12. **Harvesting:** — Tomatoes ripen in about 11 to 18 weeks after planting Harvesting may last over a period of six weeks. If fruits are to be transported for a long distance it is much better to harvest when still yellow.



## Bush Fire — The Farmers' Enemy

For many centuries, fire was the most effective means in man's fight against trees and grass. Shifting cultivators destroy trees in order to establish their farms. The herdsmen destroy trees in order to create more grassland. Grass was burnt off during the dry season in order to destroy old, unpalatable grasses and get a second growth of green grass.

Our hunters have set fire to the bush in order to drive animals in a desired direction and thus make hunting easier.

In the past, there were so many trees that man had to destroy them in order to survive. Unfortunately, this destructive influence of man on nature went so far that today, he must protect trees and grass in order to survive.

### Main Causes of Bush Fires in Ghana

Our hunters, herdsmen and shifting cultivators are the main causes of bush fires in Ghana.

### Solution

Firstly, the use of fire in hunting must be prohibited for ever.

Secondly, because there is a general shortage of animal protein, we have to increase the production of meat. This is the best way to eliminate bush meat bunting.

Thirdly, our herdsmen must realise that in many parts of Northern Ghana, burning of pasture does not promote the new green growth of grass at all: mowing instead of burning the pastures should be practiced.

On the „Abel Modern Ranch" at Doyum mowing instead of burning is practiced on the pastures, with excellent results. It would be better to make hay than to burn the grass into black ashes and thus lose this valuable material.

The tree and shrub vegetation on the pastures should not be eliminated by fire. Cutlasses, axes, bulldozers, herbicides, rotary mowers and other means should replace fire.

Fourthly, our hifting cultivators must be more vigilant while burning the bush for farming. We have to look for a substitute for the shifting cultivation in order to help our farmers abandon

frequent clearing and burning the bush. Farmers must be strictly prohibited from using fire on steep slopes, because in many cases fire spreads right up to the top of a hill. Farmers should never be allowed to use fire for clearing without permission. They should be required to have some helpers in order to check the spread of fire beyond the boundaries of their farms.

**Other Causes of Bush Fires in Ghana**

**Bad Habits:** Many people burn the bush because it has been customary to do so. Probably, some people cannot resist the urge to set fire to dry grass.

**Cooking on the Farm:** Many farmers cook on their farms but carelessly, forget to put out the fire which they have used for cooking.

**Early Burning in the Forest Reserves:** This practice has been accepted in order to avoid late accidental burning (at the end of the dry season) which causes much more damage. Yes, late burning is a bigger evil and early burning is a smaller evil. „Of two evils, choose neither", said C. H. Spurgeon.

**Gathering of Dry Firewood:** Our women usually gather only dry firewood, which is much lighter to carry from the bush to the home than fresh wood. In order to provide plenty of dry firewood, they often set fire to the bush. The method of gathering only dry firewood should be questioned!

**Palm Wine Tappers:** Palm wine tappers in the South may cause many bush fires.

**Smokers:** Bush fires can also be caused by careless smokers who throw cigarette ends into dry leaves or grass.

**Burning of Crop Residues:** Many farmers burn off rice straw and other crop residues. This bad agricultural practice may cause a large-scale bush fire.

There are of course many more causes of bush fires.

**Damages Done by Bush Fires:**

I do not know any other factor which decreases the fertility of the soil, devastates the natural vegetation, improverishes the groundwater resources, destroys personal property and harms our people more than a bush fire.



**Damages Done to the Soil:**

Good soil for farming is a blessing for the farmers and for the whole society. But how many of our farmers take proker care of the soil they culivate? How many of them know how to protect the land against erosion? How many of them understand the importance of organic matter for the fertility of the soil! and how many of our farmers are able to maintain the fertility of the soil at a desirable level?

Well, any farmer or herdsman who practices the burning of bush grass, crop residues or any other organic material suitable for compost-making, mulching or as bedding material for the livestock does not care about his soil.

The following are a few reason why:

a) Burnt grasses, herbs, leaves, braches and crop residues are not returned to the soil to form valuable humus, but merely provide ash, a great part of which is usually lost by wind, running water and leaching.

b) By decreasing the organic matter content int he soil we increase soil erosion, decrease waterholding capacity, nutrient-holding capacity and soil permeability.

c) Because of high temerpature humus, bacteria and fungi are consumed in burning litter and may be very several damaged in layers beneath the soil surface.

d) Bush and grass burning are the main cause of erosion and great floods at the beginning of the rainy season.

e) Most of the organic nitrogen, carbon and sulphur are lost in the form of gases during the burning of organic materials.

f) The burnt bush, pasture or cultivated field is exposed to the detrimental effects of the sun and yinds throughout the dry season.

Unfortunately, many of our farmers destroy the fertility of the soil by burning and other improper agricultural practices and then complain about the lack of rainfall.

**Damages Done to the Natural Vegetation**

Forest: The forest is a reservoir of water: if feeds streams, rivers and lakes when there is no rain; it reduces erosion and supplies wood for domestics use and export; it increases air

humidity and thus allows our farmers to grow cocoa, oil palm, plantain and other crops. The forest is one of the greatest natural resources in Ghana.

Unfortunately, in West Africa, one finds that man is changing the forest into savannah and then into desert. And the most destructive means man uses in devastating our forests and savannahs is the practice of bush and grass burning. And the resutls are very sad.

The vegetation in the savannah area of Ghana is becomming poorer and less vigorous. Walking througt the bush in the savannah area, one can experience a shocking view of crippled or dead trees. A very serious shortage of firewood, sticks for the yam farms and wood for the native round huts is becomming more and more serios, especially in the Upper Region. Forest litter which can improve the soil immeasurably is beeing burnt annually.

In the transitional zone between the high forest and the savannah woodland, immeasurable damage is beeing done to the fire-susceptible species.

Even in the high forest area, immeasurable damage is beeing done to cocoa farms, food crop farms and timber.

We should remember that timber is our second most important export article and cocoa, our most important export article, cannot be sucessfully cultivated outside the forest.

**Grassland**

Grass in the form of pasture is the chief source of food for the livestock. Pasture is the cheapest way of raising cattle and other animals. Grass and grass-legume mixture are the most valuable means of soil improvement and maintenance. Grass cover is an excellent control of erosion. Grass can be used for haymaking and silagemaking. Cut grass is an ideal material for making mulch on cultivated fields or as a bedding material for the livestock. Certain varieties are an excellent for roofing, making mats, baskets, hats, etc.

Unfortunately man destroys this valuable material. And the resutls are very sad.

a) burnt pastures can never provide enough new green grass for the cattle, sheep and goats;



b) in many parts of Northern Ghana, no regrowth of grass after burning can be observed during the dry season;
c) some grasses and especially valuable legume species are beeing badly thinned out by fire;
d) burning of grass increases erosion, evaporation and gradually decreases the density of grasses;
e) the soil on burnt pastures becomes much drier than on unburnt pastures.

In fact, it is very sad to watch the hungry cattle roaming on completely burnt pastures/

**Damages Done to the Groundwater Resources**

The drinking water problem is affecting more and more people all over Ghana. Our people attribute this problem to the lack of rainfall. If there is anything wrong with the rainfall, it is first of all its effectiveness. And the effectiveness of rainfall is very closely connected with the practice of the indiscriminate burning of bush and grass.

Burning of organic materials on and in the soil decreases the organic matter content in the soil, permeability to water and other important physical qualities of the soil. Thes results it the poor ability of the soil to absorb rainwater from the first rains effectively. Thies causes great surface water runoff, erosion and impoverishment of the groundwater resources.

Another factor dangerously impoverishing the groundwater resources is evaporation during the dry season. By the burning of bush, grass and crop residues, man exposes the soil to the detrimental effects of the sun and winds and thus extremely increases evaporation and impoverishment of the groundwater resources.

By preventing the indiscriminate burning of bush, grass and crop residues, we can enrish our groundwater resources.

**Damages Done to the Food and Cash Crops**

Rice, millet and guinea corn: these food crops are most badly damaged by bush fire. In Tamale alone, I found 9 farmers who lost 778 acres of rice to bush fires. Unfortunately, no statistics exist about how many acres of food crop farms are destroyed by bush fires each year.

Cocoa: During the dry season 1972—73, hundreds of acres of cocoa farms were destroyed by bush fires. Again, no statistics exist for the whole country.

Mango and kapok plantations: Thousands of kapok and mango trees are damaged or destroyed by bush or grass fires each year. In Detoyili near Tamale, almost 300 acres of a kapok plantation and 90 acres of a mengo plantation were destroyed by grass fires.

**Other Damage:**

During the dry season 1972—73, several people lost their lives in bush fires; many domesticated and wild animals usually also die in bush fires. Agricultural machinery, buildings and tools are damaged or destroyed; many fences around the dry season gardens are destroyed; many wooden bridges, telephone posts and traffic signs are damaged or destroyed, and many other damages can be listed.

**How Can Bush Fire be Prevented?**

The prevention of bush fires requires better education, improved agricultural practices, and enforcement of bush fire laws for the whole country.

Our people must understand the real danger and disadvantages of burning. We can achieve this through a better family education school education and adult education.

Bush fire is a great evil on our society and, als Leonardo da Vina wrote: „He who does not punish evil commands it to be done".

This is why we need bush fire laws for the whole country.

Finally, we have to realize that prevention of bush fires is urgently needed not only in your interest and mine, but also in the interest of the future generations



# ANIMAL MANURE

**Organic Matter:**

In the past farmers have replenished organic matter in the soil by practising shifting cultivation with long bush fallows. Since increasing population pressure requires more and more land under cultivation, the natural fallows have become shorter and in some very densely populated areas fallow periods are not practiced.

As a result of shorter fallow periods, soil becomes exhausted and crop yields decline sharply. Also the percentage of organic matter is reduced adding to a reduction in crop yield. The ability of soil to hold nutrients depends to a great extent on its content of humus. Also, a high humus content enables soil to hold large quantities of water which helps to prevent water erosion and to maintain optimum proportions among air, water, and soil. This means that soil rich in organic matter is fundamental for good farming results.

**Importance of Animal Manure:**

Animal manure is the best and also one of the cheapest organic fertilizers. It is an important source of organic matter, to keep soil fertility at an adequate level, even after many years of continuous cultivation. Farmers in northern Ghana, where considerable lifestock are to be found, know about the value of animal manure, but they do not make adequate use of it.

**Collection of Animal Manure:**

Animal manure can be collected from all kinds of domestic animals. (Cows, donkeys, goats, horses, sheep, fowls etc.) Difficulties arise especially during the dry season, when most farmers send their lifestock to the bush, where all droppings are lost.

Another problem is that farmers do not use sufficient quantity of bedding material for their animals. In most cases, however, farmers do not use bedding material at all. Such practices prevent the collection and use of adequate amounts of animal manure.

Bedding material can be made from rice straw, leaves, dry grass, sawdust, chopped millet stalks etc. It is spread on the the floor were animals are housed over night. Good bedding material will also catch large quantities of animal urine, which is almost entirely lost. One cow is able to produce about 3—6 tons of dry manure and almost 1000 gallons of urine per year, a sheep or 25 fowls 1.5 tons of manure a year. It is important to realize that 100 gallons of animal urine contain about 10 pounds of nitrogen and 10 pounds of potash. Today most of these valuable nutrients are lost.

**Transportation:**

Lack of means of transportation is in many cases one of the reasons for unsufficient fertilization with manure. Only around compounds can one find well fertilized fields. But this problem can easily be solved with either a tractor and trailer or a pair of oxen and a cart.

**Storage and Application:**

Animal manure should be stored somewhere in the shade, for instance under a big tree. Exposing manure to the sun, wind and havy rains will unquestionable cause losses of nutrients.

When animal manure is brought to the field — the best time is considered to be before the rainy season begins — it should be incorporated into the soil as quickliy as possible. Otherwise losses of valuable nitrogen is unavoidable. Tractor ploughing or, if no tractor is available, bullock ploughing helps to speed up land preparation and also to avoid losses of nutrients from farm manure.



# FERTILIZER AND APPLICATION METHODS

**Introduction:**

All soils in which plants grow are deprived of certain nutrients to a greater or lesser extent depending on the intensity of growth.

The heaviest demand on soil fertility is made where the soil is used for agricultural purposes and the plants, or parts of plants, are harvested and thus the nutrients removed from the soil.

All agricultural soils, even those high in organic matter and with intensive mineralization, will sometime be exhausted unless the nutrients are restored by balanced fertilization.

Therefore fertilization is absolutely essential, not only to maintain the natural uniformity in the soil by placing the extracted nutrients, but also to increase the fertility of the soil by producing more humus in the way of larger amounts of plant-residues which remain in the field.

**Basic Facts about Fertilizer:**

The main condition for achieving high yields is an adequate supply of the primary nutrients: nitrogen, phosphate and potash. A combination of these three main plant foods in a soil provides crops with their main fertilizer requirements. The continuous use of one plant food only will result in yields becoming less and less.

High production can be maintained only by a proper balance of plant food and by good husbandry. The plant foods supplied with the fertilizers have specific physiological functions to perform in crop nutrition and each has an important effect on the final yield and quality of the crop. To grow, plants need 16 elements. They get their nutrients from the air, water and soil.

More precisely, plants obtain:

1) from the air and water: Carbon (C), Hydrogen (H), Oxygen (O);

2) from the soil, from fertilizers and organic manures: Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), Sulphur (S), Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Boron (B), Molybdenum (Mo), Chlorine (Cl).

Calcium, Magnesium, Sulphur are classified as secondary nutrients, because they are needed in moderate or small quantities, but they nevertheless play an important role in the formation of plant tissues.

Iron, Copper, Zinc, Manganese, Boron, Chlorine, Molybdenum are classified as micro-nutrients or trace elements. They are needed only in very small amounts and are parts of keysubstances in plant growth.

The main functions of these plant foods are:

**Nitrogen** (N)

Nitrogen is essential to the vegetative growth of plants and makes up from 1 to 4 per cent of the dry weight of plants. It intensifies the green colour and increases the size of the leaves, the rate of growth and final yields.

Nitrogen is the dominant plant food for leafy crops such as cereals, grasses and leafy vegetables such as cabbages. Deficiency in nitrogen results in defective growth. The plant looses its green colour uniformly and becomes pale-yellowish.

