Farmlime Manual

For small-scale production of agricultural lime

Economic Minerals Programme
Commissioned Report CR/05/092N

BRITISH GEOLOGICAL SURVEY

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For small-scale production of agricultural lime

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Foreword

This manual has been produced as part of the research carried out by the project ‘Low cost lime for small-scale farming’, otherwise known as FarmLime. This was funded as a Knowledge and Research (KaR) project by the Geoscience programme of the Department for International Development (DfID) of the UK Government.

The stated aim of DfID research is to “alleviate poverty” through improved access to knowledge and technology by poor people. The FarmLime project comes under the KaR programme geoscience sector theme G1 that aims to “enhance the productive capacity (of less-developed countries) in an environmentally sensitive manner”. The FarmLime project aims to investigate the means of improving the agricultural performance of small-scale farms through the use of low-cost agricultural lime (aglime), produced by a facility within the farming district, using locally occurring dolomite.

The FarmLime project follows on from an earlier DfID project, 'Local development of affordable lime in southern Africa’ (1996–1998), which investigated the feasibility of producing aglime using appropriate technology. This earlier project recommended a simple agricultural lime production method. The FarmLime project used the production method as the core of its research and is essentially the implementation phase of the earlier work. This manual is set out as a concise guide to small-scale production of agricultural lime.

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31st December 2005

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FarmLime has been a multidisciplinary research project involving geologists and geoscientists, agricultural and mining engineers, agronomists and agricultural consultants, social scientists, chemists and economists. Most of the research has been carried out in Zambia by Zambian researchers and their institutes.

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Summary

This manual is a concise guide to the small-scale production of agricultural lime. It was developed as part of a research project, ‘Low-cost lime for small-scale farming’ otherwise known as FarmLime (Mitchell, CJ, 2005).

The ideal agricultural lime is a ground dolomite or dolomitic limestone with a particle size of 100% <2 mm, 60%<400µm and up to 50% <150µm (Mitchell *et al*, 1997). It is produced from limestone and/or dolomite by a three-stage process that involves extraction, crushing and milling to a powder. Agricultural lime is often produced as a co-product in operations that are primarily geared to producing road stone aggregate, quick and hydrated lime, cement and/or mineral fillers. Dedicated agricultural lime production plants do exist, especially in countries where agriculture is one of the main stays of the national economy such as in sub-Saharan Africa. Agricultural lime is also produced by small-scale mining operations.

The quarry site first has to be cleared of vegetation and overlying soil to expose the underlying rock; this can lead to the removal of a large volume of material. The rock is then extracted from the ground, using crow bars, picks and sledgehammers, and transferred to the crushing stage. This involves the use of sledgehammers and club hammers to reduce the rock to pieces smaller than 10 mm. The final production stage is carried out using a mill, such as the modified TD Hammer Mill, which produces agricultural lime. The agricultural lime produced should be packaged into 50 kg bags.

Overall, this style of small-scale production is estimated to cost in the region of US$1.20 to US$1.60 per 50 kg of agricultural lime produced.

Small-scale production of agricultural lime is considered to be cost-effective for those farmers in districts that have a need for lime and are at least 50 to 100 km from the nearest commercial source of agricultural lime.

1 Introduction

This manual is a concise guide to the small-scale production of agricultural lime. It was developed as part of a research project, ‘Low-cost lime for small-scale farming’ otherwise known as FarmLime (Mitchell *et al*, 2003).

Agricultural lime is defined as material containing “the necessary qualities to neutralise acidic soils, provide essential nutrients to promote plant growth and correct magnesium deficiency” (ARC, 1996). The ideal agricultural lime is a ground dolomite or dolomitic limestone with a particle size of 100% <2 mm, 60%<400µm and up to 50% <150µm (Mitchell *et al*, 1998). It is also used to improve the physical properties of the soil.

The production of agricultural lime is a relatively straightforward process; it involves the extraction (quarrying and/or mining) of limestone and/or dolomite from the ground and the processes of crushing and milling to a powder (Table 1). Agricultural lime is often produced as a co-product in operations that are primarily geared to producing road stone aggregate, quick and hydrated lime, cement and/or mineral fillers.

Table 1 Typical ‘large-scale’ agricultural lime production processes

Process	**Operation**
Extraction	• Site clearance, including removal of vegetation, soil and overburden • Drilling and blasting of rock ‘benches’ in a quarry • Breaking of large rocks using pneumatic drills • Removal of rock to a processing plant
Crushing	• Primary crushing (using a jaw or gyratory crusher) • Screening of crushed material to remove the fines, which usually contain soil and fine-grained material (potential agricultural lime) • Secondary and tertiary crushing using cone or jaw crushers • Screening of crushed rock to produce sized material for aggregate or feed to lime or cement plants
Milling	• Milling of crushed material using a mill (hammer, ball and/or impact mill) to produce mineral filler and/or agricultural lime • Bagging into bulk bags (<1 tonne) or small bags (50 to 100 kg)

Dedicated agricultural lime production plants do exist, especially in countries where agriculture is one of the main stays of the national economy such as in sub-Saharan Africa. Such plants often operate a much simpler production process, which nevertheless consist of the three main components of extraction, crushing and milling.

For example, in the Western Cape province of South Africa there are two types of agricultural lime production. In Bridgetown Dolomite quarry near Moorreesburg, the dolomite is hard and has to be extracted by drilling and blasting. Agricultural lime is produced by jaw crushing and impact milling of the dolomite to finer than 1.7 mm. In the Karsrivier Kalk limestone quarry near Bredasdorp, the limestone is soft and can easily be excavated using a 'ripper', which is a large metal hook fixed on the back of a bulldozer that is used to gouge out the limestone. It is then jaw crushed and milled to produce agricultural lime which is mostly finer than 1.7 mm. The production process is summarised in Figure 1.

