CROP PRODUCTION GUIDE

Handbook for the Extension Worker

CROP PRODUCTION GUIDE

1974

Handbook for the Extension Worker

IDENTIFICATION

Name .....

Town .....

P.O. Box ..... Region .....

Telephone No. ..... Motorcycle No. .....

Country .....

CROP PRODUCTION GUIDE
Handbook for the Extension Worker
by
GHANAIAN-GERMAN
AGRIC. DEVELOPMENT PROJECT NORTHERN AND UPPER REGIONS
TAMALE P.O. BOX 171
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Preface

The purpose of this Production Guide is to assist Extension Officers in helping farmers to increase their farm production and net income. The Guide has been prepared in such a way that it is hoped it will prove to be a practical book of reference, and easy to use, for Extension Officers in their daily activities. The Guide should assist Extension Officers (1) in identifying practical farm problems and (2) to help Officers show or suggest to the farmers practical means, to solve or reduce some of their problems.

Agro-economic data are provided as general background information and amassed in one place such important Extension Information as (1) rainfall data, (2) information on soils, (3) present cropping patterns and anticipated yields, (4) present recommendation on cultural practices and fertilizer-use for selected crops, and (5) practical information regarding different systems of land preparation (handhoe, bullock farming, tractor mechanization).

While the Guide is production orientated other types of practical information are also provided. For example, information is included on the construction of inexpensive farm storage facilities, methods of improved storage, marketing, and sources of fertilizer, improved seeds, credit, tools, epuiment, etc. Data on weights and measures, plus conversion tables are also presented. The Guide was prepared by the staff of the Ghanaian-German Agricultural Development Project wich serves the Northern and Upper Regions. Acknowledgement is also made to numerous people outside the Project who have contributed to the preparation of this Guide.

Revision of this Guide is anticipated as more knowledge and experience are accumulated. It is hoped that Extension Officers will provide the Project with „feedback" regarding their use of the Guide. Any suggestion or recommendation that may be useful for the preparation of the next edition will be very much appreciated.

PROJECT MANAGER
GHANAIAN-GERMAN AGRICULTURAL DEVELOPMENT
PROJECT — DEPARTMENT OF AGRICULTURE
POST OFFICE BOX 171, TAMALE

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Calendar 1973

	January	February	March
Sunday	7 14 21 28	4 11 18 25	4 11 18 25
Monday	1 8 15 22 29	5 12 19 26	5 12 19 26
Tuesday	2 9 16 23 30	6 13 20 27	6 13 20 27
Wednesday	3 10 17 24 31	7 14 21 28	7 14 21 28
Thursday	4 11 18 25	1 8 15 22	1 8 15 22 29
Friday	5 12 19 26	2 9 16 23	2 9 16 23 30
Saturday	6 13 20 27	3 10 17 24	3 10 17 24 31

	April	May	June
Sunday	1 8 15 22 29	6 13 20 27	3 10 17 24
Monday	2 9 16 23 30	7 14 21 28	4 11 18 25
Tuesday	3 10 17 24	1 8 15 22 29	5 12 19 26
Wednesday	4 11 18 25	2 9 16 23 30	6 13 20 27
Thursday	5 12 19 26	3 10 17 24 31	7 14 21 28
Friday	6 13 20 27	4 11 18 25	1 8 15 22 29
Saturday	7 14 21 28	5 12 19 26	2 9 16 23 30

	July	August	September
Sunday	1 8 15 22 29	5 12 19 26	2 9 16 23 30
Monday	2 9 16 23 30	6 13 20 27	3 10 17 24
Tuesday	3 10 17 24 31	7 14 21 28	4 11 18 25
Wednesday	4 11 18 25	1 8 15 22 29	5 12 19 26
Thursday	5 12 19 26	2 9 16 23 30	6 13 20 27
Friday	6 13 20 27	3 10 17 24 31	7 14 21 28
Saturday	7 14 21 28	4 11 18 25	1 8 15 22 29

	October	November	December
Sunday	7 14 21 28	4 11 18 25	2 9 16 23 30
Monday	1 8 15 22 29	5 12 19 26	3 10 17 24 31
Tuesday	2 9 16 23 30	6 13 20 27	4 11 18 25
Wednesday	3 10 17 24 31	7 14 21 28	5 12 19 26
Thursday	4 11 18 25	1 8 15 22 29	6 13 20 27
Friday	5 12 19 26	2 9 16 23 30	7 14 21 28
Saturday	6 13 20 27	3 10 17 24	1 8 15 22 29

Public Holidays: 01.01. New Year's Day; 01.06. Epiphany; 01.13. Gahna Redemption Day; 03.06. Gahna Independence Day; 04.20. Good Friday; 04.23. Easter Monday; 05.31. Ascension Day; 06.11. Whit Monday; 08.06. Bank Holiday; 11.29. St. Andrew's Day; 12.25. Christmas Day; 12.26. Boxing Day.

Notice

Ghana

Ghana is situated right in the center of West Africa. It is surrounded on West, North and East by Ivory Coast, Upper Volta and Togo respectively. In the South it borders upon the Atlantic Ocean. The coastline extends East to West for about 330 miles. The total area of Ghana is 92 873 square miles.

In Ghana tropical climate is dominating. Characteristics are heavy rainfall in May-Juni and in September-October and the period of no rain in January-February. Northern Ghana is strongly influenced during dry season by Harmattan which comes from Sahara bringing warm and dry air.

Physically, the country is divided into three main regions: the Costal Plain, the Akwapim and Togoland Ranges with the highest point of Ghana, the Afadjato (2 900 feet) and the northern Plains. Ghana is mainly drained by her principal river, the White Volta and its tributaries, the Red Volta, the Black Volta, Kulpawn and the Afram. Other important rivers are the Pra, Tano, Ofin, Ankobra, Densu and Todzie. The two largest lakes are the manmade Volta Lake and Lake Bosumtwi. The latter is situated 20 miles south-east of Kumasi.

Ghana's economy is mainly based on agriculture. About 70 per cent of the country's labour resources are emloyed in agriculture. Sheep, goats and poultry provide a good deal of food. There are various fruit-trees, such as avocado-pears, oranges, papaw, bananas, which in many cases grow wild in the forest. Cocoa-growing is the principal occupation in the forest belt and Ghana is by the way the world's most important cocoa producer.

Along the coast the chief occupation is fishing, farming and stock-breeding. New fishing methods, involving outboard motors, trawlers and large fishingboats with marine engines are now employed in order to increase the annual catch of fish.

In the northern savannas, agriculture is almost entirely confined to the cultivation of cereals and other crops like yam, cotton, groundnuts and legumes. There is also considerable live-stock to be found.

Compared to the rest of Africa, Ghana is quite densely populated, the total population is about 8 545 600 inhabitants. The

population distribution is as follows: Ashanti Region 1 477 400; Brong-Ahafo Region 762 700; Central Region 892 600; Eastern Region 1 262 900; Greater Accra Region 848 800; Northern Region 728 600; Upper Region 857 300; Volta Region 947 000; Western Region 768 300.

About 52 per cent of the total population is between 15 and 65 years of age, 3 per cent over 65 years and about 45 per cent under 15 years.

The country's trunk road mileage covers over 9 000 miles of which over 4 000 miles are now bitumen surfaced. In addition, over 18 000 miles of motorable roads are maintained by regional organisations and municipal authorities. Ghana's railway-lines are important transporting media for the country's natural resources, such as cocoa, logs, sawn timber and minerals.

But Ghana is not only exporting raw material, she also has developed her own idustry in various parts of the country. Since Ghana has hydro-electric power from the Volta River there is good potential for more economic independence. Ghana is also famous for mineral wealth, especially gold, bitumen, asbestos, limestone, bauxite, diamond and manganese.

Ghana possesses no natural harbours. The first deep water-harbour of Ghana was opened at Takoradi in 1928 and not until 1951 did Ghana construct another man-made harbour at Tema. The Black Star Line Ltd. and since 1969 the Volta Lines Ltd. operate a considerable number of Yessels.

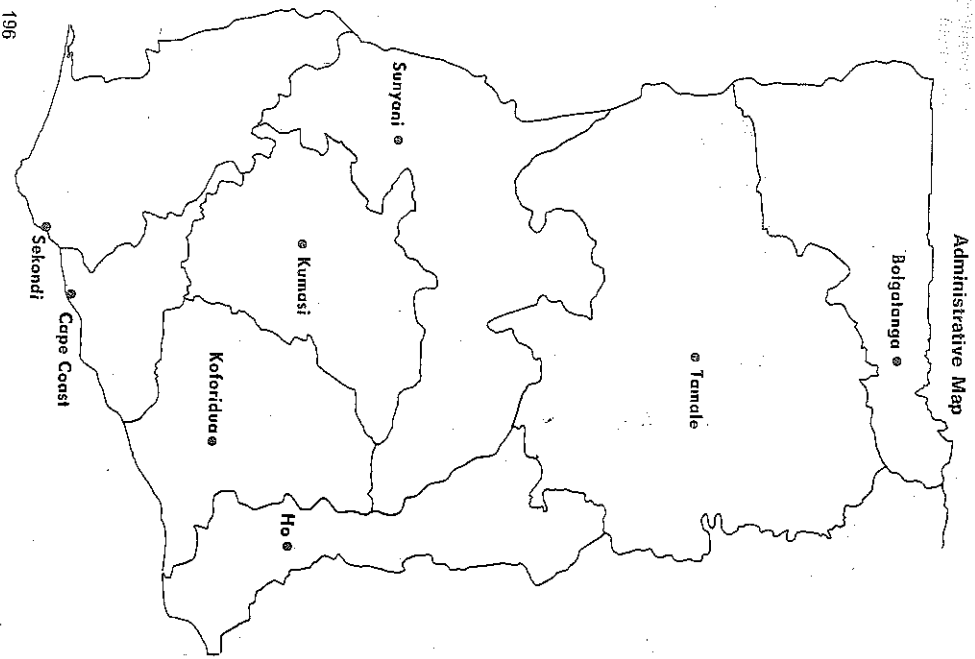
There are four airports in Ghana, situated at Accra, Kumasi, Takoradi and Tamale. Ghana Airways Company operates all interal services as well as international services.

In Ghana, English is the official as well as the commercial language. There are also several African languages and dialects spoken. The main local languages are Twi, Fanti, Ga, Ewe, Dagbani, Hausa and Nzima.

The school system comprises primary school of six years duration, followed by a secondary school course of five years. Primary and secondary schools in 1970 numbered about 44 342. There are now 118 secondary schools, 11 Government technical institutes and 102 Teacher Training-Colleges in the country. There are also three State Universities: the University of Ghana, Legon; the University of Science and Technology at Kumasi; and University of Cape Coast. Primary and secondary school education is provided free of charge by the Gogernment.

Mail service is established all over the country. Automatic telephone exchanges operate in Accra as well as in other big cities. There is also an international telex-system which provides service between Accra and London.

Ghana obviously is a country which is changing quickly and therefore this short introduction does not endeavour to give all the necessary information concerning the country, rather this short report only attempts to offer an insight into its resources, activities and the potential of the people of Ghana.



Administrative Map

Cropping Calendar N. R.

