Hand Book of Cultural Practice
for
Flue-Cured Tobacco

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This handbook is an attempt to gather together most essential information in Tobacco Production. The aim of the report is to give out first hand information to the Middle Valley concessioners and to future extension agents of the settlement. We are also hoping that this handbook will serve as supplement in any tobacco growing region in the Empire with few modifications to local condition.

The editors do not pretend to have followed any original text books, but have tried to draw the most relevant information from best sources available and from their experiences in the crop. It is presented in summarized form, in as simple, straightforward and coherent manner as possible, without losing sight of scientific method, precision and rigour.

It will be noted that tobacco joint-venture research programme with Institute of Agricultural Research had started in September 1971 at Melka Werer Station. So far some preliminary works have been done. Curing barns, grading shed and purchasing few equipment have been completed. Seeds from U.S.A. and Africa have been obtained from the trials of monthly sowing at both alluvial and verti soils and trials of variety, fertilizer and irrigation on alluvial soil. From these trials, the vegetative performances have shown good results.

The experimental programme includes three types of tobacco, Flue-cured, Dark Air Cured and Light Air Cured. However, the introduction of Dark Air Cured Tobacco, which has no paying market in Tobacco World has hindered the progress of the work.

At present there is a demand of Flue-Cured Virginia Tobacco in the country. So we strongly believe that special emphasis must given to Flue-Cured Tobacco with collaboration with Tobacco Monopoly so as to satisfy the local demand. Dark Air Cured and Light Air Cured should be given the second priority provided that written agreement are made with France or other countries without any commitments that deprive the interest of the country. For all these reasons, we have prepared Handbook of Cultural Practice for Flue-Cured Tobacco prior to other types of tobacco.

The editors of this book are deeply grateful to the Department of Agriculture A.V.A. and to all those who assisted in the preparation of this volume in a very short period of time.

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Introduction

Tobacco means money. It is not food, clothing or shelter, yet it is the most sovereign weed that over the earth provided to the use of man. However, as in the case of Rhodesia, tobacco is everything. It is the national product which is the backbone of her economy.

Tobacco farmers grow a product for which there is widespread, insistent and increasing demand not readily affected by changes in leaf prices or consumer income, and the upward trend in world population and in the number of smokers offers a steadily enlarging market. Tobacco is a commodity whose use is common to all races and all social conditions and once acquired, the tobacco habit is a tenacious one; many people would give up food rather than stop smoking. Tobacco has been denounced from the pulpit, its use has been connected with cancer and the craving for tobacco is irrational. Yet this unusual weed has been inextricably linked to man's feeling of well-being since the first crop was grown.

The botanical genus Nicotiana contains over fifty species, yet the only one which has never been found growing wild is Nicotiana tabacum, the plant whose leaves have had, and continue to have, such a tremendous impact on the world in the various guises which are collectively known as tobacco. One other species, Nicotiana rustica, is also involved in this story but it has played a very minor role, which is ever decreasing. The use of the word tobacco is generally accepted as referring to produce of the tobacco species and so it will be in what follows. Tobacco holds an unparalleled position among crop plants in several individual particulars, while in overall situation the stature achieved by the single species is truly remarkable. Some of the more noteworthy points:

1. It is one of the very few crops entering world trade entirely on a leaf basis.
2. It is the most widely grown commercial non-food plant in the world.
3. In many countries it is an instrument of very high importance in financial and economic policy.
4. Consumption is by way of smoking, inhalation of dust (snuff) and chewing.
5. As a habit-forming narcotic attacks have, with fair regularity, been aimed at curtailling or stopping its use but consumption has nevertheless marched steadily forward.
6. Originally having religious significance, subsequent claims of medicinal benefit have alternated with accusations of a positive danger to health.
The History of Cultivation

All species of tobacco belong to a genus of the solanaceae family, the Nicotianae, which number about fifty species, the majority of which came originally from South or Central America. Some species have been found in the wild state in Australia, New Zealand and Asia.

The first introduction into East Africa is thought to have been of *Nicotiana rustica*, about 1560. The Portuguese were responsible. The natives carried on its production for the next 350 years but it is not clear whether other seed was introduced during this period. In this century introductions of fire and flue-cured varieties were made and in the last thirty years organized cultivation has developed in Uganda and mainland Tanzania.

Tobacco will have reached Central Africa (Rhodesia, Zambia and Malawi) soon after its first appearance on the coast but, as in East Africa, cultivation was long confined to domestic use. In 1889 the first recorded European production was organized by the Buchanam brothers in Malawi. They exported 18 kg of leaf to the United Kingdom in 1893 which besides being the first Empire shipment since the loss of the American Colonies was the token fore runner of a trade which sixty years later was seriously to affect the American industry. This was also the year of the first commercial crop in Rhodesia but it is interesting now to realize that Rhodesian production did not exceed that of Malawi until 1926-7. We have been talking here of flue-cured cigarette tobacco, but in the early part of the twentieth century it seemed as if oriental tobacco would become the main crop of Rhodesia and strenuous efforts were made to make it so. In the event Malawi has become an important supplier of fire-cured leaf which Rhodesia has largely built up its economy on export of the flue-cured type. Zambia has concentrated also on this type but by comparison development has been very slow.

In this brief picture of the world spread of tobacco can be traced certain definite stages.

Following initial discovery there was a rapid dissemination of planting materials far and wide to become the basis of what may be called local native production and concomitantly localized commercial expansion to supply world trade. The latter concerned the United States, the Eastern Mediterranean and parts of Caribbean area and South America. This situation largely persisted until the beginning of the present century.
The areas of early commercial development had environments particularly suited to the growth of a fine product. But it is also important that there were people on the spot quick to exploit these advantages and to convince their customers that to speak of a particular type of tobacco meant by definition the produce of those limited localities. Without the twentieth-century upsurge of economic nationalism and, later, pure nationalism, this situation might have persisted. But these factors have led to a second stage of commercial growth. European colonization, particularly in Africa, and the consequent search for profitable agricultural activity was also a factor but only to provide a foundation — the building required more than local energy.

For example, Rhodesia tried very hard to build up an export trade for over twenty years. To go there in the early days and grow tobacco was often said to be the most profitable thing a man could do. But the Second World War and its aftermath upset world trading patterns, including currency. Rhodesia was able to gain a substantial footing in the United Kingdom market which it has since maintained and expanded. In 1946 the crop was just over 18 million kg and in 1964 145 million kg. It is important to note that this expansion was not built up on home demand, for 90% of the crop is always exported.
Tobacco of commerce consists of the dried leaves from several species of Nicotiana, which belongs to the natural order of Solanaceae.

These are herbaceous annuals with broad soft leaves arranged spirally on an erect stem. Lvs may extend from ground level to the base of the inflorescence. The "Virginia" varieties grows to a height of 1.50 m to 2.50 m and have leaves about 50-70 cm long and about 30-40 cm as wide.

The flowers are carried on a much branched inflorescence on the top of the plant. They are generally tubular in shape and range in colour from white to deep red, shades of pink being the most common.

The small seed is contained in a capsule which can be .62 to 1.25 cm in diameter. It is possible for one plant to produce 1,000,000 seeds.

Climate Requirements

To produce first class, bright, flue-cured tobacco it is necessary to have a hot and humid atmosphere without strong winds or hail. A certain amount of cloud is also desirable, since prolonged strong sunlight appears to be detrimental to quality.

Soil Requirements

The production of bright flue-cured tobacco of good quality requires a soil which remains free-draining and can be kept well aerated throughout the growing period.

Soils should not be too fertile nor should they be too high in organic matter.

Physical Characteristics

Soils normally chosen by the most successful growers are light-coloured, usually of grey or brown shade, and have 25 cm to 50 cm of sandy layer overlying a porous sand clay. The porous sandy clay is normally several meter thick and of red or yellow colour. Area with a high percentage of sand or gravel in the subsoil, which makes drainage to free, are usually awarded. This is due to the difficulty of maintaining an even moisture supply to the crop. Mottled subsoil indicates that the soil is subjected to poor drainage for portion of the year at least.

Chemical Properties

Slightly acidic soil is preferred. Tobacco soils should have a low cation exchange capacity, preferably with potassium more than 2% of the exchange capacity. Organic matter, total nitrogen and phosphor content should be low so that the grower has a chance of controlling crop growth.
Land Preparation

Where possible, the land is ploughed some months before the anticipated date of planting. It is left in the rough until seed beds are established and then cultivated just enough to bring it to a fine tilth, kill weeds and leave it level. Usually light disc ploughs or cultivators are used to do most of this phase of the preparation or specially made levellers to do the final operation.

Land prepared too late can result in a high proportion of "Frenching" appearing the crop, which may also be pale and slow growing due to nitrogen starvation. Early land preparation followed by too frequent working of the soil can cause the crop to be large and soft, due to a release of soil nitrogen. Over working can also destroy soil structure, resulting in poor water penetration.

Irrigation

A Furrow Irrigation is the cheapest form of irrigation and should be used unless there is good reason to use spray irrigation.

Requirements

The 1st essential is to have an assured supply of good quality water and the means of getting it to the area to be irrigated. It is then necessary to have a contour survey carried out on a small enough vertical interval to permit the design of supply ditches, irrigation furrows and drainage ditches. The soil type must be considered here as it will influence the length and grade of the irrigation furrows.

Land Preparation

The initial preparation must concentrate on grading the land to a suitable slope so that water can be run readily down the furrows without missing high spots or flooding low areas.

Special care should be taken during ploughing operations to avoid leaving high crowns and deep cut-outs at the beginning and ending of each land. As a precaution against this, it is advisable to make the last ploughing in the same direction as the rows of tobacco are to be planted.

Care should also be taken to fill in all stump holes and small isolated depressions. It is essential to realise that smoothing only entails slight trimming so that an even surface is obtained, and not soil movement on a large scale.
Supply and Drainage Works

Permanent supply ditches should be constructed well ahead of the commencement of irrigation so that the banks will have time to consolidate — unconsolidated banks are the most common cause of bank breaks. Wide, shallow ditches are preferable for ease of maintenance with farm equipment.

Checks The placing of suitable permanent checks in the supply ditches is necessary to raise the water level in each ditch above the level of the land to be watered and to enable control of the flow. Alternative types of checks which can be used are:

(i) "Overshot" check — in this type the vol. of water passing the check is controlled by the depth of water flowing over the crest of the weir.

(ii) "Undershot" check — in this type the vol. of water passing the check is controlled by raising or lowering a gate, under which the water flows.

Ditch Outlets

Suitable outlets from the supply ditches to the furrows are siphon tubes. With further experience in furrow irrigation, individual farmers may find alternative methods of discharge which are better suited to their particular conditions. Siphon tubes consisting of 3.14 cm diameter plastic piping are commonly and successfully used as an alternative to the above type of outlet. These have the advantage of being readily moveable and not requiring the ditch bank to be cut.

Operation

(1) The flow can be subdivided as required within the supply ditch system but it is generally preferable to subdivide the flow so that all watering operations can be handled from a central point, in order to reduce labor.

(If) If more than two furrows are watered from the one outlet at the same time, the resulting small furrow flows may result in waterlogging of the land and under watering of the tail land. With four furrows connected to each outlet, three should be closed off with a shovel bank and each opened up in rotation as watering of the preceding furrow is completed.
During the watering operation it is important to see that the water flows evenly and close to the plants, that the furrow is not blocked and that the water is evenly spread across the furrow. If the "water gets away" the effected outlet should be closed until repairs are made. On closing one outlet it is necessary to open another or surplus water will build up in the ditch system and possibly break the ditch bank.

**Planting**

Planting is normally done by hand following the first irrigation but it is possible to operate from a tractor-drawn planting machine. Seedlings are planted on water line on one side of the irrigation furrow or on the top ridge.

As the soil is loose at this stage and capable of absorbing water rapidly, it will be necessary to increase the rate of flow in the furrows. This is done by running the minimum number of furrows and will have the effect of bringing the water line high up on the furrow and preventing overwatering. The root zone should be soaked but not made "Sloppy".

**Establishment**

A second watering is generally given immediately after planting. Special care should be taken with both planting and establishment applications as the resultant strike will largely depend on them. This watering should be comparatively light and is applied to firm and seal the soil around the roots of the transplants.

**Subsequent Irrigations**

Subsequent irrigations will vary in number and time of application with climate, soil type, state of crops and in the Middle Valley the watering cycle of the pumping may be organized in the future.

As a general rule the next irrigation is given 7 to 21 days after transplanting. Some cultivation must usually take place during this time. A period of 10 to 30 days then elapses before the following irrigation. This allows sufficient time for the construction of new water furrows. It has been found desirable to extend this period to the limit without checking growth as this has the effect of hardening off the plants and encourages a deep root system.

An interval of 7 to 14 days usually elapses between later irrigations and another cultivation may be given after each.
Water Logging

It should be kept in mind that the tobacco plant is very susceptible to water logging. Over watering which may produce this condition should therefore be carefully avoided.

D. Spray

Sprinkler Irrigation - Water is forced into air through a nozzle and allowed to fall back on the soil. There are numerous types available commercially but nozzles fall into two main groups, depending on whether a high or a low water pressure is required. Pipes supplying these nozzles are grouped as either moveable or fixed and vary in size from 1.88 cm diameter for high pressure systems to 15 cm diameter for large low pressure installations.

The main advantage of using sprays is that no land grading (levelling) is required and areas that are too steep or too broken to be irrigated by furrow irrigation method. High capital outlay and heavy maintenance costs must be remembered when deciding if such a system should be installed. It is difficult to shift spray line in very tall crops. The use of sprays in the early growth stages followed by furrow irrigation later has given good results on many properties. In general, sprinkler irrigation has not been found to be superior to furrow irrigation and is more expensive and time consuming.

Effectiveness of Applied Water

1. For sprinkler irrigation - rain gauge type.
2. For furrow irrigation - soil moisture sample before and after irrigation.
3. For furrow irrigation - it is now possible to purchase instruments (tensiometers) which can give a continuous indication of soil moisture at any depth up to 1.20 cm. With tensiometers one can ensure that crop is adequately watered without any over watering or loss of water.
Reasons for Failures

Tobacco crops frequently fail to yield successfully under irrigation due to one or more of the following reasons:

1. Water logging, due to over-irrigation or insufficient drainage.
2. Insufficient water to moisten the entire root zone.
3. Poor quality water.
4. Intervals between waterings being too short or too long.
5. Inadequate cultivation. The surface should be disturbed as soon as possible after each watering.
6. Weed competition. Weeds can use water which would otherwise be available to the crop. They also reduce the rate of flow in the furrows.

Water Quality

When irrigation water is to be tested for suitability for tobacco irrigation, only two estimations need be made under normal conditions. These are determinations of the total dissolved solids and the chlorides. Tobacco will grow when irrigated with water of soluble salts which other crops are killed. The trouble with the tobacco is that the quality of cured leaf is affected by such water long before the living plant shows any visible symptoms.
Tobacco is always raised in seedbeds. This is because the seed is so small and because the relatively slow growth of the plant at this stage. The production of well known, healthy vigorous seedlings is a necessary if the maximum return is to be achieved from a tobacco crop.

Successful production of flue-cured tobacco depends upon an ample supply of strong, healthy, uniform plants that are available reasonably early in the transplanting season. The young seedlings are subject to damage from many weather and soil conditions as well as a number of diseases and insects. Thus they need to be looked after and managed very carefully.

The first thing to be done, in tobacco seedling production is to select the best possible site for nursery. In choosing the seedbed area, the followings should be considered:— soil, slope, wind breaks, water supply and convenience.

Soil
Select a deep, fertile, loamy soil that warms up quickly. The soil should have good moisture holding properties, but should be well drained. Avoid using heavy clay soils since they generally bake or crust easily or soils that are excessively sandy because of their poor moisture holding capacity.

Slope
Soils that slope to the south are warmer than level soils or those that slope in any direction. Try to locate bed on a soil with about a 3% slope to the south on gentle slope.

Water Supply.
Locate beds near convenient water supply, like canal, artificial pond etc so they can be watered as frequently as needed during dry periods.

Wind breaks
Winds can cause very serious damage to stands and retard early plant growth. The drying effect of the wind often can be more damaging than the cooling effect. During the plant bed season most damaging winds are from the north and west and thus it is desirable to have windbreaks on these sides of the beds.

Convenience
A good management job requires frequent trips to observe soil moisture conditions, insect infestation, disease outbreaks and general growth of plants. Thus plant beds should be located in an easily accessible place, preferably near the home. If this is not possible, locate beds at least near a good road so that they can be visited easily and frequently.
Soil Preparation

Soils in good physical condition and high in organic matter help to promote good stands and growth. Good physical condition of the soil also makes watering easier and plants can be pulled with less damage to the roots.

In new land the site should be cleared of all stumps and roots and sufficient trees removed to stop competition for light and moisture. However, a cover crop of soybeans or cowpeas will improve the physical condition of the soil and help to keep weeds from growing and producing seed on the bed site. Seed, cover crop as soon as replanting has been completed. Early destruction of tobacco plants will help to reduce insect and disease in the next year's bed. Disc cover crop in during the early fall so that it will be well decayed before time to treat for weed control.

Tobacco plants beds located on a slope should run across rather than up and down the slope to reduce erosion in the bed. Under all conditions a good drainage ditch around bed to prevent outside water from coming into bed area. Water washing into the bed may bring in live weed seed and possibly diseases.

In preparing the bed plow or disc it to the center. This tends to give a slight build-up to the center and slopes the soil to the outer edges of the bed for good surface drainage.

Tobacco seed are very small. Time spent preparing and smoothing the bed prior to seeding will be well rewarded. After the soil is broken it should be harrowed and raked until it is well pulverized, smooth and free of clods. Excessive use of heavy equipment such as tractors should be avoided after the soil is broken or tilled because of possible damage from packing.

Area Required

It is necessary to provide more than the number of plants calculated for the planting up of the field concerned. A certain % of the losses, can always be expected but adequate number should also be provided to allow for up to 100% replacement. The occurrence of severe storm low germinability % and very high insect populations may cause such losses.

Dimensions

Since it is necessary to be able to reach to the center of the bed from paths, beds are usually one meter wide. The length will depend on the shape and size of the whole site and on the type of seed bed covers available. A seedbed (10m2) which is not sown too thickly or thinly will give about 3,000 good seedlings, When the distance of the plants in the field is 0.5x1m, a total of 20,000 plants will be needed per hectare, which could be supplied by 5 seedbeds. There are often more than 3,000 plant in 10m2, but one should not use the backward ones.
The purpose of soil sterilization and fumigation is to control

1. Weeds, by killing the seeds.
2. Nematodes
3. Other noxious disease organisms

It is most important to give careful attention to the sterilization of the seedbed area, no matter what means are used. The whole area, including pathways, should be treated. The method of controlling noxious weed, nematodes, fungi and insects are use of heat and chemicals.

1. **Use of heat** - Heat can be produced by using timber, brush wood or saw mill off-cut, it should be piled to a height of 30 to 60 cm as to give sufficient heat to sterilize the top few cm of soil. This treatment is more effective when the soil is damp. However, this method has a drawback in that it will destroy or disrupt the organic matter of soil which is an important element in soil fertility.

2. **Chemicals** - Methyl Bromide is best proven chemicals for controlling weeds, nematodes. When MB is used to sterilize the soil, particular care should be taken to eliminate anything which will contribute to loss in vigor or to destruction of tobacco seedlings. For instance, depending on local condition if covers remain in position for more than 24 to 48 hrs, seedlings can be affected adversely.

   MB is used at the rate of one pound (.454 kg) per 10 m² bed. The material is used as a gas and should be kept in contact with the soil from 24 to 48 hours.

   MB has given good results locally and other places when used in the following manner:

   1) Have the soil well prepared-pulverized, free of clods and excessive quantities of undecayed vegetation. Soil moisture should be at good plowing level — not too wet and not too dry.
   2) Air temperature should be 50°F or higher.
   3) Work in preplant fertilizer if treatment is being applied just prior to seeding.
   4) Cover bed with plastic cover. Support cover off the ground with bags partially filled with straw or other suitable objects or pump up cover with air by sealing three edges and then flapping open end to force air under cover.
5) Release one 1-pound can of MB with the aid of and applicator under plastic cover.