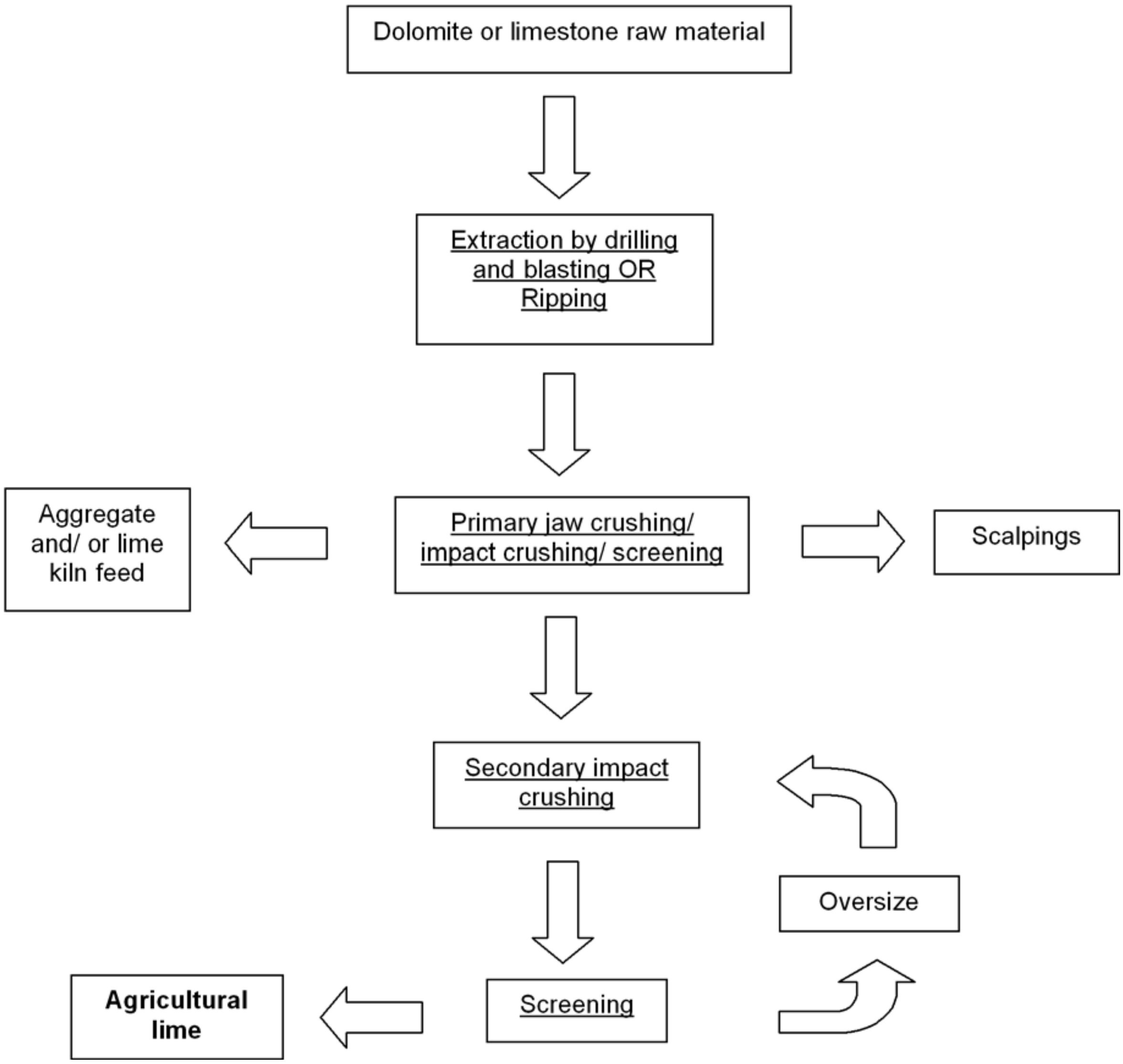

Figure 1 Process for the production of agricultural lime, Western Cape, South Africa

Agricultural lime is also produced by small-scale mining. For example, in the North-Western Province of Zambia the dolomite that occurs immediately to the south of Solwezi town is worked to produce construction aggregate and agricultural lime. The overlying soil is removed from the prominent boulder-like outcrops. Fires are set on the dolomite which when hot is doused with water to promote cracking. The dolomite is then removed using picks and crowbars. The rock is crushed by hand using hammers and sieved to remove the dust, which is sold as aglime. During peak production periods there may be as many as 50 small-scale miners quarrying and crushing the dolomite.

2 Agricultural lime production processes

2.1 SITE CLEARANCE

Manual site clearance is recommended. Bush clearing and removal of the top-most loose soil should be carried out using manual labour over an area 100m square (Photo 1). Often the bush and loose soil cover on the limestone/dolomite is limited. In the process of bush clearing and loose soil removal, some large blocks of limestone will be excavated. Depending on their size, it is recommended that these be broken up manually, using sledgehammers, and loaded onto wheelbarrows for direct feeding to the crushing stage. The estimated amount of loose limestone and/or dolomite boulders recoverable during removal of the soil is typically in the order of 5% (and less) of the total amount cleared.

In order to clear the site a labour force would be equipped with sledgehammers, crowbars, picks, wheelbarrows and protective wear. It is estimated that two thousand tonnes of soil would need to be cleared from a 100 square metre site. Assuming one man can load and move 5 tonnes per day, 2000 tonnes would take 400 man-days. At a labour rate of US$1 per day, plus equipment, it would cost US$1.13 to move each tonne of loose soil.