MONTH / CROP	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
RICE												
MAIZE												
GROUNDNUTS												
YAM												
EARLY MILLET												
LATE MILLET												
GUINEA CORN												
COTTON												

KEY: LAND PREPARATION; BASIC FERTILIZER APPLICATION & PLANTING; WEEDING; FERTILIZER TOP DRESSING; HARVESTING

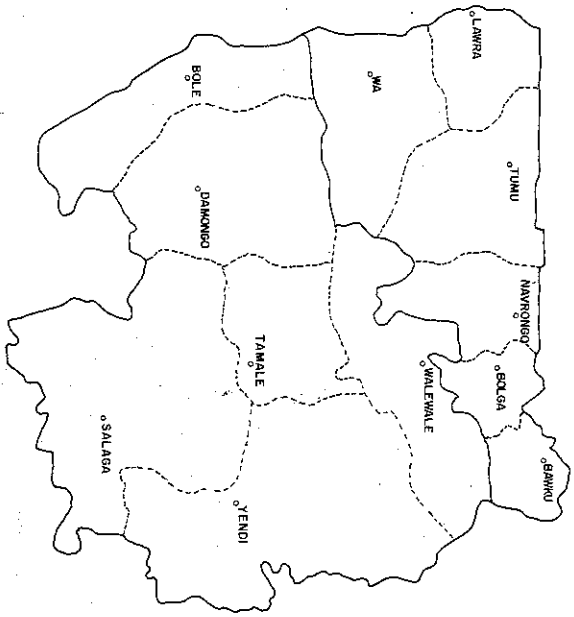
Cropping Calendar N. R.

CROP \ MONTH	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
RICE												
EARLY MILLET												
LATE MILLET												
GUINEA CORN												
GROUNDNUTS												
MAIZE												
YAM												
TOMATOES												
ONIONS												

KEY: LAND PREPARATION — BASIC FERTILIZER APPLICATION & PLANTING — WEEDING — FERTILIZER TOP DRESSING — HARVESTING

Agric. Administration of Ghana

AGRIC. COM.
COMMISSIONER
AG. AD. COM. (A. A. D)
AG. PL. COM. (A. P. D)
FA. AD. COM. (F. A. C.)
DE. RE. AD. COM. (A. T. A. D)
FIN. INST. AD. COM. (F. I. A. C.)
PRIN. SEC.
DIRECTOR
SECRETARIAT
LOCAL AGRIC. ORGANIZATIONS
RECRUITING
PLANNING BUDGET
LEGAL DISCIPLINARY
FOREIGN RELATIONS
BOARDS & CORPORATIONS
LOGISTICS
CHIEF ACCOUNTANT
D. DIR. PLANNING
REG. RURAL PLANNING
LONG RANGE PLANS
DETAILED PLANING
ECONOMIC ANALYSIS
D. DIR. OPERATIONS
ORG. ESTABLISHMENTS
TRAINING ESTABLISHMENTS
LOCAL & OVERSEAS COURSES & INSTITUTES
FOREIGN TRADE
REG. PROGRAMMES COORDINATION
INSTITUTIONS ORGANISATION
INST. AGRIC. DEV. PROJECTS
CREDIT & COOPERATIVES
INFORMATION
REGIONAL OPERATIONS
D. DIR. EXT. SERVICE
MARKETING
PROTECTION
HOME ECONOMICS
FARM MECH. & TRANSPORT
PRODUCE ECONOMICS
IRRIGATION & SOILS
FIELD CROPS
LIVESTOCK
HORTICULTURE
PRODUCE INSPECTION
EXTENSION TEAM
REG. ASST. DIR.
EXTENSION — GREA. ACCRA REG.
EXTENSION — UPPER REG.
EXTENSION — NORT. REG.
EXTENSION — ASH. REG.
EXTENSION — B. A. REG.
EXTENSION — WESTN. REG.
EXTENSION — EASTN. REG.
EXTENSION — VOLTA REG.
EXTENSION — CENTRAL REG.
PRICE & SUPPLIES
MARKETING RESEARCH
PROGRAMME COSTING
FIELD VET. SERVICES
CONTROL OF LIVESTOCK PROD.
PORT QUARANTINE
VET. INSTITUTIONS
PLANT PROTECTION
FIELD CROPS
HORTICULTURE
SOILS & WATER
ANIMAL RESEARCH
FOOD & FOOD STORAGE
EXPERIMENTAL STATIONS
AGRIC. ENGINEERING
ECONOMICS & MARKETING
VET. SERVICES
FISHERIES
SOIL CONSEV.
SETTLEMENTS
COCOA
RESEARCH



NORTHERN & UPPER REGION
AGRICULTURAL DISTRICTS

RAINFALL (mm) IN TAMALE 1961-72

	Jan.	Febr.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1961	0.0	0.0	53.3	70.6	103.4	160.8	144.0	120.1	149.4	20.5	0.0	0.0
1962	0.0	7.4	26.7	70.0	85.9	256.5	115.1	218.7	221.0	57.9	90.7	8.9
1963	0.0	27.7	15.0	133.6	98.0	163.6	207.5	389.9	386.3	243.3	0.3	0.0
1964	0.0	0.0	139.7	36.8	139.2	161.3	108.0	84.1	340.1	36.1	4.3	4.3
1965	18.0	1.0	14.7	132.1	125.4	314.5	126.0	347.0	223.8	77.0	0.0	0.0
1966	0.0	0.0	62.0	89.4	91.3	128.3	103.3	229.6	146.3	139.7	0.5	0.0
1967	0.0	22.1	63.0	98.3	127.5	178.6	130.6	311.4	153.9	38.4	4.6	5.6
1968	0.0	35.8	120.2	133.6	95.3	228.6	245.1	229.6	296.9	82.6	0.0	0.0
1969	0.0	5.6	36.8	104.2	70.2	69.0	154.2	194.6	186.5	72.4	72.0	0.0
1970	27.7	0.0	10.4	3.0	49.5	67.6	124.5	296.2	225.8	19.3	13.5	0.0
1971	0.0	14.5	145.3	85.6	184.4	75.9	154.7	144.5	321.6	74.2	0.0	1.5
1972	2.5	5.1	51.3	85.1	108.7	133.9	125.5	206.5	238.8	82.6	0.0	0.0

managerial skills of farmers becomes critical when farmers adopt new factors of production and improved production practices. When making these changes (innovations) farmers do not have a number of years of experience, nor do they have the experience derived from trial and error over the time to drawn upon to identify the most appropriate system of production for the new technology. In such cases the extension officer must devote considerable time explaining proven production practices and the new managerial considerations involved in the use of the new technology to obtain increased output and reduced costs of production.

Improving the management of new farm technology will reduce the likelihood of poor performance and augment the possibility of increased net farm income and farmers satisfaction.

The Production Guide indicates that improving the standard of agriculture and welfare of individual farmers depends of several inter-related factors at the farm level; namely, good planting materials, good cultural practices, and good management, They all contribute to high performance and are inportant to achieve increased farm production and net income.

MAIN CROPS IN NORTHERN AND UPPER REGIONS

I. RICE:

Grown as a cash crop. The crop is rapidly being developed particularly in the Northern and Upper Regions.

II. MAIZE:

Commonly grown crop in Ghana. It is grown extensively as both subsistence and cash crop. The crop is used in making Kenke and for feeding poultry.

III. SORGHUM:

Grown on large scale in Northern Region. It is grown both as subsistence as well as for brewering pito. It can be used in feeding poultry and animals but the only hitch is that it is expensive.

IV. MILLET:

The crop is grown mostly in Northern and Upper Regions. It is used mainly as subsistence crop.

V. COTTON:

The crop is gradually developing as an industrial crop in the country. The crop can be used in several ways.

VI. KENAF:

The crop is being developed gradually as an industrial crop.

VII. GROUNDNUTS:

It is one of the commonly grown crops in the country. It is grown as a cash especially in the North. The growth of this crop should be encouraged in order to keep the vegetable oil mills going.

VIII. YAM:

It is grown as a major root crop. The crop is grown both as subsistence and cash crop. The development of the crop should be en couraged.

IX. TOMATOES:

The crop is vigorously being developed as a dry season crop in the Northern an Upper Regions. It is grown mainly as a cash crop.

RICE

History:

Rice is probably man's oldest cereal crop and exceeds in acreage all other cereals. It feeds about the half the wold's population.

In Ghana, rice was known as far back as the 17th and 18th century, when it was one of the leading commercial crops.

Cultivation on a larger scale started about 47 years ago in the Western Region when the first rice mill was set up at Esiama.

Due to lack of irrigation facilities, proper agronomic practices, credit facilities to growers and ready market, this first attempt failed.

The second attempt to increase rice production was made during the World War II (1939—45) when there was world-wide shortage of food. That time, Southern Ghana, Volta- and Northern Regions were encouraged to grow more rice. Nevertheless, after the War, the encouragement to farmers was not sustained until 1963 when total production in the country was in the range of 21,000 tons (milled). Even since that time production has been subjected to considerable fluctuations as shown by the following production respectively importation figures for the years 1963—1792.

Year	Quantity Produced (Milled Rice)	Quantity Imported to supplement local consumption
1963	21,333 tons	26,357 tons
1964	28,000 „	38,269 „
1965	21,333 „	29,598 „
1966	19,333 „	48,176 „
1967	28,000 „	39,448 „
1968	25,000 „	30,000 „
1969		
1970		
1971		
1972		

Table below compares production and importation figures from some neighbouring West African Countries and Ghana for 1968.

1968	Country	Production (Milled)	Imported
	Ghana	25,000 tons	30,000
	Sierra Leone	400,000 „	22,000
	Ivory Coast	300,000 „	28,000
	Liberia	152,000 „	33,000

The figures reveal clearly that our local production falls short at a reasonable percentage of what we actually consume.

As rice is now firmly established as one of the staple foods in the Country and about 6—7 Million Dollars are spent annually on the Importation of Rice, the increase of local production is of national importance.

There are two main species: **Oryza sativa,** originating, from Asia, to which all modern high-yielding rice varieties belong, and **Oryza glaberrima,** an originality of West Africa. Oryza glaberrima varieties are stil grown by peasant farmers.

There is a considerable confusion as to what exactly is meant by the term „Upland Rice". Many people describe it as rice grown without any form of irrigation works or structures, but include as „upland rice", rice grown on low-lying areas which become water-logged during the growing season.

The term upland rice denotes rice which is grown entirely as a rainfed crop, on well-drained upland soils. This definition clearly excludes the grop grown on soils which become water-logged.

Varieties:

International Research Institutions like IRRI in the Philippines have developed new improved rice varieties which have the following characteristics:—high yielding potential, good response to fertilizers, resistance to certain pests and diseases, and lodging, short growth period and intensity to photoperiodism.

After the introduction of these varieties to upland rice growers and rice cultivation under semi-dry conditions, yields have increased considerably.

Improved varieties in use in Northern Ghana are C 4—63, IR.5, IR.20. These three varieties, that mature in about 115—135 days,

are high-yielding and have shown good response to fertilizers. However, the C 4—63 variety will be phased out in the near future as it has the disadvantage of easy lodging and sensitivity to blast and neck-rot attack.

The varieties 617 A, C.21 and Alupe have shown encouraging trial results and may be soon passed on for multiplication. 617 A and C.21 with a maturity period of about 100—115 days have shown a fast development after sowing and seem to be suitable for the higher upland soils. Alupe with a maturity period of 145—160 days may be used for deeper flooded valleys.

Cultivation Systems:

Many systems of producing rice have been developed to suit the variety of conditions. It is relatively simple to produce if practices of cultivation are adopted to meet varying agricultural conditions related to soil, climate, size of holdings and availability of water and labour. Unlike other cereals, rice can tolerate and actually grow in standing water and swampy conditions.