6) Leaves cover sealed into the soil for 24 to 48 hrs. Twenty hours is sufficient if the outside temperature is 60°F or above during the day.

7) At the end of exposure period, remove cover for aeration, leaving cover sealed in too long might over-fumigate the soil. Over-fumigation could delay germination, reduce stand, and retard growth. After aeration, cover can be spread back over the bed to keep it dry if needed.

Seedbed Fertilizer

As soon as the beds are cool, debris from the burn. They should be racked off the beds and carted away ash and fine charcoal should then be mixed with the surface soil of the bed. Any digging which will move unsterilized soil from underneath must be avoided. It will be noticed that burning has improved the physical condition of the soil if it has been done correctly. The ash adds a significant amount of potassium, calcium and magnesium to the soil when it is worked in and also a small quantity of trace elements.

When chemical fumigation has been practised, it is necessary to replace most of the nutrients supplied by the wood ash with an increased amount or different type of seedbed fertilizer. With chemically treated beds, a period of 3 days to 5 weeks, depending on the chemical used, should elapse before the fertilizer is applied. In most places, a standard tobacco fertilizer of the approximate composition 4:12:10 can be used at rate of 21b per 10ft x 4ft seed bed. (600 gm/10m²)

When beds have been burnt, a suitable fertilizer mixture will supply from 2 to 4 oz of nitrate of soda and 2 to 4 oz superphosphate per sq yd. A commercial tobacco seedbed mixture of the approximate composition 5:15:0 NO FERTILIZER CONTAINING CHLORIDES SHOULD BE USED ON SEEDBEDS.

Nitrogen Topdressing

Nitrogen top dressing is suggested only when plants are showing a yellow color due to nitrogen deficiency. One-half to 1lb. of nitrate nitrogen per 100 sq yd is suggested. This can be obtained from 3 to 6 lbs of nitrate of soda or its equivalent. Two application a few days apart is better and safer than one big application. Too much nitrogen top dressing may harm plants and cause them to be too succulent and tender to live well when transplanted.
Organic forms of nitrogen are not suggested for use as topdressing on tobacco plant beds.

Apply topdressing when plants are thoroughly dry so that the material will not stick to plants and cause burning. Pelletized materials will roll of dry plants and are less likely to cause damage than powdered materials.

If there are questions about possible burning, the material can be washed off the plants with irrigation.

Time of Sowing

The time of sowing is regulated by the time it is desired to plant in the field and the prevailing climatic conditions.

Which Tobacco seed to use?

In place with a primitive agriculture, farmers collect the seed for the following year themselves. Only seldom is this done in the right way, and very often the tobacco grown in a mixture of different types. Sometimes the peasants (like Robi) prefer a certain mixture, saying that the combination gives a tobacco of better taste. But this can only have value where tobacco is grown for local use. Where tobacco has to be sold, the more homogeneous the crop is, the more easily can the grading into standard grades be done.

The first step in improving tobacco production is to supply strong, healthy seedlings of a pure strain.

The seeds should originate from mother plants specially selected for seed production, which should then be graded and disinfected.

Grading is done with an instrument in which a current of air separates the heavy, full grown seeds from the light ones, chaff and dust.

Disinfection of seed can best be done with 1:1,000 solution of silver nitrate. Put the seeds in a loosely tied muslin bag and stir this for 10 to 15 minutes in the solution. If this is done directly before sowing, the silver nitrate should not be washed off, because the coat of it will prevent disease germs (pathogen) from the soil from entering into the germinating seed. Dry the seeds quickly by spreading them on a piece of cloth or brown paper in the sun. If the seed has to be kept for another year, the silver nitrate should be washed off by moving the bag in cold running water for about 5 minutes. Immediately after this, quick drying without heating about 50°c is needed.
In many tobacco growing areas genetically pure, well-cleaned seed is easy to obtain. The tobacco growers should obtain seed of varieties adapted to their locality. In those areas, where a certified seed program has been established, seed of any new varieties developed by an experiment station is offered for sale by certified seed dealers. This seed of known origin, purity and percent of germination is reasonable in price and the high quality. It is much more convenient for the tobacco farmer to buy the seed from a reputable dealer than for each farmer to grow, clean, treat and test his own seed for germination.

Rate of Sowing

It is very easy to sow this small seed too thickly and too deeply. The main aim in sowing is to prevent these two things happening. Plants spaced too closely are subject to more insect and disease troubles and become spindly, particularly if it becomes necessary to hold them in the bed any longer than normal. Deep sowing results in reduced numbers of seedlings and poor distribution of plants over the bed.

Tobacco seed usually has a high germination percentage. However seed less than 65% germination should be discarded. 1.2 to 1.5 gm of seed is required for 10m² seeded.

Method of Sowing - Any method which provides for a uniform distribution of seed is suitable. Do not sow too thickly. 1½ gm of well-graded, well germinating seed, mixed in two handfuls of wood ash gives a nice covering of 10m² seedbed. The surface of the bed should be levelled to avoid washing away of seed by watering, but this does not mean that the surface should be pulverized. Earth lumps of 2 or 3 cm may be seen on top of the bed.

Water, sand, sawdust and ashes are commonly used to make this dilution. (1) When water is used, a watering can should be partly filled with water and the appropriate amount of seed added. The mixture should be stirred vigorously and kept in motion while the seed is being watered evenly on to the bed. Another method with water, the seed is first laid between wet clothes until it just begins to germinate. This seed is then put in a watering can and while the water is continually stirred, it is spread over the bed with the water. Parsons used to this method get a more even spreading of the seed than with the ash mature. But the method has yet another advantage, as ants do not eat tobacco seed which has germinated.
(2) Another method is to mix the seed with dry, sifted ashes, sand or sawdust and spread it evenly over the bed. The mixture should then be firmed into the moist top soil. To get even distribution the bed should be gone over several times and in different directions.

Do not mix the seeds with fumigicides or fertilizer instead of ashes. This might result in killing the young plants as soon as the seed germinates.

**Time to Germinate**

Seedling will be seen from 5 to 20 days after sowing. The germination time depends on climatic conditions, depth of sowing, variety and age of the seed. Freshly harvested seed is notable for its irregular germination period and seed stored for more than 2 years under less than ideal conditions can show just as much variation. Seed when well-stored will remain viable for 5 to 10 years.

**Covering - Shading**

A cover is required on seedbeds to prevent the surface from drying, and to maintain as even a day and night temperature as possible. In the recent past the standard practice consisted of covering the bed with thatching grass during germination, and then replacing it by a mustin tent.

The use of a grass mulch as a seedbed cover is now recommended. Grass, being both readily obtainable and simple to apply, reduces the cost of labor, supervision and materials. The water requirements during germination appear to be less critical under mulch than under thatching grass and cloth. Growth in the early stages has been slightly slower in some cases under mulch grass, but this difference disappears before the seedlings are of planting size. The mulch gives better protection from heavy rains than cloth, and appears to prevent the soil from packing. The effect of excess salts from fertilizers or ash, appears to be more severe on mulching beds, but can be prevented by correct watering. The use of mulching grass entails a greater risk of hail damage and as a precautions old seedbed cover could be kept at the site for covering the beds when hail storms are likely to occur.

Grass for mulching should be approximately 20cm long and free from leafy matter or seeds. Fine material is preferable. The mulch should be applied sufficiently thickly so that the soil is barely visible. Since some grasses settle more than others, thinning may be required, after germination, to allow sufficient light to reach the seedlings.
Watering

Seedbeds must always be watered by using a finely divided stream, whether it is from a hose or a watering can. The use of a hose and suitably placed taps fed from a tank is desirable, but where a watering can must be employed a suitably placed, open - top tank makes the task easier.

From sowing until the plants are about 2.5 cm high, watering is done once or twice daily. After this, the frequency is reduced to minimize the possibility of fungus attack and "harden off" the plants prior to transplanting.

Care of Seedbeds

In the early stages of growth, it is essential that the seedbed is never allowed to dry out. The amount of water given at each application should be sufficient to keep the surface soil damp until the next watering. Due regard must be paid to weather conditions. Overwatering is worse than use of insufficient water.

Pests and diseases should be prevented rather than controlled after they have appeared.

Hardenning

Well hardened seedlings are always desirable but, as planting dates are advanced into dry weather, they become essential to achieve uniform and complete stands in the land.

If a cover of seedbed cloth is used, it should be removed as soon as the seedlings cover the soil - usually before they are 5cm high. The most satisfactory method of hardening off is to water the seedlings, for maximum growth until they are very near to planting size and then to stop watering for a period of 3 to 6 days. When the seedlings are wilting before 10 a.m, they should be re-watered.

Growers are warned against cutting the water off too early as tough seedlings are slow to start growing again in the seedbed. The practice of reducing the number of waterings gradually from the time the seedlings are half-grown is not advisable, as it slows growth and tends to discourage rooting in the top 5cm of soil.

It is not known how long, or how severely seedlings can be hardened without damage, but the margin of safety appears to be very wide. In dry weather seedlings have been held at planting size for a month without retarding growth on inducing early flowering in the field. Plants which have been allowed to grow long in the bed, however, have frequently been observed to flower early.
Clipping of seedlings just above the heart is a useful practice which helps to produce plants of a more even length, and prevents them from getting too long, especially in wet weather, when the water supply cannot be limited. Clipping should not be confused with hardening, however, as it does little to toughen the seedlings. If mosaic is present in the beds clipping is dangerous, as it will spread the disease. Therefore, the clippers should be washed with soap and running water after clipping each bed.

When seedlings are getting too large for planting, it is sometimes worthwhile to pull the larger ones and discard them, so that the smaller ones can be used. Later pullings are often more uniform and better than the first, but precautions should be taken to prevent the introduction of mosaic.

Sanitation

This practice is most important in preventing mosaic in tobacco plant beds. Follow these sanitation practices:

1. Do not use tobacco crop on tobacco plant bed.
2. Destroy all weeds around the bed site in the early fall and keep all weeds out or destroyed during the plant growing season.
3. Plant seed that have been thoroughly cleaned and are free of trash.
4. Avoid using manufactured tobacco products or natural leaf, especially chewing tobacco or snuff while working in the plant bed site.
**Cultural Practice**

**Transplanting**

Tobacco seedlings are best for transplanting when they have from 10-15 cm height, are thick and well hardened. The root system should be thick and bushy, carrying considerable soil.

The sooner plants can be set in the field after pulling the greater their chance of survival, as they suffer less from transplanting shock. Seedlings should be planted so that the heart is not more than an inch above the soil. Shallow planting increases the damage caused by sun scorch.

Ideal seedlings are healthy and vigorous, but have tough pliable stems; soft or brittle stems are easily damaged or broken. Before pulling the plants from the bed, water is applied to soften the soil. The bed may also be loosened by deep forking, working in from the edge progressively as the plants are removed. Rootlets should not be stripped from the plant or tap roots broken too high. If this is happening, the soil requires more moisture or further loosening. When tap roots are too long for easy planting they may be trimmed to about 7 cm long with a sharp knife or scissors.

When a seedling is set properly, the roots are in full contact with the soil moisture. This is accomplished automatically when water is used at transplanting.

To reduce losses from insects, an insecticide should be used in the transplanting water. The young plants are set on side of ridge or on the flat.

It is advisable to plant only in the afternoons and no more plants than are actually required should be pulled from the bed at any one time. A planting out trowel should be used to ensure that the tap root points down into the subsoil and not back towards the surface.

Seedlings should be set somewhat deeper in the soil than they were in the seedbed but not so deep as to cover the first leaf. Once the plants are adequately set in the soil by applying water immediately after planting they should be left for a reasonable time without water to encourage the roots to more down into the moist subsoil. When there is adequate subsoil moisture this period may be from 3 to 6 weeks. Any misses should be replaced at the earliest opportunity, as a lapse of more than a fortnight produces too great a difference between planting.
Spacing

Rows should not be closer than 1.20 cm to allow the free passage of implements once the plants are well established. Within the rows, plants are placed from 45 to 60 cm apart, depending largely on the fertility of the soil. Closer spacing gives a thinner leaf and a smaller plant. Planting too close on a fertile soil will cause too much shading, which can favor the development of white mold and also produce a leaf of poorer quality. Too great an spacing on a similar soil will cause plants to go "wild" and produce a large, heavy-bodied leaf.

The distribution of the plant population in the field of different countries is as follows:

<table>
<thead>
<tr>
<th>Country</th>
<th>Between rows cm</th>
<th>Within rows cm</th>
<th>Plants per hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhodesia</td>
<td>105</td>
<td>60-68</td>
<td>15,377-17,290</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>120</td>
<td>50-70</td>
<td>16,139-11,527</td>
</tr>
<tr>
<td>India</td>
<td>82</td>
<td>82</td>
<td>14,180</td>
</tr>
<tr>
<td>New Zealand</td>
<td>105</td>
<td>45-53</td>
<td>20,490-17,666</td>
</tr>
<tr>
<td>Japan</td>
<td>95</td>
<td>45</td>
<td>22,675</td>
</tr>
<tr>
<td>South Africa</td>
<td>90</td>
<td>30-45</td>
<td>35,200-23,910</td>
</tr>
</tbody>
</table>

Irrigation Tobacco

In years when rainfall is so low that tobacco crop would normally fail, an irrigation system can be used to produce an average yield of high-quality leaf. Even in years when rainfall is high but poorly distributed - an irrigation system can be used to apply water at crucial stages of growth to increase yield and improve quality.

In irrigating tobacco, as in irrigating other crops, time and almost of water application are important. Applying too much or too little water on applying it at wrong time, may reduce rather than increase profits.

Water management is especially critical on soils that have poor internal drainage. Heavy clays or silts characteristically have poor internal drainage. The problem also occurs in soil that have high water tables or underlain by hardpans. Because of the danger of serious root damage if rainfall is high during the growing season, tobacco usually is not planted on such soils. If you must plant and irrigate tobacco on a soil with poor internal drainage, make lighter applications of water than are recommended for other soils. Light applications reduce the danger of waterlogging from subsequent rains.
Preliminary Steps

Before you invest in an irrigation system, be reasonably sure that irrigation will be profitable. Check on:

- Water supply—Be sure there is enough water for the project you have in mind, and that it is not contaminated in any way that would make it unsuitable for irrigation.
- Well drilling—Drilling and casing are expensive, perhaps you should have a test boring made to find out whether drilling a well is justified.
- System design—The system should be primarily designed for the field, the crop, the water supply and the labor.
- Soil type and topography—Construct farm ponds on ground water reservoirs only on site where tests have shown that soil type and topography are favorable. Also, have soil tested on the field that is to be irrigated; some soils are not suitable for irrigation.

In addition, thoroughly investigate the legality of withdrawing water from any sources for irrigation purposes.

General Guides

It is not possible to give specific instructions for irrigating tobacco; there is too much variation in rainfall pattern, soil type, temperature and other factors that affect moisture availability and rates at which plants use water. However, there are general guides that are helpful in making the important decisions—when to irrigate and how much water to apply.

Following are instructions on how to use:

- Stage of growth as a guide.
- Soil moisture as a guide.
- Soil texture as a guide.
Stage of Growth as a Guide

The stage of growth can serve as a guide to irrigation because the moisture needs of the plant are different at various stages of growth. The two times in the growth of the plant when moisture is most necessary are at transplanting time and during the period between the knee-high and full-bloom stages of growth.

Transplanting Time.

Plant survival is the main concern at transplanting time; irrigation probably will be uneconomical if plant can survive without it. If rain does not come at the proper time to supply soil moisture during this period, irrigation water may be applied—

- The day before transplanting, to prevent clod or crust formation.
- The morning after transplanting to avoid leaf bruising—leaves generally wilt during hot, dry periods following transplanting.
- Before and after transplanting—often, both methods can be used to advantage during periods.

Water applications at transplanting time should be light—$\frac{1}{2}$ to $\frac{3}{16}$ inch for sandy soils and 1 to $1\frac{1}{2}$ inches for fine-textured soils.

Transplanting Time to Knee-High Stage

From transplanting time to knee-high stage, visible signs of wilt can occur without lowering the yield or affecting the quality of the crop at harvest. Irrigation probably will be uneconomical unless there are signs of rather severe stress. If the water supply is limited, this is the time to conserve water, rather than during the next period of plant growth.

If soil moisture reaches such a low level that plants are obviously suffering, however, irrigation water should be applied. This also should be a light application—about the same as that recommended for irrigating at transplanting time.

Knee-High to Full-Bloom Stage

The most critical period in the growth of the crop is between the knee-high and full bloom stages of growth. Plants develop rapidly then, and their demand for water is high. During this stage of growth, do not wait for visible signs of wilt to occur before you apply water—use soil moisture on soil texture as a guide for determining when you should irrigate.

After Full Bloom

Slight wilting after full bloom stage should not be taken as indication that you should irrigate. If it appears that an irrigation is necessary to prevent severe wilting use water conservatively—apply only about as much as is recommended above for irrigating at transplanting time.
Explanation of Terms

To make the discussion that follows more clear, these terms are explained.

Field Capacity: The highest amount of moisture the soil can hold under conditions of free drainage after excess water has drained away following a rain or irrigation that has wet the whole soil.

Available Water: The plant of water in the soil that can be taken up by plants at roles significant to their growth; often expressed inches of water per foot depth of soil. A medium-textured soil normally stores about 2 inches of useable water per foot depth of soil. Sandy soil stores less, fine-textured soils store more.

Evapotranspiration: The combination of surface evaporation and plant transpiration by which available water is lost.
SOIL MOISTURE as a GUIDE

Between the knee-high and full bloom stages of growth, irrigation usually should start when about half of the available water has been removed. There are a number of methods estimating when soil moisture falls to this level. Some of them require tests by trained persons with special equipment. Two methods sufficiently accurate for on-the-farm use are:

1. Squeezing a soil sample in the hand and observing its physical condition after squeezing.
2. Keeping a day-by-day record of estimated water use and of water added to the soil.

Hand Test Method

Squeezing soil in the hand is somewhat crude method of estimating soil moisture, but it is widely used and farmers experience in other countries shows it is a worthwhile method. If you wish to follow this method, take a handful of soil from a depth of 6 to 9 inches. Squeezing it firmly, and observe its physical condition. Soil moisture is probably is at about the 50% level or less when:

- Moderately coarse-textured soils (sandy and loamy sands) do not remain compacted when pressure of the hand is released.
- Medium-textured soils (sandy loams) form a ball, but the ball begins to break up when the hand is opened.
- Medium-fine and fine-textured soils (loams and clay loams) for a stable and slightly pliable ball.

Record Keeping Method

A day-by-day record of the soil moisture supply will help in estimating the balance of available water. Accuracy of the method depends on knowledge of the water-holding capacity of the soil, the daily water loss, and moisture added to the soil by rainfall or by irrigation.

Soil Texture as a Guide

Soil texture can also be used as an irrigation guide from the knee-high to full bloom stage of growth to prevent moisture deficiency. Table 1 is a general guide for amount and frequency of water application for soils that range in texture from sandy to silt and clay loams.
This guide is based on knowledge of how rapidly the moisture level falls in soils of various textures.

Table 1 - A guide to irrigate based on water-holding characteristics of soils of various textures.

<table>
<thead>
<tr>
<th>Soil texture</th>
<th>Interval between Irrigation</th>
<th>Amount of water to apply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Days</td>
<td>Inches</td>
</tr>
<tr>
<td>Sands</td>
<td>3 - 7</td>
<td>0.50 - 0.75</td>
</tr>
<tr>
<td>Loamy sands</td>
<td>4 - 9</td>
<td>0.75 - 1.00</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>6 - 16</td>
<td>1.00 - 1.75</td>
</tr>
<tr>
<td>Silt and clay loam</td>
<td>7 - 17</td>
<td>1.00 - 1.85</td>
</tr>
</tbody>
</table>

1 Time required for about half the available water to be lost if there is no rain. If there is a rain, compare the amount of rainfall with figures in the right column to decide how long to postpone the next irrigation.