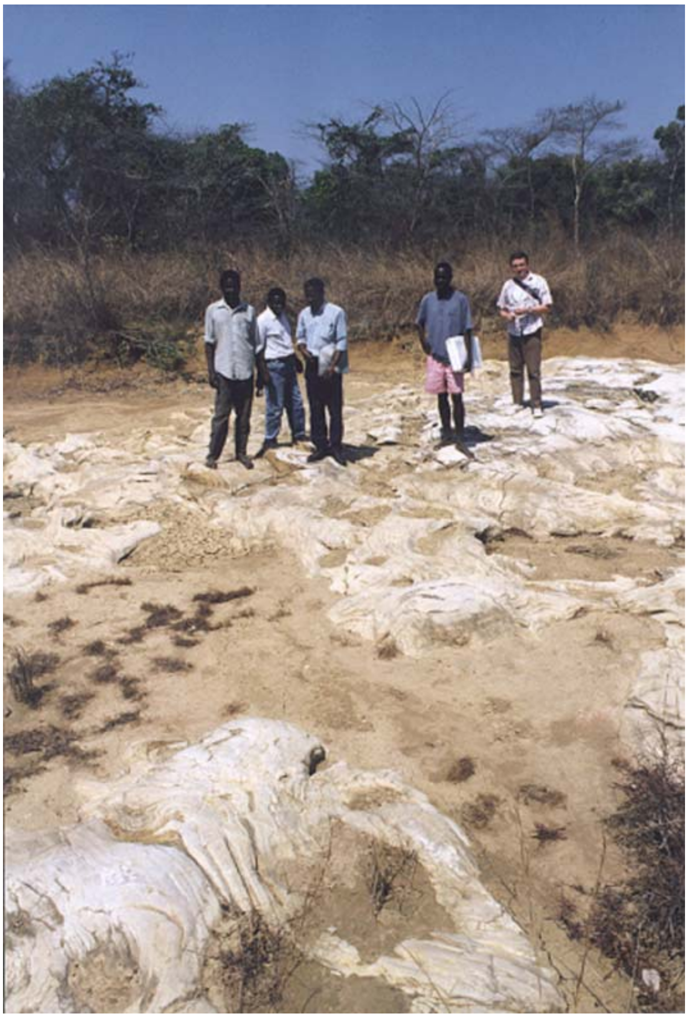

Photo 1 Partially cleared site
(Munsakamba dolomitic limestone, Mkushi, Central Province, Zambia)

2.2 EXTRACTION OF ROCK FROM THE GROUND

Manual extraction of the limestone and/or dolomite is recommended. Loose boulders can easily be removed using crowbars. The remainder of the rock will need to be broken away using sledge hammers, picks and crow bars. This process can be aided by setting fires on top of the rock and dousing with water when the rock is hot; the sudden contraction caused by rapid cooling of the rock causes it to crack open (Photo 2). A single worker will be able to extract approximately 1 tonne of rock per eight-hour working shift, adopting a shift remuneration of US$1.00 will give a unit cost of US$1.00 per tonne of rock extracted.

2.3 LOADING AND HAULING

Manual loading and hauling of dolomite with a wheelbarrow is recommended. Typical wheelbarrows in use are all-steel construction mounted on wide rubber tyres with roller bearings. They have a 70 to 80 litres heaped capacity, which is equivalent to 100 to 120 kg.

Two men working as a team (one on shovel and one on wheelbarrow) will be able to load and move 10 tonnes of limestone over an average tramming distance of 500 metres in an eight-hour working shift. Adopting a shift remuneration of $1.00 for unskilled manpower will give a unit cost of $0.10 per tonne for loading and US$0.10 per tonne for hauling. This gives a total loading and hauling cost of $0.20 per tonne.

Photo 2 Dolomite outcrops in River Solwezi dambo, Solwezi, North Western Province, Zambia.

Photo 3 Dolomite extraction site
(Solwezi, North-Western Province, Zambia)

Photo 4 Dolomite extraction site
(Solwezi, North-Western Province, Zambia)

2.4 CRUSHING

Manual crushing can be carried out but this can be a slow and expensive option. It is recommended that crushing should be carried out by a combination of coarse crushing using sledgehammers and fine crushing using a manual jaw crusher (where available).

Manual crushing should be carried out in two stages. The first stage is to reduce the rock down to about 5 to 10 cm in size; this can be done using a sledgehammer. The second stage is to reduce these rock pieces to rock chips, which are less than 10 mm in size; this can be done using 4lb hammers (Photos 3 & 4). The rate of production depends on the hardness of the rock. For hard rock each person would be expected to produce about 100 kg of crushed material, whereas for softer rock this may be as much as 150 kg. Adopting a shift remuneration of US$1.00 will give a unit cost of US$10.00 per tonne of rock extracted. It is estimated that use of a manual jaw crusher for the fine crushing stage would increase the rate of production tenfold and reduce the cost of production to about US$1 per tonne.

Photo 5 Small-scale mining area, Solwezi, North Western Province, Zambia.

Photo 6 Manual crushing of dolomite
(Mkushi, Central Province, Zambia)

Photo 7 Material crushed finer than 10 mm

2.5 MILLING

Milling of the crushed limestone and/or dolomite using a hammer mill is recommended. A modified TD hammer mill (Photo 3i to 3iii) was used in the FarmLime project; the fabrication and operation of this mill is detailed in Appendices 1 to 3. The aim should be to produce agricultural lime that contains 100% finer than 2 mm, 60% finer than 400 microns and up to 50% finer than 150 microns (Mitchell *et al*, 1998).

The crushed limestone and/or dolomite is fed into the mill at a rate of about 200 to 500 kg per hour; this varies depending on the particle-size variation of the feed material (Photo 6). The fuel consumption of the mill is about one litre of petrol for every 250 to 300 kg of agricultural lime produced. The agricultural lime produced should be packaged into 50 kg bags (Photo 7). The estimated cost of the milling stage is approximately US$20 per tonne.

Overall, production costs are estimated to be US$32.22 per tonne of agricultural lime (or US$23.22 where a manual jaw crusher is used). This is equivalent to US$1.60 (or US$1.20) per 50 kg bag of agricultural lime produced.