The two main systems are: **the wet paddy system** and **the dry system or Upland rice cultivation.**

In wet paddy cultivation, the land is wet and actually often flooded from time of weeding or transplanting until time for harvesting approaches. This method is peculiar to rice as a crop because the physical, chemical and biological conditions of flooded rice fields differ greatly from conditions of dry fields.

The cultivation system of upland rice is very similar to that employed for other cereals. Seedbed preparation, planting, weeding and harvesting are done on relatively dry soil. The minimum rainfall required for upland rice is not precisely known, and the lower limits are differently quoted to be in the vicinity of 40—50 inches. As with all rainfall crops, however, the distribution of the rainfall is of much greater importance than the actual total rainfall. Early and mid season rains are more important then late rains. The highest yields are obtained when the monthly rainfall figures do not fall below 9 inches.

Soil: Rice can be grown on almost any type of soil, both light and heavy; exceptions are infertile sandy and stony soils. The soil should have good physical and chemical properties. It should

be noted that both extreme acidity (pH below 4.5) and high alkalinity (pH above 8) are harmful to most rice varieties and cause lower yields, a mild acidity (pH 5.5—7.0) being most beneficial.

Rice Cultivation in Northern Ghana

Land-preparation:

Land-clearing is done by hand or by machine, depending on factors like availability of labour, machines, funds, farm size, density of the bush, etc. Technics employed with the mechanical clearing differ. Most common in the North is block-clearing, threes are pushed down and uprooted by the bulldozer-blade and are later heaped or windrowed with the same machine when windrowing. It has to be taken care that the topsoil remains untouched.

Whether the clearing is done by hand or by machine, stumps and trees have to be removed properly, in order to avoid damage on tractors, ploughs and harrows.

The fields should be ploughed as early as the rains permit. Weeds and other organic matter have to be incorporated so that they get rotten before planting. A proper adjustment of the plough eases the operations of harrowing, sowing and harvesting. The recommended depth is between 6" to 9" depending on depth of the topsoil. The first harrowing has to be done when the weeds have emerged on the ploughed land. The second harrowing will follow shortly before sowing. The best results in preparing a good seedbed and to destroy weeds can be achieved when there is at least 14 days time between the two harrowing and if harrowing is done crosswise.

The fertilizer types presently used on rice in the North are the compound fertilizers 15-15-15, 20-20-0 and a straight nitrogenous fertilizer (Sulphate of Ammonium).

2 bags 15-15-15 are broadcast before planting and harrowed into the soil before sowing. One bag Sulphate of Ammonia is applied as a top-dressing 4—5 weeks after sowing when the first weeding is completed. If the land is newly cleared and there is no indication for the need of potassium, 20-20-0 may be used instead of 15-15-15. Farmers who own a combined fertilizer-seed-drill apply the compound fertilizer at once together with the paddy.

Observations and experiments have shown so far that the present fertilizer recommendations on improved rice varieties under favourable weather conditions and strict application of all recommended agronomic practices permit yields up to 25 bags/acre.

Fertilization:

With the introduction of the improved high-yielding varieties and in spite of the low nutrient status of our soils, it is generally agreed upon that fertilizers should be applied to obtain maximum yields.

The most usual deficiencies encountered in paddy growing are nitrogen and phosphorus, with potassium and sulphur in limited areas.

The main plant food elements Nitrogen, Phosphorus and Potassium will be briefly discussed in the following paragraphs.

Nitrogen:

Nitrogen is the dominant factor in the food requirements of paddy and it is, together with moisture and light, the main supporting agent of vegetative growth.

If other nutrients are also plentiful, a liberal supply of this element promotes tillering, increases the rate of leaf formation and the size of the leaves and thus boosts indirectly the yield of grains per acre.

In most rice growing countries in the humid tropics, the application of nitrogenous fertilizers is one of the most effective means of increasing the rice production. Nitrogen is never entirely lacking in paddy soils, as it is already present in rain and irrigation water, and it is also fixed from the atmosphere by certain algae and nitrogen-fixing bacteria which live in the water and in the upper layer of the soil by the million. Nitrogen is also released when organic matter, present in the soil, is broken down by bacterial activities.

In most instances, however, these natural sources of nitrogen are inadequate to support a good rice crop.

A common cause of nitrogen shortage is the condition of the soil itself which may be too compact, too acid or lacking in certain major and minor nutritive elements. Under these conditions, bacterial life cannot develop and this most important process of nitrogen fixation from the air is slowed down.

Liming the soil in order to neutralize excessive acidity or adding phosphate to the soil are treatments which often act as a nitrogen dressing because the growth of algae and bacteria in the soil is boosted again and the process of nitrogen fixation is re-established.

A deficiency of nitrogen becomes apparent in the field by a general yellowing of the growing paddy and finally by withering of the older leaves.

An excess of nitrogen, relatively to the other nutrients such as phosphorus and potassium, is also very harmful. Such an excess is easily produced by too liberal dressings of nitrogenous fertilizers. Although the plant looks healthy and dark-green at first, its internal nutrient balance is upset, the abundance of nitrogen causing a relative shortage of the other nutrients in the tissues of the plant.

Consequently, an excess of nitrogen may result in phosphorus starvation or potassium shortage and in a considerable yield depression. Lodging of the paddy is a very common result of excessive nitrogen dressings and varieties which already tend to lodging by nature should be kept short of nitrogen during growth.

The observant farmer will also notice that too liberal nitrogen dressings are soon followed by outbreaks of diseases or pests as the unbalanced conditions of the rice plant invite this mishap.

Therefore, nitrogen dressings should be properly balanced by phosphate and potassium dressings according to the demands of the soil.

Phosphorus:

During the growth and ripening of paddy, phosphorus plays an important part in several vital functions. Considerable concentrations of this element are present in those parts of the plant where the greatest growth activity takes place.

This explains why phosphorus has a striking effect one the formation of new roots, on the rate of tillering and on the filling of the ear-heads.

An early phosphate dressing helps greatly to establish newly germinated seedlings or transplanted young plants because it helps in a rapid development of a healthy root system. It is through this effect that phosphorus also assists the crop in overcoming droughts when the paddy is exposed to dry weather conditions in rainfed areas.

Since phosphorus stimulates tillering, it is a general experience that this element also helps the crop to recover more rapidly from the damage caused by the attacks of caterpillars or stemborers.

Finally it should be stated that lack of phosphorus in the soil delays the time of flowering and ripening of many varieties, whereas a high phosphorus status of the soil shortens the maturity period.

Since phosphorus shortage actually means a relative excess of nitrogen, it also can be said that it is the phosphorus-nitrogen ratio, really, which influences the length of the maturity period.

In most tropical soils, phosphorus tends to accumulate in the topsoil where it is often fixed in the organic matter of the soil. When such soils are converted into paddy lands, the organic matter is broken down and phosphorus is released for the feeding of the crop.

However, these phosphorus reserves are rapidly exhausted in the course of a couple of years as large amounts of phosphorus are removed each year.

Unlike nitrogen, no new phosphorus is formed in the soil and the paddy roots cannot explore the scanty phosphorus reserves of the deeper soil layers as some deep rooted crops do.

When the phosphorus content of the soil falls to that extent, growth and yield of the paddy drops accordingly and the activities of the nitrogen-fixing organisms in the soil slow down as well. Extreme phosphorus deficiency is shown in the crop by an early withering of the older leaves, these showing a peculiar reddish-brown discolouration, whereas the younger leaves assume a dark, bluish-green hue. Other symptoms are reduced tillering, stunted growth and bunching of leaves.

Fortunately, this unfavourable situation can easily be remedied by modest but regular annual dressings of phosphatic fertilizers.

Potassium:

Potassium is the third important plant food element. In combination with nitrogen and phosphorus, potash fertilizers increase yields and, what is equally important, greatly improve the health of the crop and its resistance against disease.

This is especially true in the case of light sandy or loamy soils in which this element is very often lacking. The heavier soil types are, on the whole, better provided with potassium and do hold this element more firmly when exposed to leaching by rain or irrigation water.

During the period of vegetative growth, paddy is very sensitive to a shortage of potassium. Especially when nitrogen is in excess, the plant is forced into luxurious development and, thus, runs out of potassium easily.

Shortage of potassium at this stage of growth particularly affects the strength and firmness of the lower parts of the shoots, thus endangering the necessary support of the growing stalks.

During the stage of ripening, when the filling ear-heads grow heavier and heavier, this lack of support will prove to be fatal as the crop will lodge under the first impact of heavy wind or rain.

Since potassium also plays an important role in the regulation of the plant's transpiration, a shortage of potassium may result in a slight wilting of the green parts because more moisture is lost through transpiration than can be supplied by the roots.

To protect itself, the plant will try, under this condition, to reduce transpiration by an erect stand of its foilage and, in very severe cases, by a rolling-up of the leaves along the midnerves.

Potassium hunger is also apparent by other visual symptoms on the leaves, depending on variety. The tips and margins of the leaves may turn yellow and die off, whereas the general colour of the leaves may turn from dark-green to a typical olive-green hue.

In the event of even a mild potassium shortage, the crop is very sensitive to disease because its health is impaired already.

Any additional supply of nitrogen will accentuate the degree of potassium hunger and may bring about an acute outbreak of bacterial or fungus attack.

For this reason, the application of potassium fertilizers is often looked upon as an insurance against these hazards.

On soils poor in potassium, a substantial increase in yield is obtained from the use of potassium fertilizers. This increase is mainly found in a larger number of filled grains per ear-head, but not so much in a greater number of ear-heads per acre.

On soils where potassium fertilizers do not pay so much trough bigger yields, a modest potash application may still be a sound practice and a wise measure against the chance of unsuspected crop failure through lodging, pest or insect attack.

Sowing:

Rice seed intended for sowing should be properly stored with a moisture content not above 10 %.

Before sowing, the seeds have to be cleaned to remove all foreign matter such as weed-seeds, emptly glumes, straw, etc. Germination tests have to be carried out to determine the proper seed-rate. Treatment with Aldrex T, Dieldrex A or Ceresan will protect the seeds against fungal diseases and pests.

The rice is sown into the dry field. This can be done:

1. by seed-drill, which has the advantage of a later easier weeding between the lines, better adjustable seed-rate and depth of sowing.
2. broadcasting by machine; this method can cover large acreage, and is preferred when the land is not properly stumped and cleared.
3. broadcasting by hand; this method is still the most common one in the North, mainly practised by smaller farmers.

It can also give good results if the seeds are distributed evenly at the right seed-rate.

After sowing the seeds have to be harrowed into the soil in order to protect them against bird damage.

The recommended seed-rate for the rice varieties in use in Northern Ghana is 65—80 lbs/acre, depending on the characteristics of the variety and the germination capacity.

The best planting time for rice in the North is end of May to early July, whereby the length of the growing period of a variety and the availability of the rains have to be considered.

Weed Control:

Yield losses and quality decreases are tremendous, due to weeds.

Weeds rob the farmer of his profits by:

a) reducing yields;
b) lowering the quality of the crop;
c) harbouring insects that damage the farmers crop;
d) reducing the land value.

The farmer must therefore fight to control weeds with every possible means.

There are two major weed control measures: mechanical and chemical.

Mechanical control involves:

1. destruction of weeds and weed-seeds through plough and disc-harrow before sowing;
2. uprooting of weeds by hand;
3. the use of hoes and cutlasses;
4. use of special equipment like cultivators and this harrows.

A good seedbed preparation will minimize the emergence of weeds after sowing and thereby lower the costs of weed control significantly.

Weeding after sowing must be done as early as possible in order to avoid competition of weeds and rice plants for nutrients, water and light.