2. Approximate amount of water required to restore root zone to field capacity after about half the available water has been lost (with all allowances for evaporation and other unavoidable loss).

However for experimental purposes, tensiometer can be used to determine amount of moisture in the soil.

Using The Guides

The choice of a method to use in determining when and how much to irrigate should be based on your personal preference and experience. If you have no preference or experience, the following are suggested until you learn which method is best suited to your farm:

- During the early and late stages of growth, use plant condition as a guide. Don't irrigate until plants show signs of wilt, then irrigate lightly.
- Between knee-high and full bloom stages of growth, anticipate moisture needs. Irrigate before the plant suffers from lack of moisture. Follow one of the methods described in this handbook for using the soil as a guide to irrigation.
Cultivation

After the transplanted seedlings have commenced to grow the cultivation of the crop should begin. No crop responds more to cultivation than healthy tobacco.

Apart from breaking the crust just around each plant, cultivation should begin 10 to 14 days after planting out. The aim of such cultivation are:-

(1) to destroy weeds, which would compete with the crop for water and plant foods.
(2) to aerate the soil.
(3) to break the surface crust and make the soil permeable to rain or irrigation water. The implements used is lilestone mounted tractor.

Further cultivations are given after each waterings and with each operation a little soil should be moved towards the plants to form, ultimately, a distinct ridge along the row.

When the plants have grown 15-20 cm a second deep, cultivation may be given on these soils provided care is taken not to go too close to the row and so cut the roots. This operation consists of:-

(1) Throw a furrow away from the row on each side.
(2) Break the soil between the plants with a hoe.
(3) Flough back towards the rows and clean out the center furrow with a sweep blade.

For best results and to assist in drainage, tobacco must be grown on ridges. Initially these should be broad with flat tops to allow better absorption of early rains, with less danger of erosion than high narrow ridges. Ridges should be built up by two or three re-riding operations after the crop is established but before the plants are too large. Later re-riding can damage roots and adversely affect quality and yield. To minimize erosion losses, the furrows should be as flat as possible.

Apart from re-riding, cultivation is generally only necessary for weed control and draw soil around the exposed plant stems. Sandy soils are sufficiently porous under most conditions, and cultivation for soil aeration on infiltration of rain is not necessary. Certain soils, however, particularly those with poor physical characteristics (derived from sedimentary rocks), do not tend to crust or cake severely; on such soils, cultivation when necessary to break the crust will be of benefit.
The purpose of this operation is to construct ridges for tobacco plants in such a way as to give the plant the "ideal" environment by way of soil, space and drainage. Ploughing and harrowing to the correct standard should have resulted in a suitable soil tilth, an essential factor in creating the ideal environment for the plant.

The following points should be born in mind when setting up the machine for ridging:

1. Height of ridge.
   A final height of not more than 15 cm to 20 cm, except where the furrow is used for irrigating in that case, the ridge must be built up to 25 cm. This may be achieved when re-ridging.

2. Shape:
   Preference for a broad based ridge, with a flat slightly convex top. The top should be about 25 cm wide. The flat top will facilitate planting and will assist the infiltration of early rain.

   It is desirable to have a small time, fixed to the arm carrying the ridging discs, which will mark the center of the top of the ridge with a narrow furrow. Plants should be transplanted on this line. With the plants in this furrow, equidistant from each edge of the top of the ridge, re-ridging by machine will be easier than when the plants are off center. Plants out of line tend to be adversely affected by mechanised re-ridging.

   The furrow between the ridges should have a "U" shaped profile rather than a "V" to facilitate walking down the rows.

   It may recommended that the ridges be placed alternately wide and narrow. This reduces losses due to broken leaf when topping, sucking and reaping. The wider spaced row should be used as a walking lane and the above operation are carried out when standing in this lane.

Cultivation is a group term used by tobacco growers for operation consisting of three processes namely:

- hand hoeing and weeding
- machine cultivating
- re-ridging

The processes are interdependent and to minimize expenditure on labor, their combination should be such as to make the hand operations necessary on a small scale as possible. The purpose of cultivating are; to control weed growth, to aerate the soil, to improve water infiltration and to build up the ridges.
A - Hand Cultivation

The conditions under which hand cultivation is carried out were found to vary considerably. If it is considered that the rates of working are high, given later in this section, this is because they are based exclusively on conditions where earlier operations such as ploughing ridging, having been carried out correctly and remedial measures, such as breaking up of large clods of soil have not been necessary. In addition, the work values have been determined on the use of the swan-necked hoe, with the minimum amount of hand hoeing and the maximum mechanical work.

Hand cultivation consists almost entirely of removing weeds, by hoeing. Hand cultivation is also used for breaking up the soil crust. To obtain optimum results with minimum labour expenditure the operation should be carried out as follows:

- Hoe only in conjunction with machine cultivation or re-ridging.
- Hoe only the top 3m or so of soil to avoid damaging the fine hair roots which are found near the surface of the ridge. Damage to these fine roots will retard the plants by reducing its capacity to absorb water and nutrient.
- Hoe areas of weed infestation only
- Hoe at a stage when most damage will be done to weeds and their removal from the soil assured or their growth severely checked. This will normally be made before they reach a height of 10cm.
- Do not allow weeds to get out of control.
- If the weed infestation should, however, get out of hand, use a machine method for the furrows and lower slopes of the ridges and limit work to within 20 cm on either side of the plants.
- It should never be necessary to use hand hoeing to build up the ridge volume with soil from the furrow.

B - Machine cultivation including re-ridging

These processes, which can in most cases, with the correct solution of times and re-ridging bodies, be carried out together are best described as follows:

- Where a heavy infestation of weeds exists, it is more economical and quicker to destroy those in the furrow and on the lower slopes of the ridges by tractor operations.
- Where the weed infestation is light, those in the furrow and on the lower ridge slopes can be dealt with when building up the ridges by mechanical re-ridging, in both the above cases the weeds in the area close to the plant (about 20 cm on each side) should be hand hoed.
all machine work should be confined to the topmost soil except in the furrows and any mechanical equipment used for breaking down the soil on the side of the ridge must be used with extreme care even a slight excess penetration will cause serious damage to the plant root systems.

- When re-ridging, aim to gather as much soil as possible from the tobacco furrow which should be picked up and incorporated on the sides and top of the ridges. In carrying out this operation the most successful result is obtained by keeping the tractor speed between 3 and 4 miles per hour.

Important factors necessary for efficient machine cultivation are the correct initial shape of the tobacco ridge and the matching of the implement used to the initial ridge design. It is also important to ensure that plants are transplanted to station along the center line of the ridge.

C. Cultivation heavier soils

The very nature of soils such as sandy clay loams, makes it necessary to carry out cultivation not only to destroy the weeds, but also to break down any definitive soil crust which develops due to the action of the rain and sun.

Cultivation in these soils is best done as follows:

- Cultivation mechanically initially to loosen up the soil and subsequently to build up ridges.
- Hand hoe along the whole of the top of the ridge within the area not cultivated by machine.
- Hand cultivate only when the weed infestation warrants the work on in heavier soils, when it is necessary to break the soil crust.
- Machine cultivate and re-ridge for the 1st time as soon as the plant is large enough not to be buried by the soil thrown up. Subsequent cultivations should be carried out before the plant is too high to be straddled by the machine.
- Discontinue cultivating when the plant has reached a height of 45 cm. The number of times that cultivation is necessary depends largely on weed growth and weather conditions. An assessment must be made by the grower.

A - suggested normal frequency is given as follows:

- Within about two weeks of planting, machine cultivate and re-ridge, possibly as one process or separately if desired. Follow immediately with hand hoe on the top of the ridge.
at weekly intervals check weed infestation and control by hoeing as necessary.

continue machine cultivating and re-ridging as necessary until the plants are too tall to be straddled by the machine. Hand cultivate at the same time.

For hand cultivating the use of the swan-necked hoe is recommended because a considerable saving in labor with improved work results when using this hoe compared with the traditional hoe. The main dimensions of the hoe should be as follows:

- handle: 140-150 cm long.
- blade: 18-24 cm wide and 5 to 8 cm deep, with an angle of 60° with the handle.

Machine cultivating and re-ridging bodies may be drawn by oxen or tractor. The tractor is undoubtedly quicker and for effective re-ridging it is necessary to drive at between 4 and 6 km/h. Mouldboard, duck foot or disc bodies, all of which can be mounted and hydraulically operated, may be used.

Fertilizer

The application of fertilizer

Fertilizer can be broadcast or placed. Well before the application of fertilizer, one has to determine what kind fertilizer to use at what rate and how to place it. In addition to these the soil tests should be done, in applying fertilizer one should have to aim for top quality in tobacco and high net return. This action calls for a fertilization plan based on soil tests, depth of topsoil, and overlook some other important thing. These include soil texture and drainage, differences in varities, the effect of your rotation on cropping system, the quality of tobacco that is in demand, and your past experience with tobacco.

Any sound fertilizer program should be based on supplying the kinds and amount of nutrients needed to grown the crop and maintain the soil supply. Caution should be taken, however, not to use excessive quantities because of possible damage to the crop and/or excessive fertilizer costs.
Method of Application

Fertilizers can be broadcast or placed. Placement can be in a double or single band in the ridge, in the planting hole, in one on two dollops at the side of the planting station, a circle on the surface around the plant on deep placement at 25-40 cm. Practise varies and methods which has given poor results under some conditions may be those successfully practised in other places. For instance, where very large dressings are being applied before planting, any form of placement may be dangerous and the material is better broadcast.

There may be many kinds of application, however the most important ones are as follows:

- **Pre-Planting applications**, where the fertilizer is applied before planting.
- **Split application**, where the total fertilizer application is split into two parts, one being applied before planting and the other part not later than three weeks after transplanting.
- **Post-Planting applications**, where all the fertilizer is applied not later than three weeks after transplanting.

Under any circumstances placement in the planting hole is a hazardous practice. Unless the dressing is small and it is very thoroughly mixed with the soil, there will be root burn and even killing plants, is still high.

Rate of Application

It is very difficult to recommend the rates of fertilizer application, on the kinds of fertilizer for a particular area. Soil tests are fertilizer trial experiments should be done for several years, before determining the right rate.

Following the work done on that subject at various tobacco research stations of major tobacco producing countries, the fertilizers formula always included NPK elements in different types of soil. For instance on flue cured tobacco the growers are suggested to use in:

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P</th>
<th>K (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>20-50</td>
<td>70-90</td>
<td>70-120</td>
</tr>
<tr>
<td>Rhodesia</td>
<td>10-40</td>
<td>70-110</td>
<td>75-100</td>
</tr>
<tr>
<td>India</td>
<td>20-50</td>
<td>70-110</td>
<td>70-120</td>
</tr>
<tr>
<td>Canada</td>
<td>22-35</td>
<td>100-120</td>
<td>90-110</td>
</tr>
<tr>
<td>Japan</td>
<td>130</td>
<td>150-190</td>
<td>100-130</td>
</tr>
<tr>
<td>Australia</td>
<td>10-40</td>
<td>70-90</td>
<td>100-140</td>
</tr>
<tr>
<td>Brazil</td>
<td>25-35</td>
<td>60-80</td>
<td>50-65</td>
</tr>
<tr>
<td>Tanzania</td>
<td>10-35</td>
<td>180</td>
<td>40</td>
</tr>
</tbody>
</table>
For the Middle Valley, since there is not any work done along this line, F.A.O. Tobacco Consultant, Vanberice has suggested the following rates just to begin the programme at Melka Werer Station. His reasoning that there is no accurate information on the nutrient elements available in the soils of the region, it is consequently essential, at the beginning of the programme, to use a heavy, perhaps excessive, NPK dressing on the tobacco trials. Fertilizer experiments will later make it possible to determine the economic fertilizer rates needed. On this point, it would be advisable to carry out pot tests on these soils to diagnose mineral deficiencies so as to supplement the incomplete information obtained by soil analysis. basic NPK formulae:

- Light Air Cured Tobacco: 80N-150P-100K
- Dark Air Cured Tobacco: 120N-150P-100K
- Flue-Cured Tobacco: 20N-150P-100K
The purposes of removing the tops is to divert into the leaves nutrients which would otherwise be used by the plant to produce seed. This operation increases leaf weight, but if the leaf already has enough body, topping may be delayed or eliminated altogether. It is normally better to top high rather than delay the operation. The time to top is when flowers are showing 30-50% bloom in the field and the first topping should be carried out high on the plant unless the crop is light, when it can be lower. Topping is done one to two days after irrigating or following rain. This method is to bend the stem sharply between thumb and forefinger.

Topping tobacco plants is a small job but important operation, which occurs during peak labour loads and, if incorrectly carried out, can affect the quality of tobacco leaf and yield, particularly from the middle and upper leaves.

Topping increases the weight and size of a leaf and alter its chemical composition. Young leaves respond more to topping than older leaves and therefore the earlier plants are topped, the more leaves are affected.

Early topping, when the flower bud is clear of the upper leaves (extended bud stage), result is a high proportion of heavy bodied, relatively dark-coloured leaf. Late topping, when the plants are in full flower, on the other hand, produces a low proportion of heavy bodied, darker coloured grades in the crop and consequently decreases the crop's yield potential. It also result in an overall lower nicotine content but increases the susceptible varieties to white mould and other leaves necrosis.

The number of time topping will be required to be carried out in a land depends on the percentage of the plants ready for topping at any one time. This is related to the uniformity on eveness of growth in the land. With an uneven stand, topping may have to be carried out in up to three stages.

That frequency of topping has a more marked effect on the crop than different heights of topping and the number of leaves removed during topping should be governed primarily by the growth potential of the upper leaves, which will be less for late than early topped leaves. The upper most leaf remaining on the plant should attain a saleable size at maturity. The method of topping consists of grasping the growing point with the thumb and first finger and breaking it off at the required position without damaging the small leaf adjoining the breaking point on any of the remaining leaves on the plant.
The broken off top is dropped into the furrow.

Hands and fingers, however, get sticky with gum from the plant when topping and the provision of soap and water for washing the hands after every four or five rows may be considered.

The additional time this occupies is offset by a very slight increase in the speed of topping when the fingers are free from gum.

Each labourer works independently along the rows in his area. The size of the gang will depend on the hectareage to be topped, the period during which the operation is to be carried out and the rate of working. Plants in the land suffering from tobacco mosaic should not be topped by the worker walking down the row. A separate labourer should be attached to the gang for the purpose of topping these sick plants to reduce the likelihood of spreading the disease.
**Suckering**

Suckers should be removed when they are 2 to 6 cm long, when they are easily broken by pressure of thumb or finger. When both hands are used and the spiral arrangement of the leaves on the plant is appreciated the operator soon becomes adept at removing these suckers. If suckers are allowed to grow too large they are not easily removed and frequently the adjoining leaf is broken off. Even with the use of a knife the large suckers take longer to remove and so the overall cost of production is increased. Three to six desuckering operations may be necessary before harvesting is completed. Suckering is more difficult when the plants are in need of water.

When the plant is topped the growth of suckers is greatly stimulated and care should be taken to remove them before they begin to affect leaf quality adversely.

Suckering is a relatively simple operation in tobacco crop management but like topping, is of vital importance and occurs during the peak labour load. Leaf quality and yield will suffer if the operation is delayed, neglected or badly carried out.

The purpose of suckering is to improve leaf weight and quality by forcing the growth of the leaf which would normally lead to the development of suckers if they were not removed. The extent to which topping affects the crop can be controlled by various degrees of sucker control, which should be complete if the full benefits of early topping are to be obtained.

Partial sucker control reduces the body and nicotine content of middle and upper leaves and crops treated in this way produce a relatively high proportion of lighter coloured leaf and tip grades. Allowing suckers to develop shortly after topping has advanced stage of growth has correspondingly less effect. As with late topping, complete sucker control reduces the yield potential of the crop.

Production of higher bodied leaf following late topping and incomplete sucker control is associated with a relatively rapid of ripening; the factor must be taken into consideration when planning handling and curing facilities.

Suckers can either be removed by hand or their growth prevented by the application of a contact or systemic chemical compound.
Suckers should be removed from the plant as soon as they can be conveniently handled without damage to the leaves on the plant, and before they reach a length of 10cm. The frequency with which plants should be suckered depends on the rate of growth of the suckers, and on the quality needed in a specific area.

The number of labourers required will depend on the heetorage to be suckered, the period during which the work is to be carried out and the rate of working. The rate of working depends on the removed. The spacing of the plants has no significant effect on the value. The length of the sucker, if over 10cm, has a considerable effect of the value.
Duration of The Crop

Because of unknown of climatic conditions which occurs in the Middle Valley and the planting time (date) not yet adopted, a definite time from planting to harvesting dates for any particular variety cannot be given.

In an average crop the bottom leaves should be showing signs of ripeness 10 to 13 weeks after setting out in the field. From this time it should be possible to harvest some leaf each week for the next 6 to 10 weeks.

Ripening

Tobacco leaves ripen progressively from the base of the plant upwards. When leaf has reached full size it becomes rough to the touch and somewhat brittle. As it ripens it should feel velvety rather than sticky and furry.

Ripeness is indicated by a rather rapid change in colour and occurs in the lower leaves about flowering time. It is the change which should be watched as the general colour of the crop is governed mainly by variety and the availability of soil nitrogen. In the average crop the nitrogen supply from the soils should be waning as the crop is maturing. The colour change throughout the crop should therefore be from a green to a greenish yellow, with the ripe leaves being on the yellow side. In some varieties the midrib of ripe leaf becomes white and smooth. On heavy soils, particularly those of higher fertility, the yellow will appear only as flocks on the leaf surface. Where the plants have been starved for nitrogen all leaves may be more yellow than green and if colour alone is used as a guide many leaves will be picked which are immature.

The best indication of ripeness is probably the definite change in colour of the leaf blade which occurs close to the stem. Practical experience is necessary to enable all leaf to be harvested at the correct degree of ripeness, with leaf from near the base of the plant it may be possible to cure it properly if it has been picked before being fully ripe, as the tip leaves are approached, however, it becomes increasingly important to ensure that the leaf is fully ripe or perhaps even a little past this stage.
In some places where nitrogen tends to build up in the soil while the crop is being produced, an extra heavy watering is given to accelerate "ripening". One of the main effects of this practice is to leach out the readily soluble plant foods in the root zone at that time, particularly the nitrogen. It should not be allowed to become a "drowning."

**Harvesting**

When there are two or three ripe leaves per plant, harvesting should commence. The ripe leaf is picked from the plant as it reaches the correct stage. This is known as the priming method of harvesting. From 2 to 6 or more leaves may be picked from any one plant on each occasion but 3 to 4 leaves would be the usual number. The number of ripe leaves should be judged as the plant is approached and the topmost of these picked first, working down the plant.

**Method of Harvesting:**

We have assumed that the crop is harvested by picking the leaves when are ripe, that is, starting from the bottom, every 3 or 5 days three to four leaves. This method of harvesting is called priming. However, in some other countries and for some varieties, the whole plant is cut off. It will be used understood that in this case one harvests partly over-ripe, partly ripe and partly unripe leaves. This method of harvesting called stalk-cutting, used in the case of Light Air Cured Tobacco (Burley), very often the stalk method is followed.

2. High growing plants with 20-30 leaves are not very suitable for stalk-cutting, but low growing ones which offer not much time between the ripening of the lower and low growing ones which offer not much time between the ripening of the lower and the top leaves can be harvested in this way. It is also important how the leaves are inserted in the stalk. In the so-called "stand-up" type (Burley), the lower leaves do not perish so soon. Still, often the very bottom leaves are primed, and later stalk-cutting is applied to rest of the plant.

