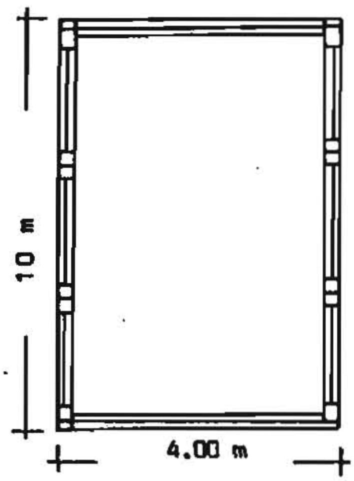
NOTE: The expansion joints can be made with pieces of wood, removing them when casting is finished; the openings then are filled with a cement mortar.

0.08-m THICK CONCRETE FLOOR



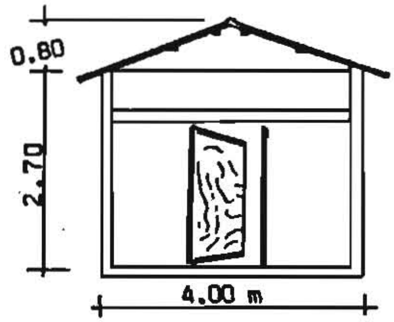
PLANO 2. EL AREA DE PICADO

DRAWING 2. CHIPPING AREA



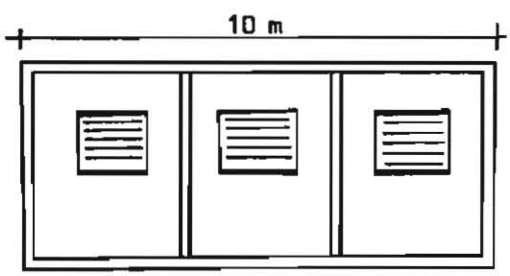
PLANTA DE CIMIENTOS
ESC _____ 1:75

TOP VIEW OF FOUNDATION
SCALE



FACHADA PRINCIPAL
ESC _____ 1:75

MAIN FRONT
SCALE



FACHADA LATERAL
ESC _____ 1:75

LATERAL FRONT
SCALE

PLANO 3. LA BODEGA DE ALMACENAMIENTO

DRAWING 3. THE STOREHOUSE

Table A1. Construction cost of 500 m^2 of concrete floor. Colombian pesos, 1984[1]

Item	Unit	Unit Cost $	No. of units	Total cost
Cement	Bag 50 kg	400	200	80,000.oo
Sand	Trip	3,500	7	24,500.oo
Chinastone	Trip	5,500	9	49,500.oo
Iron (3/8")	Rod 6 m	250	28	7,000.oo
Wood	Board	450	7	3,150.oo
Water				6,000.oo
Well				7,000.oo
Other[2]				2,000.oo
Masonry cost m^2				57,500.oo
Total cost				236,650.oo
Cost, $/$m^2$ of floor				173.30

[1] = US$1.oo = 100 Colombian pesos.

[2] = The other items include: nails, hacksaws (2), tin cans (8), wire (6 m), nylon (1 roll).

Table A2. Construction cost of chipping area (25 m^2)

Colombian pesos, 1984[1]

Item	Unit	Unit Cost $	No. of units	Total cost $
Cement	50-kg bag			
Sand	Trip			
Chinastone	Trip			
Iron (1/2")	6-m rod			
Ruralit No. 8	Sheet			
Wood	Lath (2"x4"x35m)			
Wood	Lath (4"x4"x30m)			
Other[2]				
Labor cost	m^2			
Total cost				
Cost, $/$m^2$ chipping area				

[1] = US$1.oo = 100 Colombian pesos.

[2] = Corresponds to nails, bolts, hooks, wire.