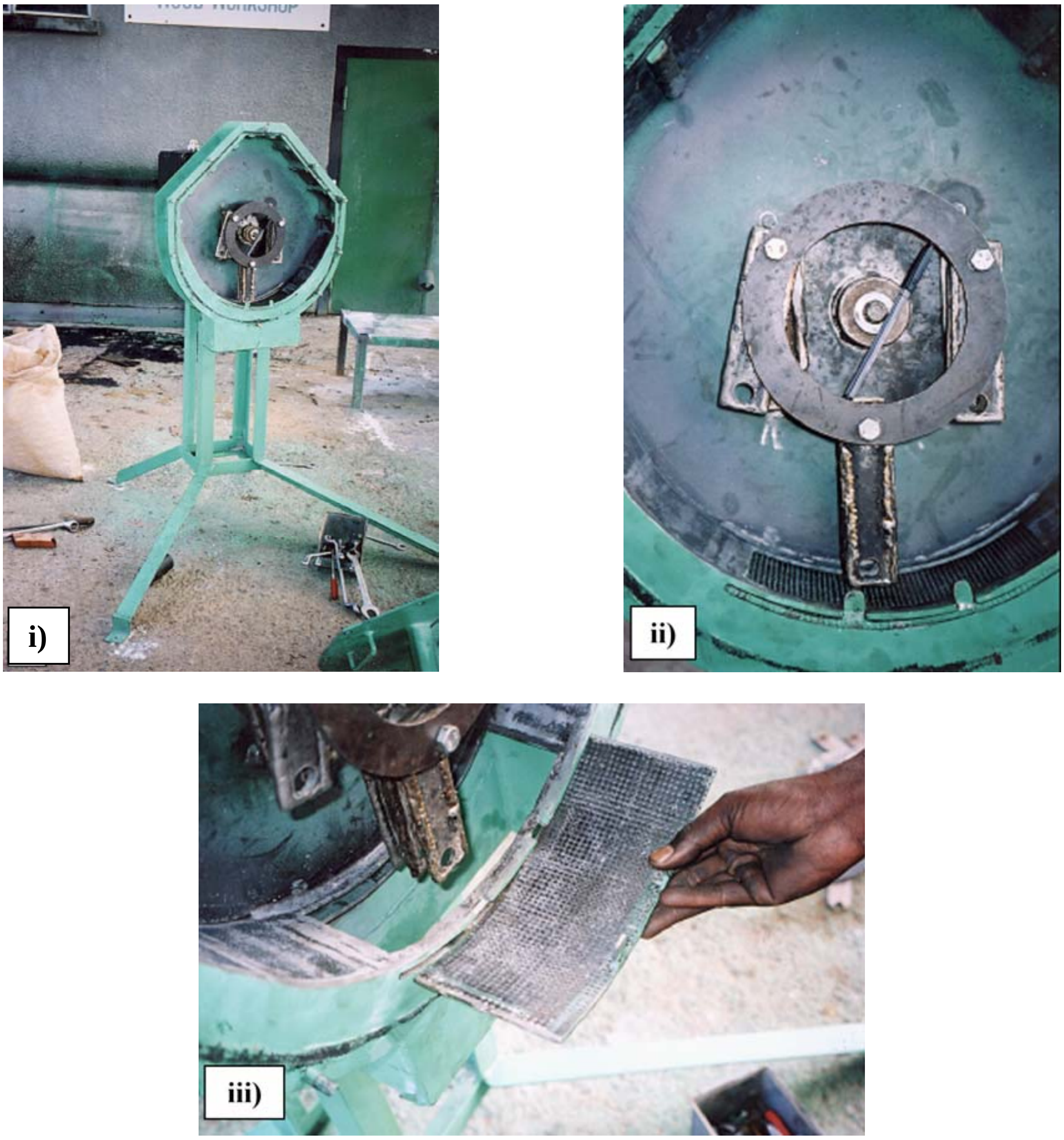

Photo 8 The modified TD hammer mill showing beaters and product screen
i) The modified TD Hammer Mill with feed assembly removed; ii) Close-up of beaters; iii) close-up of product screen with 2 mm apertures

Photo 9 Manual feeding of crushed dolomite into modified TD Hammer Mill

Photo 10 Agricultural lime as produced by the modified TD Hammer Mill

Discussion & Conclusions

The production of agricultural lime is a simple process that involves extraction of limestone and/or dolomite from the ground, crushing to finer than 10 mm and milling to a powder using a mill such as the modified TD Hammer Mill. The cost of production is estimated to be approximately US$1.20 to 1.60 per 50 kg of agricultural lime.

Small-scale production of agricultural lime using this method would be worthwhile in those farming districts where there is a need for liming of the soil and the existing producers are not located within a 50 to 100 km radius. Existing producers, for example in Zambia, sell their agricultural lime for US$20 per tonne; this is equivalent to US$1 per 50 kg bag. However, transportation costs, estimated at US$0.10 per tonne per kilometre, significantly increase the cost to the farmer. A farmer located 60 km from the nearest agricultural lime producer would have to pay the equivalent of US$1.60 per 50 kg bag of agricultural lime; this is equivalent to the higher estimated small-scale production cost.

In conclusion, small-scale production of agricultural lime is cost effective for those farmers that are in farming districts with a need for liming and are at least 50 to 100 km from the nearest commercial producer of agricultural lime.

Recommendations

FarmLime agricultural lime production methodology

It is recommended that small-scale lime production be encouraged and supported in small-scale farming districts that have acid soils and poor access to agricultural lime. The FarmLime production methodology outlined in this manual would be a suitable means of producing agricultural lime in these areas. The following is a summary of the methodology:

Extraction: Manual quarrying of carbonate rock:

- Removal of soil and overlying material
- Extraction of rock using sledgehammers and crow bars. Setting fires on top of the rocks and throwing water onto the heated rocks causing cracking helps to break up the rock
- Removal of the blocks of rock from the quarry to the crushing area

Crushing: Crushing the carbonate rock to a size suitable for milling:

- Sledgehammers are used to break large blocks of rock to fist-sized lumps
- Smaller hammers are used to break the rock down to lumps which are 10 mm in diameter and finer
- This stage could be enhanced by the use of a manual jaw crusher; this would increase the crushing rate and reduce production costs.
- The crushed rock is stockpiled ready for milling.

Milling: Production of agricultural lime from crushed rock:

- Hammer mill(s) would be used to grind the carbonate rock to a powder which has 100% of particles finer than 2 mm, 60% finer than 0.6 mm and up to 50% finer than 0.15 mm.
- The agricultural lime would be stored and sold in 50 kg bags.

Diversification of small-scale enterprise

It is recommended that small-scale private enterprises be encouraged and supported to produce agricultural lime using the FarmLime methodology. There are many small-scale operations in existence that currently produce building and road stone aggregate from carbonate rocks that are also suitable for the production of agricultural lime. These operations are well placed to make a success of the FarmLime approach. The benefits of taking this approach are several:

- Mineral production is already well established at the proposed site; this would ensure that it would have minimal additional environmental and social impacts.
- Diversification of an existing small-scale business would improve its financial sustainability and increase the job security of its workers. There is also the prospect of additional employment being created by agricultural lime production.
- The small-scale business would have a strong incentive to promote and distribute agricultural lime amongst small-scale farmers

It is recommended that the FarmLime approach to small-scale agricultural lime production should be supported through programmes such as the 'Mealie Mill' proposal outlined in Appendix 4.