3. Changing from one method to another may affect type of the end product. It will be understood that the chemical composition of the harvested leaves by stalk cutting is not the same as that from primed leaves.
When the stalk-cut plants hang close together in the dry shed, assimilation is not possible, but dissimilation and transport from the older leaves to the younger ones continues. This may be partly favourable because it keeps the younger leaves fresh for a long time and they do not dry up so green as they would have done if picked. On the other hand, so many carbohydrates and N-containing compounds are transported from the leaves to the stem that about 10% of the total of the weight of the tobacco is lost.

It will also depend on the soil on which the tobacco was grown and on the varieties, if priming is to be preferred or stalk-cutting. A strange phenomenon is that primed leaves, although losing less total nitrogen, lose much more nicotine than stalk-cut leaves. As a rule, priming should be preferred to stalk-cutting as in the case of flue-cured Virginia tobacco.

**Priming**

In picking the leaves from the plant, one should not bend the midrib down, but sideways, using only one arm, where as the other is used to receive the picked leaves. Without pressing or cracking them, one can easily hold 30 leaves on one arm. This heap is then carefully put in a basket, with the tips upwards, or on a stretcher, in which case they should be laid down flat.

Whatever the method of collecting and transporting is, the price to be paid for the leaves depends to a large extent on the care taken during harvest. A very common mistake is to leave the harvested leaves too long in the field or hang them in a windy place so that they wilt before entering the curing barn.

As we would see on curing heading, the leaf has to be still alive during the first phase of the curing. If it dies too soon, the change of the green color into yellow will not take place. This is very important in flue-cured cigarette tobacco.

About the influence of the time of day and of the weather, the following can be said. Investigations have shown that there is not much difference in the leaf if one compares milday and late afternoon, which indicates that during the second half of the day as many carbohydrates are being transported as are being produced. In the very early morning the content of starch is lower, so one should not harvest too early. On the other hand, harvesting in the middle of a hot day would result in wilted leaves. In the case of flue-curing, the barn must be filled the same day. Harvesting is therefore mostly started as soon as the dew from the leaves has disappeared.
Cigarette tobacco is harvested during the dry season of the year. When there is not much water in the leaf, the assimilates are not easily transported, but accumulate in the leaf. But if one shower of rain falls in the time while tobacco is ripening, it suddenly becomes young again. The colour becomes more green and the assimilates are transported quickly. When an unexpected shower occurs, one either has to harvest the same day, before too many changes take place, or else wait until the tobacco ripens again.
Stringing

Leaf from the field is held in loosely rolled hessian or basket in the stringing shed until it is ready for the operation of stringing. The bundles are then opened out on the tables with the tips all one way and the leaf strung on sticks. The sticks are normally 2.5 cm across and either round (bush) or square (sawn). They may be 1 to 1.5 cm in length. The string used should be of a type which will not fray nor form a felted mass when the tobacco goes into manufacture. A white twine is easier to see, and consequently to remove while grading. Unsized jute string should not be used.

A stick is place on a waist-high stand ("horse"), the string tied 10 cm from the end furthest from the operator. Two or four leaves are then taken in the left hand 5 to 8 cm below the butts, which are pressed against the stick while the right hand is used to pass the string anticlockwise around them. At the same time the leaves are given a half twist to make the butts come close together and cause the string to bind tightly. The string is held taut and another bunch is placed on the opposite side of the stick, this time passing the string clockwise around the butts. This process is repeated until only about 10 cm of stick are left, when the string is passed through slot made for the purpose or tied off.

The extremity of the butts should finish about 2.5 cm above the stick. Number of bunches to a stick will vary greatly with the size of the leaf but will generally range from 20 to 30.

If two operators are available one may pick up the leaf from the table and the other tie. The man picking leaf from the table gets the butts even and holds them at the extremity of the butts when passing the bunch to the stringer. The completed sticks are carefully laid on a bench or placed in special rocks. As soon as sufficient sticks are prepared the filling of the barn can commence. Again special care must be taken to avoid bruising.

Filling The Barn

The sticks with the leaves attached should be placed on the tiers in the barn about 20-25 cm apart so that the wilted leaves barely touch. It is advisable to fill the barn in one day with leaf which has picked earlier the same day. A partly filled barn is often easier to handle than one which contains two days' picking.
However with 4.80x4.80m (16ftx16ft) or larger barns, it may be necessary to take two days to fill barns. When this is done, the first day's picking should be placed in the lower section and a space left through which the second day's picking can be passed up to the top section. It is better to follow this procedure than to leave the leaf, strung on the first day, on rocks in the open where it may be subjected to cold dry winds. When the barn is full, readings of the wet and dry bulb thermometers within the barn are taken. The door and all ventilators are then tightly closed. Low heat is then applied.

**Curing**

The fresh leaf as it goes into curing barn usually contains about 80% of water, most of which is evaporated during the curing process. This is also an appreciable loss of dry matter in curing, often amounting to as much as 20%. After curing, the leaf, when in good condition for handling, ordinarily contains 20 to 25% of moisture. Therefore to obtain 1500 kgs of cured leaf, which represents the average yield of tobacco per hectare, it will require about 7500kgs of the fresh leaf, and 6000 kgs of water will be lost in the process of curing if at the end of curing the leaf contains 20% moisture. The successful curing of tobacco requires that, in disposing of this large excess of water, the drying be accomplished at such a rate and under such conditions as will allow those chemical transformations to take place that are needed for development of the desired qualities in the leaf. Although the properties of the cured leaf are largely dependent on its characteristics as it goes into barn, the conditions under which the curing takes place also are highly important. It is obvious, therefore, that the conditions of the curing must be under the control of the operation if best results are to be obtained, so that some sort of enclosed structure is a necessity. Moreover, the character and extent of the chemical changes required for successful curing vary with the type of tobacco involved, so that modifications in the structure for housing are necessary for curing the different types.

**Different Method of Curing**

The word curing is used, and not the word drying, because the process which the tobacco undergoes after harvest in not simply making the leaves dry. We could describe good curing as drying the leaves in such a way that undesirable compounds are eliminated and compounds which improve the quality are retained. There are different ways of curing, such as air-curing, flue-curing, fire or smoke-currings each leading to a different product. In our case we would like to concentrate on flue-curing.
Flue-Curing

The flue-curing derives its name from the metal pipes, or "flues" used in the process. The heating system in the curing barns consists of metal flues connected at one side to the furnace, running across the floor of the barn while on other side to the chimney. In other countries experience has indicated that twin furnaces give a maximum uniformity of heat with a minimum fuel consumption. The source of fuel can either wood or diesel.

Main points of flue-curing. The process, which takes about 5 days, is divided into three periods—yellowing, fixing the colour and drying. During the first period, drying of the leaf is avoided as much as possible. A building must therefore be used which can be totally closed so that the humidity of the air can be kept near 100%. To obtain this the harvested leaves should be hung in the building as fresh as possible. They are still alive, the respiration goes on and also other bio-chemical reactions of a ripening leaf, with the differences that no transport of matter from the stem of the plant to the leaf on in the opposite direction is possible. What one can see during this period is that the green colour of the leaf disappears and a yellow colour remains. Inside the leaf tissue, the starch is transformed into sugars and many protein compounds, which would give a better taste to the tobacco, are broken down. Most of these reactions can happen only as long as the leaf is alive, which means only as long as it contains sufficient moisture.

After the green colour has disappeared sufficiently, one start to dry the leaf under slowly rising temperature and restricted ventilation. Later on, more ventilation and higher temperatures are to be applied. If drying is not started soon enough or goes too slowly, the yellow colour changes into brown, and many sugars are lost.

Flue cured tobacco may show curing faults as follow: brown scald, green scald, sponge, scorched dead tissue, swell stems and barn rot etc. We can reduce or eliminate most of these curing faults with proper ventilation and temperature adjustments during the curing process. Barns must have suitable bottom and top adjustable ventilators. Heat and moisture are controlled by proper and timely adjustment of ventilator openings and temperature controls.
Curing following the position of the plant

**Yellowing**
- bottom - 35 hrs
- middle - 50 "
- top - 60 "

**Fixing**
- bottom - 35-70 hours
- middle - 50-90 "
- top - 60-110 "

**Drying**
- bottom - 70-110
- middle - 90-135
- top - 110-155
The quality and even the yield of flue-cured tobacco depend on curing to a large extent. Proper curing sets all the qualities of tobacco. Nevertheless, these qualities must be present, and the characteristics of the leaf at harvest time are therefore the important factor. The best result can be obtained only from a consistent and well mature crop. But the leaf of a good quality in the field can be damaged or even spoiled by bad handling or loading, bad curing or inadequate curing equipment. Quality may be even more reduced if the moisture content during the rehumidifying stage is too high; the leaf redden and mould may appear during storage.

Leaf Preparation for Curing

The maturity status of the leaf at harvest time is one of the determining factors of the quality on the finished product. The best is to harvest the lowest leaf sometime after maturity and the middle and top leaf when they are mature. Successful curing requires that the leaves are harvested at the same stage of maturity and at the same position on the plant. From this, plants must be of the same age and of homogeneous size and the field fertility must be uniform. Cultural practices allowing the same growing and development rhythm are therefore absolutely necessary.

It is not recommended to harvest no more than two bottom leaves at a time and no more than three leaves in the middle of the plant. Four to five top leaves must be kept for the last harvest. Not advisable to harvest after heavy rains because maturity becomes again momentarily reduced due to the fact that plants uptake again the nutrients. Under these conditions the curing is poor and the leaves are of bad quality.

Equipment

To obtain proper curing the air around the leaf must be maintained within relatively reduced temperature and relative humidity limits. Well regulated moisture is as important as well adjusted temperature. To this end a hygrometer consisting of a dry and wet bulb and a table to determine relative humidity is used.
The objective in curing tobacco is to preserve the leaf by timely drying while retaining the potential quality of the cured leaf. So tobacco curing then, is more than drying the leaf.

It involves chemical and physical changes which are necessary to obtain the high quality degree suitable for manufacturer and consumer acceptance. We must understand these changes to visualize what is happening inside the leaf. This enable us to use the controls to influence the curing process in the right direction.

Proper curing is both a biological (living) and drying process. A mature leaf as it is taken from the plant is a living complex system. It normally contains from 80-90% water and 10-20% solids. About 2% of the solids is starch. The remaining 75% is made up of numerous biochemical compounds, pigments (colour), mineral, cell tissue, etc.

In curing tobacco, we strive to:

1. Maintain life within the leaf until certain biological (living) processes take place (yellowing stage)
2. Stop chemical and enzymatic (digestive) activity by timely removal of leaf moisture (color setting stage)
3. Preserve the leaf by complete drying (killing out stage)

Change during the Yellowing Stages

In the early part of the cure (yellowing stage) the leaf must be kept alive until certain biological processes take place, the principles of which are the disappearance of the green colour (chlorophyl) and the conversion of starch into sugar.

At the same time, moisture must be removed without hindering these biological processes. Through stomato in the leaf, a continuous exchange of gases (O₂, CO₂) and water can take place. Oxygen when enters the leaf during the curing process is necessary for:-

1) Proper yellowing.
2) Starch conversion.
3) Enzymatic activities during the yellowing stage.

Yellowing occurs as chlorophyl breaks down or disappears. This yellow pigments, which are there initially, are uncovered and become visible. Amount of chlorophyl in the leaf may vary with degree of ripeness, the variety, fertilization etc. However the rate at which the chlorophyl disappears will increase as moisture is removed and as the temperature is raised to about 35 to 41°C or sometimes to 43°C. This is true as long as the leaf contains enough moisture to continue the living processes.
Another important change during the yellowing stage is the conversion of starch into sugar. When the leaf is burned, it is high in starch and low in sugar. Through hydrolysis, combining with water, starch forms glucose. Through respiration, part of the glucose is transformed into fructose can combine with glucose to form suerose. Thus, as the starch decreases with time, the total sugars increase. Although independent of each other, the conversion of starch and the breakdown of chlorophyl occur simultaneously. Thus, the disappearance of green pigment is generally a useful, visual measure of sugar formation.

It should be noted that varieties differ in the degree of yellow showing at given time during this stage. This must be considered in estimating when the leaf is yellow enough to begin the colour-setting procedure. Thin varities that grow with a yellow cast in the field appear ripe than they are at harvest time. They appear yellow in the barn before the desirable chemical changes have progressed for enough. Many times this results in pale, stick, immature leaf.

A small portion of these sugars are burned up (oxidized) and in the process release carbon dioxide that escapes through the stomata. Through the oxidation of sugars, heat energy is released. This energy loss causes the "heating up" of piles of tobacco in the shed or barn. Another important physical change in the yellow stage is the loss of water. Under normal conditions, about 20-30% of the water should be removed from the leaf during yellowing. However, if the leaf is dried too fast the green colour may be set, and certain chemical and biological changes stopped. Then the cured tobacco may give a harsh irritating smoke. The desirable chemical changes during curing and in aging are actually a mellowing process which makes the smoke milder, sweeter and more pleasing.

Change in the Colour Setting and Leaf Drying Stage.

Yellowing conditions are maintained till most leaf have an homogeneous color; lemon, lemon orange or orange. After this the stage of colour fixation takes place. To this end temperature is gradually raised while relative moisture is reduced so as to kill and dry the tissues.

Green tobacco will be obtained if the leaf are not yet completely yellow. On the contrary if yellowing is too long, chemical changes continue and result in a progressive browning of the tissue caused by the production of darkened pigments. This happens when the temperature of the leaf is raised too rapidly and too high while there is excessive moisture in the leaf.
The oxidation rate of polyphenols within the leaf will be excessive. Under these conditions complete browning can occur within a few minutes at a leaf temperature of 54 to 58°C.

Impatience to capture the desirable yellow colour frequently results in the temperature being raised above 54-58°C range too quickly. This results in brown scald. Sponge-graying that results from extending the yellowing period too long should not be confused with the brown scald mentioned here.

Changes in The Stem Drying Stage.

The colour is fixed when the leaf limb has lost the most part of its water. At that time, the lowest part of the limb which are most exposed are completely dried. Only the area of the leaf near the midrib, especially at the basis, contains still some water.

In the killing out stage, the object is to complete the removal of moisture from the stem and leaf so as to preserve the leaf. Once the leaf dry, major bio-chemical changes have ceased. There is some small loss in volatile compounds, which results in a loss of weight, especially if the temperature is raised too high.

The killing out temperature should not exceed 77-80°C. Otherwise, scorching tobacco, as indicated by red pigment, may result.

Controlling The Curing Environment.

With an understanding of some of the change that take place in the leaf during the curing operation, it is easier to provide the correct environment around the leaf during each stage of the cure.

The grower influence the cure by controlling three environmental factors around the leaf:

1) air temperature
2) air moisture content or relative humidity
3) air movement.

These three factors cannot be independently controlled under all conditions. An adjustment to change one factor may alter another factor.
Temperature

Temperature is controlled by the amount of heat introduced into the barn. Amount of heat required to maintain given temperature is determined by:

1) the amount of fresh air entering the barn.
2) the temperature of the fresh air.
3) the amount of water being evaporated from the leaf.
4) how well the barn is insulated.
5) the volume and temperature of the tobacco in the barn.

Relative humidity

Relative humidity, which influences drying rate, is controlled by manipulating both heat and ventilation.

Since there are certain limitations on temperature at various stages of the cure, humidity is adjusted largely by increasing or decreasing the ventilation. As ventilation is increased and more fresh air is introduced into the barn, relative humidity decreases if the same inside temperature is maintained.

Air at higher temperature has more drying potential at the same relative humidity. By raising the air temperature from about 28-39°C, the water holding capacity of air is about doubled. If the relative humidity is maintained constant for those temperatures the leaf will dry about twice as fast as the highest temperature.

Air Movement

Air movement, or air flow, in barns is accomplished by natural or forced ventilation. In natural ventilation, the heated air is lighter than the colder air, causing it to move upward. As the heated air flows upward, heavier outside air tends to press through openings, and settles to the bottom where it is heated and rises.

Thus, the amount of ventilation obtained by natural convection depends on the amount of ventilator opening, location of the openings, and the difference in inside and outside temperature, as well as barn height. Very rapid air movement isn't necessary under normal conditions during the yellowing and stem drying stages in conventional curing.
During the stem drying stages, a small amount of ventilation should be provided after reaching 77°C. This assures low humidity until the majority of the stems are dry, especially in tight conventional barns, reducing the ventilation saves the heat.

**Operational Procedure in Conventional Barn.**

Curing is more or less varying according to:

1. Meteorological conditions.
2. The position of the leaf on the stem.
3. The size, quality and stages of maturity of the leaf,
4. Production practices such as height of topping, spacing and fertilization.
5. Spacing of the tobacco in the barn.
6. Characteristics of different varieties.

With so many variables to contend with it's easy to see why a single schedule hasn't been outlined by which all flue cured tobacco can be cured.

It is important to anticipate the need for ventilation adjustments early rather than lay behind and find the tobacco in a "sweet" and damaged state before vents are opened.

Amount of vents openings in the various stages should be adjusted according to:

1. how tight the barn is
2. how heavily the barn is loaded.
3. differences between inside and outside temperatures.
4. Wind
5. rate at which the tobacco is yellowing and drying.

We should baffle open bottom vents if wind is blowing against one or more sides of the barn. The object is to equalize air movement through the bottom vents on all four sides. Without baffles the wind may blow through large vents openings and sweep the heated air out the opposite side of the barn. Screen wire, sacks, plant bed canvas may be used, if necessary for this purpose.

**General Conditions**

**Yellowing stages.**

1. Start temperature generally 2 to 5°, above outside temperature, or about 28-32° with a relative humidity of about 80-90%. Close down vents and heat just enough, if necessary, to obtain these conditions. Excessive heat at that time may cause the leaf to dry too badly and the green colour to become fixed.
2. In a well isolated barn temperature can be raised immediately or 6 hours after loading from 32 to 41°C, an ideal range for yellowing; it must be maintained till complete yellowing. During this period, the hygrometry in the barn will evolve so as to modify progressively the difference between the dry thermometer and the wet thermometer by 2 to 3 degrees. This can be obtained generally by closing the vents. If ventilation is required try to obtain this difference in temperature by maintaining the top vent closed. On the lower tiers after 12 hours, that is to say early in the day following or harvest, the tip and the margin of the bottom leaf begin to yellow. The middle and top leaf take more time, the tips begin to yellow only after 24 hours or even more. The leaf in the lower tier yellow more rapidly than these on the top tiers.

Time: 12-24 hours
Temperature: 32-41°C
Temperature difference: 2 to 3 degrees,
Vents: bottom: close; top: close or ¼ open.

3. When the leaves are half yellow, increase ventilation to obtain 1 4 degrees difference at the hydrometer. If this difference exceeds 4 degrees, reduce ventilation.
Maintain temperature between 35 and 41 degrees and a 4 degrees difference.
On the lower tiers complete yellowish occurs 30 to 40 hours after loading; at this stage, the midribs and veins are still green. There again the leaf at the bottom of the stem yellow.

4. When the leaf is yellow, except at the midribs and veins, increase ventilation to raise hydrometer difference to 5 degrees. Half open the bottom vents or a quarter, adjusting them as required.
For the late part of yellowing raise temperature progressively to 43°C to set the colour even if the veins are still relatively green.
To make the colour fix more rapidly, offers the advantage to dry the leaf before they are becoming brown. The bottom leaves indeed yellow and brown rapidly if they are not dried. The leaves higher on the stem must have less green veins when fixation starts. The highest leaves must not be green or only very slightly. On the lower tiers generally the leaf become sufficiently yellow after 36 to 62 hours, according to their position on the plant.

Time: 36-62 hours
Temperature: up to 41°C
Temperature difference: 5 degrees
Vents: bottom: ¼-½; top: ¼-½
5) For the next 5 to 10 hours, maintain a temperature of about 44 to 46°C, with a difference of 8 to 12 degrees. By this time the leaf should be a rich yellow colour and the tails slightly curled.

Vents: bottom: open

top: 1/3 to ½ open.

The curer must be careful not to lag or get behind in the rate of drying during late yellowing and leaf drying stage. Otherwise, a "sweet" may develop accompanied by brown scald.