Table A3. Construction cost of a storehouse (168 m^3) Colombian pesos, 1984[1]

Item	Unit	Unit cost $	No. of units	Total cost $
Cement	Bag 50 kg			
Blocks	Block			
Rubblestone	Trip			
Sand	Trip			
Chinastone	Trip			
Iron (3/8")	Rod 6 m			
Iron (1/4")	Rod 6 m			
Iron (1/2")	Rod 6 m			
Eternit No. 8	Sheet			
Sawhorse	Sawhorse			
Wood	Board			
Wood	Lath (2"x4"x10m)			
Wood and iron				
Window	Window (1x1m)			
Wooden door	Door			
Draft blocks	Meter (10 units)			
Other[2]				
Labor Cost	m^2			
Total cost				
Cost, $/$m^3$ of storehouse				

[1] = US$1.oo = 100 Colombian pesos

[2] = Refers to nails, wire, lashing, and water.

ANNEX 2

TABLES ON CONTROL OF FRESH CASSAVA SUPPLY, PROCESSING, AND SHIPMENT OF DRY CASSAVA

Table 4A. Summary of establishment costs of a natural cassava drying plant with 500 m^2 of drying floor. Colombian Pesos, 1984[1]

Detail	Unit cost $	Partial cost $	Total cost $
A. Facilities			
Concrete floor (500 m^2)			
Chipping area (16 m^2)			
Storehouse (168 m^2)			
Wire fence (120 m)			
B. Equipment			
Chipping machine (with spare disk)			
Gasoline motor 8 HP plus coupling			
1 weighing scale (500 kg)			
C. Tools			
3 metallic wheelbarrows			
6 metallic shovels			
5 wooden rakes			
5 collectors			
400 hemp packages			
1 plastic tent (250 m^2)			
SUBTOTAL			
Contingencies (5%)			
Working capital			

[1] = US$1.oo = 100 Colombian pesos

Table A5. Control of raw material supply.

Date	Suppliers	Fresh cassava (kg)	Observations

Table A6. Overall control of the drying process

Lot No.	Chipping date	Fresh cassava		Dry cassava		Collecting	Observations
		kg	sacks	kg	sacks	date	

Table A7. Control of dry cassava shipments

Lot No.	Shipping date	Dry cassava		Observations
		kg	sacks	

ANNEX 3

GUIDE FOR MAINTENANCE OF A GASOLINE MOTOR

To fill the fuel deposit

Model, type, and code numbers are engraved here

Oil filling cap

Oil draining cap

AIR FILTER

Carry out the maintenance operations of the air filter periodically. Clean and impregnate the element with oil every 25 hours (or once a week) under normal conditions; clean it more frequently if the enviroment is dusty.

FILTER WITH OIL FOAM

1. Remove wing nut and cover
2. Pull the oil foam up holding it by the base
3. Press the oil foam downward as shown in the figure and remove the inner body of the filter
4. Assemble as indicated in the figure. Tighten the wing nut.

1. WASH WITH KEROSENE OR LIQUID DETERGENT AND WATER
2. DRY THE OIL FOAM BY WRAPPING IT WITH A CLOTH AND PRESSING
3. IMPREGNATE WITH SAME TYPE OF OIL USED FOR ENGINE
4. PRESS TO ELIMINATE EXCESS OIL

FILTER WITH DRY ELEMENT

To clean, lightly hit the element (upper or lower part) against a flat surface or wash with foamless detergent and rinse with water from the inside until clean. Dry with air before using again. DO NOT OIL.

FILTER WITH DOUBLE ELEMENT

Clean and impregnate foam prefilter with oil every 3 months or every 25 working hours whichever occurs first.

1. Remove the upper screw and cover
2. Remove foam prefilter by pulling upward
3. A - Wash the oil foam with water and liquid detergent

   B - Wrap the element with a cloth and press to dry

   C - Add 0'03 liters of the same type oil used for the engine. Press so oil is distributed uniformly.
4. Put the element in the paper cartridge. Put the cover on again and screw tightly.

Remove the paper cartridge once a year or every 100 working hours, whichever occurs first. Clean by hitting lightly on a flat surface. If very dirty, change it or clean with water and liquid detergent. Rinse until water comes out clean. The cartridge must be completely dry before reusing.