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Appendix 1 The modified TD Hammer Mill

Design of the Mill

The TD Hammermill is unique on the Zambian market and is the newest and latest hammer mill technology to be introduced (Figure 2). Within the competitive market for mealie meal, the TD hammer mill is designed to increase income for the mill owner. The mill is designed to be portable and flexible so that the owner can compete with other hammer mill owners and industrial millers. The TD hammer mill consists of 12 hardened spring steel hammers (assembled on set of rotor-rings and spacers). The rotor assembly is directly driven by a Briggs and Stratton 8 or 11 hp-petrol engine through a coupling shaft.

- Portable mill using pick up vehicle or animal drawn carts (4 to 5 men for short distances)
- At least 180 kg lime per hour- using 3 mm sieve
- No building costs
- Movable form one market to another
- Direct access to customers
- Cost effective petrol engine

The original TD hammer mill has the following components:

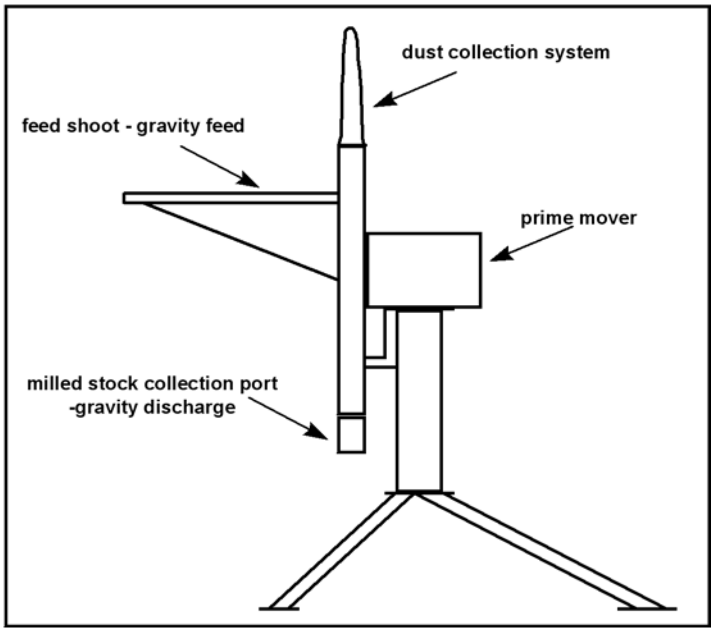


Figure 2 The original TD Hammer Mill

Modification to the original TD Hammer Mill

The original TD Hammer Mill was designed for use as a maize mill. For the FarmLime project the mill was redesigned, following laboratory and field milling trials, for use in production of agricultural lime.

The modifications to the mill were made with the objectives that it remains portable, is robust enough for milling of limestone and/or dolomite, has better dust control, requires low maintenance and uses a simple engine with a high efficiency drive mechanism for the hammers. A key-way connection between the driving shaft and the rotor assembly was adopted, reinforced by central bolting.

To minimise dust loss it was recognised that the mill inlet and outlet should be restricted and that rubber lining should be included in the fabrication to reduce dust loss through the joints. The design of the mill body was changed to remove the outer casing and a circular or oval shaped outlet channel was adopted. This greatly reduced the dust emissions and allowed easy fixing of the sack to the outlet channel.

To improve the grinding efficiency of the mill it was recognised that the mill hammers should be hardened and the mill liners be made easy to remove and be increased in number. The thickness of the hammers was increased from 4 mm to 6 mm. The working surfaces of the hammers were reclaimed using eutectic 680 electrodes that increased the surface resistance to wear and tear. The number of mill liners was increased to enable a greater milling rate. They were also made removable to allow for replacements of worn liners (each hammer being 295 mm long by 115 mm wide).

To improve the life of the product screen it was recognised that it should be made stronger. The screen cage was redesigned to accommodate thicker screens, which were made from 5 mm thick mild steel plate. Where available 3 mm thick stainless steel sheet should be used. An allowance for small screen movements was incorporated to take care of dynamic impact shocks.

The Engine

A single piston Briggs & Stratton combustion engine powers the TD hammer mill. The engine has a 3-litre fuel tank situated above the carburettor chamber. The ignition system incorporates a friction wheel that ignites the single spark plug at high-speed rotation.

The Mill Chamber

This consists of two plates (stationary and movable) fabricated from 2 mm mild steel plate. The moveable plate consists of an intake gate and a hopper that facilitate mechanisms for charging the mill and holding of primary material respectively. The stationary plate provides support to the moveable plate, rotor assembly and sieve. The inside of the stationary plate is lined with liners to facilitate the crushing process.

The Mill Stand

The stand offers support to the entire mill. It is provided with four legs to enable it to withstand vibrations and provide stability during operation. The legs are also used to assist manual handling and transportation of the hammer mill.

The Rotor Assembly

This forms the major working part of the mill. It is made up of 12 hardened spring steel beaters/hammers assembled on a set of rotor rings and spacers. The inner rotor ring provides mechanism for coupling onto the engine shaft (figure 3).

The Product Screen

The recommended screen size is a 3 mm aperture screen made from 5 mm thick mild steel plate. This size could easily be made in any workshop using a 3 mm drill. There are screens of similar size (3 mm) that are used in the milling of maize and can be found in some shops that stock agricultural processing equipment, but these are quite thin. When the screen is worn out or perforated it must be changed immediately. The screen will become damaged approximately after milling 100 bags of 90 kgs of limestone.

Mill fabrication

The mill could be made by any workshop that has the capacity for medium metal working operation, i.e. cutting, bending, milling, grinding, turning and welding. Table 1 gives the parts and materials required to fabricate the mill components. The parts drawings and details are given in Appendix 2.

Table 1: Materials for parts Fabrication

PART	MATERIAL
Chamber	Main body = 6 mm Mild steel plate Cover = 4 mm thick Mild steel plate
Rotor rings	Mild steel plate 10 mm thick
Beaters	Spring steel 50 mm x 5 mm
Spacers	Round Bar diameter 16 mm
Bolts	Standard parts
Liners	10 mm x 5 mm Flat Bar
Stand	50 x 50 x 5 mm Angle Iron
Hopper	Mild steel plate 4 mm thick

Fabrication of mill parts

The critical processes for fabricating the parts are given in Table 2.