Colour Setting and Leaf Drying Period

For this phase, temperature should be raised and relative humidity rapidly decrease so that the leaf removed from the lower tiers may keep their yellow color.

On the other hand, changes in the temperature and relative humidity must be slow enough to allow the leaf in the higher tiers to keep on yellowing and drying slowly. The best is to modify at the same time both temperature and relative humidity.

If relative humidity is too little reduced when temperature increases the leaf beated (Scalding) more rapidly. Moreover, this scalding will appear the more rapidly and will be the more important the higher will be relative humidity.

1) So the next 10-15 hours, gradually increase the temperature (1-2°C per hr) from 46-55°C.

This is very important stage of the cure.

It requires careful judgment of the condition of the tobacco, progress of color setting and leaf drying.

The leaf browns easily at 55-58°C.

So to prevent undesirable discoloration, the curer should dry the leaf tissue to a save level of moisture before raising the air temperature about 55°C.

- Temperature gradually from 46-55°C (1 or 2°C per hour)
- Difference (dry/wet) gradually form 12-18°C.
- Vents: bottom open; top ½ to fully open,

2) In the next 5-10 hours raise the temperature by about 1 or 2°C per hour, moving gradually up to 65°C in this period.

Vents: begin reducing the opening in top or bottom vents during this period, especially in the latter part.

Killing out stage

Increase the temperature at the rate of 3-4°C per hour until 77°C is reached. Maintain a temperature not over 80°C until the stems are dry.

Vents: reduce the top and bottom vents opening in the early part of this period.
Curing Charts & Tables have been presented. These charts and tables are an accumulation of data of a number of years from other countries. They can be used as a general guide to the procedure assuming the following factors which affect the curing are ideal.

1. Climate - during growth and at the time of curing.
2. Varieties
3. Soil type
4. Fertilizer
5. Irrigation
6. Harvesting - degree of ripeness
   - uniformity
   - Handling (Field to barn)
7. Barn - Insulation
   Ventilation
   - Method of heating
   - Size
   - Shape
   - Loading
CONVENTIONAL FLUE CURING (NOT A PATTERN FOR EVERY BARN OF TOBACCO)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Leaves</th>
<th>Length (hours)</th>
<th>$T^\circ$ dry ($^\circ$C)</th>
<th>$T^\circ$ diffuse ($^\circ$C)</th>
<th>R. H.</th>
<th>Vents bottom</th>
<th>Vents top</th>
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<td>12-20</td>
<td>26-32</td>
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<td>80-90</td>
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<td></td>
<td>½ yellowing</td>
<td>10-24</td>
<td>32-38</td>
<td>3</td>
<td>77-80</td>
<td>close</td>
<td>close or ½ open</td>
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<td></td>
<td>(1°C per hour)</td>
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<td>8-14</td>
<td>38-40</td>
<td>4</td>
<td>71-75</td>
<td>close</td>
<td>½ open</td>
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<td>44-55</td>
<td>8-12</td>
<td>66-42</td>
<td>open</td>
<td>1/3-½ open</td>
</tr>
<tr>
<td></td>
<td>(1°C per hour)</td>
<td></td>
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</tr>
<tr>
<td>Color setting</td>
<td></td>
<td>24-32</td>
<td>46-55</td>
<td>12-18</td>
<td>42-32</td>
<td>open</td>
<td>¾ or open</td>
</tr>
<tr>
<td>Leaf drying</td>
<td></td>
<td>5-10</td>
<td>up to 65</td>
<td>&gt;18</td>
<td>&lt;32</td>
<td>½ open</td>
<td>⅔ open</td>
</tr>
<tr>
<td>(1°C per hour)</td>
<td></td>
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<tr>
<td>Killing-Stage</td>
<td>mibrib</td>
<td>24-32</td>
<td>up to 77</td>
<td>&gt;18</td>
<td>&lt;32</td>
<td>½ open</td>
<td>¾ open</td>
</tr>
</tbody>
</table>
Special Condition

Wet Tobacco

Prolonged periods of rain can make the drying process more difficult, the leaves drying too slowly even with maximum ventilation, and wet tobacco may increase difficulties from barn rot.

If the tobacco is wet with dew or rain when barned, the starting temperature should be on the high side for this stage until the surplus water has been flushed from the surface of the leaf and from the barn.

Temperature: between 35 to 42°C
Vents: Bottom and top fully open from 6 - 8 hours if wind is blowing, baffle bottom vents.

Thereafter, follow normal temperature and ventilation procedure.

Tobacco with large growth and full of sap.

If the tobacco is large with big stems and full of sap from:

(1) plenty of rain
(2) high nitrogen fertilization.

Yellow at a temperature on the high side. This is especially important for tobacco from the lower part of the plant. Be careful not to set green colour in the tobacco.

Temperature: between 35 and 42°C
Vents: bottom and top (½ to full open from the start until the surplus moisture is eliminated).

Provide more than normal ventilation throughout the yellowing and early leaf drying stages.

Dry weather tobacco.

In hot, dry weather, it may be difficult to maintain temperature during the yellowing stage without setting colour. Since the outside temperature is frequently high, this will mean yellowing at slightly higher temperature than normal.

With reduced ventilation, drying can be slowed to allow time for yellowing. So keep the moisture in the barn fairly high in the early stage of yellowing by adjustment vents.
When outside air on tobacco is warm at housing time, the heat controls can be set to give desired yellowing temperature at the start rather than gradually.

**Temperature**: directly from 32 - 40°C  
**Vents**: top and bottom closed to hold moisture in the barn during yellowing stage. Less ventilation than normal may be required during the early leaf drying stage.

Often hot, dry weather tobacco will be harvested before the middle and butts of the leaf are thoroughly ripe to avoid excessive firing at the tip and margin. The leaf tip and margin should dry early. Then slow down to give the middle and butts of leaves plenty of time to ripen and yellow in the barn before setting the colour.

**Immature Tobacco**.

In tight barns, yellow at fairly high temperature and extend the length of yellowing period, and afterwards brown on red colours may easily take place.

The leaves on the upper part of the stem turn colour less rapidly, so that it is generally easier to dry the leaves which are not ripe enough on the upper part of the plant than those on the lower part. The latter are actually quite green and brown very rapidly yellowing.

**Vents**: Closed from the beginning to keep moisture in barn. Reduced ventilation during yellowing and leaf drying period.

**Overripe Tobacco**.

Yellow with fairly high temperature for existing condition (in the beginning 35 - 45°C)  
**Vents**: ½ to full open throughout yellowing and leaf drying stages.

Total curing time may be shortened slightly, especially in the leaf drying stage.
Tobacco affected in the field by brown spot

- physiological leaf spot.

Yellow at high temperature (35 to 42°C)
Vents: ½ to fully open.

Early, rapid drying will check the leaf spotting and reduce the amount of dead, chaffy leaf.

During the 44 - 49°C phase, try to slow the rate of drying by reducing ventilation and levelling of temperature advance. This will give the middle of the leaf and the butts time to complete yellowing.

The result will be less green and a more mature appearance in the leaf.
Flue-cured tobacco has an unfortunate tendency to develop various blemishes and imperfections during curing. These emanate from five main sources:

1) Physical damage such as bruising, shading and sun scorch.
2) Disease organisms such as barn rot and barn spot.
3) Errors in curing technique such as fixing green, run back and searching.
4) Physiological processes such as guinea-fowl spot and black tobacco.
5) Slate, sponge and other similar colour imperfections.

Fixing of the green colour.

A temperature higher than 43°C kills the tissue of the leaf, preventing the chemical transformations that result in yellowing.

When the temperature exceeds 43°C before yellowing is completed, the green is more or less fixed, according to the stage of yellowing where the change in temperature took place.

At the start of yellowing, a few hours at 43°C, is sufficient for fixing the green colour. It can perhaps be fixed at less than 43°C, if the leaf has lost too much humidity.

To remain alive, the leaves must retain a certain amount of water. The green colour must be eliminated even at the expense of other leaves, as they may brown.
Brown Scald.

One of the principal causes of browning is a yellowing that lasts too long. The leaves must be kept alive long enough to permit the chemical reactions necessary for yellowing to take place. But once this has been achieved, the tissues must be killed to prevent any further reaction.

Browning by prolonged yellowing is most commonly found when the ripening at harvesting is not uniform. The ripened leaves brown before the others have had the time to yellow completely. Chemical reactions which lead to yellowing and then browning occur more rapidly in thin, lower leaves than in the thick, upper leaves of the plant. Therefore, the lower leaves must be dried quickly as soon as they are yellow.

Abnormally thin leaves which are not ripe enough brown when they are dried quickly. To avoid browning by excessive yellowing, the leaves must be of equal ripeness and uniformly dried in the fixation phase. The best results for fixing are obtained by raising the temperature while lowering the moisture in the barn. It is not a good practice to count solely on the rise of temperature for curing.

Sponging.

There is general agreement on the definition of sponge as opposed to slate, but it can be extremely difficult to distinguish between them when examining individual. Sponge is accepted as being a brownish discoloration that can occur on any leaf, regardless of the way it has developed on the plant. The affected leaf takes up condition, may have perfectly satisfactory texture and appears to be quite normal apart from being discoloured. Sponge is caused by faulty curing technique usually associated with a hold-up of moisture in certain parts of the barn. Contributory causes includes over - packing, insufficient ventilations over - colouring and raising temperatures at the incorrect rate. The only sure way to distinguish between slate and sponge is to compare tobacco from different parts of the barn. If there is a big difference
in the amounts of discoloured leaf from different tier positions, the cause is probably sponge. Sponging can be reduced by improving the barn and its ventilation, and by all steps taken to make air circulation and heat uniform and increase the fixing rate.

**Slate.**

Slate is a condition in which tobacco leaves, when picked at the correct stage and cured properly, turn grey, such leaves tend to be thick, narrow and poorly expanded, probably because of stress conditions during growth. These appears to be connected in a complex way with nitrogen uptake and metabolism. In the light of present knowledge, growers can take the following steps to minimise slate:

- Avoid lands that are unsuitable for tobacco production, i.e. wet lands etc.
- Ensure that soil pH is kept at about 5.5 by maintenance dressings of lime.
- Ensure that ample nitrogen is available during the period of maximum growth.
- Plant when there is a reasonable expectation of good growing conditions for the crop.
- Keep the crop free of weeds.
- As far as possible, avoid imposing or aggravating stress conditions by extreme cultural practices i.e. very high plant populations, very late topping and poor sucker control.

**Ink Spots.**

These are ink spots on areas of irregular browning, very dark brown or black, that appear towards the end of yellowing on at the beginning of fixation. They occur in conditions of relatively high moisture, especially when water condenses on the leaves at temperatures of 40 - 46°C.
Faulty ventilation, due to poor usage or insufficient opening of vents on else to an over loaded barn, is the main cause. The longer the leaves are exposed to temperatures of 40 - 46°C, the more evident the symptoms become.

Thin leaves, not ripe enough, are subject to this problem. Unfortunately, in order to yellow perfectly, they require degrees of temperature and relative moisture which must be maintained over a longer period, which favors the appearance of spots. To avoid this, the vents must be opened wide enough and the recommendations given concerning harvesting, loading the barn and drying must be followed.

Scorching.

The dry leaves redder or turn reddish-brown within several hours at temperatures of more than 77°C. This coloration being unacceptable, the temperature at the end of drying must be kept lower than 77°C.

Reddening can equally occur in badly insulated barn, in cool and windy weather, a time when the tobacco must sometimes be exposed to a temperature higher than 70°C for a prolonged period.

Rehumidifying.

At the end of fixing the leaves tend to disintegrate and are too fragile to handle. They must absorb a little water to become softer.

In the conventional barns, opening the doors for several nights to expose the leaves to moist air is sufficient. In order not to lose the moisture absorbed during the night, leave the doors and windows closed during the day, except during humid weather.

When the air is too dry, artificial methods must be applied. Steam must not be over used. An excess causes the leaves to redden and exposes them to mould in the storage house. Steam is not ideal because it supplies too much heat and moisture in too short a time period. The best solution is to pulverize enough water into fine drops to compensate for the high moisture absorption by barn interior.
Continue this treatment so long as the leaves have not absorbed enough water to loss their fraibility. It is also essential that they not absorb so much that they risk mould at the store house. Once the resoftening is completed, the tobacco must be taken out of the barn as soon as possible, otherwise the alternating of fixing and humidification could cause a reddening of tissues.

**BULKING.**

Once the leaf can be handled, the tobacco is hung from the barn. The tobacco may be graded or sorted into various qualities directly after coming from the barn.

To ensure full pliability, a period of storage in a bale or bulk is needed so that a properly conditioned lamina can spread its moisture into the veins and all traces of green disappear.

Leaf can be bulked while in hands, or still tied to the stick. The second method needs more place and calls for a large supply of sticks. Leaf must be bulked or baled on the farm unless the lower half of the midrib can be snapped clearly. It is better a little dry than over-conditioned. A thinner leaf is more susceptible to damage from over-conditioning.

Tobacco subjected to pressure when too moist will rapidly lose colour and show dark lines wherever it has been folded and exhibit so-called water staining. In extreme cases, heating, severe blackening and mould may occur.

The process concerned is the following: the cured leaf is untied from sticks to enable it to be bulked by hand without the stick so that the sticks may be used again. Bulking is carried out to store the leaf conveniently until such time as it can be graded.

It is wise to build a bulk higher than 1.60 m and the base must be on a slightly raised wooden platform. It is found that a settled bulk after 30 days at the maximum height of 1.60 m contains an average of 150 kgs. of leaf per cubic meter of volume of bulk.
Bulks should be built in the bulking shed so that they are accessible from at least three sides. Sufficient room should be left to enable the untying table to be located at one end. Such an arrangement will provide room for removing leaf from the bulks for grading. No moisture should be allowed to enter the bulks through leaks in the roof or from damp walls. Bulk should always be covered after completion.

**Bulk According to Plant Position.**

Leaves from a normal tobacco plant commence to ripen from the bottom, so "lug" will be harvested first, then "cutters", "leaf" and "tips". Stack tobacco in bulks, according to pickings, or groups of pickings, so that stocks in the bulk shed represent in the main Lugs, Cutters, Leaf and Tips. It is appreciated that in a small or uneven crop it is more difficult to separate the groups properly, but growers are advised to work on the average and not to depart from the principle involved. By bulking these groups separately and treating each group as a unit when grading, the task is made much simpler.

**Bulk Down.**

At regular intervals the bulks should be carefully examined for the presence of mould or for excessive development of heat, as a result of its having been bulked too moist. Should any suspicious symptoms be detected, the bulks should be taken down and the leaf shaken and aired before rebulking. In fact, it is desirable to make it a routine procedure to turn all bulks at least once. The leaf should be allowed to remain in bulk for 5 or 6 weeks before being removed for grading.

**Preparation for Market.**

The method employed in the handling of tobacco leaf after curing will appreciably affect the quality and value of the product. Consequently, just as must care should be exercised in the subsequent operations as in the curing itself. Before handling, the leaf should be brought into
"condition" or "order" so that it may be handled without mechanical damage, and so that the chemical changes which tend to improve the colour, flavour and aroma may proceed normally. Too much condition will tend to darken the colour, and may even result in the development of mould in the leaf. Where this is present there is a marked unpleasant "funky" odour, and in extreme cases the leaf will show definite signs of decay. Leaf in correct condition will be sort and pliable, with the exception of the butt ends of the midribs which should be only slightly pliable. A little experience will soon make one adopt at determining this requirement.

Conditioning for Grading.

Conditioning of leaf entails the addition of moisture to the whole body of the leaf tissue and not simply the outer layers. Rapid methods of attaining this objective usually result in a "false condition", which is rapidly lost during handling. To a very large extent the method to be employed will determined by atmospheric conditions at the time. When moist nights are being experienced it will usually be quite sufficient to expose the leaf over night with the door and any vents full open. Normally the leaf will be in good condition by morning, but under certain conditions of high atmospheric moisture this may be attained before day light. In this case, it would be desirable to cover the leaf as soon as the correct condition has been attained.

When atmospheric conditions are so dry that leaf may not be conditioned by these means resource must be made to some way of artificially humidifying the air. This may be done by using a commercial humidifier. Alternatives are to close the shed and spread wet bags over the floor, or else low pressure steam is introduced into the closed shed. In each case, the shed should remain closed for some considerable time in order that the moisture may penetrate the leaf. Of these methods, the second is the slowest but there is less risk of "false condition" than with the last.
When conditioning leaf, care must be taken that the leaf is not too soft (moist) nor too dry. If too soft, there will be a loss in colour with a risk of heating and bulk mould developing with subsequent serious or total loss. If too dry when pressed down, the leaf will break, resulting in damage to its physical appearance and the making of "Scrap". Leaf should always be handled with just sufficient moisture content as is necessary to avoid damage.

Grading.

Grading is simply the sorting of leaves into uniform lots according to body, colour and degree of damage or spotting. Where tobacco is sold by auction there is nothing more to it than this, and if the job has been done properly each lot will clearly fall into a particular classification. But the classification is applied to the tobacco - the tobacco is not sorted to fit the classification. In countries where production is under contract or produced for one market the buyer usually stipulates, in the form of a detailed specification, the grades he requires and the tolerances in each.

The categories forming the basis of flue-cured tobacco grading in many places and countries refer to the position of the leaf on the plant in the field. A normally grown flue-cured plant in America, Canada and Rhodesia produces priming at extreme base, lugs at the base giving way cutters which, in turn, run into leaf with tips right at the top. Originally, the division was into lugs and leaf only, but as cigarettes absorbed more and more of the flue-cured output the middle leaves, which provides excellent material for cutting into rag, became a category of their own and were appropriately named cutters.

Primings (P) A sub-group of lugs composed of very thin or tissuey, pale, silky and premature. Leaves which are low in oil and wax and which have a dull or dingy finish.
Lugs (X) are usually smallish in size and, maturing first, will show no response to topping. They are thin, usually bright and are subject to a fair amount of mechanical and disease damage. The very bottom ones may be called sand lugs or prinings and perhaps not even considered worth reaping - they are very thin and inclined to have a chance of cured into acceptable tobacco and not decay on the plant. A well-grown crop can produce very fine, elastic, slightly orange lugs just above this level.

Cutters (C) picked from the lower-middle and middle portion of the plant. They are thin to medium in body, ripe and well-developed, retaining a lot of natural oil. They usually posses the widest spread of any leaves on the plant, and midribs, although not as fine as in lug leaf, are finer than in leaves of the leaf group. Leaves from the cutter group are soft, and skoly to handle, are elastic, and posses a high finish or natural shine. Cutters are free from most of the physical damage associated with lugs.

Leaf (L) grades are good deal heavier with rather less elasticity. They show a major response to topping, but despite the leaf broadening are still relatively lont and narrow compared with lugs and cutters. Colours are orange to mahogany. Usually, they can be satisfactorily ripened on the plant and it is quite essential to satisfactory quality that they are very fully ripe before reaping.
Tpees (T) will have grown almost completely under the influence of topping, but are very-narrow in relation to length. They are heavier than leaf, with poor texture. There is often difficulty in ripening the tips and they are frequently reaped unripe with appropriately poor smoking qualities, although with only traces of running green. Basic colour will be darkish. True tips are not highly regarded. The very last picking is sometimes known as greentips.

It is emphasized that although these descriptions refer to particular leaves from a very-well-grown plant in a good environment, they have also become grade standards. It would be wrong to imagine every lot of tobacco being classified according to the position on the plant from which its particular leaf came. It is, however, classified according to the resemblance of its leaf to fixed standards reflecting optimum growth. The two may not be the same thing. A luggy tobacco can come from the bottom of the plant or be short, rather dry-natured thin tobacco from the middle of a poorly grown plant whose field culture has gone astray. Two other terms may be met and need explanation. Wrappers (no relation to cigar-wraper leaf) are very fine quality tobaccos, of a certain minimum length which come from the middle of the plant. They form only a small percentage of even the best crops. The name derives from original American usage in wrapping chewing plugs. Smoking leaf describes definite leaf-type tobacco which is rather thin and grainy and perhaps a little overripe.