Some caution is required if used in excess. It can cause a growth which makes plants particularly susceptible to disease. Only legume crops such as clover, alfalfa, groundnuts and beans can use air-nitrogen. They are able to do this because of special microbes which live in small nodules on the roots of these plants.

Chile Saltpetre is the oldest nitrate fertilizer. It occurs in large quantities as deposits in the rainless regions of Chile, from where it got its name.

The inexhaustible supply of nitrogen gas is the atmosphere with a content of 78 % nitrogen. The problem of combining the gases nitrogen and hydrogen on a large scale to form ammonia was solved in Germany fifty years ago. Today most of nitrogenous fertilizers are manufactured from atmospheric nitrogen.



**Phosphorus** (P)

It is in short supply in most soils. Phosphorus makes up about 0.1 to 0.4 per cent of the dry matter in the plant and 0.7 to 1 per cent of the grain weight and is essential for all divisions and for the development of the plant tissues in the growing stage. Phosphorus accelerates the ripening of fruits, stimulates root development, assists in the early establishment of the plants, shortens the period of immaturity. It is the dominant food for most root crops and is also of special value for leguminous crops because it stimulates the activity of nitrogen-fixing bacteria. Phosphate in the seed-bed is essential for all crops. On most soils water-soluble phosphate is preferable to the insoluble form.

Plants suffering from phosphate deficiency are characterized by a poorly developed root system and a generally disturbed growth. The leaves are often small and of reddish-brown, purple or bronze colour.

The two substances from which superphosphate is prepared are ground phosphate rock and fairly concentrated sulphuric acid. Basic slag is a by-product of the steel industry where the original iron ores contain appreciable phosphorus.

**Potassium** (K)

Represented by $K_2O$ it is not a constituent of the tissues of the plant but occurs in a state of solution in the sap. It makes up 0.5 to 4 per cent where all divisions and growth processes are most active. It appears to play a vital part in the utilization of other nutrients and in the synthesis of proteins and fats.

Potash encourages healthy growth, renders crops more resistant to drought, diseases and extremes of temperature, improves the quality of the crop.

Potash plays an important role in the production of sugar and starch, in the regulation of water conditions within the plant cells and in the transpiration of water. Potatoes, cassava, yams, peas, beans, tomatoes and fruit-trees are among the most inmportant potash responsive crops. Potassic fertilizers are soluble.

Potash deficiency causes yellowing of the tips and margins of older leaves, which may become necrotic in the later states of growth. Plants suffering from Potassium-shortage are less

resistant to pests, diseases and drought. Their stalks or straw are oft and lodging often occurs. Seeds are shrivelled or not completely filled. Fruit and vegetables have no flavour and poor keeping quality.

Potash is a product of nature which is found in subterranean deposits in some parts of the world and is exploited by mining. The potassium present in mineral fertilizers is the same element as the potassium in the soil, in the plant, in human and animal organism, in organic manures and in sea-water. The biggest subterranean deposits are found in Germany.

Apart from the major nutrients (NPK), plants for their well-being require also other nutritive materials although in smaller amunts. They are called secondary nutrients and have to perform certain indispensable functions in soils and plants.

**Calcium** (Ca)

Applied to soils in form of agricultural lime, it controls acidity and also improves soil structure so that NPK-fertilizers can work better.

For plants it is needed for normal grain and seed formation, the vigour of growth and the stiffness of stalkes and straw. Seed-legumes, such as cowpeas and groundnuts for instance, are especially sensitive to calcium-shortage.

**Magnesium** (Mg)

In case of deficiency this element is added to the soil as Dolomitic limestone or in other forms mixed with commercial fertilizers. Its effect on soils is similar to that of Calcium. Plants need it for the formation of the green colour, of sugar and of oils and fats. Magnesium also regulates the absorption of other nutrients especially Phosphorus. On Mg-deficient soil, plants remain weak and often show a discolouration of their leaves (yellow stripes on maize).

**Sulphur** (S)

This element is present in most soils, especially in those with high organic matter content. Sulphur is essential for green colour formation. Roots of legumes need sulphur for nitrogen supply. Formation and transformation of chemical compounds within plants are often depending upon the presence of this secondary nutrient.



Finally, there is another group of elements for which plants have a demand. The deficiency of these is very high and they are required only in very small quantities just like salt, pepper and other spices in our own food. Therefore they are named Micro-Nutrients. Plants require for normal development, maturing and yielding 7 micro-nutrients:

Boron, Molybdenum, Copper, Zinc, Iron, Chlorine, Manganese.

Most of them in their original form are metals and cannot be used by plants as such. To become available they have to be converted into other compounds by chemical processes. Minute quantities of these micro-nutrients are essential for plant life but excess supplies are highly toxic to plants and can make soils unsuitable to plant production for years.

The majority of soils have no micro-nutrient problems but light sands, organic soils and the ones with a very high pH are often deficient in one or more of these elements. Shortage symptoms are often very characteristic but require interpretation by trained personnel.

**Remember**

Plants require a balanced diet of major, secondary and micro-nutrients. Soil tests show which nutrients are deficient in soils. The shortages indentified can be replenished by proper fertilization.

**Types of Fertilizers:**

**1. Nitrogen Fertilizers**

Three groups of nitrogenous fertilizers are distinguished according to the form in which the nitrogen is available in them:

1. Nitrate fertilizers (sodium nitrate, calcium nitrate, potassium nitrate)
2. Ammonium fertilizers (ammonium sulphate)
3. Amide fertilizers (Calcium cyanamide, urea).

There are also fertilizers containing nitrogen both in the form of nitrate as well as in the form of ammonium nitrate (calcium-ammonium-nitrate).

Fertilizer materials containing only nitrogen are the following:

| | |
|---|---|
| Ammonium Sulphate | (21 % N) |
| Calcium-Ammonium-nitrate | (20-26 % N) |
| Ammonium-Sulphate-nitrate | (26 % N) |
| Urea | (45-46 % N) |

a) **Nitrate fertilizers:**

In consequence of the ready mobility and rapid absorption of the nitrate by the plant, all the nitrate fertilizers are particularly well adapted for use as top-dressing as well as for the rapid counter action of nitrogen deficiency when it becomes visible. The advantage is that even by broadcasting the fertilizer on the surface of the soil, the nitrogen quickliy reaches the roots.

On the other hand, there is the increased danger of leaching of these fertilizers especially under humid conditions.

b) **Ammonium Fertilizers:**

The ammonium is absorbed by the soil like the potassium and is thus to a large extent protected from leaching. Ammonium fertilizers consequently do not act as rapidly as nitrate fertilizers. In soils where the microbial activity is strong, the ammonium is rapidly transformed into the nitrate form. The most important ammonium fertilizer is ammonium sulphate, which is the most widley used nitrogenous fertilizer.

c) **Amide Fertilizers:**

In the amide fertilizers the nitrogen for the most part is not directly available to the plant but is made available by chemical changes in the soil, or in the plant.

Calcium cyanamide acts slowly but for a longer period than the ammonium or nitrate fertilizers.

Urea with 46 % nitrogen is the highest concentrated nitrogenous fertilizer in solid form. It is also remarkable that urea is an organic compound. Due to its great solubility and ready absorption through the leaves urea in combination with plant-protection materials is frequentliy applied in the form of nutrient sprays.

## 2. Phosphate Fertilizers:

Like the nitrogenous fertilizers, phosphate fertilizers can be divided into three groups:

1. Fertilizers with water-souble phosphoric acid.



2. Fertilizers in which the phosphoric ayid is soluble in citric acid or ammonium citrate.
3. Phosphates in which the phosphoric acid is not soluble in any of the mentioned solvents.

**Group One:**

| | |
|---|---|
| Single Superphosphate | (16—20 % $P_2O_5$) |
| Triple Superphosphate | (43—49 % $P_2O_5$) |
| Monoammonium Phosphate | (11 % N, 52 % $P_2O_5$) |
| Diammonium Phosphate | (21 % N, 52 % $P_2O_5$) |

The great advantage of the water-soluble phosphate fertilizers lies in the fact that the phosphoric acid can be absorbed quickly and thus is available to the plants in the early stage when the root system is not yet fully developed and the plants respond particularly well to easily available phosphoric acid. The particularly favourable effect of superphosphate in arid areas is mainly due to the ready availabilitiy of its phosphoric acid. Water-soluble phosphoric acid is rapidly transformed in the soil into a waterinsoluble form which, however, in most soils remains available to plants to a certain extent. There is almost no danger of leaching.

**Group Two:**

| | |
|---|---|
| Basic slag | 16 % $P_2O_5$ |
| Dicalcium phosphate | 39 % $P_2O_5$ |

The fertilizers of this group are particulary suitable for the treatment of acid soils because the danger of irreversible fixation of the phosphoric acid as phosphates of iron and aluminium is less than with the water-soluble phosphatic fertilizers. Moreover, as a result of their basic reaction and the quantities of reactive calcium which they contain, they act particularly well on acid soils.

**Group Three:**

Rock-phosphates:

Rock-phosphates are the raw material for the production of the mentioned phosphoric fertilizers, except of basic slag.

## 3. Potash Fertilizers:

All potassium fertilizers contain the plant nutrient potassium in a soluble form which is readily available to the plant.

The most important potash fertilizers are:

a) Mariate of potash (potassium chloride) 40-50-60 $K_2O$;
b) Sulphate of potash 48—52 % $K_2O$

For the majority of plants and soils the chloride and sulphate of potash are to be regarded as of equal value. The chloride is very mobile in the soil and consequently in humid climates is rapidly leached out, whilst the potassium is absorbed by the soil colloids and retained in the soil.

Sulphate of potash is to be preferred to Muriate of potash in arid regions. This also applies to many crops in which it is particularly important to obtain definite quality such as higher oil and starch content.

**Straight, mixed and compound fertilizers:**

**Straight or single fertilizers** contain only one of the essential nutrients. They are adequate by natural supply of the other nutrients or when used in combination with fertilizers containing the other essential nutrients.

This means that for balanced fertilization with nitrogen, phosphate and potash, three individual fertilizers have to be applied.

**Mixed fertilizers** contain two or more nutrients. However, being mixtures of straight fertilizers, they have certain disadvantages, e. g. limited storage ability, separation of ingrendients during storage and transport and sometimes during application, and in general a lower nutrient concentration.

**Compound Fertilizers:**

Compound fertilizers contain two or more nutrients chemically combined, so that each individual granule contains the nutrients in the proportions defined by the formula.

The risk of incorrect fertilization resulting from the use of mixed or straight fertilizers is minimized through the use of compound fertilizers. In general one might distinguish three main categories of compound fertilizers according to the nutrient concentration.

1. Low-concentrated grades (15 to 25 per cent of total nutrient content). **Examples:** 3-6-9 and 4-15-0.



2. Medium-concentrated grades (25 to 40 per cent of nutrient content). **Examples:** 16-20-0 and 10-10-10.
3. Highly-concentrated grades (more than 40 per cent of nutrient content). **Examples:** 20-20-0 and 15-15-15.

**Amounts, methods and time of Fertilizer application**

**Amounts of fertilizer to be applied:** The amount of fertilizer to be applied depends on the amount of nutrient needed and the fertilizer grades available. In general, different crops require different amounts of fertilizer.

When deciding the amount of fertilizer to be applied farmers and field-workers should contact the nearest Agricultural Officer. Recommendations are to be strictly observed.

**Method of Application:** There are three main ways to apply fertilizers:

a) **Broadcasting:** — Fertilizers can be broadcast by hand or by machine. The fertilizer is first distributed uniformly over the soil. It may be left on the surface or worked into the soil by tilling or ploughing. Phosphatic and potassic fertilizers are often applied in this way.

b) **Row or band placement:** — The fertilizer is applied by making a small trench with a hoe or a cutlass next to a planting row and appling the fertilizer in it.
Where crops are cultivated by hand and planted in hills a pinch of fertilizer may be dropped in the row or planting hole and covered with soil.

c) **Top-dressing:** — When fertilizer is broadcast after the crop is growing we say it is top-dressed. The practice of top-dressing generally applies to nitrogenous fertilizers only, because nitrates move downward in the soil and must be available in sufficiently large quantities in the topsoil at periods in plant growth as tillering, shooting, leaves formation, etc. Nitrogen may be applied in split or divided applications.

**Time of Application:** — The time of application differs from crop to crop and from District to District. Also in this case farmers and field-workers should contact their District Officers of the Ministry of Agriculture, in order to get appro-

priate information together with correct recommendations. The time of application is very important and much care should be taken by field-workers concerned.

**Economics: —**
The subsidy on fertilizer in Ghana recently amounts to a percentage of about 60 %.

This subsidy has been in effect for 5 years and has promoted the fertilizer use. But when fertilizer is used other costs are involved:

a) Costs of fertilizers.
b) Transport of fertilizers from the market to the field.
c) Distribution of fertilizers on the field.
d) Costs of harvesting the additional crop (yield increases due to fertilizers).
e) Costs of threshing the additional crop, in case off small grain.
f) Costs of transport of the additional crop to the market.

By far the greatest costs are those for the fertilizer itself. As a rough approximation for benefit estimates it is conventient to calculate the difference between the value of the obtained crop increase and the fertilizer costs. This value will be called „net return", and it must be kept in mind that the other smaller costs listed have also to be subtracted.

For a quick introduction of fertilizer use it is of paramount importance to prevent by all possible means a wrong use by farmers, which would cause them monteary losses and could mean a drawback.



## Seed Multiplication

The aim of the Seed Multiplication Unit is to increase and encourage the use of improved seed with high yielding quality developed through research fo the improvement of adequate food production for the country.

This is achieved by:

1. Increasing growing of breeder seed on its foundation farm for distribution to contract growers.
2. Organising contract growers to undertake further multiplication of foundation seed to meet the seed needs of the country.

**Seed Multiplication procedures**

I. General Seed Certification Standards

The purpose of seed certification is to maintain and make available to the public a high quality seed of crop plant varieties which are so grown and distributed as to ensure varietal indentity and purity.

Also to be included in regulations: marking and labelling, seed testing, seed crop inspection, sampling and samples.