Table 2: Critical Metalworking Processes

PART	Processes	MATERIAL
Chamber	Cutting, bending and welding	Main body = 6 mm Mild steel plate Cover = 4 mm thick Mild steel plate
Rotor rings	Flame cutting and milling	Mild steel plate 10 mm thick
Beaters	Cutting and heat treatment	Spring steel 50 mm x 5 mm reinforced with eutectic 680 electrodes
Spacers	Cutting, turning and boring	Round Bar diameter 16 mm
Bolts	From shelf	Standard parts
Liners	Cutting and grinding	10 mm x 5 mm Flat Bar
Stand	Cutting and welding	50 x 50 x 5 mm Angle Iron
Hopper	Cutting, bending and welding	Mild steel plate 4 mm thick

Assembling the mill

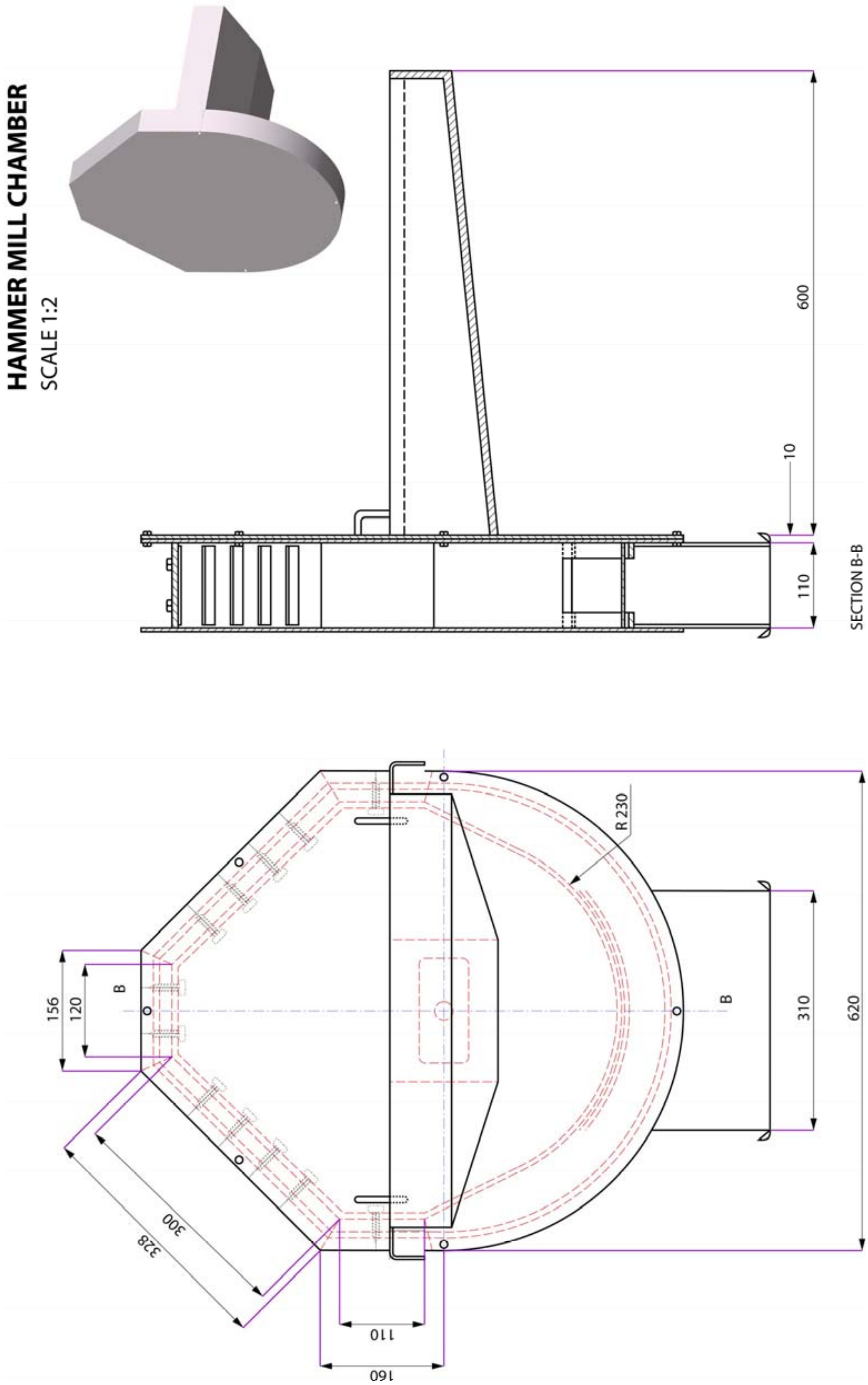
The overall mill assembly is carried out in three stages of sub-assembly, i.e. the chamber, rotor and stand. It is absolutely crucial that these assemblies are subjected to a critical dimensional analysis at the time of assembly, with the engine shaft a reference position. This is because the engine shaft should as far as possible run true and should not be subjected to any bending stress as a result of misalignment at assembly stage. The three sub-assemblies indicating critical dimensions are given in Appendix 1.

Balancing of mill

This is the most important stage in the final assembly of the mill. Since the hammers/beaters are not fixed positions in the rotor sub-assembly, this offers the most important consideration for mill vibration analysis. For fixed beaters, the analysis is much simpler than on non-fixed condition. The best option in this situation is to ensure that all beaters are of the same weight before final assembly. It is recommended that a high precision weighing scale be used to reduce the differences in weights, especially after welding with eutectic 680 electrodes.