Hand-weeding is the most common method practised on our farms. The disadvantage of this method is that it is tedious and time-consuming. However, presently, it is less expensive than chemical weed control and is therefore recommended.

Chemical control may be recommended for large mechanized rice farms with high yield expectations and where hand-labour is not available.

Herbicides can be applied pre- emergent and post-emergent. As many fields are flooded after sowing, the application of a post-emergent herbicide with a tractor-mounted sprayer becomes problematic.

Hand- sprayers on the other hand can not cover large acreages. A good selective pre-emergent herbicide should be more suitable

for our conditions on large mechanized rice farms. At present the cost of herbicides for one acre of rice is around C 20 as compared with C 10 hand-weeding. Their application therefore is only justified if high yields can be expected.

The most common weed species collected from the main rice-growing areas during the 1972 cropping season are shown in the table below:

SPECIES	Nyankpala rice fields	Farms on yendi road	Kokobilla rice fields	Walugu rice fields	Salaga rice fields	Bawku rice fields	Damongo rice fields
Rottboellia Exaltata (Monocot.)	×	×	—	—	—	×	—
Digitaria Acuminatissimum (Monocot.)	×	×	×	—	—	×	—
Setaria Anceps (Monocot.)	×	—	—	×	×	—	—
Panicium Subalbidum (Monocot.)	×	×	×	—	—	—	×
Cyperaceae (Monocot.)	×	×	×	×	×	×	—
Paspalum Commersoni (Monocot.)	×	×	×	—	×	×	×
Paspalum Orbiculare (Monocot.)	—	—	—	×	×	—	×
Fimbristylis Dichotoma (Monocot.)	—	—	×	×	×	—	×
Physalis Angulata (Dicot.)	—	×	×	—	—	—	×

SPECIES	Nyankpala rice fields	Farms on yendi road	Kokobilla rice fields	Walugu rice fields	Salaga rice fields	Bawku rice fields	Damongo rice fields
Cleome Viscosa (Dicot.)	—	×	×	—	—	×	—
Borreria Filiformis (Dicot.)	—	—	×	—	—	×	×
Eragrostis Squamata (Monocot.)	—	×	—	—	—	—	—
Pandiaka Hendelstii (Dicot.)	—	—	×	—	×	×	—
Sporobolus Pyramidalis (Monocot.)	×	—	×	×	×	×	×
Hyparrhenia Rufa (Monocot.)	×	×	—	—	×	—	—
Mollugo Nudicaulis (Dicot.)	—	—	—	—	—	—	×
Dactyloctenium Aegyptium (Monocot.)	×	×	—	—	—	×	×

Pests and their control:

In rice the group of stem borers (dark-headed, asiatic. pink, yellow and white stem borer) and the army-worms, different plant-suckers and hoppers cause most of the damage. All these insects feed and live on, the cultivated plants. Utmost attention must be paid in order to prevent the destruction of farmer's efforts by insects. Old plants, stubbles and bushes have to be burned, removed or ploughed down. Rotation of crops helps against staying of the insects on the field from year to year. Application of fertilizer and of good seed too helps that strong plants develop with a quick growth.

Control of insects by chemicals is possible and is only applied when all other measures fail. Skilled personnel and heavy capital investment are necessary, and not be needed if the above-mentioned measures of prevention are applied.

Control of diseases:

Pyricularia oryzae-blast is one of the most feared fungus disease in rice. Brown, spindle-shaped spots appear on tissues, spread and emerge into each other until the plant is destroyed. The disease attacks the plant in the early seedling-stage and later just before flowers appear, known, then, as neck-blast or neck-rot. The infestation may come from soil, seeds, old plants and host-plants. Conditions which favour the spread of the fungus are high humidity (conidia need free water to thrive), high night temperatures and cloudy days. Too high nitrogen supply coutributes to the danger of infestation. Faulty fieldpractices, late weeding, water logging through too much irrigation, sandy, light and shallow soil with a deficiency of nutrients may contribute to a quick multiplication of the disesase.

To reduce the danger of an attack, burning and removal of old plants and stubble are advisable with the use of clean and dressed seed at a proper seed-rate. The field must be well maintained and resistant varieties should be used.

Chemically, the rice can be dressed with organo-mercuric-powders and later the fields may be sprayed with fungicides or antibiotics. Care must be taken as some of the chemicals are toxic to humans as well as to plants.

The second known fungus disease (mycosis), **helminthosporiosis or brown spot,** develops reddish spots on leaves, ovalshaped with a light centre. This fungus is seed-born and conditions like those with blast favour its multiplication, especially low availability of nutrients and lack of potassium, manganese and magnesium.

To control the disease, poor soil conditions have to be improved, the fields well prepared and only very healthy and dressed seed should be used.

By severe attack, chemical control may be necessary but more investigation work has to be done in Ghana, in order to know the extent of the damage of this two fungus diseases (mycoses) in the country.

HARVESTING:

Harvest the crop when more than 85 % of the grains on the panicle are firm and clear in appearance, regardless of how green the leaves or straw are. Many nitrogen-responsive varieties have dark green leaves and stems even after the grains are fully ripe.

Delayed harvesting reduces yields because grains will fall from the panicle before harvest. Also, when harvested late, the panicle may shatter during cutting, carrying, stacking and threshing.

Delayed harvesting also increases the amount of sun-cracked grains. Furthermore, delayed harvesting may cause a total loss through bush fire, etc.

On most farms harvesting is done with the sickle or hand-operated knives. The plants are cut at about 1½—2 feet of the straw and are dried in the field. If the threshing is to be done later, they are piled into stacks with the panicles towards the centre in order to permit further drying of the grain.

Threshing and Winnowing:

The most common method of threshing is by hitting a certain quantity of the harvested crop with sticks on the hard floor or sandy clay. This is usually done by men and women with the women more engaged in the winnowing process. The most common method is hand winnowing — using large calabashes when the wind is blowing.

Maize (Zea Mays L.)

History:

Maize has been grown for thousands of years in the Americas, but it was not until Columbus returned to Spain from the New World that maize started to move into the rest of the world. The **Portuguese** brought it to West Africa in the early 1500's. Because it was easy to grow and had many uses, it spread quickly and became a very important part of the diet of many West Africans.

Varieties:

Maize is adapted to nearly all of Ghana, and in many areas, two crops a year are grown. The total acreage of maize in Ghana (major and minor seasons) is over 1 million acres.

The choice of variety is very important. When available, improved varieties should be grown as these have been shown to stand better and yield more than the local varieties. Varieties presently recommended include Diacol 153, Composite 2 and Mexican 17. Diacol 153 has a more yellow, softer kernal than the other varieties and, while it is not quite as well liked for human consumption, it is slightly better as a livestock feed.

Land Preparation:

With the first slight rains from April to mid May, ploughing and disking should be done in the North, to allow for optimum planting. Harrowing twice may help to control weeds, although care must be taken to avoid extreme pulverization of the soil which may expose it to the danger of sheet erosion. After ploughing, disking and harrowing, the soil is ridged. Ridges must be made across the slopes to check erosion and run-off. Where erosion is not a problem, planting can be done on flat ground after ploughing and harrowing, and ridging can be carried out at the time of the first weeding.

Fertilizer Recommendation and Application:

The present fertilizer recommendation for maize is two bages of compound fertilizer (15-15-15) per acre, spread on the land before planting. 1 bag of sulphate of ammonia per acre should be used in addition for top-dressing, 5-6 weeks after sowing.

Planting:

The best time to plant varies from region to region. In general, planting should start after the first rains of the season. In the northern savannah zone, mid-May to mid-June plantings are recommended. In the forest zone, mid-March to early April, and in the coastal savannah zone, mid-April planting dates are recommended. Rate and spacing: As a general recommendation, a plant spacing of 3' x 1', which gives a plant population of about 14,500 plants per acre, should be adequate for most conditions when fertilizer and improved seed are used.

Weed Control:

Weed control begins before the maize is planted. A well-performed first tillage, whether with plough and disk or cutlass and hoe, is the first step in successful weed control. Early weed competition is very damaging to maize; this is why weeding at this stage is very necessary for good yields. Weeds are also smaller and easier to kill at this stage. Hand weeding is more practical for small farmers, but on larger acreages, particularly with mechanized systems, chemical weed control may be best or even necessary. Chemical weed control using recommended herbicides offers the maize farmer the best way of preventing weeds.

Insect Control:

Maize is attacked by many insects, but only a few can be considered as major pests. In the seedling stage, cutworms and wire worms can do considerable damage, and there attacks are very heavy, replanting may be necessary.

The major insect problem in mature maize is stem borer. Many different chemicals have been found effective.

Harvest:

Most maize in Ghana is harvested, husked and shelled by hand. However, machinery for husking and shelling is becomming available. Large mechanical harvesting machines (maize combines) are doing an excellent job, but are very expensive and are therefore practical only on very large farming operations.

Hand harvesting can be done at any stage of maturity. Maize matures from 60 to 112 days after planting, depending on the

variety planted and weather conditions. When fully mature, the plants turn from green to yellow and then to brown, and the husks dry and loosen.

Storage:

Proper storage of maize grain is very necessary to avoid loss of quality and weight. Maize stores best with 11 to 13 percent moisture content, but most maize is harvested with between 20 and 25 percent moisture. It is therefore necessary that some means of drying be used to provide proper storage conditions. Moist maize is more apt to rot, lose viability and be attacked by insects.

Sorghum — Sorghum vulgare

1. History

About 75 per cent of the world crop of grain sorghum is used for human consumption from prehistoric times, mainly in parts of Africa and Asia.

Sorghum is the principal food crop of Northern Nigeria, where it accounts for about one third of the arable acreage and it should be the same in the Northern part of Ghana.

2. Varieties

Data on promising varieties:

Variety	Height	Maturity	Planting time	Yield/ acre (lbs)
SK-MDW (dwarf late)	6,5—8 ft	110 days	May—June	1500
CK-FF (dwarf late)	5,5—6 ft	110 days	May—June	1000/1200
Yadole (dwarf early)	6,5—7 ft	75—80 days	May—June	3000
Naga white (dwarf early)	6,5—7 ft	75—80 days	May—June	2800
AA 226/3 N (tall late)	10—13 ft	107 days	May—June	1250
Mankaraga (tall late)	12—15 ft	124—125 days	May—June	1200/1500
A 313 (tall late)	12—15 ft	110 days	May—June	800/1000
Bawku white (tall late)	12—15 ft	107—115 days	May—June	1100
WX 60 (dwarf late)	5,5—6,5 ft	100 days	May—June	2000

3. Soil and climate

Under dry conditions sorghum can produce a bigger crop than maize because of its ability to interrupt growth and to remain dormant during drought, resuming growth after rain. It has a high resistance to desiccation, a low transpiration ratio, a large number of fibrous roots, and the ability to produce a crop from the

tillers and branches developing after rain. It tolerates wet conditions better than maize and millet.

The soil type for best production is sandy to sandy loam soil pH 5.5 to 5.8.

4. Land Preparation

Thorough hoeing or ploughing and disc harrowing is necessary. Ploughing should start in March-April, 6" deep, harrowing in May and ridging in June.

5. Fertilization

Two bags of compound fertilizer (15 x 15 x 15), applied before planting. On light soil it is better to apply half of the total amount as a basal dressing, with the remainder applied in one ort two top dressings.

6. Crop Rotation

Northern Region: first year sorghum; second maize; third groundnuts 2—5 tons farmyard manure on maize plus fertilizer.

Upper Region: first year early millet; secound groundnuts; third sorghum and manure 4—6 tons plus fertilizer.