II. Certifying Organization

The National Seed Committee, acting on behalf of the Ministry, is charged with duties of prescribling rules and regulations relative to the enforcement of the Act, the appointment of inspectors, collection of fees, issuance of tags and the actual enforcement of the law and regulations promulgated by the Committee. The Seed Multiplication Unit of the Ministry of Agriculture is the Certifying Authority.

III. Eligibility Requirement for Growers who Produce Foundation, Registered and/or Certifield Seed.

1. Each grower must have adequate farm equiment and acres to undertake the planting, cultivating, harvesting and processing of crops, He must have access to insecticides, herbicides, fungicides and fertilizer and equipment to apply these chemicals.
2. The grower's honesty and integrity must be unquestionable.

3. The farm must be well isolated from other farms and crops in accordance with the minimum seed certification standards.
4. Each grower must file an application with the certifying authority; this must be approved and a permit issued before the grower undertakes production of certified seed.
5. Each grower, before obtaining inspection and receiving certification of seed crops, shall agree to pay all regularly assessed fees, and to abide by the Ghana Seed Laws.
6. The grower must permit the official field inspector all the freedom he needs to thoroughly inspect granaries, equipment, seed stocks and records necessary for the execution of an accepable certification programme.
7. Growers will be expected to attend the regular meetings called by the Certifying Authority and such other meetings as may be called for educational purposes.

IV. Eligibility Requirements for Certification of Crop Varieties.

1. Only those varieties which are approved by the National Seed Committee shall be eligible for certification. Once certification is refused for a given bbatch of seed, all subsequent seed increases from the particular batch will be ineligible for further certification.
2. It is important that certified growers check with the certifying authority concerning the approval of a new variety before launching a planned certified seed production programme with such a variety.
3. The National Seed Committee
   in its publication of recommended varieties
   1. must describle and document those characteristics of the varieties which give it distinctiveness and merit. The following information must be supplied:
      a) A statement of the variety's origin.
      b) A description of the variety's morphological, physiological, cytological, pathological, entomological, chemical and other important characteristics which distinguish it from other varieties.
      c) The variety's suggested ecological region of growth.
      d) Evidence of performance, including data on yield, insect or disease resistance and relevant information in support of the application for certification. The performance test shall include approbriate check varieties.
      e) The procedure to be followed in maintaining foundation und registered seed; the recommended generations of increases; and a description of any special requirements or limitations which must be observed to maintain varietal characteristics.



V. Restrictions of Number of Varieties

Only one variety of the same crop species may be grown for seed production on a farm, except after prior approval by the certifying authority.

VI. Classes of Seed Recognized in Certification

Four classes of seed shall be recognized in seed certification, namely, breeder, foundation, registered and certified seed.

1. Breeder seed (White tag) is defined as that limited amount of seed used by plant breeder in actually breeding or maintaining a strain or variety. Breeder seed is always under the direct supervision and control of the plant breeder and is never available for sale and use by the general public. Breeder seed is to be tagged with a white tag labelled „Breeder Seed".
2. Foundation seed (blue tag) shall be the progeny of breeder seed so handled as to most nearly maintain specific genetic indentity and purity as designated by the official seed certifying authority.

   Foundation seed may be produced only by or under the direct supervision of an agronomist a) on an experimental station; b) on a farm destignated as an official branch of the experimental station with qualified plant breeder in charge of such production, or c) on a farm operating under contractual agreement with and under the direct supervision of the originating or sponsoring plant breeder. Foundation seed shall be tagged with the tags issued by the official seed certifying authority. Foundation seed shall be the source of the registered seed.
3. Registered seed (purple tag) shall be the progeny of foundation seed. Registered seed shall be so handled as to main-

tain satisfactory genetic indentity and purity as designated by the official seed certifying authority. Registered seed shall be tagged with purple tags issued b the official seed certifying authority.

4. Certified seed (yellow tag) shall be the proggeny of foundation or registered seed produced and handled in such a way as to maintain satisfactory genetic identity and purity as approved by the official seed certifying authority. Seed reproduced from yellow tag certified seed is not eligible for certification.

5. When the supply of registered seed is not adaquate because of:

   a) adverse environmental conditions

   b) expansion of national agricultural targets

   (when it becomes necessary to have adaquate supply of seeds), certified seed may at the discretion of the certifying authority be the progeny of certified seed, if the genetic purity will not be altered by permitting such exception.

VII. Eligibility of Land

Certified seed must be produced on land which has not produced any other variety of the same crop or uncertified crop of the same variety for a certain length of time as prescribed in the individual crop standards. It is important that the land be free of volunteer plants of the same crop. Land used for the production of certified seed must be free from all weeds whose seed cannot be separated from the crop seed.

VIII. Field and Bin Inspection

Field inspectivn of every field intended for production of foundation, registered or certified seed stocks shall be made at the request of the grower by an approved field inspector, at least once during the growing season and prior to harvesting. Inspectors shall examine fields thoroughly enough to accurately determine wheter or not the crop concerned meets all field requirements as it stands at the time of the field inspection. Detailed notes for each field inspected shall be made by the inspector and filed in the certifying authority's office. The grower agrees that



his entire stock of classes of seed held in storage shall be subject to inspection by the National Seed Committee or its authorized agent at any time.

IX. Seed Treatment

All seed planted for the production of Certified Seed should be treated against pest and diseases.

X. Isolation of Fields

Fields producing seed for certification must be separated from other fields by definite boundaries. Crops that are crosspollenated must be separated in compliance with the isolation requirements set up for individual crops.

XI. Rogueing Fields

Fields offered for certification shall be rogued prior to inspection to remove off-type plants and weeds. In cross-pollenation crops, as for example in maize, the contaminant must be removed just before flowering.

XII. Disease

Plant disease shall be considered in determining wheter or not a crop shall be finally approved as foundation, registered or certified. Tolerances will depend on the seriousness of the diseases, wheter or not they are seed-borne and can be controlled effectively by see treatment. Tolerance schedules will be prepared by the Seed Certifying Authority and approved by the National Seed Committee and may be revised from time to time as and when this becomes necessary.

XIII. Sampling and Laboratory Analysis

It is important that a true representative sample be taken from each batch of seed for seed analysis. The analysis of the sample must indicate that the seed complies with the seed certification standards before certification can be completed on the batch of seed.

Equal portions shall be taken from evenly distributed parts of the quantity of seed to be sampled. The required size of the sample is outlined in the standards for each individual crop in Schedule I. A probe or trier should be used in sampling seed in bulk or bags. Seed in bulk should be sampled at least seven or eight

uniformly distributed parts of the quantity of seed beeing sampled. When a quantity of seed consists of 10 bags or less each bag should be sampled. In quantities of more than 10 bags, stratified samples shall be taken, and 20 % of the batch shall be sampled.

XIV. Tagging and Sealing

All certified seed offered for sale by the Registered Seed Grower must be tagged.

Tagging and sealing of certified seed will be done by the authorized agent of the certifiying authority.

The analysis data on the tag shall include:

1. Name of crop
2. Variety
3. Code number of grower
4. Purity analysis
5. Germination percentage
6. Data certified
7. Batch number
8. Seed treatment (a conspicous label marked POISON and the name of the chemical used must be shown on the bag)
9. Date of expiry
10. Inspector's certificate number.

XV. Procedure for the Acceptance of New Varieties

1. New varieties should be tested for yield, survival, disease reaction and other important characteristics in comparison with standard commercial varieties, using experimental techniques that assure valid measures of differences and their significance.
2. Such tests should include not less than three replicates of each selection, and all entries shall be randomized in the performance tests.
3. Each performance tests should include not less than three competitive varieties or selections for comparison purposes.
4. The result of such performance test should be reviewed each year by the National Seed Committee.



5. The annual report on such performance tests should be filed with the seed certifying authority.
6. A new variety to be approved as bebing eligible for certification must be superior to existing commercial varieties in one or more characteristics important for the crop, and be at least satisfactory in respect of other major characteristics.

# Techniques of Crop Storage

**Background**

Hitherto, mankind accepted losses from insect damage as a natural phenomenon about which little could be done. In Ghana, it was estimated in 1959 that, when cereal crops are kept in store for six months, over 20 % of the grain is destroyed or damaged by insect attack. This is a serious state of affairs when one considers the amount of time, money and energy expended in growing a crop. If a farmer could have the use of the whole of the harvested crop, he could then either sell the surplus which at present is lost to insects to give him additional revenue or he could grow a smaller acreage to give the same quantity as is at present available for human consumption.

In some parts of the Northern and Upper Regions, the availability of all the harvested crops as human or cattle food could mean an end to the seasonal shortages which at present occur regularly. This would also mean stabilisation of prices an the farmer's income throughout the year.

In Ghana, though some modern types of storage exist for the privileged few, the following types are common to the subsistence farmer.

**Crib Storage:**

Maize is traditionally stored in cribs. This is common in the Volta region and other parts of Southern Ghana where there is often a shortage of timber. The crib consists of a circular wooden platform raised about four feet from the ground on which one builds a circular stack of maize ears, complete with sheath. These stacks are usually about six feet in diameter and six feet high. When the stack is completed a roof is placed directly over it; this is usually made of thatch, though some farmers use tin sheets.

In Ashanti, the cribs are made of local materials; e. g. oil palm mid ribs, split bamboo, split barassus palm and sometimes roughly sawn planking; they are usually built 3—4 feet off the ground, have walls 4—6 feet high and a roof of thatch or shingles. The cubic capacity of these cribs varies between 160—300 cubic feet. Since one tone of maize on the cob complete with



sheath occupies 250 cubic feet, the capacity of these cribs varies from 0.65—10.8 tons; the average is 3—7 tons.

The main problem of maize storage in Ashanti and Southern Ghana is the high moisture content (varies between 21 and 30 %). With this type of storage however, there is no problem because the grain is stored on the cob and there is complete ventilation. Thus, there is a gradual drying out of the grain until it reaches an equilibrium level; usually 15—17 %.

Rice is also stored in cribs in southern Ghana:
In the savannah regions of Noth Ashanti, the rice is stored on a high platform (5—6 feet), and the stack of grain (which also often contains guinea corn) is thatched before the start of the rainy season.

In some parts of the Northern Region, others, particularly the Gonjas, build cribs with grass matting (zaana mats) 1—2 feet off the ground and store complete heads of rice. Those in the compound farming areas store their rice in earth-walled granaries similar to those used for guinea corn and millet.

**Guinea Corn and Millet:**

These crops are frequently cropped together and are usually stored together in the Northern and Upper Regions. In these areas, the crops are harvested between November and December, and sun-dried on the flat roofs before storage. Moisture contents before storage are about 12 %. Crops are often stored in solid and substantial granaries.

The Dagarti and Lobi in the North-West build their granaries as part of the compound house. The floor is raised above ground level and consists of beams laid on big stones. Thus, there is an air space between the floor of the granary and the ground which prevents the transference of ground moisture into the granary. The granary is usually about six feet in diameter and six feet high, with a conical shaped roof ending in a manhole which is the only entrance to the granary.

The walls and the conical roof are made of mud to which a cement-like substance has been added. Guinea corn and millet are stored on the head.

At the time of storage, the best heads are selected and tied together to be used as seed for the next planting. These bundles

are the last to be put into the granary, beeing stored on the surface of the loose heads.

Similar granaries are found in the North-East (Navrongo district), but these stand separately in the yard of the compound. These are taller, eight to nine feet, and slope gradually to the top which has a wider manhole then those of the Dagarti.

The Frafras have smaller granaries which also stand in the yard but which form part of the compicadet wall system which separates off the sections of the compound.

Apart from these ways or types of storages, seed is also stored in other ways which differ from tribe to tribe. Thus, seed can be stored in sizeable pots, gourds and earthern silos. Beans and bambara beans are stored in pots int he North-West. Before storage, these are mixed with ash, possibly to minimize pest attack. Earthern silos are used for storage of groundnuts in the Kusasi area, though these generally remain the property of women.

Seeds, particularly guinea corn, millet and okro to be used for the next season, are bundled up, tied and hung at a place where there is smoke. This reduces the moisture content as well as pest attack hazard.

**Better Storage Possibilities**

1. The Christian Council of Ghana in Garu, Upper Region has developed a new type of silo. Its construction requires two bags of cement, stones and gravel. It has a capacity of between 9—16 bags of maize or guinea corn. The overall cost of building such a silo is about ten cedis. This type of silo can go a long way to help the locil farmers because the costs are within their reach.

2. **Concrete Silos:**

   They are durable and good but expensive; more so, as cement is at present not easy to come by. They have a capacity of about ten tons and therefore suitable for the medium-scale farmer.

3. **Plastic Silos:**

   Also have a capacity of about 10 tons and are suitable for the medium-scale farmer.



4. **Aluminium Silos:**

   These are common on the state farms e. g. Demon State Farms. They habe a capacity of about 50—60 tons. This construction is quite expensive and only suitable for the large-scale farmer.

5. **Buildings for Bags:**

   These are large buildings for storage of produce in bags. They are expensive and are suitable for large-scale farmers. The main advantage of these types is that produce can be stored for long periods. Precautionary measures such as fumigation and application of insecticides can easily be carried out.

   On other hand, the local types could be developed further, since these depend solely on local materials; this would also conform with the principle of self-reliance pursued.

# A Design For Constructing Grain Silos

**Building instructions:**

The grain storage silo as described here is used succesfully in Northern Ghana. The great improvement compared to the traditional store is that the silo gives better protection against rodents and insects.

When the filled silo is hermetically closed, by pasting mud at the sides of the manhole and the chute, the seeds develop $CO_2$ gas which stops the development of insects.

By building several silos or by common use of several silos, the silos can be emptied one by one, and so the time that a silo is open is reduced.

**Materials required:**

325 mudblocks size 4" x 4" x 6".

The blocks are made out of laterite and water, they sundried. Fig. 5 shows a block mold with which 3 blocks can be made at the same time. The mold is made out of 2 boards of approx. 18 x 4 inches, with 4 boards of 4 x 6 inches in between.

At each end, there is a board as a handle.

2 bags of cement, for mortar and concrete.

Wood; **Timber** for the chute, see fig. 2. The 4 boards (2 x A, B and C) from a spout with one straight and one slanting end. In B is a slot in which a slide can be pulled up and down.

**Boards** for the top, frame A, B and C, and for the topcover, D (see fig. 3).

Rocks or laterite stones for the foundation.