Each of the major categories is divided firstly according to a number of quality characteristics, then colour and finally on the basis of so-called special factors like:-

1. Texture, ripeness and colour.
2. Degree of damage.
3. Degree of trashiness.
4. Amount of sponge and blemish.
5. Length and width of leaf.
6. Degree of green and green cast.
On this basis, the United States official schedule contains 172 grades and that of Rhodesia 220, while Canada has only 56 basic grades. However, there is no virtue in having a large number of grades for one's own sake. One has the number and the system likely to sell the crop to the best advantage.

India is the only major exporting country employing a system based mainly on colour and body, but without reference to position on the plant. The grading system of India is very similar to the one which our Tobacco Monopoly has for the domestic consumption grown within the Empire. At present it has six grades. Whereas all tobacco in America, Rhodesia and Canada is officially classified at the time of sale, only India's tobacco intended for export receives this treatment. Such system is called Agmark.

Baling.

"Presentation" is an important factor, so bales should be square and neat. If the bales are too loosely packed without tie layers they will bend in the middle and considerable damage to the tips will result. "Condition" must be carefully watched. If the bale is "Soft" but considered "Safe", avoid over pressing and keep the weight down. If too dry, recondition; otherwise further damage will be done.

After-Sale Processing.

After purchase of the tobacco the cigarette manufacturer has to continue leaf preparation towards optimum smoking quality. Tobacco is usually purchased from farmers with varying moisture contents and in farm grades. Neither of these suit the merchant or the manufacturer and, in addition, the form of packing may be unsuitable for travel and prolonged storage. Immediately after purchase, the farmers' packages are broken down, blended together as necessary to form manufacturing grades and re-dried. The latter may be preceded by stripping, i.e. removing the midrib or increasingly commonly by threshing. The threshing process extracts the midrib from the lower two-thirds of the leaf and presents the lamina in broken pieces.
REDRYING.

The object of redrying is to reach a safe storage moisture content and, most importantly, to ensure that the chosen content is uniform throughout the consignment. Farmer (1946) mentions this standardization of moisture content as a most necessary prerequisite of proper ageing. Recently our Tobacco Monopoly has planted Redrying Machine at Head Office.

An accurate consistent moisture content, varying only within very narrow limits, is essential with leaf destined for the United Kingdom market both because of the very high import duty rates and the increased duty payable on tobacco imported at less than 10% moisture. The redrying process involves drying leaf down to a very low moisture by heat, then cooling it and finally putting back the desired amount of condition with steam. The three stages are encountered by slow passage of leaf on a conveyor through a series of continuous compartments. Loose leaf, strips and threshed lamina move on an apron while tied tobacco is straddled on sticks which rest in spracket type chain links. The speed of tobacco travel will vary a little according to the conditions mentioned, but 45 minutes from beginning to end would be a fair average. Leaf is normally taken straight off the redrying machine and packed, while still warm, into cases, hogs heads on bales, as appropriate in the particular country. It is mechanically pressed to a suitable density and is now ready for storage on shipment and to begin the process of ageing.

AGEING.

Ageing is the final stage in the creation of optimum smoking quality. The leaf develops its full flavour, becomes distinctly more aromatic and usually darkened in colour. The fuller bodied the tobacco the more aromatic and usually darkens in colour. The fuller bodied the tobacco the more marked, as generalization, will the ageing changes be. Nevertheless, all tobacco improves in storage after redrying,
even if the extent of this improvement is confined to smoothing the rough edges of the smoke and removing the sharp taste of freshly cured tobacco. In any given crop, leaf reaped unripe will age with greater difficulty and with poorer results than that reaped ripe, but even unripe tobacco will improve. The time required for ageing will obviously vary with the tobacco, but a period of one to two years will cover most instances. The process is relatively rapid at the beginning and progressively tapers off. Prolonged storage can, to a slight extent, lead to a deterioration from the high point reached at the optimum period of ageing, but this is normally of little consequence. Unlike the fermentation of other tobaccos, ageing of flue-cured leaf takes place in the complete absence of any external control. Once packed after redrying, the tobacco follows its normal course whether it be storage for local manufacture or travel for export. Disposal of leaf from this point is strictly of manufacturing concern.

Mineral Nutrition and the Need for Added Fertilizer.

Plants grow by absorbing water and mineral elements from the soil and carbon dioxide through the leaves. A number of individual items are essential, to the extent that growth and development will only occur so long as all are adequately available and will stop or be modified as soon as any one becomes in short supply. The deficient item can often be water, it may be sunlight and even CO₂ but most frequently it will be one or more of the mineral elements obtained from the soil. This is fortunate. It is relatively easy to apply nearly all, and certainly the main, minerals to soil in the form of fertilizers. In fact there is some advantage in starting off with natural deficiencies for by suitable fertilizer additions the amounts available to the plant can be controlled. Maximum vegetative growth is not always desirable. All this is very relevant to tobacco, where the aim is to produce a leaf of certain fairly sharply defined chemical composition to meet important quality standards.
It is usually considered convenient to talk of major elements or macronutrients and minor trace elements or micronutrients. Minor elements are required in very small amounts, but absence can cause death or very poor performance. There is no response scale, accepting the accuracy limits of practical application; either a minor element is deficient or it is not. In fact, the almost magical transformations which have been achieved by adding tiny quantities of the appropriate element in the relatively rare cases of minor element deficiency have led to all sorts of disorders being hopefully labelled as a problem of trace elements.

In the normal mixed tobacco fertilizer there are six to eight elements which may be absorbed by the plant. Only three of these, the most important major nutrients namely nitrogen, phosphorus and potassium are shown in the grade formula.

Calcium and Sulphur are present in the plant in fair quantity and are best considered as major nutrients but their importance is masked by the fact that they are either rarely deficient or are applied in sufficient quantity in the compounds used to supply N, P and K. Magnesium may also be needed in fair quantity but it has to be supplied separately. All other elements are classed and act as minor nutrients.

Mineral absorption in excess of strict nutritional requirement can be a most unfortunate occurrence, as will be seen in the case of chlorine. It is to be expected that environmental and cultural differences would much affect the total of nutrient accumulation. Notable is both the low actual phosphorus uptake and the fact that it is still being appreciably absorbed toward the end of the growing period. Nitrogen and potassium absorption, on the other hand, was much more concentrated during early growth.
Nitrogen.

Nitrogen is essential to the growth of all higher plants. It may be derived from the soil or may be absorbed directly from fertilizer or from the breakdown of microorganisms. Some of which can fix relatively large amounts of atmospheric nitrogen or convert complex nitrogen compounds to a form which may be used by the crop.

It is vital for leaf and plant development, but an excess can ruin quality. Choice of soil depends much on the nitrogen content and its pattern of release. Nitrogen is a constituent of the compound which gives tobacco its strength, nicotine; it is easy to apply as readily soluble fertilizers as well as being readily leached from higher soils. Its obvious importance, coupled with a relatively easy availability control, calls for much careful managerial thought in making assumptions about the likely weather and attempting to balance the yield and quality responses for a maxim return per land unit. Some later decisions to be made on the crop, such as the height of topping, also require thought, but even this is very much related to its nitrogen status. Nowadays the nitrogen nutrition of flue-cured tobaccos has received much scientific attention; a reflection both of the predominating importance of bright tobacco and of the fact that the dividing line between benefit and detriment is so narrow in this instance.

Nitrogen is used by higher plants to form proteins. In the botanical family to which tobacco belongs some of nitrogen is also used to produce alkaloids. In the genus Nicotiana (tobacco) nicotine is the main alkaloid formed. Thus, of course, is the main substance which gives tobacco its peculiar characteristic. Under some conditions another alkaloid, normicotine, is formed which is undesirable as far as smokers are concerned.

The amount of nitrogen available to a large extent governs the size of the plant as well as the size and weight of individual leaves. It is therefore, apparent that it has a direct and marked effect on the total crop yield.
Nitrogen content, being closely linked with "body", burn, and nicotine content, has a very real influence on the value of the crop.

In the field, provided other elements are in adequate supply, and bearing in mind inherent type differences, the depth of green colour is very closely related to nitrogen content. A very deficient plant will have pale small leaves which tend to grow upright at an acute angle to the stem. General growth is on a small scale with a thin stem and maturity is delayed. Leaf harvested from such crops cures out pale, thin and lacking in texture. Excess nitrogen gives a dark, almost black colour, generally an exaggerated scale of vegetative growth, a much increased proportion of stalk to leaf and of midrib to lamina, and delayed maturity. Cured leaf will be dark from thin to completely trashy, lacking texture and of poor smoking quality.

It is important to remember that the previous history of the land, particularly recent cropping and cultivation practices, may have far more effect on the amount of nitrogen available to the crop than type on amount of fertilizer used.

**Deficiency Symptoms.**

The colour and size of the tobacco plant reflect the nitrogen status of the crop very well unless moisture or pests are limiting factors.

The most essential requirement for recognizing deficiency symptoms is a thorough knowledge of the plant itself - its life history and habits, how it looks and how it acts at all stages of growth. It is also necessary to know how diseases and insect pests affect the plant, so their effect may not be confused with symptoms of plant - food deficiency. The successful grower has this knowledge through long acquaintance with the plant under practical conditions. In fact, once he learns what the deficiency symptoms are, he may be able to recognize them much better than the specialized scientist, who is less familiar with the plant under all the conditions of practical culture.
Under field conditions, the most common deficiency in tobacco probably is a shortage of nitrogen. As a matter of fact, the nitrogen supply for the tobacco crop must be controlled to produce leaf of a certain type. Some types of tobacco must even grown under conditions of relative nitrogen starvation - flue-cured tobacco, for example, and to same extent burley and Maryland. Cigar leaf, on the other hand, can be produced successfully only when there is an abundant or luxury consumption of nitrogen by the plant.

Even when tobacco must be grown under conditions of relative nitrogen deficiency, the supply cannot be reduced to the proper point until the plant has reached a certain size and stage of maturity. This is apparently an important requirement if the tobacco is to ripen properly. The plant may show signs of nitrogen deficiency at any period of growth, from the seedling stage to maturity. The effect first becomes apparent as a decrease in the normal green color. At the same time, growth slows down or stops.

After the first change in the greenness of the plant, the lower leaves turn lemon yellow to orange yellow, the shade apparently depending on the intensity of the green before the nitrogen deficiency occurred. The darker shades of yellow occur on the plants that had the deeper shades of green. This yellowing is followed by a drying up, on firing, of the yellowed leaves. The number of leaves the plant loses depends on its size and the acuteness of the shortage of nitrogen.

The remaining leaves on the plant tend to assume an erect position, forming acute angles with the stalk. The bud leaves tend to retain their normal condition. Apparently their needs are met by a transfer of nitrogen from the older leaves. If the nitrogen shortage from the older leaves. If the nitrogen shortage becomes acute at the flowering stage, flowering and fruiting are accomplished by a similar transfer of nitrogen from the older tissues, but the quality of seed is reduced.

A nitrogen deficiency appears to reduce in same way the water content of the plant. This probably accounts for the fact that a nitrogen shortage and water shortage sometimes show much the same symptoms. A nitrogen shortage, however, may occur when the plant is standing in water all the time as in a solution culture.

The effects of a nitrogen shortage can be seen in the cured leaf. Its size is reduced, the amount of reduction depending on the stage at which the storage occurred. The colour is also affected, differently with different types and methods of curing.
The flue-cured type of tobacco has the desired lemon-yellow color only when the nitrogen supply is reduced to the points of deficiency at ripening stage. The nitrogen supply is also known to influence nicotine content to a great extent, low nitrogen generally producing a leaf with a low nicotine content.

**Symptoms of Excess**

The use of too much fertilizer with a relatively high nitrogen content, over-preparation of the land, selecting a naturally fertile soil, and topping too early or too low may induce a high level of nitrogen in the leaf. This will be shown by a large, dark green leaf with a fleshy midrib which is slow to ripen. When it does ripen, such leaf can prove difficult to air and comes from the barn dark, thin and papery. The proportion of trashy "non-descript" leaf can be very high.

A choice is available between the forms in which nitrogen may be applied. Animal manure is, among other things, a source of nitrogen, but its very variable composition and degree of decomposition are disadvantages and it is scarcely used, except on heavy, dark tobaccos. Other organic sources such as various oil-seed meals, fish meal and even dried blood are used on high-nitrogen tobacco and particularly cigar crops. Mineral sources cover ammonium, nitrate and urea. Nitrate is the most readily available but also the most readily leached. Ammonium is less mobile and, when applied as sulphate, also takes care of sulphur requirements but it appears detrimental at high rates and its continued usage has a marked effect in increasing soil acidity. Urea is relatively quickly available; it resists leaching and modern form with negligible biuret content are very satisfactory. It has so far proved difficult to incorporate urea as the source of nitrogen in compound mixture—the vehicle by which the magoty of tobacco is fertilized. Most commercial tobacco mixtures contain both ammonium and nitrate in proportion which are suitable to local circumstances according to the above principles.

**PHOSPHORUS**

Phosphorus is of great in tobacco nutrition and usually applied in greater quantities than can be accounted for by plant absorption. It is commonly applied as calcium or ammonium salts of the phosphoric acids and referred to as phosphate. Contents are expressed in terms of phosphorus pentoxide.

It has been proved that in many respects phosphorus and nitrogen act in opposition as far as tobacco is concerned. This is particularly so in the case of maturity. While nitrogen has a retarding effect on ripening, phosphorus tends to accelerate ripenings,
Under ideal conditions phosphorus may induce ripening to commence as much as three weeks early.

Soil phosphate mobility is very restricted and many soils have the ability to fix the element into forms unavailable to plants. Extreme deficiency gives dark-green stunted growth of short, rather pointed leaves which tend to lie nearly horizontal, giving an open, flat storing appearance and very delayed maturity. The cured leaf lacks lustre and the lower leaves on the plant may have numerous brown spots but this is not a very characteristic indication. Even where the deficiency is insufficient noticeably to restrict growth, symptoms such as abnormally pointed, dark leaves with a flat surface and the absence of twist or puckering of the leaves often indicates that the plant would respond to additional phosphate. There is clearly a nitrogen-phosphate relationship where by an apparent deficiency or excess of one can mean merely an imbalance between them. This has, however, limited application and there is no evidence that the ill-effects of very high soil nitrogen can be counteracted by even higher phosphate dressings; the evidence is in fact the other way. The most important obvious function of phosphorus is the promotion of ripening and this is linked with increasing carbohydrate content. The young plant begins to absorb phosphorus at an early stage. This and the poor mobility in the soil suggest that a carefully placed application before or immediately after planting will make most efficient use of phosphate fertilizers. Side dressings will not normally be effective.

Deficiency Symptom

Practically all tobacco soil exception those derived from phosphate limestones are initially deficient in phosphorus. Phosphorus deficiency, however, causes tobacco plants to exhibit growth effects less characteristic than those resulting from shortages of any of other essential elements.

The symptoms that serve to identify phosphorus deficiency a certain type of slow growth and lack of maturity. With this stunted growth, the plant assumes a rosette condition. The color is very dark green. The size and shape of the leaves are altered. The leaves tend to be narrow in proportion to length. Usually, no abnormality of the leaf appears other than in size, shape, and color. The bud leaves tend to retain their normal appearance; possibly because phosphorus is transferred to them from the older parts of the plant. Similarly, flowering and fruiting are successfully accomplished when the shortage becomes manifest at this stage of growth.
If tobacco is to have the desired quality when cured, it is essential that the leaf reach a certain stage of maturity before harvest. Leaves from plants suffering from phosphorus deficiency are immature and therefore have an undesirable quality. The cured leaf tends to be dark brown, dark greenish or black. Maturity of the crop is frequently delayed until late in the season, when the weather is unfavourable for curing, especially in the case of air cured types.

Organic sources of phosphorus are usually some form of bone meal and these are used on some cyar crops. Inorganic forms may be divided between those whose so-called available phosphate is soluble only in citric acid and those where a large proportion, or all, is water soluble. It is accepted that the phosphate requirements of tobacco need to be applied in the water-soluble form.

**POTASSIUM**

Potassium is one of the most important nutrients controlled by the farmer when tobacco production is being undertaken. Potassium is a bone and needed in large amounts. Contents are frequently referred to in terms of the oxide. The salts, being freely soluble, are mobile in the soil and fairly readily leached in sandy soils.

Severe deficiency is shown by stunted growth and a characteristic chlorosis which spreads inwards from the tip and later the sides of leaves. Immediately in the wake of this chlorosis necrotic spots start to coalesce and the tissue disintegrates. The browning of the leaf tip edge may be called rim-firing.

A most important and very noticeable potassium effect, which has been noted by many scientists, is a positive influence on burning capacity. Tobacco leaf from which potassium has been leached will not burn. Furthermore, it has the ability to counteract the deleterious effect on burning of some other elements – notably chlorine.

Potassium sulphate (sulphate of potash) and potassium chloride (muriate of potash) are the main fertilizer forms. The choice between sulphate and muriate depends entirely on the chloride status of the soil, which is rarely so low as to favour entire use of muriate.
Calcium

Calcium and potassium are normally the largest constituents of plant ash. One or the other may predominate. Severe calcium deficiency is shown by a malformation of the young bud leaves, which gives the appearance of growing away from insect damage done in the very early stage of development. Usually the leaf tip is absent and the sides are wrinkled. Usually calcium obtained from fertilizer mixture like superphosphate.

Sulphur

Although a relatively large amount of sulphur is used by plants there is normally ample available in the soil. In addition, tobacco receives a lot of readily available sulphur from the superphosphate and sulphate of potash applied to the crop.

Other Nutrients

The elements required by tobacco for normal growth not included in the usual fertilizer mixtures are magnesium, boron, iron, manganese, copper, zinc, molydenum and chlorine. These elements can be applied to the plant, when deficiency symptoms are absorbed. Other than this, pot experiment can be conducted to study the actual deficiency symptoms.
Curing of the leaf is one of the final efforts in the labours of a long season. Therefore every effort should be made to provide the best curing facilities possible and add to the quality of the final product. To produce flue-cured tobacco efficiently and ease the task of grading, it is necessary to have several specialized buildings on the farm.

The essential functions performed in these buildings are stringing, curing, ageing, grading, tying and baling. The following points should be considered before any buildings are erected.

1. Is the land suited to the tobacco production?
2. Is there water nearby suitable for irrigating tobacco? If so, what capital is required for irrigation facilities?
3. What is the best site for the buildings?
   - Should be close to the house.
   - Be centrally placed in relation to the tobacco fields.
   - Have easy access to road.
   - Be above flood level
4. What is the fire risk?
   - Should buildings be separate?
   - Will they be too close to existing structures?
5. Are the designs the best for the place and the type of leaf expected?
6. What is the likely cost?
7. Can extensions or addition be made easily and without undue expense?

In the case of farms with existing facilities for handling flue-cured tobacco, it is also desirable to consider these points when additions or modification are contemplated.

The Curing Barn

The curing barn is the most specialized structure of the group and must be designed for cheapness, durability, fire resistance, ease of erection, ability to retain heat or moisture, ease of filling and unloading, suitable control of temperature or humidity and economy of fuel.
It must be suitable for the particular fuel or range of fuels which the grower intends to use and also for the type of heating unit which he has in mind. Site keeping in mind the general requirements for all buildings, the curing barn should be placed so that it is not exposed to excessive wind and is either on the highest land available or sufficient drainage can be provided to prevent the floor becoming wet. It should also permit easy loading and unloading, keeping in mind the movement necessary from stringing area to barn and barn to storage.

**Lay-Out of Buildings**

Few farm operations provide such an opportunity for time and motion study as the handling of tobacco from the curing barn to the finished bale.

A possible general lay-out of building is shown in the diagram on the next page.

Attention should be drawn to the spaces shown between the barns, the stick bulking shed and grading shed. The advisability of constructing barns as separate or multiple units depends mainly on the fire risk and therefore largely on the materials used.