7. Planting Methods and time — Seed rate

Planting should be done on ridges 15" high 12" wide on top 36" wide at base in mid-June.

Three seeds per hole will give 21 000 to 22 000 plants per acre. Seedrate: 5 lbs per acre.

8. Weed and Pest Control

The seed should be weed-free at the start and should be weeded when the plants are 3 weeks old and later until the crop is high enough to overcome the weed.

Insect control: The Midge (Cantarinia) the larva of which may cause damage which reduces the yield by 50 % can be controlled by early planting and spraying the crop at flowering and again 10 days later with Sevin mixed at the rate of 43 g in 1 gallon of water. Spray 12 gallons per acre. Other insects are of little importance under present systems of agriculture.

Disease control: Grain smut — All grains of infected ears are converted into cylindric sacks containing masses of black spores. For control, treat seeds with Aldrex T, Ceresan or other seedressing chemicals on the base of mercury compounds. Head smut (Covered smut) may cause up to 10 % and is the worst disease of sorghum.

The floral structures are partly or entirely replaced by smutted galls, in the beginning covered by a pseudo-membrane. After rupture of this membrane the spore mass is scattering.
Control measures are the same as for grain smut.

9. Harvesting and storage

Procedures are similar to those of millet. Harevsting is generally done by hand. Plants are cut with cutlasses, the heads cut off tied together and dried on the floor or roof of buildings to a moisture content of 12 per cent. The dried heads may be stored in any dry building or baskets built for such storage purposes.

Spraying with 4 oz. of Gammalin „A" dust on 1 cwt. of heads will prevent loss if the storage is to be more than 6 months.

Millet — Penisetum cinereum

1. History

The term „millets" comprises a number of fine-grained cereal crops that have been cultivated and used as bread grains from prehistoric times. In all parts of Africa with a Sudanian climate, millet is one of the most widespread food crops. It is the principal crop in the compound areas of the Upper Region.

2. Varieties

Date on promising Varieties:

a) Early Millet

	Maturity	height
Manganara No. I	2—3 months	5—7 ft.
b) Late Millet		
Myanza II	4½—5 monts	12
Local		12—17 ft.

3. Climate and Soils

Millet is a traditional grain crop in the drier parts of tropical Africa. It can be grown successfully on granite sands which are too lighttextured for sorghum. On heavier textured soils it does better but cannot compete economically with sorghum. Because millet will give a yield on soils too poor to support any other grain crop, provided that they are well-drained, its use tends to be restricted to the lighter soils in low rainfall areas.

Millet needs less total rainfall than sorghum, although it can withstand drought. It can markedly reduce the transpiration rate, especially from the upper leaves, by closing the stomata during the heat of the day. Water stress in the first three weeks of growth has little adverse effect, whereas stress in the four to six week period delays maturity and reduces height, ear length, leaf number, yield per ear and 1000 grain weight.

Yields tend to be correlated with rainfall after planting.

4. Land Preparation

On small scale, field preparation is done by hand. On large farms ploughing and double harrowing is advisable. The fields should be ploughed 6 inches deep during March. Harrowing in April and ridging in May should follow before planting early millet.

5. Fertilization
When using compounds, apply either 2 bags of 20-20-0 or 15-15-15 as a pre-planting brodacast, but split dressing is preferable on light soils.

6. Planting Methods and time — Seed Rate
Sow on ridges „36 apart and 12" between plants. Sow 5 seeds per hole and thin later to one plant 15—20 days after germination. The planting time for early millet is in May, for late millet in June-July.
Millet is often interplanted with Guinea corn.

7. Weed and Pest Control
Weeding is necessary in the first growing period until the crop is high enough to overcome the weeds.
Field pests are mainly stem borers, they may be controlled with insecticides, applied 2 weeks and 4 weeks after sowing.
Always follow the recommendations provided by the manufactuerers and use extreme care in handling and applying these chemicals. Some of them are very poisonous to human being.
Head smut: Inflorescenses of the plant are converted into smutted gales, first covered by a false grey membrane. Later after rupture of this membrane dark brown spore masses become free.
For control, seed dressing with Aldrex T or Ceresan will help.

8. Harvesting
Harvesting is done by first bending the plants to the ground and then cutting off the heads which are carried home in baskets.
Where mechanical equipment is used, the crop is cut with corn binder, cured in shocks and threshed with a flail, small combine or thresher.

9. Storage
Millet may be sun-dried on the floor of the compound or the flat roof of the houses. If thoroughly dried no seed treatment is necessary for short storage periods.
When millet is stored more than 3 months in local silos, storage pests attack it often. Gammalin A dust will help to control storage pest. About 4 oz/cwt. is sufficient. Gammalin A does not affect gemination of the grain nor does it produce taint when the millet is used for food or pito.

Cotton Gossypium sp.

1. History

Cotton, also called „White gold" or queen of fibrous plant, has been grown in India for making clothing dating from about 3000 B.C., and in certain other countries:

2570 B.C. Textiles and cotton yarn discovered in preceramic finds at Huerta Prieta.

1500 B.C. Hymns of Reiveda provide first literary proof of cotton.

indefinite Pre-Inca tombs found in Peru with looms similar to those used in India.

555 B.C. Cotton grown in kingdown of Weroe, Sudan and so on.

Cotton growing has gradually increased in the countries of the old and New World climatically best adapted to its culture. As regards to climatic requirements, the cotton plant flourishes in the semi-arid and irrigated arid regions of the tropics and sub-tropics especially, between 41° Lat.N. and 36° Lat.S. Approximately 70 countries produce cotton, the main are in oder of area under cultivation: India, U.S.A., U.S.S.R., China, Brasil, Pakistan, Uganda, Mexiko, Egypt, Turkey, Sudan etc.

Cotton cultivation is also being promoted in many other countries in Africa, with further potential growing areas yet to be developed.

	Area in 1.000 acres.
Uganda	2.160
Egypt	2.000
Sudan	1.250
Nigeria	905
Chad	670
Mozambique	645
Tanzania	560
U.A.R.	375
Ghana	5

II. Soil and Climate

1. Cotton thrives on any type of soil as long as the other growth factors are given, and practically all soil types are found in the World's Cotton growing regions, except extremely sandy and very heavy clay soils. The soil must, however, be sufficiently deep, porous or well aerated, free from stagnant water and should have adequate nutrient elements. These are more often abundant in soils in the arid zones than in those of humid regions.

   Lime content of soils should be at least 0.5 %. Soil reaction should be somewhere between 6.0 and 7.5. Cotton is sensitive to high acidity of the soil — it does best on neutral or slightly alkaline soil reaction.

2. Temperature is the most important limiting factor in cotton cultivation — sufficient warmth with strong sunshine. During the whole cotton growing season the temperature should not fall below 77° F (25° C). Temperatures below 64° F (18° C) retard the germination and even later growth.

   Strong winds are unfavourable especially during flowering and ripening periods.

   Evenly distributed and sufficient rainfall is necessary from germination to flowering season, if irrigation is not possible. After flowering, dry weather conditions are necessary for ripening and for the formation of good qualitiy fibre and seed.

III. Varieties

Recomended and cultivated in Gahna at this moment:
Allen 333, BJA 592, HAR 444-2

The varieties Allen 333 and BJA were imported by Cotton Development Board from the neighbouring countries.
BJA 592 and HAR 444-2 show more or higher productivity than Allen 333.

HAR 444-2 as the newest variety will later replace the Allen 333, as is done in the neighbouring cotton regions.

IV. Land Preparation

Preparation of the field prior to sowing ensures a porous soil, friable and sufficiently aerated. This is done by
a) Tractors — Ploughing, and ridging
b) Bullock — Ploughing, harrowing and ridging
c) Hoe — superficial hoeing and ridgnig.

The raised ridges benefit the soil by rapid warming in the sun, enabling the young plants to utilize a deep upper mould, and also the farmer can easily control the weeds.

V. Fertilization

Fertilizer recommendations in the various cotton growing areas vary considerably with the type of soil, climate, irrigation conditions and rotation of crops. The fertilization in the Northern part of Ghana is done in two spreadings.

— First, the compound fertilizer 20-20-0 at the rate of two bags per acre is spread just after thinning out the plants or first weeding.

— Second, a complement of Ammonium Sulphate should be applied at the flowering period, at the rate of ½ bag per acre.

VI. Sowing

1. In the Northern and Upper Regions, the Farmers should start planting at the beginning of June (Beginning of rainy season).

2. According to varieties, germination potential, method of sowing and distance between the rows, about 13 to 26 lbs of seed per acre is sufficient.

3. Hand sowing by dibbling consists in making holes in advance and placing 4 to 6 seeds in each. The appropriate depth of sowing is about 1 inch in heavier soil and up to 2 inches in lighter soil. The planting distance should be 30 inches between the rows and 8 inches within the rows.

   Under the present planting method, too many plants will initially shoot at irregular intervals. By removing and thinning out seedlings, the most sturdy plants are

able to develop properly. The best time for thinning out (two plants per hole), is probably when the plants are 6—7 inches high, which is reached 30 to 40 days after coming up. By a distance 30 x 8 inches and two plants per stand, it will give 53,000 plants per acre.

VII. Weeding

Cotton is very susceptible to competition from weeds, and a plantation infested with an abundance of weeds is therefore liable to considerable yield loss. Many of these weeds are also known to be host of cotton pests.

Careful preparation and an intensive cultivation of the soil will reduce the weed growth, and spread of weeds may be stopped by systematic crop rotation. Weed control by hoeing is widely practised.

VIII. Disease and Pest Control

The insect problems facing today's cotton farmers have increased as the amount of the land devoted to cotton has increased. Cotton insects now can live their entire lives without having to travel more than few feet to find their favorite food. Farmers have found that intensive cultivation has made it virtually impossible to control the insects. Allow crop rotation by leaving the land fallow. Their experience has shown that chemical control of insects is necessary if the pests are to be prevented from devouring the crop.

From germination to harvest, the cotton plant is exposed to attacks from numerous bacteria and fungus disease as well as from a number of animal pests.

1. Disease of roots, seedlings, leaves und stalks.

   On the roots, seedlings, leaves and stalks of the cotton plants, there are a lot proved species of mould fungi and bacteria. Some of the main cotton diseases described:

   a) Black arm disease: — Xanthomonas malvacearum — Attacks begin on leaves, causing between veins on the under side water spots, which later discolour and dry out. The infection then spreads to stalks,

buds and fruit capsules, and also effects the seed (boll rot). Shedding of leaves and bolls can cause heavy damage. Favoured by rainy, moist weather, and communicated by seed, the infection is carried from plant to plant.

Seed dressing with mercury compounds (15 to 20oz/bag) can control this disease.

The Upland varieties have proved to be resistant to the disease in America and Africa.

b) Pink boll rot — Glomselloc gossypii Edy. —
Seedling show large red spots girdling the stem and killing it. Dark red sunken spots on the bolls, later turning brown or black. Generally a slimy pink is exceeded in the centre of the spots. Leaves usually are not so seriously attacked as seedling and bolls. Spots on leaves cause scold effect. Seed treatment with mercury compounds 15 to 20oz per bag can control the disease.

Further destroy infected plants and avoid excessive manuring with nitrogen.

c) Damping — off — Rhizoctonia spec. —
The seed fails to germinate, or if so then only partially. Older plants wilt or stunt, usually in patches, their roots rot and show shredding of bark.

Seed treatment with seed disinfectant or base of mercury 15—20oz/bag or with a fungicide on base of other active ingredients. Further it is important to select suitable dates for sowing to ensure as quick a germination as possible.