Sand and soil for concrete and mortar.

**Building description:** (see fig. 1).

The silo is built on a foundation of rocks (I), on this the silo (II) with a chute in the bottom (IV). The top is a concrete seal with a manhole that can be closed with a concrete cover (III). The inside diameter is 36" and the inside hight 80". The capacity is 1 ton of grain.



I. **Foundation:**

One layer rocks, 8" high, is placed in a circle with a diameter of 48 inches. On this flat rocks are put, which will be masoned into a firm floor with mortar (1 cement: 5 **rough** sand). The spaces between the bottom rocks must be kept open for ventilation. No moisture will be absorbed by the cement floor, when there is a good ventilation.

II. **Wall:**

In the first course eighteen blocks are placed in a circle on the mortared floor; the chute is placed in this first course. The slanting side of the chute has to be flush with the inside surface of the blocks. For the chute 1" boards are used.

On top of the first course three more courses are placed, using mortar. Then with sand or soil a slanting floor is made in order to make the grain stream easily to and out of the chute. The highest point of the inside floor in 12" above the foundation.

Then both the inside floor and the inside wall are plastered with mortar. When the floor has hardened, loose sand is put on it to avoid falling mortar sticking to the floor.

After this, 14 layers of blocks are put on with mortar.

In- and outside are plastered.

III. **Top and cover:**

To be able to pour concrete for the top, 3 frames are necessary, A, B and C, see fig. 3. The hight of the frames is: A=2", B=3", C=1", see fig. 4. Frame A is put on a flat place. B is laid in the middle of A. Between A and B concrete is poored (1 cement : 2 sand : 4 crushed rocks) to the level of A (2 inches).

Immediately after pooring, frame C is placed around frame B on the wet concrete.

The space between B and C is then filled with concrete. In that way a top of 2" thickness is obtained, with a manhole around which is a collar with an extra thickness of 1".

Fig. 4 shows a section of the top just after the pooring of concrete. The cover is poored in frame D, the thickness of this one is 2".

After the concrete has hardened, the frames are removed. To make it easier to remove frame C, it is handy to make one board a bit longer. The roof is placed on top of the silo, and gaps will be filled with mortar.

Finish by giving the silo a coat of whitewash, apart from looking nice it will also keep the temperature inside donw a few degrees.

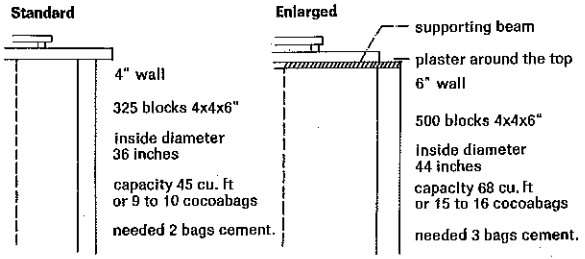
**Modifications to the standard size.**

I. It is possible to make a silo with the same top and size blocks as the standard size, only the silo is bigger.

Instead of putting blocks length wise in a circle to make the 36" diameter, we put them side wise in a circle and make a diameter of 44". The top will fit just over the inside edge of the wall. It will have to be supported by 2 beams. A 2" x 2" timber is strong enough.

Plaster mortar around the outside of the top so the top cannot move and the rainwater will go off nicely.

**Comparison between standard model and enlarged model.**






II. Another modification is to leave the chute out, and not slant the floor; this will increase the capacity of the silo by half a bag.

In some cases farmers feel more secure without the chute.

III. To build bigger silos according to the same plan is possible, only the walls have to be thicker and stronger the bigger we make a silo.

**IMPORTANT.**

Grain should be absolutely dry before it is put in a silo. Moist grain will start to rot, the silo will crack and all food is lost. At Garu, grain is dried in the sun for about 5 days. The relative air humidity is then around 35 to 40.

GRAIN STORAGE SILO.
Side view

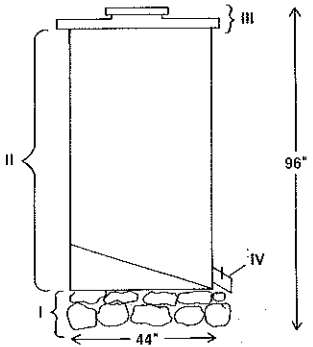



Fig. 1

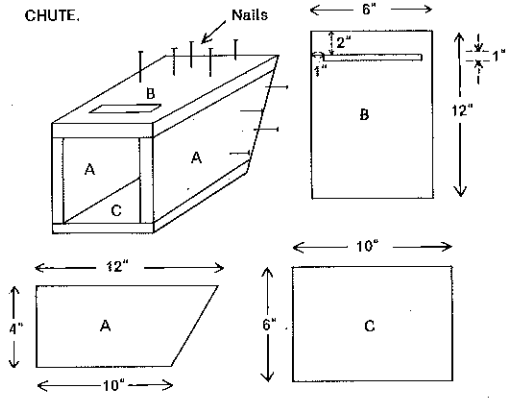
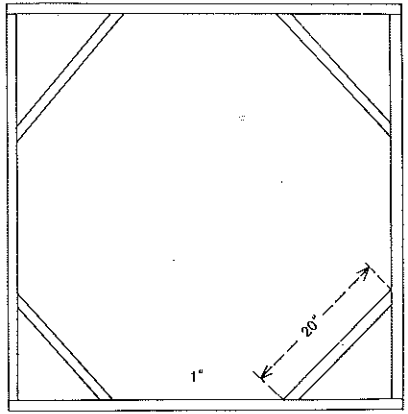
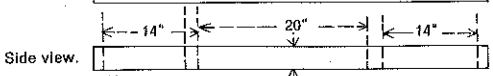



Fig. 2



FRAME A
Top view



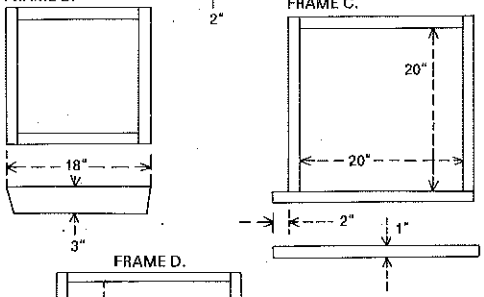




Fig. 3

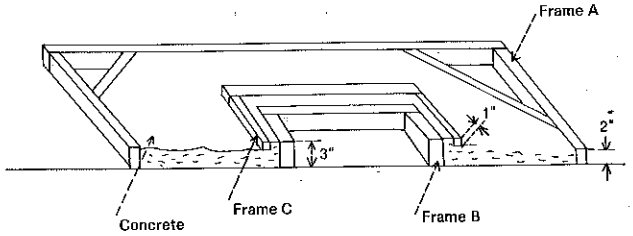



Fig. 4

BLOCK MOLD.

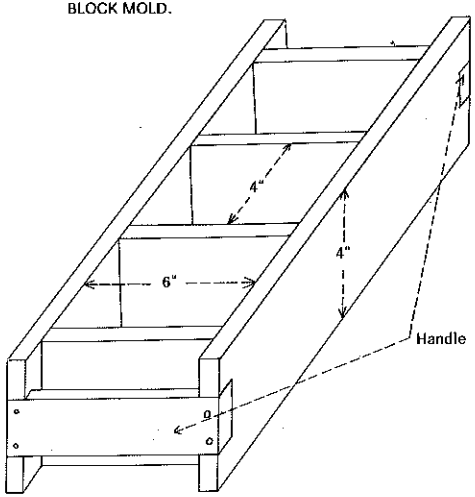



Fig. 5



## Processing Requirements for Paddy

The Rice Mills can only produce good rice when the paddy brought by the farmers is of good quality. The time of harvest is very important, because when the rice is harvested too late the moisture content of the paddy is reduced to about 5% and the result is a high percentage of broken rice during the process of milling. The most suitable moisture content of paddy rice for milling is as high as 12—14 %. If the moisture content is higher, the rice will smear over the shelling stones, pearling cones and wires and the whole unit must be stopped and cleaned. However, this does not happen very often, as the rice dries very fast during harvesting time.

When more varieties of rice are grown on one field the rice is very often mixed, which makes it also very difficult for the miller to produce quality rice, because most varieties differ in size, shape and weight. Therefore, all farmers must make sure that varieties are not mixed neither on the field nor in the store.

If a scale is available the bags of paddy rice to be sent to the rice mill should be filled to the correct weight in order to save time and additional work. Even more important is proper precleaning on the field before bagging because the rice mills do not accept paddy bags with a high content of foreign matter. Firstly it would be a cheat by the farmers beyause the foreign matters are included in the weight and would have to be paid for. Secondly the intake capacity of the mill diminishes when the content of the foreign matter in the paddy rice is higher than 7%.

### The Process of Milling

The paddy has to pass through different stages of the mill before it is ready for consumption. The first section in the mill is the cleaning unit which cleans the paddy. From there it goes through the sheller where the paddy is shelled to about 85 per cent, followed by the separator unit which separates the bran and husk, leaving a mixture of paddy and shelled rice. The next unit is the paddy separator unit which separates the paddy from the shelled rice. The remaining paddy goes into the return sheller.

The shelled rice then enters the polishers where it is polished. After that the polished rice is graded by sieves into different grades (1, 2, 3, 4, bran) and bagged.

There is also a large number of small rice mills existing in the country, the so-called huller mills. As these mills have only a rotating sheller shaft for processing, the percentage of broken rice is very high. For that reason many people parpoil their paddy before they send it to such small mills for processing.

**Parboiling**

The method of parboiling the paddy has many advantages and is used in many rice-producing countries. Parboiling means that the paddy is boiled and dried before it goes through the milling process. Parboiled rice has a much higher content of nutrients than rice processed without parboiling. Also the percentage of broken rice is greatly reduced. Sometimes it may occur that the processed parboiled rice has a brownish colour and therefore many people prefer non-parboiled rice. As this is only a matter of prejudice the public should be educated and parboiled rice promoted.



# Plant Protection

A. **Definition of Injuriousness:**

As soons as weeds and pests in the growing crops become so numerous that the damage would affect the yield considerably, control measures have to be applied to avoid even greater damage and loss.

B. **Losses in Production of Crops through Pests, Diseases and Weeds and the Significance of Plant Protection:**

The total loss of crops through pests, diseases and weeds occurs more often as one would assume. With the development of highly effective insecticides, fungicides and herbicides, the threat of famine and related hardships have been greatly reduced.

The world harvest of crops suffers great losses every year; these become even greather with increasing yields. Below is a compilation of the losses in the production of crops, in per cent of potential world harvests:

| | Pests | Disease | Weeds | Total |
|---|---|---|---|---|
| Rice | 27 | 9 | 11 | 47 |
| Maize | 12 | 9 | 13 | 34 |
| Millet | 10 | 10 | 18 | 18 |
| Groundnuts | 17 | 12 | 12 | 41 |
| Cotton | 16 | 12 | 6 | 34 |
| Sugar-cane | 20 | 19 | 16 | 55 |
| Cocoa | 13 | 21 | 12 | 46 |
| Wheat | 5 | 9 | 10 | 24 |

More than 90 % of the world's rice production is grown in Asia. The losses differ from area; about 14 % in Japan, but almost 60 % in the South East Asian countries.

The above-mentioned losses in the production of crops give an idea of the possibilities and importance of preventive measures and the use of chemicals in plant protection. The figures also show that there is still a great need for the improvement of plant protection measures.

C. **Methods of controlling insect pests and crop diseases**

In addition to chemicals such as insecticides or fungicides, crops can be protected from insect attack and diseases by:

I. physical and mechanical means
II. cultural methods
III. biological control
IV. plant quarantine.

**I.** The measures consists of destruction by mechanical means, burning, teapping, using protective screens or barriers, etc.

Infected or infested plants can for instance be removed by hand and destroyed if only few plants are affected. Grasshopper eggs can be collected and destroyed as a means of controlling infestation. Rhinoceros beetles and removing dead truss from the plantations.

**II.** The control of insects and crop diseases by cultural practices — that is, by using those methods of planting, growing and harvesting which will prevent or lessen insect or disease damage — is an important aspect of improved crop husbandry.

Cultural control of insect pests and disease include:

a) Planting varieties which are resistant or tolerant to insect infestation or disease infection, or which possess some mechanical or physical characteristic which either serves as a barrier to infestation or prevents development of larvae or spores of disease causing fungi on the plant.
b) Ploughing may either kill insects directly, or it may bury the eggs os deeply that few adults can emerge. Ploughing also eradicates alternative hosts or weeds upon which insects might feed or breed. By exposing insects or their eggs to natural enemies or adverse weather conditions, ploughing may control many potentially dangerous pests and diseases.
c) Proper agronomic practices such as good seed bed preparation, early sowing, rate and depth of planting, proper harvesting etc. will help control insect pests and diseases.
d) Crop sanitation is an important preventive measure and includes destruction of crop residues, control of weeds which are often alternative hosts, and destruction of volunteer crop (this means: crops grown from self-sown seeds or from roots or stubble).



e) Crop rotation: Some insects feed on relatively few plants-and many crop diseases are restricted to a few hosts usually of the same family. A proper rotation of crops is therefore an effective means of controlling these pests and diseases.

**III.** The enemies of insects such as pathogenic bacteria and fungi, nematodes, spiders and predaceous insects and insectivorous birds have been used by man to control insect infestation.

**IV.** Plant quarantine is a very important point. The disease or pest is prevented from entering or establishing itself in areas or countries which are free of it by leagl restrictions. There are four methods of plant quarantine:

a) inspection of point of destination
b) inspection and certification of point of origin
c) complete embargoes
d) controlled introduction of plants.

D. **Methods of chemical plant protection and their application.**

**I.** Seed-dressing:

Insecticidal/fungicidal seed dressings are used to protect the seed or young plant against several soil-borne diseases and insect and animal pests which will otherwise kill the seedlings before they emerge or after they emerged. For instance, smut spores already on the seed will germinate with the seed, infecting the seedling. The fungus then grows up through the stem of the plant and reaches the flowers in the young ear, infecting the forming grains. The use of seed-dressing will be break the cycle by killing spores on the seed. Seed dressing may applied by any method which ensures and even covering of the seed with powder.