The main advantages of multiple units are compactness, a saving in construction costs and the fact that a small wall area is exposed to the weather. With a single units, the chief advantages are a minimum fire risk to other structures, the elimination of heat leaks to adjoining units and the ease of carrying out maintenance.

It would be wise to consider the following points as helpful suggestions:

**Bulking:** A minimum of 1/8 of bulk space per 300kgs of tobacco.

**Boiler:** This should be placed as central as possible to all steaming operations. It is almost essential, and certainly good economy, to have all steam lines well lagged.

**Grading:**

(a) **Area:** A minimum of 1.44m² of table per grader.

(b) **Light:** Lighting of a grading shed should give consideration to two main factors:

(1) Proportion of the day available for grading and
(2) diffusion of light with as few shadows as possible.

These considerations lead to the recommendation of two basic types of lighting which have proved to be satisfactory:

(1) A saw-tooth structure making use of North light in order to lengthen the span of the grading day.

(2) Use of artificial light.
Plan and Elevation of a Suitable Arrangement of Tobacco Buildings.
Foundation

The foundations should be at least 45 cm below ground level. If reasonably firm conditions have not been found at this depth the foundation should go deeper.

Since barn walls are relatively high and there are no internal partitions it is essential that the foundations be of sufficient area and strong enough to prevent movements which may cause even small cracks to develop.

Dimensions

The size and number of barns will be governed by the area to be planted to tobacco, the maximum yield per hectare and the labor available.

As a rough guide it is usually found that two 3.6m by 3.6m (12ft x 12ft) and one 4.8m x 4.8m (16ft x 16ft) units six or seven tiers high will deal with the crop from 2 to 2.8 hectares of irrigated tobacco.

The smaller units are an advantage when picks are light but it is wise to have at least one large unit available for times when many leaves ripen at once.

The height of barns is governed by the type of floor and the number of tiers required. Five to seven tiers is the usual number, since any more greatly increase the difficulty of handling leaf with the barn.

Tiers

The height of the first tier will be governed by the type of floor and the heating unit being used. Distance between tier poles will be governed by the length of leaf expected from the particular variety and cultural conditions in use. A common distance is 60cm (2ft) but it can be increased or decreased depending on the condition.

Capacity

The capacity is determined by the number of loaded sticks which may be accommodated in the barn.

A 3.6m by 3.6 (12ft x 12ft) five-tier barn might hold a total of 300 sticks of 1.20 meters length while a 4.8m by 4.8m (16ft x 16ft) should hold 100 sticks per tier.

Floors

Concrete floor is preferable, however if the cost is high, earth floors are satisfactory, provided they are kept dry. If they tend to remain damp, coarse gravel or ashes should be used to build up the level until a dry surface can be maintained.

It is an advantage to have the floor well below ground level but the site and cost of excavation may be against this.
Walls

It is desirable to plant for a cavity wall with or without special insulating material. Depending on the capital and materials available in the vicinity, it can be built of bricks or natural stone.

Furnaces

Experience in many tobacco countries has indicated that twin furnaces give a maximum uniformity of heat with a minimum fuel consumption.

The twin furnace unit permits moderate firing, which results in less loss of heat up the chimney and less burning of fuels. It also facilitates "cooling off" when the fires are drawn. The indications are that the saving of fuel more than offsets any additional expense involved.

Common bricks, lime mortar or cement mortar are not satisfactory in furnace construction as they are tend to disintegrate and thus constitute a fire hazard. Fire bricks and high alumina bauxitic cements are recommended if available in the country. These will lengthen the life of the furnace and give the necessary fire protection.

Where furnaces are installed at the back adjacent to the chimney it is advisable to provide moderate rain shelter for the attendant. This will ensure closer attention to firing temperatures during inclement weather.

Roof

Corrugated iron roofing is preferable to asbestos cement roofing. An iron roof is desirable and provision for top ventilators should be made during construction. The asbestos cement cracks easily if put on under tension and is highly dangerous for anyone climbing on the roof. In the case of fire, asbestos cement tends to explode, leaving the roof wide open and thus reducing any chance of controlling the fire.

Ventilators

The top ventilation is most important. If the vent is properly constructed, the bottom vents need only be openings of sufficient size with no provision for adjusting the opening.

The type of top vent was thoroughly tested in Georgia (U.S.A) and is now widely used in Rhodesia, Malawi and Australia. It is simple, effective and besides providing ventilation can be opened fully to allow light to enter while work is being done inside the barn.
The vent runs the full length of the gable and can be adjusted from nothing to more than 1.08m$^2$ (12ft$^2$) in 3.6m by 3.6m (12ft x 12ft) barn, thus giving a much wider range than is usually needed.

The bottom vents should be placed at regular intervals around the foundations and should lead the air to the heating surface, NOT UP TO THE LEAF. When the top vent is fully open, it should be possible to have at least one quarter of that area available when all bottom vents are opened.

Doors

The door should be light as much as possible. It should have stout, non-stagging hinges, fit snugly and have a catch which can be operated from inside or outside.

The main door is to allow leaf on sticks to be moved into and out of the barn rapidly with as little labor as possible. It therefore needs to face both stringing area and storage shed.

Single or double doors may be fitted according to the size of the building and the way in which sticks are handled.
Heating Systems

In most places the barns are heated by wood fires and a series of flues made of flat galvanized iron moulded to round pipes of about 25-30 cm diameter. The furnace is usually made of bricks, concrete or clay and is mainly external to reduce the fire hazard and permit the use of long logs.

The flues carried hot air to and fro across the floor of the barn and finally took heat and fumes out vertically with the chimney opening being above highest part of the building.

Chimneys were usually firmly fixed to exterior walls to prevent fire and reduce "hot spots". Various cross connectors or "bleeds" fitted with dampers were used in an endeavour to obtain an even distribution of heat.

Recently liquid fuel became more popular, flues were generally retained but furnaces became smaller and were often placed entirely inside the barn with only a small door opening to the exterior.

There is a big price variation in oil burners and when making a choice it should be kept in mind that the cheapest unit may also be the one which is wasteful of fuel.

There are various types of burners are still in use which range from small units fed from a central fuel supply but placed several feet apart on a separate small chimney to carry fumes out through the roof.

Other burners have a forced air blast from an electrically driven fan. These require continuous power from a 240 volt system but may be readily fitted into most of old type furnace-flue systems.

Fuel

Although many tobacco countries use liquid fuel, in Ethiopia wood is cheap source of fuel. The major advantage with liquid fuels is that once the burners and fuel system are correctly installed they require little attention and temperature may governed automatically by a suitable thermostat in the barn and the valve on the fuel line. It is still necessary for the grower to check the humidity in the barn so that he can provide the correct amount of ventilation.

Wood is preferable than liquid fuel for its cheapness, however, an attendant stand by is need day and night. Beside this, there is a possibility of a sudden temperature change which can be cause by lack of attention or unsuitable wood that can ruin all leaf in the barn at the time.
Before the harvested leaf can be loaded into a barn it must be attached to sticks. In order to prevent damage to the leaf and provide some comfort for workers, this should be done under cover, preferably in a place protected from strong winds or direct sunlight. The structure should be placed so that it permits ready access to the barn and also entry of the conveyance used to bring in leaf from the field.

It is usual to have at least one side completely open or at most provided with hessian which can be put up to stop excess wind, sun or rain. A stabilized earth floor is quite suitable provided it can be kept dry.
BULK STORAGE

Apart from barns, the next most specialized building on a tobacco farm is the bulk shed.

When this is built the main aim should be to provide a structure in which leaf will improve during the storage time between when it is removed from the barn and when it is sent to the selling floor.

In such a building it should be possible to have complete darkness, a relatively even temperature and humidity, and freedom from fungus and insect pests.

To fulfill these requirements it is desirable to have a building with a raised floor, a sound roof, double walls with the minimum number of openings, and a full ceiling.

Since it is necessary to keep openings to a minimum, their placement should be considered carefully. Apart from the door and one or two openings to admit light when required, the main consideration should be to provide air circulation should the atmosphere within the shed become too moist.

Sufficient space must be available to store all leaf harvested in any one season. Near the end of the season when only one or two barns are being used, the barns are suitable for storing leaf. If such barns have concrete floor, it will be more suitable for leaf storage.

GRADING ROOM

Tobacco can only be satisfactorily stored in solid buildings of good construction and with a concrete floor. A grading or sorting shed requires in addition, a plentiful well-directed source of light and, very probably, a means of a portable humidifier dispensing an atomized mist or simply a powerful fan drawing air through a soaked porous medium such as wood wool. The light can be artificial (fluorescent 'colour-corrected' tubes are best) with outside light excluded. The aim in Rhodesia is as 30 lumens per 930 cm² over the grading table. Roof lights at 10% of floor area on side lights, on the wall not receiving direct sunlight, at 12.5% of floor area should both provide suitable conditions of natural lighting with preference for the former.
Extensive, fairly contiguous areas of a large-leaved crop such as tobacco naturally attract those insects to whom it can be a food source, in the same way that suitably adapted organisms find a good environment for growth and reproduction. Generally diseases cause greater financial loss than insects. There are, of course, insects which may cause some damage in their own right but major contribution to loss of crop is through transmission of virus diseases.

**General Control Considerations**

Insect control is much concerned with chemicals and there are tendencies, greater than in the case of diseases, to use these materials either when economically unjustified or when cheaper methods would be more effective. The role of hygiene has perhaps even greater opportunities of success in the case of insects than it has in disease control. The insect has more closely defined needs for hibernation and wintering than a fungal spore. A clearing of plant debris and tidying up of hedgerows can have an important effect in reducing the pest populations available immediately to attack the following season's new plantings.

Breeding cycles are more precise and the prevention of further generation at the end of a season, by destroying all food material as soon as the crop is finished, can much reduce early attacks in the following season. With insects there is also concern with potentially very damaging infestations of tobacco in store and here hygiene is quite vital for any effective control, even though full use be made of insecticides.

Insecticides may act by contact, through being ingested or by activity of the vapour phase. It is possible to have the same material exercising control by more than one method. Fumigation is, of course, limited to the soil and enclosed buildings. The development of systemic insecticides which are absorbed and circulated in the plant sap has been helpful in better controlling some sucking insects. It is now possible to apply some of these materials to the soil for natural root absorption. Problems of building up populations with insecticide resistance have arisen in some instances, but alternative treatments have always, as far, been available. Some insecticides are very toxic to human life and need using with great care. It may be emphasized again that insecticides are generally for use when, despite all the cultural and sanitary precautions, serious damage is still being done by insect pests. There are some exceptions to this, such as the precautionary use of soil insecticides to protect young seedlings just after planting in the field and the use of systemic aphicides but it is otherwise a very expensive unnecessary and possibly dangerous past time applying insecticides, unless they are really needed.
There is generalized farmer tendency to define control as the complete suppression of a pest or disease. The sight of a few live insects is too often the signal to get out a spraying machine, instead of merely being a warning to keep the situation under close observation. The only instance when the sight of a few insect pests ought to raise more excitement than their mere numbers justify is in the case of the cigarette beetle. This pest can easily get out of hand, to become very costly in terms of control measures and damage. Always it is economics which count; with many field pests a degree of damage may be less costly than the control measures which could prevent it. Using calculations made to determine the break-even point with horn worms, it was found that twelve spray applications effectively controlled an outbreak on experimental plots. Neighbouring farmers using their own judgement used twenty-four applications to control the same outbreak to the same degree (Lawson and Halb, 1964). Apart from unnecessary cost, these matters are very relevant to insecticide residues.

Insecticide Residues

Relative to their potential importance, residues have received little attention. Before the Second World War insecticides were mainly in organic and often based on arsenic. After the war chlorinated hydrocarbons and organophosphorus compounds ousted the inorganics; in 1952 arsenicals were removed from the list of insecticides recommended against horn worms. The concern was thus originally with arsenic, and experiments showed tobacco to absorb it readily when applied to the soil or plant. It was found that cigarette arsenical contents in America rose fairly steeply through 1917-52 to around 50 ppm.

The new materials brought their own problems. The Entomology Faculty of North Carolina State College (1958) reported on the contribution of residues to off-type flavours. Method of use, time of application and rate were all relevant. Foliar toxaphene could be detached but soil applications could not. Soil applications of BHC to a previous crop could be picked out. The majority of the substances tested did not leave smoke-detectable residues, especially when used at recommended rates, but endrin and TDE were questionable when used in excess.

When studying absolute amounts of foliar residues it is important to examine commercial crops, for actual applications and recommendations may be two different things, with the former tending to exceed considerably the latter.
Florida wrappers had the highest DDT and endrin residues, presumably reflecting the seriousness of even slight damage to this type. Flue-cured leaf from Georgia and South Carolina had the highest DDT and TDE residues for this type, as might be expected from the greater prevalence of bud worm and hornworm attacks in the south. Cigarette smoke values for TDE and DDT were nearly double those found in 1956-58. The high yields of endrin from cigarettes at 1 ppm and even up to 2 ppm led to the withdrawal of American recommendations for its use on tobacco. Toxaphene is also off the recommended list, for foliar application, in some American growing areas owing to the risk of tainting.

Studies have shown that the figures reported for flue-cured tobacco are lower than those on the green leaf, by virtue of appreciable losses during curing. The smoking may occasion further loss so that only a small amount of the original residue appears in the mainstream smoke. Bowery and Guthrie (1961) found that twenty times the recommended rates of azinphos-methyl would have to be applied on the day of priming to detect measurable amounts in mainstream smoke. For carbarly four times the recommended rate would be needed under the same conditions, for mainstream detection. Guthrie and Bowery (1962) have shown that mainstream smoke recovery proportions of added endosulphan and isobenzan were similar to those for carbarly. Although the majority of materials do not apparently present a taste or flavour hazard in America there is a clear case for residue testing with all new materials.

There is some variation between countries in the amounts of detectable residue remaining on sprayed tobacco. Distinct cured-leaf taints have been reported in Queensland, Australia, from field use of BHC, chlorano, toxaphene, TTC, a azinphos-methyl, and dimethoate and these materials no longer recommended for use in the state. The findings in respect of azinphosmetul are contrary to those in America while dimethoate is not considered objectionable either in Rhodesia or America. Environmental differences would be expected in commercial culture, with greater persistence likely where the crop receives nil or very small amounts of rainfall. Rhodesia operates an approval scheme, covering both active ingredient and formulation, in collaboration with United Kingdom manufacturers and the only insecticides recommended for use on tobacco are: DDT, aldrin, dieldrin, heptachlor, dometomemethyl, dimethoate, diculfoton, phorate, phosphamidon and menazon. It is considered that the relatively few pests attacking Rhodesian tobacco can be adequately controlled by one or other of these materials.
Insecticide Application

Disappointing results will occur if the chosen insecticide is not adequately applied and may lead to unjust condemnation of the material. Soil incorporation will give poor control of cutworms since these pests operate on the surface. On the other hand, complete incorporation is required for fully effective control against a true soil pest. Guthrie et al. (1960) found key to wireworm control was through mixing of insecticide in top 15 cm of soil! The use of a rotary hoe might sometimes be justified. Mixing with fertilizer for banded application gives poor efficiency. For foliar application, the choice between dusts and sprays may be a matter of convenience or simply the availability of water. Dusts can be very effective and adhere very firmly to plant surfaces. If applied when dew is on the leaf, the fine moisture drops can aid the spread of dust particles, but large drops of water from rain can have the opposite effect. Dust will be more susceptible to wind drift and loss than sprays. Using sprays gives a choice between emulsion concentrate and wettable powders. Under some conditions the emulsion solvents may cause plant damage. For spraying, the two most common nozzles are a flat fan-spray jet and a hollow-cone nozzle. The former is more effective in applying residual sprays, for instance, to the insides of buildings, while the hollow cone is probably better for field work.

Biological Control

Biological control has not been effectively applied to any tobacco insect problems, although many pests are kept in some degree of check by natural predators. Mechanical control is very effectively employed in some countries. The hand picking of caterpillars, beating of grasshoppers and the digging out of crickets are examples. It is surprising how effective and cheap these treatments can be in small-scale agriculture.

Soil Pest

The term covers larvae of a number of species of the family Noctuidae, order Lepidoptera, which are characterized by a habit of chewing the stalks of young tobacco plants. Garner (1946) stated that over twenty species were known to feed on tobacco. Robb et al. (1959) named three species as being the most destructive in North Carolina: the black cutworm, Agrotis ipsilon, the granulate cutworm. It is widely distributed and has been reported from Canada, Rhodesia, India, Japan and Bulgaria. A. Segetum causes damage in East and Central Africa, and Japan
DDT gives a good control; it is recommended as most effective insecticide in Rhodesia. The Rhodesian recommendation for seedbed application is 560 gm of 75% wettable powder in 180 liters of water applied at about 27 litres per 24 m². Large plants may necessitate a higher rate of application. Young seedlings less than two weeks old are likely to be damaged by DDT but after this stage the recommended rates will cause no injury.

False WireWorms

These pests of field tobacco in Africa are species of two genera of the family Tenebrionidae. All are long, yellow, wormlike creatures which bear much resemblance to true wireworms, but have thickened antennae, large prominent front legs and are much more active in the soil. The eggs-covered soil. Hatching shortly afterwards, the larvae live on roots and organic matter. If the field is planted with tobacco then its roots will form part of the diet. Stems that have been attacked can be recognized by scars of feeding channels. These can be relatively deep and severely retard growth or even kill the plant. The measures detailed for cutworm will also control false wireworm.

Wireworm

Wireworms are hard, shiny, thin worms which inhabit soil; some species feed on plant roots and stems. When tobacco is planted out, the wireworms surviving the destruction of the original host plants and later cultivation may attack tobacco. Plants may die if attacked during the week following transplanting.

The egg, larval and pupal stages of wireworms are passed in the soil and often occupy a period of a year or more. The larva, which is usually less than 5cm in length, is yellow or brown and may have a rounded or slightly flattened body. The adults are known as "click" beetles.

Control

1) 900 gm of parathion active ingredient per .405 ha.
2) 450-900 gm of diazinon active ingredient per .405 ha.

Mole Crickets

Mole crickets found mostly in seedbed area. They feed on roots and near-ground plant parts, but the main harm to tobacco is through physical damage to seedbeds.
In the process of coming to the surface at night to feed, burrows several meters long are created just under the surface, which uproot germinating seedlings and disturb water movement. The insects' preference for damp conditions tends to make seedbed areas attractive.

Control

Parathion 450 gm of 15% wettable powder in 450 litres of water, applying through watering can, will treat 160m².

ABOVE - GROUND PESTS

(1) Harvester Ants

Found in Africa and some other countries, these ants create a nuisance by collecting freshly-sown tobacco seeds into heaps, either above or below ground. Lots of seed are liable to be unjustly blamed for poor germination when in fact they have been carted away.

Control Aldrin or DDT wettable powder, watered on to the bed just before or immediately after sowing, is a suitable control.

(2) Stem Borers (Scrobipalpa heliopa)

The damage, which just qualifies as being above the ground, is done by caterpillars of small moths. They are not generally of great importance but cause irritating damage through the planting of attacked, but apparently healthy seedlings, which either die or make very poor growth. Eggs are laid on the leaf or midrib or, more commonly, the stem. The hatched larva enters the tissue and bores to the stem where it stays to feed and pupate. The plant's response is a characteristic swelling surrounding the feeding cavity, which is typically just above ground-level. The injury has been referred to as pregnancy disease. Special control measures are usually unnecessary but routine DDT sprays will be effective against stem borers, although the vulnerable period of the insect is very short.

(3) Leaf Miner (Potato Tuber Moth)

Phthorimaea operculella

Recognition: Brown patches on the leaves caused by white worms up to 8 mm. long feeding inside the leaf. The worms can be seen if the brown skin covering the leaf mine is carefully peeled back.

Control

1. Spray with 1 litre of 50% fenitrothion E.C in 100-800 litres/ha. of water according to the spraying machinery available.