2. According to WIESMANN (Untersuchungen an den Prädatoren der Baumwollschädlinge in Ägypten im Jahre 1951/52 Acta Tropica, Vol. 12 No. 3 1955) normal cotton farmer includes 23 species of insects, 3 types of spiders and 1 acaride species.

   Some main cotton pests are here described:

   a) Cotton leafroller — Sylepla derogota —
   The small butterfly of this parasite, lays its eggs on

the under side on the leaf, whence the caterpillar perforrates the leaf to the centre rib. The leaf rolls up, is held together by thin threads, and serves as protection for the chrysolis.

Treatment with systemic insecticides e. g. Bidrin or Dimecron will control the leaf roller.

b) Red spider — Titranychus telarius —
Often very numerous, this tiny mite (0.5 mm long) sucks leaves and twigs, which becomes stunted. In the initial stage of infection the leaves shrivel and assume a reddish tint (red rust). Spread by many cultivated and wild plants.

Spraying repeatedly with systemic preparations such as Bidrin or Dimearon or apply acaricides on base of tetradifon, binapaerye or kelthane.

c) Cotton boll worm — Heliothis armigera —
Also feeds on tomatoes, tobacco and maize. The boll worm destroys beds and capsules, with greater damage in hot countries, and prefers maize flower tufts to cotton flowers; heads of maize therefore serve as traps. The cycle of development lasts 40 days, thus 5 generations may be raised during the vegetative period. The carterpillar migrates from capsule to capsule.

Spray or dust with insecticides on base of endosulfon, methylparathion, demeton, endrin etc. may control the cotton boll worm.

d) Sudan boll worm or red boll worm — Diparopsis costanea —

The little moth lays its eggs on all parts of the plant, and the caterpillars, which emerge after 3 days, bore into buds and bolls and completely destroy the contents. The pupa state occurs, after 3 weeks, in the soil, and the moth emerges after a further 10 days.

Spray or dust with insecticides on base of endosulfon, methylparathion, demeton, endrin etc. may control the Sudon bollworm.

e) Red bug or cotton stainer — Dysderauspecies — (or other bugs (Oxycarenus species, Nesara species etc.).
The tips of the shoots and the young capsules bitten by this parasite ripen permaturely and shed, and contamination makes useless the fibre of the attacked bolls.
Dust with insecticides on base of parathion, endosulfan, demeton, endrin etc. will help to control these parasites.

f) Cotton Aphid — Aphis gossypii Glov. —
The parasite sucks parts of the plant, causing stunted sprout and leaf growth especially in dry years. On the sugar containing secretions of the aphids, fungi grow and cover the plant. In profusion the insect cause heavy yield losses through shedding of capsules.
Dust or spray such as based on endosulfan, parathion, demeton, endrin etc. may control the cotton aphids.

g) Jassids — Empoasca devostans Dist. —
Small greenish leaf hoppers as well as their nymphs suck on the leaves causing them to turn yellow and to bend their edges downwards. Heavily infested plants stunt, flower buds and bolls may drop or open prematurely.
Dust or spray with insecticides on base of methylparathion, endosulfan, demeton, endrin will control the Jassides.

h) Sping bollworm — Earias Specias —
A small greenish or brown caterpillar bores into the buds and shoots of the plants and later in the bolls. Infested top shoots become black and drop, bolls fall on the ground, and affected parts of the plant show holes.
Recommended insecticides, based on endosulfan, asinphos, trichlorphon, endrin etc. may be control for the bole worm.

3. Application equipment and instructions.
Sprayer, rather than duster, are more suitable for cotton insecticide application at present.

Knapsack hand pump or compressed — air sprayers with 2 to 3 gallon capacity can be used for insect control on 2 to 5 acres field of cotton. One compressed — air sprayer would be sufficient to spray 2—2½ acre of full grown cotton in a day. The are also adaptable for home vegetable gardens and control of household insects including mosquitoes.

Motorized knapsack sprayers are more suitable for larger cotton fields. This sprayer would be capable of treating 10 acres of mature cotton in a day.

Tractor — drawn field sprayer, perhaps even aerial application, are items for future considerations.

Application: The farmer should always read carefully the tables on the containers of insecticides and follow strictly the given instructions provided by the manufecturers or the recommendation given by the Cotton Development Board, in applying and handling these chemicals. Some are very poisonous to human being. Plant control is necessary every two or three days for adult insects, larvae and eggs.

The spraying should start just before or when hatching is taking place.

In general, spraying will be necessary every 7 to 10 days, starting 30—40 days after planting.

Spraying should be done early in the morning and should be stopped at least 10.00 o'clock. At this time the updraft will reach a strength that will carry away the sprayed insecticides.

3—4 weeks before harvesting, spraying should be stopped but Insecticides should be available, when the farmers start planting their cotton crop.

IX. Harvesting

First picking should not be started until ⅔ of the bolls are widley open.

Following this system one labourer can pick 50—100 lbs per day, and it is more efficient than looking every morning for a few newly opended bolls.

Two to three pickings in total will be enough.

For quality reasons the third picking should be separated and not mixed with the first two pickings.

Further, picking should not start in the morning before 9.00 o'clock, until the seed cotton is absolutely free from dew. Clean picking causes more work and better organisation during the harvest, but is the guarantee for good quality cotton and high price.

1. Uprooting:
   Immediately after harvesting, the cotton plants should be cut, or if possible, uprooted; put these plants in heaps and burn them — Otherwise it provides excellent surviving conditions for the cotton insects during the next dry season and it will give more insect problem for the next growing season.
2. Rotation system:
   Cotton should not be planted on newly cleared busland
   1st season: Maize
   2nd season: Cotton
   3rd season: Groundnuts/Beans
   4th season: Cotton
   5th season: fallow or maize

X. Ginning

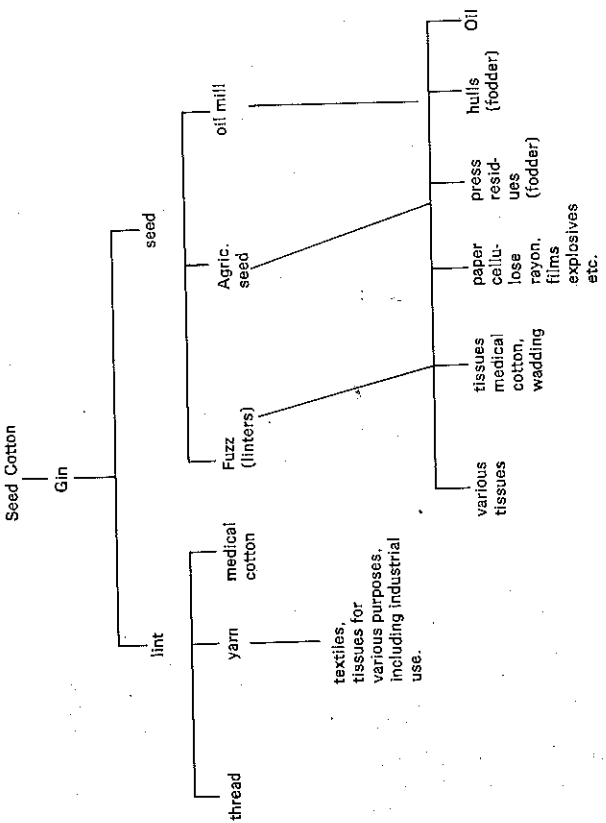
After harvesting the cotton must be separated from the seed. Only pure fibre provides a high grade marketable product. In most producing countries the crop is ginnend immediately after harvesting, in some other countries the seed cotton is stored for about a month before ginning.

Now-a-days, ginning is done by cotton ginning machines (roller-type gins or saw-type gins) in ginning centres. The average ratio between unravelled seed kernels and lint is 3 to 1. Important factors after ginning are length of staple, colour, fineness and tensible strenght of fibre.

XI. Use of Cotton Products

In countless centuries cotton threads and yarns have been processed into woven goods and textiles.

The main purpose of seed processing in the oil milles is the production of oil. Oil content of the seed is 18—22 %. The use of harvested cotton are illustrated in following diagramm:



KENAF (Hibiscus — Cannabinus)

Kenaf is considered a good substitute for jute and urena. It is grown and processed in many countries all over the world. In India for instance the annual kenaf production represents over 30 per cent of the total soft fibre production in the country. Kenaf is also grown in Middle- and South-America, USA, Southern Europe, USSR and many countries in Africa. Kenaf is known by many names such as bimilipatan jute, siam jute, meshta, stockroos, chanvre de guinee, to mention only a few.

Varieties and Photoperiodicity:

Photoperiodism greatly effects the growth, yield and quality of kenaf. Most varieties grown on commercial scale require 12½—13 hours of daylight and more for vegetative growth. If the daylight drops under this limit, the plants will stop growing, flowering occurs and the plant will set seed. Much emphasis has been placed on the development of varieties which are less sensitive to the photoperiod. In northern Ghana the following varieties are recommended: „2032"; „G 45"; „Cuba 108"; and the local variety „Roselle". Good quality and high yields under local conditions are typical attributes of these varieties.

Soil and Climate:

Kenaf is adapted to a wide range of soils. If adequate fertilizer is provided it tolerates even poor, sandy soils. In Ghana kenaf of excellent quality is grown especially in Upper Region around Wa and Navrongo, but also in other districts. Optimum soil conditions are well drained sandy clay loams with adequate humus and a pH of 6—6.8. The ideal climatic conditions for kenaf are in subtropical or tropical areas. Abundant rainfall is necessary for high yields. For good growth the monthly rainfall should not drop under six inches even though some drought can be tolerated.

Land Preparation and Sowing:

Kenaf does best on a well prepared seed bed. The planting distance for fibre production is 6—8" between rows and 2—3" apart in the drills. Approx. seedrate per acre is 25—30 lbs/acre. The planting distance for seed production is 12—16" between

rows and 6—8" apart in the drills. Approx. seedrate is 10—15 lbs/acre. Planting in moist soil ½" deep and even coverage of seed ensures uniform germination and even stand. Broadcasting is not advisable. Planting time is generally at the beginning of the rainy season.

Fertilization:

Before planting, the soil should be analyzed. There is no other way to determine the amount of available nutrients. Depending on the analysis the amount and kind of fertilizer has to be choosen. General fertilizer recommendations are:

N 40 lbs/acre = 2bags sulphate of ammonia
P_2O_5 40 lbs/acre = 2 bags single super
K_2O 60 lbs/acre = 1 bag muriate of potash

Before planting all the phosphate and potash plus ½ bag of sulphate of ammonia must be applied, followed by harrowing. When plants are 4—6" high, the balance of the sulphate of ammonia is applied as top dressing between the rows.

Weed Control:

Sowing immendiately after the last operation of seed bed preparation favors kenaf plants and reduces the possibility of weed development. Under optimum conditions kenaf will outgrow most broad leafed weeds. Kenaf should not be planted on land that is infested with vining type weeds such as „morning glory". During the first few weeks of plant development weeding is strongly advisable.

Pest Control:

Kenaf is attacked by several serious insect pests. Some of them are: Lygus,, Corn earworm, Spiny bollworm, and Cotton stainers. Control measures are necessary especially in cotton growing areas. Kenaf is also susceptible to several diseases, but anthracnose is the most severe. There are now high yielding varieties which are resistant to anthracnose. Another but more serious pest is „root knot nematode". The best and cheapest method of control against this nematode is crop rotation.

Harvesting and Processing:

When the first flowers appear on the kenaf stalk, the crop must be harvested. Late harvest reduces the quality of the fibre.