Following methods are in use:

1. Automatic seed treater — usually used for large-scale operations (seed cleaner — Tamale).
2. A drum or an eccentrically mounted rotary drum.
3. Any small container — emty kerosene tine, calabashes, etc. The container should be not more than half-full, and mixing is continued for at least 3 minutes.
4. Sprinkling powder over the seed on an open floor and mixing with a shovel.

Depending upon the mode of action, insecticides may be divided into:

**III.** Insecticides

1. Stomach insecticides: applied to feeding surface or food of the insect, which is poisoned after swallowing the insecticide with the food.
2. Contact insecticides: kills the insect by direct contact with the body. It is applied either direct to the insect or to a surface over which it may walk or crawl.
3. Systemic insecticides: they are absorbed by the plant and kill insect pests inside the plant or feeding on the sap of the plant.
4. Fumigants: the insect is killed by inhaling poisonous vapours, usually in a enclosed space.
5. Aerosols: space sprays which kill flying insects by contact. Some insecticides act in more than one way — as contact protective and stomach poison. Insects with piercing and sucking mouth parts (aphids) can usually be controlled by contact or systemic insecticides, while those of the chewing type (locusts) can be destroyed by stomach poisons.

Insecticides are applied in:

1. the dry powdered form as dust
2. liquid form as sprays or injections
3. gaseous form as fumigants
4. mixed with solids and put out as baits.

Powders: In the dry form as dust, these have some advantages over spraying, as they are easier to apply and need less time for preparation. The machinery for application is also lighter. However, dusts are usually not as effective as sprays because they do not adhere to plants as well.

1. **Liquids:** Liquid insecticides are applied as suspensions, emulsions or solutions.
    1. Emulsions: many insecticides are marketed in a form which is dissolved in oil (xylene) with an emulsifier added (miscible liquid). When water is added to such a concen-continuous phase and the insecticide as the disperse trate, an emulsion is formed, with the water as the phase (very minute droplets).



2. **Solutions:** the insecticide is dissolved in petroleum oil and ready for application.
3. **Suspensions:** the insecticide is used as a spray. (Water dispersible powders). Some powdered insecticides are soluble, others insoluble and form suspensions with water.

**Preparation of Liquids for Spraying:**

1. Preparation of emulsions: Half-fill a container with clean water and slowly pour in the required quantity of liquid insecticide, stirring all the time. Add the remaining water and again stir thoroughly. The mixture is now ready to pour into the spray container and apply to the crop.
2. Preparation of Suspensions: Dispersible powdered insecticides are often used in preparing foliage sprays. In preparing such foliage sprays, the powder should be well-creamed with a small amount of water, then added to the bulk of the water. The suspension should be stirred vigorously, for some powders do not mix well with water.

**Application of insecticides:**

Any efficient low to medium-gallonage sprayers, such as mist blowers or knapsack sprayers, may be used to apply insecticidal liquids. Insecticidal dusts may be applied by means of any type of dusting equipment which gives distributions of the powders which do not mix well with water.

**IV. Baits:** Many destructive insect pests (locusts and grasshoppers, mole and field crickets, ants and vegetable weevils) are attracted by baits and can therefore be poisoned by baiting. The bait usually consists of a base (carrier) and an insecticide (poison) moistened with sufficient water or oil. Bases or carriers commonly used in preparing baits consist of 1 part cereal bran or corn meal mixed with 3 parts of sawdust or cotton seed hulls. Sawdust alone may be used, but this is not as good as when mixed with bran. Citrus pulp is also attractive to grasshoppers. Vegetable weevils may be baited using finely chopped portions of the favourite food plant of the weevils.

**Preparation of Baits:**

Add sufficient water to moisten the insecticide and thoroughly mix with the recommended amount of bran. The water should be

just sufficient to moisten the bait so that it will crumble easily when spread.

**Application of Baits:**

1. The baits may be scattered on the field by broadcasting as evenly as possible over the areas where the grasshoppers are feeding. This is usually satisfactory for nurseries or where small areas are baited.
2. For larger areas, the bait may be spread in wide strips at intervals, as a barrier across the line of migration of the hoppers.

**Time of Application:**

Baits are more effective when applied at the time when the grasshoppers are feeding on the ground. This is usually in the morning or evening, for grasshoppers normally cease ground feeding and crawl up on shrubs and weeds to escape the afternoon heat. Mole crickets also crawl out of their hideouts to feed in the evening.

**V. Fungicides:**

Many fungi are parasitic plants which cause disease to economic crops and consequently lower crop yields. Protection against disease-causing fungi may be obtained by:

1. dusting or
2. spraying.

In other cases, the chemical should prevent the fungus from establishing itself but should leave the host plant or economic crop unharmed. The aim of applying fungicide is to maintain a fungicidal coating over the vulnerable parts of the plant for as long as possible. Howeyer, because of rains and the appearance of new unprotected growth as the plant develops, it is often necessary to repeat the applications at frequent intervals.

Most fungicides are water-dispersible powders containing:

1. metallic copper in the form of cuprous oxide
2. organic mercury compounds or
3. various organic compounds. Convenient sprayers include knapsack sprayers, mist blowers etc. They can also be applied as dust.



# Tractor maintenance and preparation of farm machinery

Proper maintenance and care of farm machinery often determines the difference between a successful and an unsuccessful farmer.

Because if a farmer spends most of the season struggling with his equipment he wastes valuable time and equipment when he needs it most.

The prevention of breakdowns ist therefore most important when working with farm machinery. Of course, repairs or replacements cannot always be avoided but at least minimized through preventive practices. Accordingly, owners of farm machinery should be conscious of this responsibility, obey maintenance schedules and pass on any information concerning the machines to the operators.

**Tractor Servicing Schedule**

This is a general schedule applicable to all wheeled tractors. However if instruction manuals are available for your tractors and farm implements, they should be studied thoroughly and schedules of service carried out accordingly.

The „HOURS SERVICE" refers to the number of working hours of a tractor. Consider only the hours of actual operation when no meter is fitted, other than that, read the working hours as shown by the meter. The respective services should be carried out after the tractor has completed the number of hours as shown in this schedule.

**10 Hours or Daily Service**

1. FUEL — top as needed. Fuel care is very important. Fuel should be stored under a roof to avoid contamination by water and dirt.

   Filtering is advisable when filling the tank of a tractor. Where no proper filters are available a clean piece of cloth will do. Use quality fuel only.
2. WATER — remove the radiator cap. Check water level in the radiator and top with clean water if required. The water

level should be visible inside the radiator. When the engine is hot allow any steam to escape before removing the cap completely. Check screen and clean if necessary.

3. AIR CLEANER (oil bath type) — remove and clean and refill oil bath air filters to level marks with clean engine oil. Do not overfill. Inspect the element assembly and wash with gasoil if it is necessary. Under conditions of extreme dust, service the air cleaner twice daily.

   If a pre-cleaner is fitted, remove the bowl for cleaning, remove dirt and reinstall. Never leave the dirt to accumulate above the level mark and service very frequently in extremely dusty conditions.

4. ENGINE OIL — After the engine has been stopped for about 10 minutes, check oil level with dipstick in the sump. Remove and wipe dipstick, then reinsert and remove it again to check oil level. Refill when necessary with oil of correct grade to bring the level to the „full" mark on the dipstick. See that you do not allow dirt to enter the hole when checking. Ensure tractor stands on level ground.

5. GREASING — Wipe away all old grease and dirt from the grease-parts and apply good quality grease, using a high pessure gun, until all the old grease has been remored. Wipe off surplus grease. For detailed information on greasing for your specific type of model, refer to the operators manual.

**50 Hours Service**

1. Carry out a 10 hours service.
2. FUEL FILTERS — If any foreign matter is visible in the glass bowls (water etc.) open the drain plug and drain plug and drain until only diesel fuel flows out. To reduce overnight condensation in the fuel-tank, fill fuel always daily after completing work.
3. FLUID LEVELS — TRANSMISSION, HYDRAULIC, REAR AXLE — Check oil level in transmission, hydraulic and rear axle by either check plug or dipstick.
   Since these devices vary in type and location from one marke to another, it is suggested to check on your operator's manual when in doubt. Use only the recommended oils. If a back pulley or power steering is fitted, check as well.



4. BATTERY — Clean the top of the battery, remove the vent plugs and check level of electrolyte (water). Always use destilled water for refilling. The water level should just cover the separators (appr. 0.25 inch.). Do not use any exposed flame for checking electrolyte level. Grease terminals with battery grease to avoid oxidation.
5. FAN BELT — Check condition and tension of fan belt. A correctly tensioned belt will deflect about 0.5 inches total movement when pressure is applied midway between the generator and crankshaft pulley. To adjust the belt, slacken the generator securing bolts and re-position as required.
6. TYRES — Check tyre pressure with an airguage. The pressure varies with tyre size and operating conditions, but 26 p. s. i. in front and 16 p. s. i. at the rear is normal for most types. However for correct inflation see your operator's manual. Bad tyres give bad work.

**150 Hours Service**

1. Carry out a 50 hours service.
2. FRONT WHEEL BEARINGS — Remove cups, clean, check and replace after proper grease is applied. Dirt should never be allowed to enter bearings. For this operation, jack up the front wheel.
3. CLUTCH — Check clutch pedal free travel and adjust if necessary.

   Loosen rod clevis lock nut and turn clevis to in — or decrease length of rod until correct pedal free travel is obtained. Adjust according to the manufacturer's specification. Always remember to take your foot off the pedal when the tractor is in operation.
4. ENGINE OIL — Change engine oil at this stage only when tractor was operating under very dusty conditions. Under normal conditions change engine oil after 300 hours.

**300 Hours Service**

1. Carry out a 150 hours service.
2. ENGINE OIL — Run the engine to normal operating temperature, then remove the plug from the soil sump and drain the engine oil completely. Refill the engine with oil of the correct quantity.

IMPORTANT — The tractor has to stand on level ground. Never use discarded oil a second time.

NOTE — The oil change period of 300 hours assumes that maintenance of the engine assemblies, e. g. aircleaner, has been efficiently fulfilled and fuels are of the recommended specification. If this does not apply, more frequent changes (150 hours) are due.

3. ENGINE OIL FILTER — To change, unscrew the centre bolt; remove the filter body and discard the replacable element and sealing gasket. Clean filter body and install only new elements and rubber sealings. Examine the rubber joint washer in the filter head for leakage.

   On models equipped with disposable filters remove and discard filter and install new one.

4. GENERATOR BEARING — Lubricate the rear end bearing slightly with engine oil. New models are normally self lubricant and thus require no attention in this respect.

**600 Hours Service**

1. Carry out a 300 hours service.
2. FUEL FILTERS — Close the fuel tank shut-off valve and remove the filter bowls from the filter body. Discard the element and sealing rings. Wash the bowls and bodies with clean fuel. Insatll new elements and sealing rings. Absolute cleanliness must be observed during this operation. Open the fuel tank shut-off valve and bleed the fuel system.
3. STEERING BOX — Check oil level of steering box by removing the check plug. If required, top up the oil to the level of the check plug hole!

**1200 Hours Service**

1. Carry out a 600 hours service.
2. TRANSMISSION, REAR AXLE AND HYDRAULICS — Change all oils when tractor is at operating temperature. The three assemblies can either be one or two to three separate lubrication units. Accordingly drain and filler plugs are available. The lift arms must be lowered when draining the oil. Fill with new oil of the specified type until it reaches the level plug hole. Start the engine, fully raise the lift arms, then add oil to bring the level up to the level plug hole again.
3. RADIATOR — Drain, clean and flush radiator. Refill with clean water only. This will prevent a choked cooling system.
4. HYDRAULIC FILTER — Both inlet and exhaust filters in the hydraulic system should be inspected and replaced if necessary. Absolute cleanliness is most important when working on the hydraulic because dirt is the biggest enemy of the hydraulic system.
5. Arrange to have the following items done at the same time by your dealer.
   a) Injectors serviced
   b) Examination of valve springs and setting of valve tappet clearance.
   c) Others according to specification.

**Note:** In addition to the above, certain operations must be carried out on a new tractor or self propelled machine during the running-in period. For these operations refer to the operator's instruction book.

**Preparation of Tractors and Implements**

1. SERVICING — General lubrication requirements.
   a) Various types of oils (e. g. engine oil, transmission oil) for tractors, selfpropelled machines (e. g. combine harvester) or stationary engines (e. g. rice thresher)
   b) Oil and greases for bearings, chains and driving mechanismus etc. For all lubrication details study your operator's manual or the recommendation of the lubricant manufacturer.
2. WASHING — A tractor should be cleaned thoroughly at least once a month; actually all slack periods should be utilized for cleaning farm machinery since it can never be overdone. Oily

dirt deposits are removed with diesel, but care should be taken not to get diesel on tyres because it corrodes rubber. Any leaks are easy to spot on a washed tractor.

3. REPAIRS — Any seriously damaged part should be repaired immediately, in order to have the machine always ready when required. A stripped bolt, bent arm or worn out disc may become a serious problem if not attended to in time. A certain amount of tools are therefore required on all farms. Also the most important spareparts should be kept at the farm. Contact your dealer to find out what tools and spareparts are required for your tractor or machine.

4. OILING AND GREASING — After a machine is repaired and cleaned well and not to be used for some time a thin coat of grease or oil (used oil will do for some purpose) should be spread over all working metal surfaces. Oiling prevents rust and prolongs the life of a machine in general.

5. COVER — When all operations are completed accordingly, place the machine under some kind of cover. A shed made from strong poles and corrugated iron sheets will serve the purpose. Weathering accounts for a lot of damage on machines or implements.

6. TRACTOR RECORDS — In order to allow a regular tractor maintenance, it is essential that a log book is kept for each tractor or selfpropelled machine. Apart from telling you when the next service is due, a tractor log book does as well supply you with some useful managerial information, such a rate of work, fuel consumption etc. If your tractor happens to have no meter, then you work on your watch hours although this is not so accurate. All one has to do is to enter the hours of work carried out each day in order to be aware when one of the aforementioned services is due. At the nearest figure it should be carried out immediately. If such records cannot be obtained from your dealer you can easily prepare one yourself. A simple but sufficient record is shown below:



Month March 1973

| Date | Hours run by engine | Fuel added (GLS) | Oil added (PTS) | Type of work | Maintenance | Driver |
|---|---|---|---|---|---|---|
| Total/ February | 2.068 | | | | | |
| 2/3/73 | 12 | 18 | 1 | Ploughing | | |
| 3/3/73 | 14 | 21 | — | Ploughing | | |
| 4/3/73 | 8 | 12 | — | Harrowing | 300 hrs service carried out | |
| Total/ Month | | | | | | |

**FAULT FINDING SECTION**

This section shall only be a general guideline for farmers and operators to find faults and defects on tractors which are not working properly.