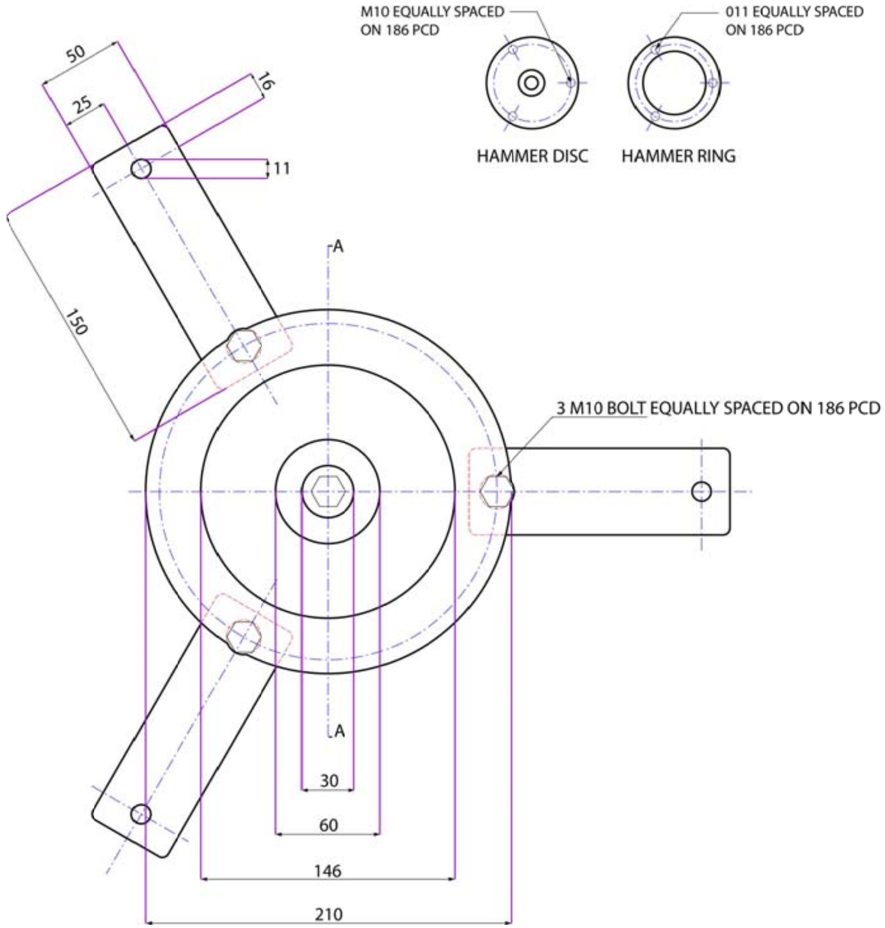
The final assembled mill should be subjected to vigorous tests to determine the quality and quantity of output, and also the amount of vibration. While minimum vibrations are anticipated during milling, these should not make the mill move about.