There are several methods of harvesting and processing kenaf, depending upon economics and upon the use of the product. The most widespread and simplest method of harvesting is hand cutting with a sickle or a knife. Mechanized harvest is also possible. The plants must be cut, the woody pith and also some of the pectinous substances removed before the fibre can be spun. The best quality of fibre is produced by ribboning, followed by retting. Ribboning means removal of the inner woody portion of the stem. Retting is the bacteriological decomposition of the pectinous substances which bind the fibres together.

To reduce transportation costs ribboning in the field is recommended, it also allows the organic matter in the pith to remain in the field.

Decortication:

Decortication involves the mechanical removal of the woody portion and some of the gummy substances. Decorticated fibre cannot be spun into as fine a yarn as retted fibre and therefore its use is limited to coarser materials. It has, for instance, often been converted into bags usable for various agricultural products.

Groundnuts (Arachis hypogaea L.)

History:

The origin of groundnuts is believed to be Brazil from where they spread to the other continents. About 1880, Groundnuts started to play a certain role in the world trade for food and oil crops and they now range sevond in importance as crop used for vegetable oil production.

Varieties:

Manipinta — This variety has been tested by the Crop Reseach Institute in various locations. It is high yielding and has a high oil content and is therefore subitable for oil extraction. Other varieties are still being tested.

Biology:

Groundnuts belong to the family of leguminous crops. Hundreds of varieties are known all over the world, however they can generally be grouped into three types.

1. The erect bunch type whose nuts cluster around the base of the main stem and matures in 90 to 110 days.
2. The semi erect bunch with the nuts clustered around the main stem which matures in 130 to 140 days.
3. The true spreading type which produces flowers along the stems and thus has nuts scattered away from the base of the stem. This type matures very late and is more difficult harvest.

Land Preparation:

Groundnuts require thorough seedbed preparation which can be done by ploughing and harrowing or hoeing. All weeds should be completely buried or removed.

Fertilizer Recommendation and Application:

The present recommendation is two bags of single superphosphate, applied before planting. This type of fertilizer gives better results than other forms of phosphate because of its content of calcium and sulphur which has shown to be important in groundnut nutrition.

Planting:

Both planting on ridges and the flat are practised in Northern Ghana. There is no evidence yet to show one method of planting superior to the other. However ridge planting makes harvesting easier, but in dry areas ridges loose the soil moisture quickly. A planting distance of about 24 inches between rows and 6 inches in the rows are recommended. A high plant population (40,000—50,000 per acre) is essential for a good crop and also helps to control weeds in the latter stage of the growing period. All seeds sohuld be dressed with organo-mercury powder like Dieldrex A before planting. The time of planting in Northern Ghana is generally in May/June.

Weed Control:

Presence of weeds is a great source of yield reduction. Hoeing should be done at least two times during the early growing stage. A good groundnut crop is closed by the time of flowering and does not need any more growth care.

Diseases:

Rosette: — a virus disease carried by aphids causes either extreme stunting with small markedly mosaiced leaves or slight stunting in which the leaves become chlorotic with dark green veins. Selection of resistant varieties, early planting, close spacing and seeddressing with Dieldrex A help to minimize the infection.

Cercospora leaf spots: — are caused by fungi which produces spots on the leaves. In humid weather the disease spreads fairly rapid. The leaves turn yellow and fall off. Spots may appear on the stem, weakening them. Finally, the plants die prematurely. Spraying with 6 grams Duter per gallon of water at the first appearance of the disease result in some control. If necessary, spraying should be repeated after 2 weeks.

Pests:

Termites: — attack the roots, tunnel into them and the plants finally die. Some control may be obtained by Aldrex 40 mixed with fertilizer and applied shortly before planting.

Harvest:

When the leaves begin to yellow and the kernels are fully developed and coloured, harvesting may begin. The nuts should be dug out and left to the sun for drying for about 10 days. The nuts may then be stripped from the haulms and again sunried before they are shelled or taken to the decoriator mill. Much of this work is normally done by hand, but there are some small machines like groundnut stripper and sheller which are quite useful.

Storage:

Storage of groundnuts is no problem. They can be stored shelled as well as unshelled. If pests attack the unshelled groundnuts, they can be controlled with Gammalin A dust.

Yam

History:

Yam is one of the most important food crops in West Africa because of its high concents of carbohydrates. About 650 species are known all over the world but only ten are important as food crops.

Vartieties:

The following four varieties are the most common ones in West Africa and therefore mostly planted in Ghana:

- White yam (Discorea rotundata POIR.) — is especially suited to the climatic conditions of Northern Ghana, grows very well in the light sandy soils of the savanna zone with long dry season.
- Yellow yam (Discorea cayensis LAM) — its inside is coloured yellow due to the high carotin content. Prefers areas with shorter dry season.
- Water yam (Discorea alata L.) — can produce very big tubers but is not so common as it cannot be used very well in preparation of „fufu".
- Bitter yam (Discorea dumetorum KUNTH) — can produce high yields per acre but is not so widerspread because of its bitter taste.

Landpreparation:

The land should be either ploughed or hoed at a depth of approximately four to five inches. In most cases mounding is practised in Northern Ghana. Yam can also be planted in ridges, in order to mechanize the various operations bu it is not common in North Ghana. The mounds may vary in size but normally they are about 2 to 3 feet high and 3 to 4 feet wide at the base.

Fertilizer recommendations and application

The present fertilizer recommendation for yam is two bags of compound fertilizer (15—15—15). One bag should be broadcasted before mounding, the second one should be sprinkled around the mounds when the vines are 1 to ½ feet high.

Planting:

Planting of yam in Northern Ghana starts towards the end of the dry season in order to take advantage of the early rains. Usually large tubers are cut into pieces, each with 3 to 4 „eyes" and used for seeds. The order of preference for the different part of yam planting are: head — tail — middle. The method of using whole small yam tubers for planting has shown that better yields can be achieved as compared with other planting practises. These seedlings are obtained by leaving a small piece of the yam tubers on the roots when harvesting. The pieces will then develop into small tubers and can be used for planting Treatment of the setts with a fungizide powder is advisable. To avoid drying out of the young shoots, seeds should be planted deep in the mound with the „eyes" facing upwards. For prodection of the seeds, mounds should be mulched at the time of planting. This is usually done by placing a „cap" of dry leaves or grass on top of the mound. The cap is being prevented from being blown away by weighing it with a small stone or loose soil. Mulching is particularly necessary in the hot dry conditions of the North, for it keeps down the temperature within the mound and so reduces deteriotation during the period of dormancy before the rains. Staking is necessary to enable the vines to climb. Tall poles have shown to produce higher yielding plants presumably by encouraging more luxuriant foliage.

Weedcontrol:

Weeds should be cut down regularly. Use of chemicals is not necessary.

Diseases:

Many types of leaf spot affect yam. These diseases are not particularly destructive and control measures have not been developed.

Insect pests:

Yam beetles and termites damage the tubers while they are growing. Some control can be obtained by treating the setts used for planting with fungicide powder.

Harvest:

When the leaves have died at the end of the rainy season, harevesting can start. Wooden tools should be used so as not to injure the tubers.

Storage:

Commonly in Northern Ghana, the yam tubers remain in the soil and are removed according to demand. By this method the tubers may start germinating again and thereby loose quality and taste. They can also be attacked by pests. Storage in an airy dry shed is advisable.

Tomatoes: Lycospersium esculentum

In old books on gardening, tomato appears under the name „LOVE APPLE" but since the earliest days it has been known by the latin name **Lycospersium esculentum.** It is a vegetable, one of the basic and, therefore, irreplaceable ingredient of human diet. It is reasonably rich in vitamin and minerals. It has a great commercial potential not only in Ghana, but other developing nations of tropical Africa.

Tomato as any other vegetable, can neither stand the heavy rains of the wet season nor the dry spell of the dry season, for that matter, its cultivation is still limited to traditional varieties and methods and only irrigation or adequate water supply can guarantee the cultivation of this vegetable.

History:

The origin of tomato is still not known. Some writers on gardening contrast the popularity of this fruit in France and Italy with its unpopularity in Great Britain. But some authorities say that tomatoes were introduced in Great Britain as far back as 1596 when the red-fruited, white-fruited and yellow-fuited types seemed to have appeared about the same time. In the eighteenth century, other types were seen in the same country such as the cherry-shaped, the pear-shaped and so on, and today it is still possible to get varieties that bear fruits of the same various shapes, sizes and colours.

Today, African developing countries have realiyed that tomatoes is one the best vegetables to be grown in the tropics and that no soup is complete without it, thus the out-cry for its production to elevate shortages in the green or fresh form and also to feed it's factories.

PRODUCTION TECHNIQUES

1. **Site Selection:** — Tomato plants in the open-air when properly grown and carefully fed, bear heavier fruits throughout the period they occupy the ground than they do in green houses and there is seldom any difficulty in fertilization. Every flower seems to set and produce fruit. It prefers a dryish atmosphere and moderately high temperature coupled, of course with plenty of sunlight and air. In Ghana, tomato-

cultivation in the open air is practiced under temperature of about 60° F to 85° F. Temperatures higher than above tend to inhibit fruit setting, medium rainfall with irrigation is recommended.

2. **Soil:** — The soil must be well drained sandy loam to clay loam rich in organic matter and nutrients. Soil pH being 5.0 to 7.5. Unused soil is more prefered.

   Tomatoes do not do well in rainforest areas. Steep stapes are not preferable since control of erosion may present a big problem. Very flat soils may also favour the incidence of fungus diseases unless they are well drained or rainfall is mild. Gentle slopes are the best.

3. **Varieties:** — Is is very difficult to make a decision with regard to varieties, for the old adage „One mans meat is another mans poison" is almost as true to tomato varieties for growing in the open air as of any garden subject which is affected by soil, climate, treatment of the gardener and so on. The following have however proven successful under Ghanaian experiments even though there may be others equally good.

   Roma, Marglobe, Zuarungu, Fireball, OK 1, OK 5, C.P.C.2, MH 6/1, Malanucie, Puck Mani local, Ponderosa, Red Plum, Ruby, Turrialba, Zuarungu Improved, Amateur, Anahu, Dwarf gem., Early dwarf, leader and Pearl harbor.

   Even though all varities grow well especially in the dry season, its advisable to contact your nearest extension agent when choosing a variety for your garden.

4. **Site Preparation:** — Tomatoes if not intended to be interplanted as companion crop with any cash crop in which case the major crop takes the upper hand in cultural practices, the site should be devoured of stumps, roots stones etc.

   They should be dug out to a depth of 18 inches, Ploughing and harrowing should be done to a depth of about 10 inches depending on depth of the top soil.

5. **Fertilizer or Manure:** — During ploughing and harrowing, apply farm-yard-manure. If no organic manure is used, on sandy loam soil, apply on prepared land before transplanting.

600 lbs 5—20—20 per acre or 150 lbs/acre sulphate of ammonie, 270 lbs/acre double superphosphate, 200 lbs/acre muriate of potash. On clay loam 5—20—20, 800 lbs/acre or 200 lbs/acre Sulphate of ammonia, 360 lbs/acre double superphosphate and 265 lbs/acre muriate of potash. Where mixtures are difficult to obtain, apply 3 cwts compound fertilizer (15—15—15) to an acre before transplanting and top dress with sulphate of ammonia before first fruits are set.

6. **Planting Time:** — Tomato is a vegetable that can be obtained three times a year especially in the Northern and Upper Regions of Ghana. For these two regions ,ist crop should be sown in January and transplanted to the field from February 21st to March 31st.