NOTE: Clean more frequently if working environment is very dusty.

FILL THE CARTER WITH OIL - Use high-quality detergent oil, classified as "For SC, SD, SE, or MS Service". Do not use any type of additive.

Summer - (Temperatures above 5ºC). Use SAE 30 oil

Winter - (Temperatures below 5ºC). Use SAE 5W-20 or 5W-30. If not available, use SAE 10W or 10W-30.

NOTE: If temperature below-18ºC, must use SAE 10 or 10W-30, diluted in 10% Kerosene.

INSTRUCTIONS: Place engine levelled. FILL THE CARTER UNTIL IT OVERFLOWS or until reaching the oil rod FULL mark.

FILL THE GASOLINE DEPOSIT

Use "regular" clean and fresh gasoline, without lead. Fill the deposit completely:

DO NOT MIX GASOLINE WITH OIL

PERIODICALLY CHECK THE OIL LEVEL (every 5 working hours). MAKE SURE OIL LEVEL IS MAINTAINED.

CHANGE THE OIL after the first 5 hours of operation. Then, change it every 25 hours. Remove the draining cap and empty the oil while the engine is still warm. Remove the filling cap or oil level rod and refill with appropriate oil. Place the cap or rod again.

GEAR OIL CHANGE (GEAR OPTIONAL) by removing the oil level cap. Remove the oil draining cap located in the lower part of the gear cover and empty out the oil every 100 hours. To refill, remove the oil level control cap and the oil filling cap and add oil (same type as used for the carter) through the filling hole until overflowing through the oil level control hole. Put both caps on again. The oil filling cap has a venting hole and must be placed on the upper side of the gear cover. If gear cover does not have an oil filling cap, the gear is lubricated with the same oil used in the engine carter.

CLEANING THE COOLING SYSTEM

Dirt of chaff can enter the fan casing with the cooling air and block the cooling fins. Working under these conditions can cause overheating and damage the engine. Remove the fan casing and clean the cooling fins as shown in the picture.

CLEANING THE COMBUSTION CHAMBER

During engine operation, carbon deposits accumulate in the combustion chamber which have been formed in the cylinder head, piston head, and around the valves. Excessive carbon deposits will reduce power output and will shorten the valves' operation life.

Take the cylinder head apart and clean carbon deposits every 150 working hours.

SPARK PLUG CLEANING

Clean the spark plug and calibrate to 1.75 mm every 100 working hours. The spark plugs must be cleaned by scrapping or brushing with a wire brush and washing them with commercial solvent or gasoline.

ATTENTION: SPARK PLUG CLEANING BY SANDBLASTING MAY DAMAGE ENGINE.

Abbrasive particles may remain adhered inside the spark plug after cleaning when sandblasted.

These sandy particles can come into the engine due to insufficient cleaning of the spark plugs and may even cause "unexpected wearing" where there is no evidence of misuse or negligence by the user.

PHOTO:

200 mg of sand remain from sandblasting the spark plugs, forming a circle as large as a dime. This amount can remain inside the spark plug after sandblasting.

"RECOMMENDED OIL" INFORMATION

Adequate lubricants are essential for the engine's life. Problems that arise in operating a four-stroke, one-cylinder engine vary depending on use, working conditions, and utilization frequency. Nevertheless, the adverse effect of those problems can be reduced chosing an adequate lubricant.

WHAT SHOULD A GOOD LUBRICANT DO?

A good lubricant must protect the engine in three ways:

1. Lubricating

It must lubricate precision and small tolerance parts, reducing friction and wearing.

2. Cooling

It must be a cooling agent to maintain the piston, connecting rod, and bearings temperature, under safe operating conditions. This is very important for the Briggs & Stratton engines since there is no water-cooling system for moving parts.

3. As seal

It must act as the sealing agent between the cylinder walls and piston rings in order to assure adequate compression and prevent exhaust gas coming into the carter.