Appendix 2 Modified TD Hammer Mill Components



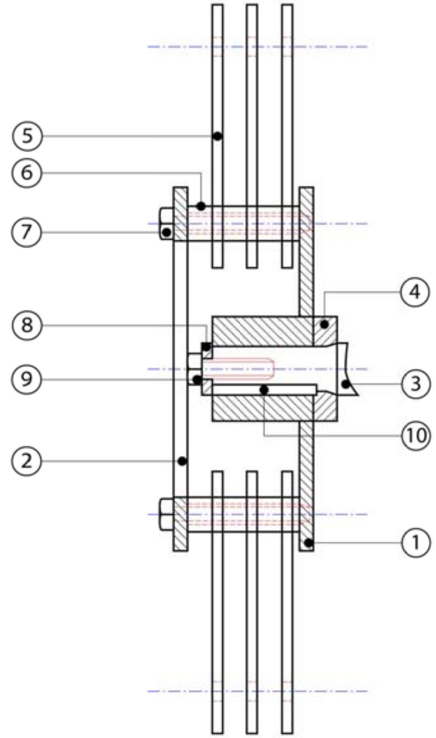
HAMMER MILL ROTOR

SCALE 1:1

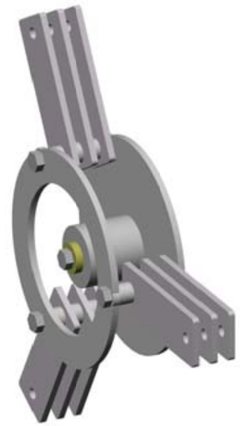


HAMMER DISC

HAMMER RING



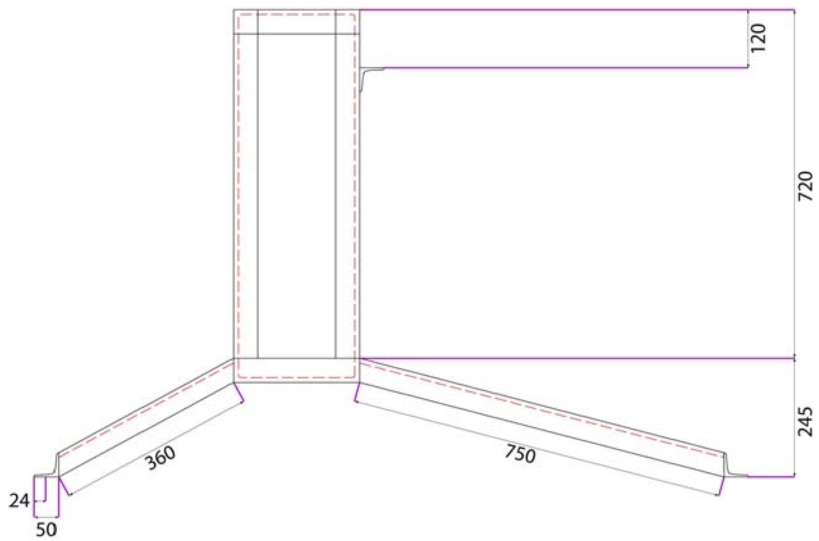
SECTION A-A

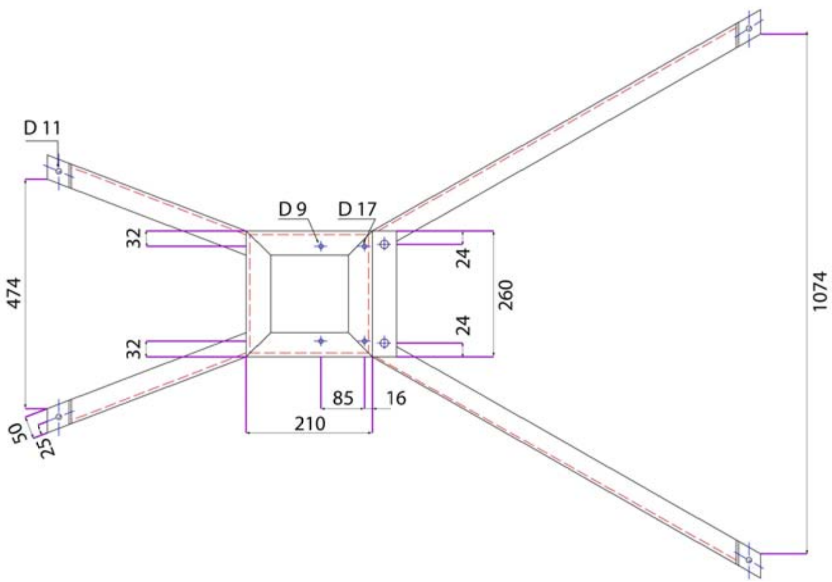


ITEM NO.	QTY.	DESCRIPTION	MATERIAL
10	1	KEY	MS 6mm
9	1	MAIN BOLT	M 12 X 50
8	1	WASHER	MS R 30
7	3	BOLT	M10 X 100
6	9	HAMMERS SPACER	MS R 25
5	9	HAMMERS	HCS
4	1	SPACER	MS R 60
3	1	ENGINE SHAFT	
2	1	HAMMER RING	8mm MS PLATE
1	1	HAMMER DISC	8mm MS PLATE

HAMMER MILL STAND

SCALE 1:4





Appendix 3 Operation and maintenance of modified TD Hammer Mill

Starting

Before starting

1. Move choke to choke position
2. Move throttle to *FAST* position
3. Release fuel shut-off valve, if equipped
4. Move stop control to *ON* position if equipped

Note:

If engine is equipped with oil, flickering light in rocker stop switch will warn of low oil level or engine will stop and not be able to be restarted. Add oil; fill to *FULL* mark on dipstick. Do not over-fill.

Stopping

Do not move choke control to choke position to stop engine; backfire or engine damage may occur. Move the throttle contro1 to *IDLE* or *SLOW* position, if equipped. Then turn key to *OFF* or move stop control to *OFF* position. Close fuel shut-off valve.

Note:

Always remove the key from the witch when equipment is not in use or left unattended. When the engine is transported, close the fuel shut-off valve to prevent leakage.

Troubleshooting Tips

<u>Engine won't start</u>

a) Check fuel (adequate amount, stale, water in fuel)
b) Is spark plug lead attached to spark plug?
c) Are remote controls functioning properly?
d) Is the engine properly primed?

<u>Engine won't turn over</u>

a) Safety Control handle (rotary mower) depressed
b) Check oil (over-filled, insufficient, dirty)
c) Battery condition (electric start only)
d) Check for obstruction under deck

<u>Engine smokes</u>

a) Check oil level (over-filled?). Use a high quality detergent oil classified 'for service SE, SF, SG and SAE 30'
b) Check paper cartridge (plugged or oil soaked?)
c) Check air cleaner element (plugged or dry?)

Mill vibrates while running

a) Check for bent or damaged beaters

b) Check for damaged blade hub

c) Look for loose mounting bolts and/or broken welds

Engine runs for a short time, then stops

a) Check fuel level

b) Check fuel cap for clear vent holes

Table 3: Maintenance Schedule

ACTIVITY	TIME					
	First 5 hours	**Every 8 hours or daily**	**Every 25 hours or every season**	**Every 50 hours or every season**	**Every 100 hours or every season**	**Every season**
Change oil	✓			✓		
Check oil level		✓				
Clean around muffler, springs and linkages		✓				
Change oil if operating under heavy load or high ambient temperature			✓			
Service air cleaner/pre-cleaner cartridge			✓			
Clean and inspect spark arrester, if equipped				✓		
Clean fuel filter				✓		
Replace spark plug					✓	
Clean cooling system					✓	
Check valve clearance						✓

Safety Precautions

DO NOT run engine in an enclosed area. (Exhaust gases contain carbon monoxide, an odourless and deadly poison).

DO NOT place hands or feet near moving or rotating plates.

DO NOT store, spill or use petrol near an open flame, nor near an appliance like a stove, furnace or water heater that uses a pilot light or can create a spark (i.e. avoid naked flames).

DO NOT refuel indoors in an unventilated area.

DO NOT remove fuel cap nor fill fuel tank while engine is hot or running. (Allow engine to cool 2 minutes before refuelling).

DO NOT operate engine if gasoline is spilled or when smell of gasoline is present or other explosive conditions exist. (Move equipment away from spill and avoid any ignition until gasoline has evaporated).

DO NOT transport engine with fuel in tank or with fuel shut-off valve open.

DO NOT move choke control to CHOKE to stop engine.

DO NOT tamper with the governor springs, links or other parts to increase engine speed (run at speed set by equipment manufacturer).

DO NOT check for spark with spark plug removed. Use an approved tester.

DO NOT crank engine with spark plug removed. (If engine is flooded, place throttle in FAST and crank until engine starts).

DO NOT strike flywheel with a hammer or hard object as this may cause flywheel to shatter in operation. Use correct tools to service engine).

DO NOT run engine if equipment is not stable and tipping can occur. Mount equipment to a stable base.

DO NOT operate engine without a muffler. Inspect periodically and replace if worn or leaking. If engine is equipped with muffler deflector, inspect periodically and, if necessary, replace with correct deflector.

DO NOT operate engine with an accumulation of grass, leaves or other combustible material under, around or behind muffler/converter.

DO NOT touch hot muffler, cylinder or fins, which can cause burns.

DO NOT start engine with air cleaner or air cleaner cover removed.

Prevent accidental starting by removing spark plug wire and grounding it when servicing engine or equipment.

KEEP cylinder fins and governor parts free of dirt, grass and other debris, which can affect engine speed.

PULL starter cord slowly until resistance is felt. Then pull cord rapidly to avoid kickback and prevent hand or arm injury.

USE fresh gasoline. Stale fuel can gum carburettor and cause leakage. Check fuel lines and fittings frequently for cracks or leaks. Replace if necessary.