   2nd Crop — Sow seed from May 15th—31st. Transplant to field about June 21st to 30th.

   3rd crop — Sow seed from August 15th—21st. Transplant to field from September 21st—30th.

   Tomatoes find it difficult to set any fruit successfully during the period February 15th to March 31st due to very high night temperatures. Planting programmes should therefore be planned to avoid this.

7. **Rotation:** — Tomatoes like any other vegetable should not be grown on the same field every year. Rotate it with cabbage or other vegetables. However, never plant tomatoes following egg plant or peppers or egg plant following tomatoes and peppers. The following is suggested when tomatoes are involved.

   1st Crop — Leafy vegetables such as cabbage, cauliflower, lettuce, spinach, kale or collard greans.

   2nd Crop — Follow first crop by root crop such as carrots, onions, beetroot, radish or turnip.

   3rd Crop — Follow second crop by fruit farming vegetables such as eggplants, beans, peppers, tomatoes, okro, cucumbers etc.

8. **Nursing of Tomatoe-Seeds:**

   a) Seed Boxes and trays: — Tomatoes like other vegetable seeds require sowing in nursery before transplanting to the field. They are normally planted in seed boxes, pri-

cked out to field when the plants are about 6 inches high. Sizes of boxes are not important but must be 4—6 inches deep with drainage holes about 1/4 inch in diameter at the bottom and about 6 inches apart to allow excess water to drain out.

   b) Seed box Preparation: — The bottom of the box must be covered with a thin layer of small stones or gravel to prevent particles blocking drainage holes. Fill the box 1/2 inch to top with soil or mixture of good fine loam and vegetable compost in approximately equal proportions. Do not forget to use sterilized soil! Sterilization can be done in two ways, either by chemicals or by steam. (Ask your Technical Officer for advice). Surface soil should be reduced to a good tilth, levelled and firmed. Before firmnig, mix into the top two teasponnful of single superphosphate and one teaspoonful Sulphate of Ammonia per square foot or box 18 — 8 inches (better ground to powder). This gives the seedlings a good start after transplanting. Avoid seeds washing to one side during watering. This can be checked by placing the box in a container with one inch water. Leave the box in the water for the soil to get socked from bottom to surface. Shade the seed box.

   c) **Sowing In the Seed Box:** — Make groves not more than 1/2 inch deep and three or more inches apart with a blunt stick about the size of a lead pencil. Plant in rows or lines not too close together. Three ounces seed will be enough for planting an acre.

      Scatter the soil over the seeds and lighty firm. Water ligthly by sprinkling. Keep it constantly moist but not wet. When the seeds have germinated, it may be necessary to thin out. This ensures healthy sturdy growth.

   d) **Before Transplanting:** — It is better to prick out 2" apart into manured nursery beds when the first true leaves appear. These should be grown in the shade. A few days before transplanting, the seedlings should be hardened (acclimatized) by gradually introducing them to sunlight. Smokers should remember that virus disease can be transmitted to tomato plants on the fingers if the hands are not washed after touching tobacco.

9. **Transplanting:** — Where rainfall is heavy, raised beds are preferred but in areas where rainfall is light, flat or sinking beds should be prepared. Transplant to field beds when seedlings are about 4—6 inches high. Transplanting is best done in the late afternoon or during cloudy weather. Set plants not more than ½ inch deeper than they stood in the nursery bed. Firm soil around the roots making sure there are no air pockets.

   After setting, use one cup starter solution around each plant, Make this solution by dissolving four teaspoons of 10—10—10, 15—15—15 or any complex fertilizer in a gallon of water. Mix well. This will help to get the plants a quick start. Mulching keeps the soil damp, cool and soft around the roots of the plants and should not be overlooked during dry weather. Avoid using disease or insect infested material.

10. **Growth Care:** — Tender care is needed in dealing with tomato seedlings. Watering should be adequate and carefully done. Over watering causes „damping off".

    As plants grow upwards, they require staking with sticks 5 feet long, pushed 1 foot deep. Plants should be tied to the stakes at 12" intervals. If good sized fruits are required, the plants must be debudded as soon as side shoots develop in the axils of leaves. Care must be exercised to avoid confusing these flower-shoots, which grow on the stem, not in leaf axils. The later can be recognised quite readily by producing flower buds and little or no leaves. This pruning can be one once every week or ten days. It helps ease disease control practices and harvesting.

11. **Pests and Diseases of Tomatoes:** — Planting on virgin fields and rotation help elimate pest and disease incidence on tomato fields. Where nematodes are suspected, fumigate the soil with D.D.T. or Nemagen 2 weeks before transplanting.

    Pest: — Major pest are grass hoppers and moths. Control by applying Sevin at a concentration of 1 oz. in 2 gallons/water or D.D.T. as 5 % dust at 30 lbs/acre applied immediately after transplanting. Below are few disesases and their control measures: —

Common Name of Disease	Scentific Name of Disease	Nature of Damage or Disease symtoms	Treatment or control
Early Blight	Alternaria solani (E 11. et. Marl.)	Dark brown or black spots with concentric zones on the leaflets; on fruits black or brown sunken lesions, tissue leathery.	1. Crop rotation. 2. Seed treatment with mercuric or organic fungicides. 3. Repeated spraying with Zineb, Ziram, Maneb or other organic fungicidas.
Septoria leaf spot	Septoria lycopersici speg.	Small water-soaked, circular spots on the under surface at first of lower leaves. Spots enlarge, margins become black brown with sunken white or gray centre; defoliation.	1. Eradication of solanaceous weeds, long rotation (at list 4 years) 3. Repeated spraying with copper compounds (at 7to10 days) or organic fungicides like Zineb (at 6 to 7 days).
Leaf Model	Cladosporium fulvan, cook.	Irregular cholorotic spots at first on the lower leaves, which turn greyish-black On green fruits, infected areas appear black, leathery while on ripening fruits they are yellow and sunken.	1. Use resistant varities. 2. Control of humidity. 3. Repeated spraying with Zinam, Ferbam Menab, Captan or other organic fungicides.
Leaf mottling	Virus	Leaves mottled, distorted, reduced in size, Flowers fail to set fruits.	1. Eradication of affected plants. 2. Eradication solanaceous weeds.
Bronze leaf spot	Virus	First, brown spots on the leaves which enlarge, distortion of leaves and stem, dropping of fruits.	
Blossomend rot	Nutritional disorders	Sunken dars brown lesions at the blossom end, internal discoloration of the core —	1. Bring soil to good fertility 2. Regular watering. 3. Application of calcium. 4. Mulch in dry season.
Root-Knot	Meloidogyne spp.	Galls are produced on roots, leaves become pale in colour the stem becomes spindy and dwarfted. Swellings on the root vary from spheroid galls to elongated spindles. Affected plants form only a few fruits, sometimes the whole plant dies.	1. Long term rotation with non-susceptable crops. e.g. corn and cassava 2. Use non affected seedlings. 3. Use resistant varieties. 4. Seed bed and field fumigation with methyl bromide and nematicides such DDT and nemagon respectively

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

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

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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.

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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.

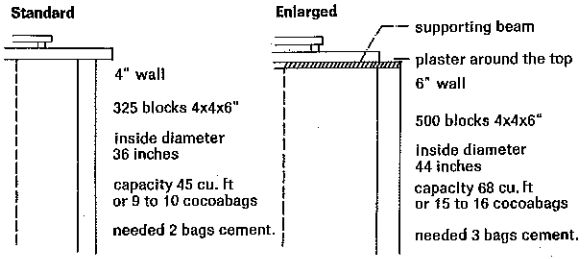
Modifications to the standard size.

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

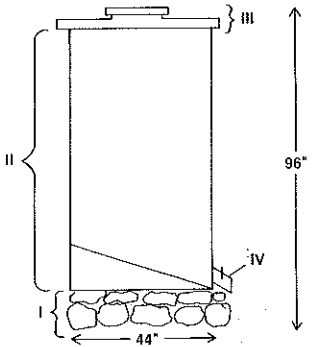


Fig. 1

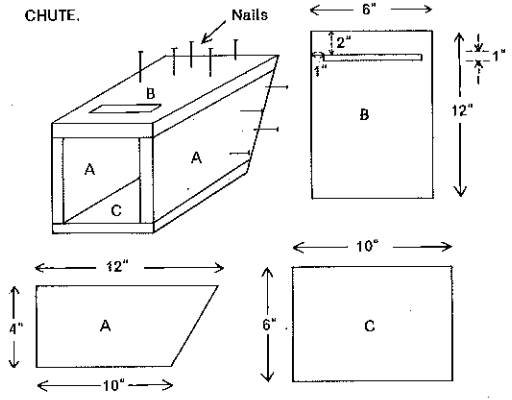
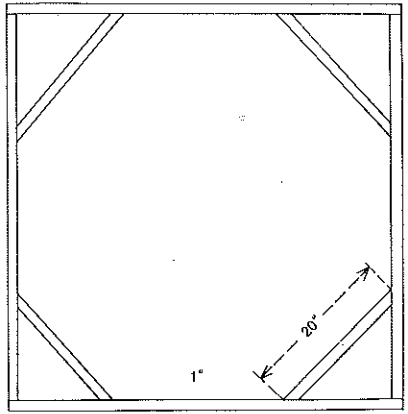
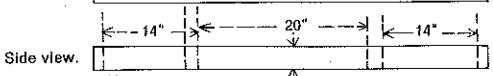


Fig. 2

FRAME A
Top view





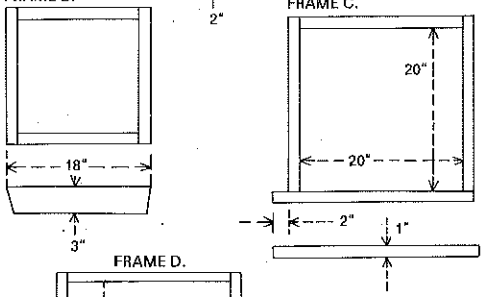


Fig. 3

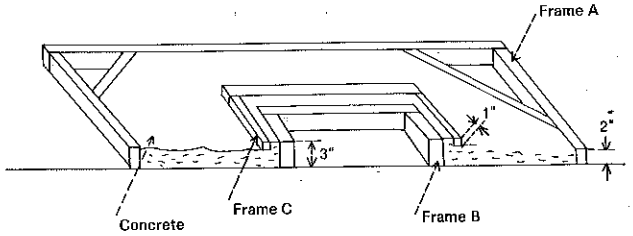


Fig. 4

BLOCK MOLD.

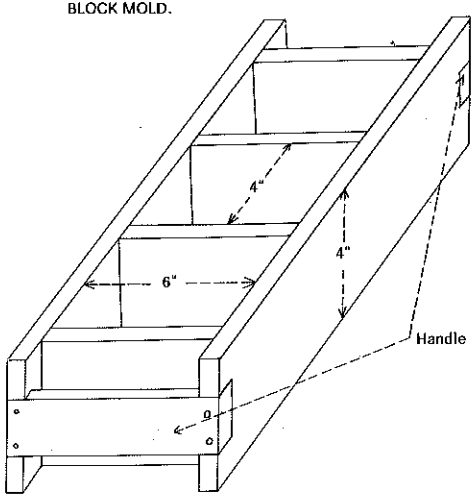


Fig. 5

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 Check carburetor adjustment
	Water in oil	Replace cylinder head gasket 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		

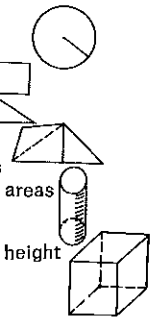
Measures of weight: Metric — Conversion to imperial

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