HIGH QUALITY NEEDS

To dully protect an air-cooled engine it is important to select a high-grade lube oil with detergents and anti-oxidants. Each gallon of burnt fuel produces almost a gallon of water. When an engine is working "at nominal temperature", most of this water goes out along with the exhaust gases without causing damage. However, when the engine is cold, part of this water condense on the cold side of the cylinder and goes into the carter; it mixes partially with burnt fuel particles and with oil residues, causing a fuel oxidation that forms acids and mud. Although this happens particularly during winter it can become a constant problem when the engine is used intermitently.

On the other hand, high temperatures oxidize the oil in the same way that the grease remaining in a small warm container would cause smoke and carbon. This type oxidation results in the formation of a film which is the main cause of piston rings and intake valves blocking. At the same time, mud is formed hindering normal lubrication.

OIL CLASSIFICATION

The American Petrol Institute (API) classifies lube oil following the service they are intended. The adequate grade for Briggs & Stratton is API's MS for heavy duty engines. Some oils are graded "MM-MS-DG", which means they are adequate fo light service (MM), as well as for heavy duty for gasoline engine and general diesel (DG) engine use.

New engine service GRADATION "SC", "SD", y "SE" are similar to the current API "MS" gradation. Nevertheless, there will be a period of time during which lube oils will be identified with both gradations, old and new. Consequently we recommend the use of any type of a good quality detergent oil graded MS, SC, SD or SE.

During winter (below 5ºC)

Use SAE 5W/20 or else sW/30

If not available, use SAE 10W or else SAE 10W/30

In summer (above 5°C)

Use SAE 30

If not available, use SAE 10w/30 or else SAE 10W/40

In addition lube oil should MS, SC, SD, or SE service graded.

Gasoline information

There are different kinds of fuels. Everybody knows that there are regular, extra, non-lead, low lead content gasolines and that the octane index makes the difference. B & S engines are designed to work at full satisfaction with an 85 or higher octane index fuel.

Considering that "regular" gasoline or non-lead or with low lead content in the USA has at least 90 octane, this is the gasoline recommended for Briggs & Stratton.

Utilization of fuels without lead or with low lead contents will reduce combustion sediments, generally increasing the engine's life.

Consequently, it is better to gasoline without lead or with low lead contents as much as possible.

Differences according to seasons

However, there are people who do not realize that the "components" of fuel or gasoline are changed at least four times a year, having an important effect on engine operation more so than the octane index.

During winter, fuel is mixed with a highly volatile and light element in order to make strating easier in cold weather. During summer fuel is less volatile to avoid "boiling" and creating a steam cloud. This change in the mix way be completely satisfactory for automobiles. which use the fuel as soon as it is bought. Nevertheless, it can cause problems to the owner who stores gasoline to be used from time to time.

Old gasoline causes problems

Gasoline as well as oil, is subject to oxidation which causes gum deposits in the carburator. This can cause a lot of problems; the most normal is blocking of the intake valve. To avoid this problem, the best would be to buy gasoline depending on the fuel tank size as is done with automobiles. This would be ideal, put not practical. Therefore, and assuming tht what the owner wishes to have fuel at hand, the following recommendations should be followed.

1. Do not store fuel from one season to anothe:
2. Store gasoline in a fresh place, in order to reduce oxidation to a minimum
3. Keep the fuel tank either completely empty or totally full, whenever the engine is not in use. Air in the tank provokes oxidation. The fuel in a full deposit tank is less exposed to contact with air.

Independently from the type of engine or the equipment it drives, there are certain normal check-outs tht can be followed whenever the engine does not start or does not run adequately.

The following indications are a guide for troubleshooting in case problems arise. Skilled personnel and adequate tools are needed.

Most engine failures or complaints can be classified as one or various of the following causes:

1. Does not start
2. Trouble to start
3. Kick back at start
4. Low power output
5. Vibrations
6. Irregular running
7. Over-heating
8. Very high lube oil consumption.