1. Engine does not start or stops running

| CAUSE | CORRECTION |
|---|---|
| Fuel tank empty | Fill tank and bleed fuel system |
| Engine stop control knob in „stop" position | Push in engine stop control knob |
| Air enters fuel pipe connections | Seal connections and bleed fuel system |
| Starter turns too slowly | Charge battery |
| Starting system defect | Check battery-cables and connections |
| | Check starter (workshop) |

| | |
|---|---|
| Injectors do not inject properly | Check pessure and injection diagram. Replace injection nozzles if necessary (workshop) |
| No compression: valves do not close completely | Adjust valve tappet clearance (workshop) |
| No compression: valves do not move freely | Clean valves with mixture oil and diesel (workshop) |
| No compression: valves are worn out | Regrind valves or replace them with new ones (workshop) |
| No compression: Piston rings are worn | Replace piston rings (workshop) |

2. Engine output too low

| | |
|---|---|
| Oilbath aircleaner is plugged with dirt | Clean aircleaner completely and renew oil |
| Fuel filters are dirty | Clean housing and replace old filter elements |
| Foreign matter in fuelpump | Clean fuel pump (workshop) |
| Injectors do not inject properly | Check pressure and injection diagram. Replace injection nozzles if necessary (workshop) |
| Injection pumps worn out | Overhaul or exchange injection pump (workshop) |
| Compression too low | Check valve tappet clearance, piston rings, cylinder liners and cylinderhead gasket — replace defective parts (workshop) |
| Cylinders are worn out | Overhaul engine (workshop) |

3. Engine overheats

| | |
|---|---|
| Engine is overstrained | Reduce strain or load or shift into lower gear |
| Insufficient water in radiator | Top up water in radiator — check for water leaks |
| Fanbelt too loose or broken | Tighten fanbelt or replace respectively |
| Radiator plugged with dirt, insects or other foreign matter | Clean radiator with air or water under pressure |
| Thermostat does not work properly | Replace thermostat |



| | |
|---|---|
| Injectors inject too much fuel | Adjust injection pump (workshop) |
| Ignition timing is not correct | Check and adjust injection pump (workshop) |

4. Engine smokes abnormally

| | |
|---|---|
| Engine overstrained | Reduce strain or load or shift into lower gear |
| Oilbath aircleaner dirty | Clean airfilter completely and renew oil |
| Injectors are not working properly | Check pressure and injection diagram. Replace injection nozzles if necessary (workshop) |

5. Engine is knocking

| | |
|---|---|
| Injection nozzles keep dripping after fuel injection | Check pressure and injection diagram of injection pump. Replace nozzles if necessary (workshop) |
| Piston wrist pin, connection rod bearing or crankshaft bearing is worn out | Check and repair accordingly (workshop) |
| Flywheel bolts slacked | Tighten or renew flywheel bolts (workshop) |

6. Engine oil pressure warning light is on

| | |
|---|---|
| Oil filter dirty | Wash or replace oil filter element |
| Oil pressure too low, due to lack of oil in engine oil sump | Top up oil in engine oil sump |
| Short circuit in wire between oil pressure switch and warning light | Check wire for short circuit and repair (workshop) |
| Oil pressure switch is defective | Replace oil pressure switch (workshop) |
| Oil pressure too low due to worn out bearings | Check crankshaftbearing and connection rod bearing. Replace bearing if necessary (workshop) |

7. Generator warning light is on

| | |
|---|---|
| Ignition key not fully inserted when engine is running | Push ignition key in |
| Fanbelt too loose or broken | Tighten fanbelt or replace respectively |
| Generator or cut-out relay defect | Check generator and cut-out relay and repair (workshop) |

8. Faults in electrical system

| | |
|---|---|
| Wire connections loose and without contact | Check, clean and tighten connection |
| No electric contact between battery terminals and battery clips | Clean battery terminals and clips, apply battery grease to both to prevent oxydation and tighten clips properly |
| Ground contact wires have no contact | Check, clean and tighten connections |

9. Clutch do not work properly

a. Clutch is slipping

| | |
|---|---|
| No free travel of clutch pedal | Adjust free travel of clutch pedal |
| Clutch lining oily | Check oilseals of gearbox and crankcase and replace leaking one (workshop) |

b. Clutch is jerking

| | |
|---|---|
| Clutch lining worn off | Renew clutch lining or exchange clutch plate (workshop) |
| Too little free travel of clutch pedal | Adjust free travel of clutch pedal |

c. Noises in gearbox when putting in gears or shifting

| | |
|---|---|
| Too much free travel of clutch pedal | Adjust free travel of clutch pedal |



## Bullock farming

About 90 % of the farming population of Northern Ghana are using hoes and traditional methods for farming. The acreage farm size is about 5 acres.

Bullock ploughing which was the first step to mechanized farming in almost all countries of Europe or North America was introduced during the 1930's in certain districts of Northern Ghana. In the Eastern parts especially Bawku and Navrongo Districts it was very succesful, but failed in the Western Districts.

A new attempt is now being made to reintroduce this useful farming system as it will not be possible for the majority of farmers to obtain loans from the Banks to take up mechanized farming on commercial scale.

The advantages of employing bullocks for farm work are very clear and convincing:

1. Bullock farming enables smallfarmers to increase acreages and production of cash crops thus raising their standard of living.
2. Bullock farming is with in the managerial, technical and financial means of most of the smallfarmers.
3. In spite of increased acreage the manual work of the farmer will not increase, for the bullocks can work fast and can be used in many ways on the farm e.g. ploughing, ridging cultivating, carting inputs, produce, firewood etc.
4. The bullocks normally roaming about without much work can be put to much better use by training them for field work.
5. The use of bullock ploughs incorporated with a package of improved inputs (fertilizer, high yielding seed varieties) will increase yield and total production.

Of course one can only expect good work from bullocks when they are in good condition, therefore the farmers have to take good care of them.

1. In order to stand the work every day the bullocks have to be fed with grain concentrate in addition to the daily grazing. For the dry season, hay, groundnut haulms, bean vines

etc. should be stored to keep the bullocks in good condition for the ploughing season.

2. The state of health of the bullocks has to be observed and any signs of sickness or disease reported to the nearest Veterinary Officer of the Ministry of Agriculture.
3. A shed within a faced area is the best place to keep the bullocks at night. This shed also gives shelter against rain and sun.

Several centres for the initial training of bullocks are already set up in Northern Ghana by the Ministry of Agriculture and Church Organisations. More stations will be established in the near future to guarantee adequate training facilities and extension service. The Ministry of Agriculture in also prepared to assist in the supply of bullock ploughs and spare parts. Farmers who cannot finance their team of bullocks and plough completely can apply for a loan from the bank through the Ministry of Agriculture.

The combined efforts of the extension offices and farmers should help in the promotion of bullock farming and by it contribute toward a sound development of Agriculture in Northern Ghana.



## Bush-Clearing

Throughout Ghana there are thou sands of acres of fertile land lying dormant and unproductive. In order to feed the ever growing population more food must be produced and therefore the acreage extended.

Within the last few years and through the increasing importance of rice cultivation in Northern Ghana, large areas of land have already been developed.

With the expansion of acreage and the growing number of commercial farming much more land has to be cleared within the next few years.

There are several methods of bush-clearing by machine depending on the density of the bush and the size of trees. Clearing by hand is still common. The method used for bush-clearing is not decisive, it depends normally on the availability of machines or labour and varies from area to area. Of course, the economics of it have to be considered as well and the most economical method available chosen.

All tree-stumps and bushes should be removed to have the field free of any obstacles at the time of mechanized field operations. The roots should be dug out as well because stumps and roots left on the field account for a lot of the damage done to machines and tractors, thereby shortening the life of the machines, and increasing the repair costs. Many days of valuable time — especially during the time of ploughing and seedbed preparations when the machines are needed most — are being wasted due to break-downs caused by poorly cleared fields.

When clearing very large areas it is advisable to divide the field into sections and leave strips of trees and bushes between each section to prevent wind erosion. If this is not done the wind will blow the fertile topsoil away, especially the sandy soil, and can make the field barren within a few years. Once a field is affected by wind erosion to a certain extent it will be very difficult to bring it back to a fertile status again.

In many cases it can be observed, especially when the clearing is done by caterpillar-tractors, that the topsoil is just pushed away and the undersoil comes up. No farmer who hired machines

for bush-clearing should permit such careless and ignorant work. Of course, some disturbance of the topsoil can never be avoided but it should be minimized to a tolerable extent.

The normally rather thin layer of topsoil contains the nutrients and humus which are needed by the plants. As soil tests have proven, the content of humus in the soils of Northern Ghana is comparatively low, so it is of great importance not to destroy the bacteria in the soil which are needed to build up humus and the soil structure and keep the soil fertile. Heavy machines used for bush-clearing as well as bush-clearing by burning can destroy the bacteria, so every farmer should supervise the operations carefully, for proper land-clearing is the first step to successful farming.



## Services of your Agricultural Development Bank

The Agricultural Development Bank can make loans for almost any agricultural purpose. Depending on the purpose and type of loan and other factor,

— loans are made for various periods of time up to fifteen years;
— various periods of moratorium are given before repayment starts;
— interest is charged at from 6 % to 9 %;
As much as possible of the loan is made in kind rather than cash.

This is the way to apply for a loan, and some of the details the Bank will need to know before a loan can be considered:

1. You may either visit or write to the nearest office of the Bank. The Bank's Offices are in Accra, P. O. Box 4191, Hohoe, P. O. Box 143, Koforidua, P. O. Box 124, Kumasi, P. O. Box 3841 Tamale P. O. Box 376.
2. Firstly, the Bank will need to know:
   — what you plan to do;
   — wheter you have the land;
   — what experience you have in farming;
   — how much money you wish to borrow;
   — what items you wish to use the money for;
   — how much of your own money you wish to invest in the project.
3. If you make your first contact by letter, you will probably be invited to come to the Bank to discus the above items and others that apply to your particular case.
4. If you make your first contact in person, that discussion will be at that time if you have your plans well in mind. If you do not, you will be asked to return when you are prepared for the discussion. In certain circumstances, you will be asked to consult the agricultural extension officer in your particular area to help you develop your ideas before your come back to the Bank for the discussion.
5. If you sans sound feasible, you will be given a formal application to complete and return. You will be asked to provide

some other documents at the time you send the official application. The exakt nature of these documents will depent on the type of loan you are asking for and on other factors. You will almost certainly be asked to provice evidence that you have the right to use the land you plan to farm.

6. After your application and supporting documents are received, they will be studied. If the plan still appears feasible and if the legal documents are in order, the Officer of the Bank will visit the project with you. After this, he will prepare a written report which will show your plans and proposal in detail and will include a carefully computed financial analysis of the operation. This report will be studied by the Management of the Bank.
7. If the report is approved, you will be given a formal offer of a loan. This offer will indicate in detail such items as the amount of loan, the purpose of the loan, the conditions you must meet, and the time by which the loan must be repaid.
8. If you accept the offer, disbursement will be made, unless some irregularity is discovered.

**Rice**

Estimates for a rice farmer who has been given a loan to purchase a tractor and implements to cultivate a certain acreage (for a tractor loan, not less than 150 acres) are prepared as follows:

1. Land Clearing — ¢ 20 — ¢/40.00 per acre
2. Tractor and equipment X ¢ 12,000.00
3. Seed (improved) — ¢ 6.00/acre
4. Fertilizier:
   2 bags 15-15-15 — ¢ 5,60
   1 bag Sulphate of Ammonia — ¢ 2.00
   ¢ 7.60 per acre
5. Land preparation (ploughing and double harrowing) ¢ 2.00/acre. When the applicant has no tractor, the Bank pays ¢/14.00 per acre.
6. Sowing (Planting), Broadcasting ¢ 1.00/acre
7. Fertilizer application, Broadcasting ¢ 1.00/acre
8. Weeding (2x) ¢ 6.00/acre



9. Harvesting (Mechanical or Manual) ¢ 15.00/acre
10. Supply of Bags ¢ 8.00/acre
    (Based on yield of 8 bags/acre and vost of each bags ¢ 1.00).
11. Transportation ¢ 2.40/acre
    (Based on 30p per bag with a yield of 8 bags per acre).
12. Contingency allowed 5 %
13. Interest charget 6 %
    a) Tractor loan (Capital Investment) is amortised over 4—5 years.
    b) Land Development (Clearing is alortised over 4—5 years.
    c) The production or working capital is amortised over one crop year; that is, the applicant is expected to pay off the working capital together with interest on it immediately after harvesting. Any customer who fails to pay off his working capital loan in full will not be granted any further loan facility, unless there is proof that there was a crop failure due to adverse weather condition and not because of negligence on the past of the customer. Where adverse weather causes or contributes greatly to a crop failure, the outstanding loan (unpaid balance) may be rescheduled.

**Cotton**

Cotton farmers are recommended to the Bank for an loan by the Cotton Development Board. The farmers are expected to cultivate not less than 5 acres. The loan is utilised for bullocks, bullock ploughs, and maintenance of the farm. The Cotton Development Board provides such inputs as fertilizer, seeds and insecticides. Repayment of the loan is channelled through the Cotton Development Borad, Repayment is normally spread over 2—3 years.

**Classification of loan application:**

Applications for loans received by the Bank are classified as —

(I) Individual applications
(II) Partnership applications
(III) Co-operative applications
(IV) Group farm applications,

and each application is considered on its merits. The Bank receives applications for loans from individuals each day. Normally, partners who wish to be considered for a loan by the Bank are expected to have their partnership registered.

The co-operative department recommends their primary societies to the Bank for loan consideration. Group farms should normally be recognised by the Ministry of Agriculture before the Bank can finance them. It is therefore important that farmers, who want for form. groups should channel their applications through the District Crop Production Officer who in turn will forward the applications to the Divisional Agricultural Officer of the Region for selection. The final selection of the Group Farms is made by the Bank with the hilp of the Divisional Agricultural Officer and the Regional Agricultural Officer.

**Role of the Technical Officer**

The „Package Deal" agreement signed between the Bank and Ministry of Agriculture expects the Technical Officers to recommend good and hardworking farmers from their Distrect or Sub-District to the Bank for financial assistance. When the loan is granted, it is expected that the Officer will closely supervise the project and help the farmer achieve his objective.

**Financing of Other Crops**

In the past, the Bank had financed only rice and cotton in the Northern Region, but the present policy is to finance as many crops as possible, especially where the market for such a crop is assured. Loans may also be made available for farmers interested in animal husbandry.

**Conclusion**

The Technical Offivers has a role to play in helping the good and hardworking farmers obtain loans from the Bank, Where good farmers are selected for the Bank the farmers success will be noticed and the Officer will be praised for his good selection, but where lazy farmers are recommended to the Bank, their failures will cause the Bank to think twice before accepting any farmer recommended by the Officer.



## Trouble — shooting hints for motor cars

### 1. ENGINE

| Observed Fault | Possible Cause | Remedy |
|---|---|---|
| Starting difficulties | Ignition spark fails | Check ignition spark at spark plugs |
| | | Adjust breaker points |
| | Wet distributor cap or cables | Check spark plug cables |
| | | Dry wet areas with rag |
| | Spark plugs oily | Clean or replace spark plugs |
| | | Adjust gap |
| | Gas mixture fails or is not inflammable | Check for fuel in tank |
| | | Clean fuel filter |
| | | Check fuel pump for delivery |
| | | Clean and adjust carburetor |
| | | Check float valve |
| High fuel consumption | Improper fuel mixture | Check carburetor adjustment |
| | Partial choking | Adjust choke |
| | Improper float valve adjustment | Replace float valve |
| | | Adjust float |
| | Air filter dirty | Clean air filter |
| Poor power | Ignition timing | Check ignition timing |
| | Carburetor adjustment | Check carburetor adjustment |
| | Compression too low | Check for worn out piston rings and for burnt valves |
| Overheating | Watershortage | Top-up radiator |
| | Leaking cooling system | Repair water leak |

| Observed Fault | Possible Cause | Remedy |
|---|---|---|
| | Fan belt too loose | Tighten fan belt |
| | Radiator surface dirty with insects and dust | Clean radiator surface |
| | Thermostat defective | Replace thermostat |
| | Retarded ignition | Adjust timing |
| Noise | Spark knocking | Use higher octane fuel (Super) |
| | Sparking advance | Adjust timing |
| | Too much valve clearance | Adjust valves |
| | Crankshaft and connecting rod bearings worn out | Regrind crankshaft, replace main bearings and connecting rod bearings |
| | Piston bushings worn out | Replace piston bushings |
| | Loose flywheel | Tighten flywheel |
| High oil consumption | Oil leakage | Replace damaged gaskets and seals |
| | Piston rings or valve shaft guides worn out | Repace piston rings or valve shaft guides |
| Thin-bodied oil | Fuel in the crankcase | Replace fuel pump diaphragm<br>Check carburetor adjustment |
| | Water in oil | Replace cylinder head gasket<br>Check engine block for cracks |
| Weak oil pressure | Oil pressure switch defective | Replace oil pressure switch |
| | Oil filter clogged | Replace oil filter element |

| Observed Fault | Possible Cause | Remedy |
|---|---|---|
| | Crankshaft and connecting rod bearings worn out | Regrind crankshaft |
| **2. CLUTCH** | | |
| Clutch slips | No clutch play | Adjust clutch free travel |
| | Linings are oiled up | Replace gaskets and seals |
| | Linings excessively worn | Replace linings |
| | Clutch overheated | Replace clutch pressure plate |
| Clutch does not separate | Clutch play too large | Adjust clutch play |
| **3. BRAKE** | | |
| Brake pedal must be pushed far | Brake linings worn | Adjust brakes |
| Poor brakes | Brake linings worn out | Replace brake linings |
| | Brake linings oily | Replace gaskets and seals |
| No brakes | No brake fluid in master cylinder | Fill up brake fluid, bleed brake system |
| | Leakage in brake system | Check for leakages |
| Locking of wheels | Unsuitable brake linings | Install suitabe brake linings |
| | Linings are dirty | Clean break linings |
| Overheating | Brakes are too stiff | Slack brake adjustment |
| | No free travel at brake pedal | Adjust brake pedal free travel |
| **4. STEERING AND TYRES** | | |
| Vehicel sways | Too much play in steering | Adjust steering gear |
| | No toe in | Adjust alignment |
| | Tie rod ends worn out | Replace tie rod ends |

| Observed Fault | Possible Cause | Remedy |
|---|---|---|
| Shaky steering wheel | Front wheels unbalanced | Balance front wheels |
| | Steering damper defective | Replace steering damper |
| | Front shock absorber worn out | Replace defect shock absorber |
| | Wheel suspension worn out | Repair wheel suspension |
| | No toe in | Adjust alignment |
| Tyres wearing | No toe in | Adjust alignment |
| | Tie rods are bent | Straighten or replace tie rods |
| | Wrong tyre pressure | Check tyre air pressure |
| **5. ELECTRICAL SYSTEM** | | |
| Battery will not hold charge | Short circuit in wiring | Check for short circuit |
| | Battery plates sulphated | Charge battery |
| | V-belt too loose | Tighten V-belt |
| Battery overcharges | Regulator not working properly | Repair or replace regulator |
| Starter trouble | Battery discharged | Charge battery |
| | Battery terminals loose | Tighten battery terminals |
| | Starter pinion sticks in toothed flywheel | Try to turn crankshaft |
| | Pinion does not engage in toothed flywheel | Replace overrunning clutch |
| Generator lamp does not go out when engine is in motion | V-belt loose or torn | Tighten or replace V-belt |
| | Generator brushes jammed or worn | Clean or replace brushes |
| | Regulator does not work | Repair or replace regulator |
| | Generator does not charge | Overhaul generator |



# Selected Conversion Tables

## Conversion tables for sqm and sq.ft.

| sqm | sq.ft. | sqm | sq.ft. | sqm | sq.ft. |
|---|---|---|---|---|---|
| 0.092 | 1 10.764 | 3.252 | 35 376.74 | 6.410 | 69 742.72 |
| 0.186 | 2 21.528 | 3.345 | 36 387.50 | 6.503 | 70 753.48 |
| 0.279 | 3 32.292 | 3.437 | 37 398.27 | 6.596 | 71 764.24 |
| 0.372 | 4 43.056 | 3.530 | 38 409.03 | 6.689 | 72 775.01 |
| 0.465 | 5 53.820 | 3.623 | 39 419.80 | 6.782 | 73 785.77 |
| 0.557 | 6 64.584 | 3.716 | 40 430.56 | 6.875 | 74 796.54 |
| 0.650 | 7 75.348 | 3.809 | 41 441.32 | 6.968 | 75 807.30 |
| 0.743 | 8 86.112 | 3.902 | 42 452.09 | 7.060 | 76 818.06 |
| 0.836 | 9 96.876 | 3.995 | 43 462.85 | 7.153 | 77 828.83 |
| 0.929 | 10 107.64 | 4.088 | 44 473.62 | 7.246 | 78 839.59 |
| 1.022 | 11 118.40 | 4.181 | 45 484.38 | 7.339 | 79 850.36 |
| 1.115 | 12 129.17 | 4.274 | 46 495.14 | 7.432 | 80 861.12 |
| 1.208 | 13 139.93 | 4.366 | 47 505.91 | 7.524 | 81 871.88 |
| 1.301 | 14 150.70 | 4.459 | 48 516.67 | 7.618 | 82 882.65 |
| 1.394 | 15 161.46 | 4.552 | 49 527.44 | 7.711 | 83 893.41 |
| 1.486 | 16 172.22 | 4.645 | 50 538.20 | 7.804 | 84 904.18 |
| 1.579 | 17 182.99 | 4.738 | 51 548.96 | 7.897 | 85 914.94 |
| 1.672 | 18 193.75 | 4.831 | 52 559.73 | 7.989 | 86 925.70 |
| 1.765 | 19 204.52 | 4.924 | 53 570.49 | 8.082 | 87 936.47 |
| 1.858 | 20 215.26 | 5.017 | 54 581.26 | 8.175 | 88 947.23 |
| 1.951 | 21 226.04 | 5.110 | 55 592.02 | 8.268 | 89 958.00 |
| 2.044 | 22 236.81 | 5.202 | 56 602.78 | 8.361 | 90 968.76 |
| 2.137 | 23 247.57 | 5.295 | 57 613.55 | 8.454 | 91 979.52 |
| 2.230 | 24 258.34 | 5.388 | 58 624.31 | 8.547 | 92 990.29 |
| 2.323 | 25 269.10 | 5.481 | 59 635.08 | 8.640 | 93 1001.05 |
| 2.415 | 26 279.86 | 5.574 | 60 645.84 | 8.733 | 94 1011.82 |
| 2.508 | 27 290.63 | 5.667 | 61 656.60 | 8.826 | 95 1022.58 |
| 2.601 | 28 301.39 | 5.760 | 62 667.37 | 8.918 | 96 1033.34 |
| 2.694 | 29 312.16 | 5.853 | 63 678.13 | 9.011 | 97 1044.11 |
| 2.877 | 30 322.92 | 5.946 | 64 688.90 | 9.104 | 98 1054.87 |
| 2.880 | 31 333.68 | 6.039 | 65 699.66 | 9.197 | 99 1065.64 |
| 2.973 | 32 334.45 | 6.131 | 66 710.42 | 9.290 | 100 1076.40 |

**Example:** sqm 1.765 19 sq.ft. 204.52

19 sq.ft. = 1.765 sqm
19 sqm = 204.52 sq.ft.

## Conversion table (ha/acres)

| ha | | acres | ha | | acres | ha | | acres |
|---|---|---|---|---|---|---|---|---|
| 0.405 | 1 | 2.47 | 14.164 | 35 | 86.49 | 27.923 | 69 | 170.51 |
| 0.809 | 2 | 4.94 | 14.568 | 36 | 88.96 | 28.328 | 70 | 172.98 |
| 1.214 | 3 | 7.41 | 14.973 | 37 | 91.43 | 28.732 | 71 | 175.45 |
| 1.619 | 4 | 9.88 | 15.378 | 38 | 93.90 | 29.137 | 72 | 177.92 |
| 2.023 | 5 | 12.36 | 15.783 | 39 | 96.37 | 29.542 | 73 | 180.39 |
| 2.428 | 6 | 14.83 | 16.187 | 40 | 98.84 | 29.946 | 74 | 182.86 |
| 2.839 | 7 | 17.30 | 16.592 | 41 | 101.31 | 30.351 | 75 | 185.33 |
| 3.237 | 8 | 19.77 | 16.997 | 42 | 103.79 | 30.756 | 76 | 187.80 |
| 3.642 | 9 | 22.24 | 17.401 | 43 | 106.26 | 31.160 | 77 | 190.27 |
| 4.047 | 10 | 24.71 | 17.806 | 44 | 108.73 | 31.565 | 78 | 192.75 |
| 4.451 | 11 | 27.18 | 18.211 | 45 | 111.20 | 31.970 | 79 | 195.22 |
| 4.856 | 12 | 29.65 | 18.615 | 46 | 113.67 | 32.374 | 80 | 197.69 |
| 5.261 | 13 | 32.12 | 19.020 | 47 | 116.14 | 32.779 | 81 | 200.16 |
| 5.666 | 14 | 34.60 | 19.425 | 48 | 118.61 | 33.184 | 82 | 202.63 |
| 6.070 | 15 | 37.07 | 19.829 | 49 | 121.08 | 33.588 | 83 | 205.10 |
| 6.475 | 16 | 39.54 | 20.234 | 50 | 123.55 | 33.993 | 84 | 207.57 |
| 6.880 | 17 | 42.01 | 20.639 | 51 | 126.03 | 34.398 | 85 | 210.04 |
| 7.284 | 18 | 44.48 | 21.043 | 52 | 128.50 | 34.802 | 86 | 212.51 |
| 7.689 | 19 | 46.95 | 21.448 | 53 | 130.97 | 35.207 | 87 | 214.98 |
| 8.094 | 20 | 49.42 | 21.853 | 54 | 133.44 | 35.612 | 88 | 217.46 |
| 8.498 | 21 | 51.89 | 22.257 | 55 | 135.91 | 36.017 | 89 | 219.93 |
| 8.903 | 22 | 54.36 | 22.662 | 56 | 138.38 | 36.421 | 90 | 222.40 |
| 9.308 | 23 | 56.84 | 23.067 | 57 | 140.85 | 36.826 | 91 | 224.87 |
| 9.712 | 24 | 59.31 | 23.471 | 58 | 143.32 | 37.231 | 92 | 227.34 |
| 10.117 | 25 | 61.78 | 23.876 | 59 | 145.79 | 37.635 | 93 | 229.81 |
| 10.522 | 26 | 64.25 | 24.281 | 60 | 148.27 | 38.040 | 94 | 232.28 |
| 10.926 | 27 | 66.72 | 24.685 | 61 | 150.74 | 38.445 | 95 | 234.75 |
| 11.331 | 28 | 69.19 | 25.090 | 62 | 153.21 | 38.849 | 96 | 237.22 |
| 11.736 | 29 | 71.66 | 25.495 | 63 | 155.68 | 39.254 | 97 | 239.70 |
| 12.140 | 30 | 74.13 | 25.900 | 64 | 158.15 | 39.659 | 98 | 242.17 |
| 12.545 | 31 | 76.60 | 26.304 | 65 | 160.62 | 40.063 | 99 | 244.64 |
| 12.950 | 32 | 79.07 | 26.709 | 66 | 163.09 | 40.468 | 100 | 247.11 |
| 13.354 | 33 | 81.55 | 27.114 | 67 | 165.56 | | | |
| 13.759 | 34 | 84.02 | 27.518 | 68 | 168.03 | | | |