If the cause of malfunction is not easily found, check the compression, ignition, and carburator system. This check-up, systematically done, can be accomplished in a few minutes. This is the fastest and surest way to find possible damage and at the same time shows possible failures which could arise later, permitting their correction before the damage occurs. The basic procedure for check-ups is the same for all types of engines. Differences as per engine model, will be discussed under the corresponding item.

NOTE: Sometimes susspected malfunctioning of the engine, may be damage in the equipment it drives. In equipment malfunctioning is suspected, please read: Influence of Equipment Driven on Engine Performance.

Compression check out

Turn the crank shaft against compression. When loose it should rebound forcefully.

NOTE: If the engine is equipped with and "easy spin" starting system, turn the crank shaft counter clockwise to achieve a good compression check out. If compression is found to be low, it can be due to:

1. Loose spark plug
2. Loose cylinder head screws
3. Broken cylinder head gaskets
4. Burnt valves and/or valve seats
5. Poor valve opening
6. Bulged cylinder head
7. Bent valve shafts
8. Worn out cylinder and/or piston rings
9. Broken connecting rod

IGNITION CHECK OUTS

Remove spark plug. Quickly turn crank shaft while holding the spark plug cable end 3 mm away from the cylinder head. If there is a spark, ignition is working satisfactorily. Try a new spark plug.

If no spark is produced, it can be due to:

1. Incorrect air gap between coil and fly wheel
2. Worn out bearing and/or crankpin of fly wheel side
3. Broken fly wheel pin
4. Incorrect gap between contact points
5. Dirty of burnt contact points
6. Worn out or choked bridging contact points
7. Short-circuited ground cable (if there is one)
8. Short-circuited stop switch (if there is one)
9. Broken capacitor
10. Broken coil

CARBURATION CHECK OUT

Before performing a carburation check out, make sure that the fuel deposit has enough fresh and clean gasoline. If fuel is gravity fed (Flo-Jet), check that the by-pass valve is open and that fuel flows freely through the fuel line. In all models, perform a check out and adjust needle valves. Check if the choke closses completely. If the engine does not start, remove and examine the spark plug.

If the spark plug is wet, it can be due to:

1. Choke too closed
2. Very rich fuel mixture
3. Water in the fuel
4. The carburator valve is blocked in an open position (Flo-Jet carburator).

If spark plug is dry it can be due to:

1. Carburator gasket leakages
2. Obstructed filter or valve due to dirt or gum (Pulsa-Jet and Vacu-Jet carburators)
3. Carburator valve is blocked in closed position (Flo-Jet carburator)
4. Fuel pump does not work (Pulsa-Jeft carburator).

An easy check out to know if fuel passes through the carburator to the combustion chamber, is to remove the spark plug and add some fuel through the spark plug hole. Replace spark plug. If the engine starts and then stops proceed with the dry spark plug check outs.

INFLUENCE OF THE EQUIPMENT DRIVEN ON ENGINE PERFORMANCE

Very often what is suspected to be an engine malfunction, such as difficult start, vibrations, etc., is rather due to damage in the equipment driven by the engine. Considering that there are so many and different equipment driven with Briggs & Stratton engines, it is impossible to give a complete list of the differente situations that may arise. Some problems due to the equipment itself and the most common causes are:

DIFFICULT START (KICKBACK) OR NO START

1. Loose belt. A loose belt as well as a loose blade can cause a kickback effect that will counteract the starting torque.
2. Starting with charge. When starting the engine check if the equipment driven is disconnected or if it is connected, check the starting load which may not be very strong.
3. Check that the remote control choke "Choke-A-Matic" is in the correct position.

VIBRATION

1. Unbalanced rotating parts.
2. Bent crankshaft.
3. Worn out blade coupling. If blade coupling allows blade displacement which cause unbalances, it must be replaced.
4. Loose mountain bolts. Lock them.
5. Broken base plate. Repair or replace.

LOSS OF POWER

1. Driven equipment is blocked or dragged. If possible, disconnect engine and operate driven equipment manually to find the cause.