## Weight and measure conversion

| Kilometres | | Miles | Centimetres | | Inches |
|---|---|---|---|---|---|
| 1.609 | 1 | 0.621 | 2.540 | 1 | 0.394 |
| 3.219 | 2 | 1.243 | 5.080 | 2 | 0.787 |
| 4.828 | 3 | 1.864 | 7.620 | 3 | 1.181 |
| 6.437 | 4 | 2.485 | 10.160 | 4 | 1.575 |
| 8.047 | 5 | 3.107 | 12.700 | 5 | 1.969 |
| 9.656 | 6 | 3.728 | 15.240 | 6 | 2.362 |
| 11.266 | 7 | 4.350 | 17.780 | 7 | 2.756 |
| 12.875 | 8 | 4.971 | 20.320 | 8 | 3.150 |
| 14.484 | 9 | 5.592 | 22.860 | 9 | 3.543 |
| 16.094 | 10 | 6.214 | 25.400 | 10 | 3.937 |
| 32.187 | 20 | 12.427 | 50.800 | 20 | 7.874 |
| 48.281 | 30 | 18.641 | 76.200 | 30 | 11.811 |
| 64.375 | 40 | 24.855 | 101.600 | 40 | 15.748 |
| 80.468 | 50 | 31.068 | 127.000 | 50 | 19.685 |
| 96.562 | 60 | 37.282 | 152.400 | 60 | 23.625 |
| 112.655 | 70 | 43.495 | 177.800 | 70 | 27.592 |
| 128.750 | 80 | 49.709 | 203.200 | 80 | 31.496 |
| 144.843 | 90 | 55.923 | 228.600 | 90 | 35.433 |
| 160.936 | 100 | 62.136 | 254.000 | 100 | 39.370 |

## Weight and measure conversion

| Kilograms | | Pounds | Litres | | Gallons |
|---|---|---|---|---|---|
| 0.454 | 1 | 2.205 | 4.546 | 1 | 0.220 |
| 0.907 | 2 | 4.409 | 9.092 | 2 | 0.440 |
| 1.361 | 3 | 6.641 | 13.638 | 3 | 0.660 |
| 1.814 | 4 | 8.818 | 18.184 | 4 | 0.880 |
| 2.268 | 5 | 11.023 | 22.730 | 5 | 1.100 |
| 2.722 | 6 | 13.228 | 27.276 | 6 | 1.320 |
| 3.175 | 7 | 15.432 | 31.822 | 7 | 1.540 |
| 3.629 | 8 | 17.637 | 36.368 | 8 | 1.760 |
| 4.082 | 9 | 19.842 | 40.914 | 9 | 1.980 |
| 4.336 | 10 | 22.046 | 45.460 | 10 | 2.200 |
| 9.072 | 20 | 44.092 | 90.919 | 20 | 4.399 |
| 13.608 | 30 | 66.136 | 136.379 | 30 | 6.599 |
| 18.144 | 40 | 88.185 | 181.840 | 40 | 8.799 |
| 22.650 | 50 | 110.231 | 227.298 | 50 | 10.999 |
| 27.215 | 60 | 132.277 | 272.758 | 60 | 13.198 |
| 31.751 | 70 | 154.323 | 318.217 | 70 | 15.398 |
| 36.287 | 80 | 176.370 | 363.677 | 80 | 17.598 |
| 40.823 | 90 | 198.416 | 409.136 | 90 | 19.797 |
| 45.359 | 100 | 200.462 | 454.596 | 100 | 21.997 |



## Temperature conversion Centigrade — Farenheit

| C | F | C | F | C | F |
|---|---|---|---|---|---|
| — 100 | — 148 | 9 | 48.2 | 40 | 104.0 |
| — 90 | — 130 | 10 | 50.2 | 45 | 113.0 |
| — 80 | — 112 | 11 | 51.8 | 50 | 122.0 |
| — 70 | — 94 | 12 | 53.6 | 55 | 131.0 |
| — 60 | — 76 | 13 | 55.4 | 60 | 140.0 |
| — 50 | — 58 | 14 | 57.2 | 65 | 149.0 |
| — 50 | — 40 | 15 | 59.0 | 70 | 158.0 |
| — 30 | — 22 | 16 | 60.8 | 75 | 167.0 |
| — 20 | — 4 | 17 | 62.6 | 80 | 176.0 |
| — 18 | — 0.4 | 18 | 64.4 | 85 | 185.0 |
| — 15 | 5.4 | 19 | 66.2 | 90 | 194.0 |
| — 12 | 9 | 20 | 68.0 | 95 | 203.0 |
| — 10 | 14 | 21 | 69.8 | 100 | 212.0 |
| — 9 | 15.8 | 22 | 71.6 | 110 | 230.0 |
| — 8 | 16.6 | 23 | 73.4 | 120 | 248.0 |
| — 7 | 19.4 | 24 | 75.2 | 130 | 266.0 |
| — 6 | 21.2 | 25 | 77.0 | 140 | 284.0 |
| — 5 | 23.0 | 26 | 78.8 | 150 | 302.0 |
| — 4 | 24.8 | 27 | 80.6 | 160 | 320.0 |
| — 3 | 26.6 | 28 | 82.4 | 170 | 338.0 |
| — 2 | 28.4 | 29 | 84.2 | 180 | 356.0 |
| — 1 | 30.2 | 30 | 86.0 | 190 | 374.0 |
| 0 | 32 | 31 | 87.8 | 200 | 392.0 |
| 1 | 33.8 | 32 | 89.6 | 210 | 410.0 |
| 2 | 35.6 | 33 | 91.4 | 220 | 428.0 |
| 3 | 37.4 | 34 | 93.2 | 230 | 446.0 |
| 4 | 39.2 | 35 | 95.0 | 240 | 464.0 |
| 5 | 41.0 | 36 | 96.8 | 250 | 482.0 |
| 6 | 42.8 | 37 | 98.6 | 300 | 572.0 |
| 7 | 44.6 | 38 | 100.4 | 350 | 662.0 |
| 8 | 46.4 | 39 | 102.2 | 400 | 752.0 |

How to find Farenheit:

$$\frac{°C \times 18}{10} + 32$$

how to find Celsius:

$$\frac{(°F - 32) \times 10}{18}$$

## Plant populations per acre at various row spacings

| Plants Per Ft. of Row | SPACINGS BETWEEN ROWS | | | | | |
|---|---|---|---|---|---|---|
| | 8 in. | 10 in. | 14 in. | 18 in. | 20 in. | 40 in. |
| 20 | 1,306,800 | 1,045,440 | 746,740 | 580,800 | 522,700 | 261,360 |
| 18 | 1,176,120 | 940,896 | 672,066 | 522,720 | 470,530 | 235,244 |
| 15 | 980,100 | 784,080 | 560,055 | 435,600 | 392,025 | 196,020 |
| 12 | 784,080 | 627,264 | 448,044 | 348,044 | 313,620 | 156,816 |
| 10 | 653,400 | 522,720 | 373,370 | 290,400 | 261,350 | 130,680 |
| 9 | 588,060 | 470,448 | 336,033 | 261,360 | 235,315 | 117,612 |
| 8 | 522,720 | 418,176 | 298,696 | 232,320 | 209,080 | 104,544 |
| 7 | 457,380 | 365,904 | 261,359 | 203,280 | 182,945 | 91,476 |
| 6 | 392,040 | 313,632 | 224,022 | 174,240 | 156,818 | 78,408 |
| 5 | 326,700 | 261,360 | 186,685 | 145,200 | 130,675 | 65,340 |
| 4 | 261,360 | 209,088 | 149,358 | 116,160 | 104,540 | 52,272 |
| 3 | 196,020 | 156,816 | 112,011 | 87,120 | 78,405 | 39,204 |
| 2 | 130,680 | 104,544 | 74,674 | 58,080 | 52,272 | 26,136 |
| 1 | 65,340 | 52,272 | 37,337 | 29,040 | 26,136 | 13,068 |

Note: Table shows the rapid increase in plant population as rows are narrowed. It is important, that extra fertilizer and moisture is provided for, as plant population is increased.



## Application of fertilizer

| kg/ha | lbs./acre | ounces/acre | Great-Britain |
|---|---|---|---|
| 2 | 1.784 | 28.54 | |
| 3 | 2.677 | 42.81 | 1 oz./sq.ft.= |
| 4 | 3.569 | 57.08 | 305 g/sqm |
| 5 | 4.461 | 71.35 | |
| 6 | 5.352 | 85.62 | 1 cwt./acre = |
| 7 | 6.245 | 99.89 | 125.52 kg/ha |
| 8 | 7.138 | 114.16 | |
| 9 | 8.030 | 128.43 | 1 lb./100 sq.ft.= |
| 10 | 8.922 | 142.70 | 4.880 kg/ha |
| 11 | 9.814 | 156.97 | |
| 12 | 10.706 | 171.24 | 1 lb./sq.yd.= |
| 13 | 11.599 | 185.51 | 543 g/sqm |
| 14 | 12.491 | 199.78 | |
| 15 | 13.383 | 214.04 | 100 g/sqm = |
| 20 | 17.844 | 285.40 | 0.327 oz./sq.ft. |
| 25 | 22.305 | 356.75 | |
| 30 | 26.766 | 428.10 | 100 kg/ha = |
| 40 | 35.688 | 570.80 | 0.796 cwt/acre |
| 50 | 44.610 | 713.50 | |
| 60 | 53.532 | 856.20 | 1 kg/sqm = |
| 70 | 62.454 | 998.90 | 0.204 lb./sq.ft. |
| 80 | 71.376 | 1141.60 | |
| 90 | 80.298 | 1284.30 | 1 kg/sqm = |
| 100 | 89.220 | 1427.00 | 1.842 lbs./sq.yd. |

## Measuring water

One inch of rainfall means 100 tons of water on every acre.

A gallon of water equals 231 cubic inches and weights 8—1/3 pounds. A cubic foot of water equals 7—1/2 gallons and weights 62—1/2 pounds.

Doubling the diameter of a pipe or cylindrical vessel increases its capacity four times.

water expands 1/11 of its bulk freezing.

## STANDARD WEIGHTS AND MEASURES

### Measures of length: Imperial

| | | | |
|---|---|---|---|
| 12 inches | = 1 foot | 220 yards | = 1 furlong |
| 3 feet | = 1 yard | 5280 feet | = 1 mile |
| 5½ yards | = 1 rod | 1760 yards | = 1 mile |
| 22 yards | = 1 chain (Gunters) | 8 furlongs | = 1 mile |
| 100 feet | = 1 chain (Engineers) | | |

### Measures of length: Metric — Conversion to imperial

| | | |
|---|---|---|
| 10 microns (u) | = 1 millimeter (mm) | |
| 10 millimeters | = 1 centimeter (cm) | = 0.39 inches (approx.) |
| 10 centimeters | = 1 decimeter (dm) | |
| 10 decimeters | = 1 meter (m) | = 39.37 inches |
| 100 meters | = 1 kilometer (km) | = 0.62 mile (1.61 invers) |

### Measures of area or surface: Imperial

| | | | |
|---|---|---|---|
| 144 | square inches | = 1 square foot | |
| 9 | square feet | = 1 square yard | |
| 30¼ | square yards | = 1 square Rod | |
| 160 | square rods | = 1 acre | 640 acres = 1 square mile |
| 43,560 | square feet | = 1 acre | = 6,272,640 square inches |
| 4,840 | square yards | = 1 acre | |

### Measures of area: Metric — Conversion to imperial

| | | | |
|---|---|---|---|
| 100 | square centimeters | = 1 square dm | |
| 100 | square decimeters | = 1 square m | = 10.76 square feet |
| 10,000 | square meters | = 1 hectare (ha) | = 2.47 acres |

### Measures of capacity: Imperial

| | | | |
|---|---|---|---|
| 2 teaspoons | = 1 desertspoon | 4 quarts | = 1 gallon (gal) |
| 2 desertspoons | = 1 tablespoon | 8 gallons | = 1.28 cubic feet |
| 2 tablespoons | = 1 fluid ounce | 1 gallon of water | = 10 lbs. |
| 5 fluid ounces | = 1 gill | | |
| 4 gills | = 1 pints (pt) | | |
| 2 pints | = 1 quart (qt) | | |



### Measures of capacity: Metric — Conversion to imperial

| | | | | |
|---|---|---|---|---|
| 10 milliliters | = 1 centiliter | = 0.07 | gil | = .493 teaspoon |
| 10 centiliters | = 1 deciliter | = 0.176 | pint | |
| 10 deciliters | = 1 liter | = 1.760 | pints | = 0.22 gal. |
| 1 cubic centimtr. (water) | = 1 g | = 0.0351 | ounces | |

### Measures of weight: Imperial — Avoirdupois

| | | | |
|---|---|---|---|
| 27.34 grains | = 1 dram | 28 pounds | = 1 quarter |
| 16 drams | = 1 ounce (oz) | 112 pounds | = 1 hundredweight (cwt) |
| 16 ounces | = 7,000 grains | 2000 pounds | = 1 short ton |
| | = 1 pound | 2240 pounds | = 1 imp. long ton |
| 14 pounds | = 1 stone | | |

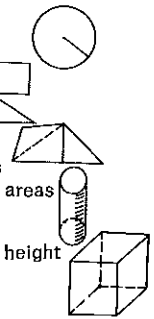
### Measures of weight: Metric — Conversion to imperial

| | | |
|---|---|---|
| 10 milligrams | = 1 centigram | |
| 10 centigrams | = 1 decigram | |
| 10 decigrams | = 1 gram | = 0.0351 oz. |
| 1000 grams | = 1 kilogram | = 2.20 lb. |

### Several conversion factors

| | | | |
|---|---|---|---|
| feet to meters | = 0.30 | inverse | = 3.28 |
| yards to meters | = 0.91 | inverse | = 1.09 |
| acres to hectares | = 0.40 | inverse | = 2.47 |
| gallons to litres | = 4.55 | inverse | = 0.22 |
| pounds to kilograms | = 0.45 | inverse | = 2.295 |
| kilograms per hectare to pounds per acre | = 0.89 | inverse | = 1.12 |

### Measurement formulas



| | |
|---|---|
| Area of a circle | = radius x radius x 3.142 |
| Area of a rectangle | = lenght x width |
| Area of a triangle | = 0.5 x base x height |
| Area of a quadrilateral | = divide into two triangles with common base; find areas separately and add. |
| Volume of a cylinder | = radius x radius x 3.142 x height |
| Volume of a box | = length x width x height |