2. Spray with 2 litres 50% malathion E.C. in 100-800 litres/ha. of water according to the spraying machinery available or spray with a mixture 20m/. 50% malathion E.C. in 10 litres of water.
3. Spray with 1 litre 5% fenthion E.C. in 100-800 litres/ha of water according to the spraying machinery available.
Or spray with a mixture of 10 ml. 5% fenthion E.C. in 10 litres of water.

Note: A sporadically serious pest in the Awasa area.

4. Peach Aphid - M. yaza Persicae

Recognition: Colonies of small, green, slow-moving, soft-bodied insects on flower buds, soft shoots and the underside of young leaves.

Control
1. Spray with 1 litre of 40% dimethoate E.C. in 100-800 litres/ha of water according to the spraying machinery available.
Or spray with a mixture of 10 ml. 40% dimethoate E.C. in 10 litres of water.

2. Spray with 1 litre 40% formothion E.C. in 100-800 litres/ha. of water according to the spraying machinery available.
Or spray with a mixture of 10 ml. 40% formothion E.C. 10 litres of water.

Note: A possible carrier of virus diseases. A good is essential if aphids are to be effectively controlled by endosulfan.

3. Spray with 1 kg of 50% endosulfan W.P in 100-800 litres/ha. of water according to the spraying machinery available.
Or spray with a mixture of 10 g of 50% endosulfan W.P in 10 litres of water.

5. Tobacco Whitefly (Bemisia tabaci)

Recognition: small, white, scale-like insects on the underside of leaves. If the plant is shaken a cloud of very small, white, moth-like insects flutter out but rapidly resettle.

Control: The measure detailed for leaf miner will be also control for white fly.

Note: An important carrier of virus diseases.

6. American Rollworm - Heliothis armigera

Recognition: Green or brown caterpillars present up to 4 cm long with longitudinal light and dark stripes feeding on flower buds.
1. Dust with either 5% DDT dust at the rate of 15-20 kg/ha. Or 10% dust at the rate of 8-10 kg/ha.

2. Spray with either 4 litres of 25% DDT E.C. Or 1.25 kg of 75% DDT E.C. Or 1.25 kg of 75% DDT w.p in 100-800 litres/ha of water according to the spraying machinery available.

3. Spray with a mixture of either 40 ml. of 25% DDT E.C or 12.5 gm of 75% DDT w.p in 10 litres of water.

4. Spray with 1 kg of 50% endosulfan w.p. in 100-800 litres/ha of water according to the spraying machinery available. Or spray with a mixture of 10 gm of 50% endosulfan w.p. in 10 litres of water.
A number of insects feed on both unmanufactured and manufactured cured tobacco, but over 99% of all damage is done by two of them; the cigarette beetle, Lasicoderma Serricorne (F) and tobacco moth, Ephestia elutella (Hb.). Neither is confined to tobacco and they can both thrive on a number of other stored products.

Cigarette beetles are dark brown and a little under 3.2 mm long. The larva is white, fattish, thickly covered with fine hairs and about 4.8 mm. long. Adults do not live long and lay most of their eggs within ten days of emergence. Length of life cycle depends on temperature and humidity.

Tobacco moth is a small and grey, with a wing span of about 16 mm. The pinkish-white, brown-headed larva has small brown spots along its back and grows to a length of around 13 mm.

Both insects have a world wide distribution but the beetle is more adapted to the tropics and subtropics, with the moth more prevalent in temperature areas. The moth larva prefers high-sugar, low nicotine tobaccos and has only been recorded attacking flue-cured and oriental. Feeding is heavy. Complete leaves may be devoured, leaving only the main veins and midrib. In moving, the larva leaves a silken web, which is a good diagnostic indication of its presence.

Control
1. Routine precautions measures must be taken carefully. The first requirement is cleanliness. Farm buildings should away be cleaned, through complete removal and destruction of all tobacco debris at the end of each season. The walls need white washing or painting and all inside surfaces spraying with 75% DDT w.p. at the rate of 450 gm, in 4.50 litres of water per 90m².
2. The safest insecticide for routine tobacco store treatment is pyrethrum, used as a light oil-based mist or aerosol formulation, containing a synergist.
3. Fumigation.
The organized culture of near contiguous areas of tobacco has often provided ideal conditions for the spread and multiplication of disease organisms which are adopted as tobacco parasites. Peculiar problems are caused by the crop value being in the leaf. Diseases which only slightly damage a leaf's photosynthetic efficiency can much reduce its value as an article of trade. Care is also needed to avoid spray residues which can persist through the processing and mar smoking quality.

General Consideration Control Measures

Hygiene and culture practice

The basis of control is still rotation, hygiene and generally sound culture. None cost any money. Resistant varieties and chemicals are valuable aids to sound farming but profits will decline if they are regarded as substitutes for it. Rotations may be simple to frame, as in Rhodesia, where there is only one major soil-borne disease—nematodes. On the other hand, the presence of several major soil diseases, as in the American flue-cured growing areas, causes problems. Crop can be found which will check the development of both root-knot and lesion nematodes. Black shank is no problem in this respect, with tobacco as the only host in its areas of production. Bacterial wilt will attack ground-nuts and most vegetable crops so they must be left out of cropping systems where wilt is serious but maize and some grasses (teff) are satisfactory. The particular system used depends on what a farmer knows his major problem to be. This may of course change from time to time and flexibility over choice of crop sequences is an essential weapon in the disease battle. It has, however, been shown quite conclusively that an adequate form of alternate cropping will reduce respective disease incidences and raise crop returns, over those from continuous tobacco planting, in the case of nematodes, black shank and bacterial wilt.

Change in cultural methods and shifts in varietal type, introduced for other reasons, can affect disease incidence. Since the mid 1950s brown spot has changed from a minor to a major problem in the American flue-cured areas. This is likely to be related to the major swing away from Hicks Broadleaf type varieties to thinner broader-leaved types. In Rhodesia, frog-eye infection was a major disease in early 1950s, probably causing more loss than any other. It is now of little concern. Part of the changed situation reflects market requirements, but the major influence has been that of earlier planting much reducing infection incidence (Cole, 1966a)
Hygiene and prompt destruction of crop residues are of the greatest control value. Rapid pulling of tobacco stalks at the contribution to reducing root-knot nematode populations. The early ploughing under of old stalks and debris helps to reduce the mosaic incidence in future crops.

The following operations found to reduce losses due to these pests and diseases like brown spot, nematodes, mosaic, budworms, horn worms and flea beetles:

1. Cut or pull out stalks immediately after completion of harvest.
2. Flough -out tobacco stubbles for exposure to wind and sun.
3. Two weeks later, disc under old tobacco crop refuse.
4. Seed winter cover crop for erosion control.

Resistant Varieties

Resistance is graded in variety specifications and needs relating to particular disease and cropping situations. Low resistance is satisfactory if disease levels are low and long rotations are followed. Moderate resistance will give profitable returns under medium disease infestation, where suitable crop sequences are practised. Neither of these resistance levels would give satisfactory returns from continuous tobacco culture under a disease situation. High resistance should cope with most disease incidence, but prolonged continuous tobacco cropping could produce situations where it, too, would be inadequate. Tolerance is something less than resistance. It implies particular disease susceptibility but a tolerant plant is likely to suffer less damage in any given circumstance. NC 95 is highly resistant to galling by M. incognita and nematode does not reproduce its roots. It nevertheless enters them and heavy infestations depress yield, due to retarded early growth. Kutsaga K is resistance to white mould.

Chemicals And Soil Fumigation

Chemical sprays are in fairly general use on seed beds and will often give some control of disease under conditions. Field spraying is not generally practised and does not for part of American recommendations, but it is recommended for white mould control in Rhodesia. Soil fumigants are a different matter. Originally concerned with nematode control, and used only as nematocides, subsequent development have widened their scope to cover other soil-borne diseases. Ethylene dibromide and dichloroprophane are nematocides only but dichloropropene does have slight fungicidal properties. Proprietary soil fumigants which contain one or more of these fungicidal compounds plus nematocides are recommended in America for reducing the incidence of black shank, black root rot and bacterial wilt in addition to controlling root-knot and lesion nematodes.
Their use might permit use of moderate or low varietal resistance in high disease situations or where rotations are not practised. It should be mentioned that varieties possessing the desirable degree of resistance for a particular farmer may have other characteristics which are not so attractive. In those circumstances, soil fumigants may enable varietal choice to be based more upon factors other than disease resistance.

The Fungus Diseases

It will be convenient to divide the consideration of individual diseases as far as possible according to their relation to the management phases of the crop. It is not intended to consider the full details of each pathogen for ample such accounts are available elsewhere (Hopkins, 1956; Lucas, 1965).

Diseases Principally of the Seedbed

Damping Off: Pythium spp.

The name is normally applied to a rot of seedlings caused by several species of pythium and it is not confined to tobacco. The fungus normally attacks the stem, at ground-level, which is characteristically girdled by a ring of dead brown tissue. The plants topple over and the leaves than rot into a shapeless slimy mass. Unchecked the disease spreads outwards, to leave circular patches of rotten material on the surface of the bed. All of seedling growth are susceptible. Occurrence just following germination can cause rapid disappearance of the stand without detection of the disease unless observation is very close. The end-point in that case there is an associated leaf spot where the infection starts.

Damping-off should not occur in the well-managed seedbed site. It only spreads under conditions of very high humidity, such as occur with a combination of overwatering, lack of ventilation and too dense a population of seedlings. When the disease is noticed the relevant management factors should be checked first and if that does not effect a cure affected patches and surrounding areas may be dusted with a copper fungicide.

Anthracnose: Colletotrichum spp.

Primarily a seedbed disease; the taxonomy of the causal agent is uncertain. Colletotrichum tabacum. Boning is frequently indicted but C. nicotianae and C. destructivum are also used to name the species attacking tobacco. Usually a major threat only to seedling production.

The initial infection appears as pale water-soaked spots on the seedling leaves closest to the soil.
The center turns pale brown or grey and papery but is often surrounded by a water-soaked halo. The spots may remain small, forming a characteristic pattern of small, almost white areas on the leaf surface. It is also possible for the larger spots to become zonate with a white center, which can cause confusion in identification. But the presence of black lesions on the underside of the smaller veins normally denotes the presence of anthracnose. Although outbreaks are related to humidity and temperature the range of tolerance is much greater than for damping off and control is not possible simply by varying management. The fungus can persist in the soil, on infected trash and on a number of alternate hosts. The two former are of more importance in considering seedbeds. The disease can be seed-transmitted.

Copper fungicides will not control anthracnose. If a seedbed leaf spot of apparent fungal cause is not controlled by copper than anthracnose should be suspected. Control can be affected with dithiocarbamate dusts or sprays, Zineb, thiram, maneb and ferbam are all suitable compounds. Zineb can also be used as a drench before sowing, to control infection from the soil but seedling growth may suffer after such treatment and is likely to be retarded. Seed should be sown earlier on treated beds. The other compounds should not be used as soil treatments. Where methyl bromide is used for nematode and weed control it will also take care of soil-borne anthracnose. Seed should be obtained from clean crops but seed treatment can be effective. Infected seedlings should not be planted but if expediency dictates otherwise, at least those with stem lesions should be discarded, for they will either die or grow poorly. In wet conditions leaf infection can persist in the field and cause some damage.

Oolidium Seedling Blight: Oolidium brassicae. This in itself is a minor disease caused by an obligate parasite which has a fairly wide host range. It is soil borne and causes a brown decay of the roots accompanied by a yellowing and dying of the upper parts. It has assumed greater importance following identification as vector of tobacco necrosis virus. Seedbed fumigation with methyl bromide is a control.
Diseases of Seedbed and Field

Wildfire and Angular Leaf Spot: Pseudomonas spp.

The causal organisms are bacteria and respectively named *Pseudomonas tabaci* and *Pseudomonas angularis*. The two are apparently identical except for the ability of *P. tabaci* to produce a toxin, which is not possessed by *P. angularis*. Both are of worldwide distribution and are either a very minor problem or become severely epidemic. This particularly applies to the aptly named wildfire. The disease is known for the very marked yellow halo surrounding a necrotic spot, but under the wet conditions suitable for an epidemic the necrotic areas enlarge exceedingly rapidly and the yellow surround may be completely absent. Wildfire is very susceptible to environment and thrives when the leaves are sodden and water-soaked. Seedbeds are an ideal medium for rapid spread but it can be equally rapid in the field, though conditions need to be very humid indeed.

Angular spot is also appropriately named, for its spots, much darker than wildfire and without the halo, are limited by the small veins and have an angular appearance. The spots are usually very small in the seedbeds and need close observation for detection. In the field they can run together and become nearly circular. They are sometimes zonate. In bad attacks the veins may also rot and become black. Both these diseases are spread by heavy rain, although any conditions giving rise to water-soaked residues such as general dampness and soft rain can be equally effective. A dry period seems to check wildfire completely but angular spot is more liable to continue spreading at a much reduced rate.

These diseases can be seed-borne and the bacteria also occur on old tobacco refuse and on the roots of many plants including infected tobacco seedlings. Seed infection is not now considered an important source of inoculum. Nevertheless seed dressing with silver nitrate is a prudent precaution. General cultural hygiene, including destruction of old debris, will cut down the initial supply of inoculum. In the field crop rotation will be helpful but the other crops need careful choice. Copper-based sprays or dusts are effective controls both in seedbed and field. Frequent application is often necessary in the moist weather that favors epidemic spread. Streptomycin has also proved an excellent control when applied as a weekly spray, with some evidence that it also acts as an eradicant. It is important to control seedbed outbreaks and plant only uninfected seedlings. Although field outbreaks can occur from inoculum in the field, one potential source is removed if the seedlings are clean. Resistant varieties have only recently been released and these are confined to Burley and cigar-binder types.
Frog-Eye: Cercospora nicotianae

The disease is widely reported from most tobacco-growing countries. In wet seasons in Africa it can be serious, when the spots may almost completely cover the leaf surface. Even minor infections are very serious on cigar-wrapper crops, where appearance is of such importance. It occurs equally in seedbeds and field and often continues to develop during the early stages of curing.

The characteristic lesions are small and lightish brown with white parchment-like center. Unfortunately white center may be absent. Under some conditions longer and fairly large necrotic areas may appear which can be destroy much, or all, of the leaf. These areas can be slightly zonate and more than one type of spot may occur on the same leaf. Confusion with other leaf spots thus very likely and positive identification often depends on microscopical examination. Frog-eye does not, however, attack the stalks or midribs. Development of infection in curing flue-cured tobacco leads to barn spot. These are usually small but they can occur in very large numbers; the colour is a uniform brown or black. Green spots may occur on air-cured tobaccos as a result of late frog-eye infection and are particularly noticeable on cigar-wrapper leaf.

Infection is encouraged by wet weather. A combination of frequent rain and warm temperatures can cause rapid spread, particularly in seedbeds. It is generally accepted, although without direct evidence, that the planting of infected seedlings increases the chance and severity of field attack. In the field typical infection appears first on the lower leaves and moves upwards as senescence advances. In Rhodesia tobacco with field-type spots has found buyer favour in recent years, disease incidence being regarded as indicator of leaf maturity. The atypical lesions may, however, become serious on immature leaves and call for difficult decisions on reaping policy. Although visible field symptoms are much more apparent on ripening (i.e. nitrogen-deficient) leaves, in fact ample nitrogen increases susceptibility. Spots on such leaves remain very tiny in the field but develop in visible profusion in curing, as barn spot. Coarsely grown tobacco with excess nitrogen is often infected with the atypical form of the disease.

Seedbeds should be kept free of infection either by routine spraying or regular sprays once the disease has been noticed. In the latter instance very early recognition is vital. Spray frequency depends on the weather and should increase in wet conditions.
Normally, weekly application of Bordeaux mixture or a proprietary copper compound will be adequate. In areas where the disease is particularly trouble-some, careful selection of healthy seedlings and the dipping of them in a suitable fungicide before planting is a useful precaution. Field spraying can be carried out, but it is very laborious. Planting clean seedlings and good field management, including adequate hygiene, will normally preclude serious epidemics. In Rhodesia early planting has given decreased incidence of frog-eye infection. The development of barnspot may be inhibited by yellowing at 368 and 100% relative humidity, but such conditions do not provide an ideal curing environment.

Brown Spot: Alternaria tenuis

Nomenclature has caused some confusion. The causal agent was generally referred to as A. longipes. This is another leaf infection of wide occurrence in tobacco-growing areas. It is favoured by warm climates and spreads rapidly in high humidity. The disease is rare in seedbeds but can occur under ideal weather conditions and where hygiene has been poor.

The typical lesions are more or less circular, darkish brown and definitely zonate. They may or may not be a surrounding yellow halo. The yellow area can be very extensive and cover large areas of the leaf far in advance of the spots, perhaps causing the whole leaf to die prematurely. Distinct, sharply demarcated spots are more characteristic of dry-weather infection. The yellowing is due to a chlorophyll destroying toxin. As with frog-eye the lesions may not be typical. Under epidemic conditions large areas of tissue, or even the whole leaf, may go brown and be destroyed.

The disease starts on the bottom leaves, as they approach senescence, and then moves upwards. This movement upwards can be well ahead of normal ripening and render difficult 'reaping ahead of the disease'. The brown-spot fungus is not an obligate parasite. It exists as a saprophyte on general plant debris, including that of tobacco. The fact that it appears late in the season and then becomes progressively more severe has been attributed to an increase in parasitic virulence, resulting from successive infection cycles. Early in the season it can enter only through damaged or weakened tissue, but towards the end it is able to attack any living tobacco tissue. It allows that the longer initial infection can be delayed the better the chance of restricting overall crop damage. The relevance of hygiene and old crop destruction is obvious. Brown spot activity continues during flue-curing and extensive toxin production can cause previously undamaged leaf portions to cure out dead and almost black. The fungus also causes stem and seed-pod lesions.
Adequate control measures are not yet available. Prevention by using seed treated with silver nitrate, field hygiene and growing soundly fertilized crops on suitable soils is all important. Fungicide spraying can be useful but it must be started early at the first signs of infection and then rigorously continued. Copper compounds and maneb have been used with some success. Field spraying of the order required is, however, very expensive. Sources of resistance are known, but no commercial resistant varieties are available.
White mould is known also as powdery mildew and white rust. It is a serious disease in East, Central and South Africa. It is currently considered the most serious field disease in Rhodesia. Particularly severe at higher altitudes in Africa, it has been the limiting factor in delineating areas of Virginia-type flue-cured cultivation. The disease can occasionally be seen in seedbeds but is of no consequence there; the damage is done in the field.

The symptoms are commendably characteristic and cannot be confused with those of any other disease. The patches of greyish white mould usually appear first on the frills at the base of the bottom leaves. Infection may remain in this state, but if conditions are suitable the white patches will soon appear on other parts of the upper leaf surfaces and eventually run together. Progression can be steady and relentless, eventually involving all leaves. Infection is not always made obvious by fungal growth on the surface but in its absence the leaves assume an anaemic yellow colour. The fungus is likely to move ahead of ripening. Infected leaf areas, whether white or not, cure black and papery. Heavily infected leaves are thus not worth reaping.

White mould is another disease with apparently very precise environmental requirements for optimal development. High humidity and cool temperatures have been commonly assumed as necessary. It was suggested that environmental influences upon host susceptibility may throw more light on the problem than sole consideration of their effects on the parasite. Nutrition is involved, with an increased susceptibility when proportions of free amino acids are low and an inhibition of fungal growth on leaves moderately deficient in potassium. The latter causes abnormal increase in amino acid content. Leaves were not susceptible until they stopped expanding, which was at least six weeks after emerging from the bud and this susceptibility decreased again once only the upper leaves remained on topped plants. Irrigation in dry weather increased the speed of fungal spread and also the susceptibility of uninfected leaves.

Good field practice is the main control. Correct soil choice, proper fertilization, wider rows to increase air circulation and early planting with help. The measures will not be enough under favourable conditions for the fungus but weekly spraying with dinocap will control the disease even if it is established before the first spraying. The period between six and thirteen weeks is the susceptible time and when control measures are needed.

Infection always starts at the proximal end of the leaf and early sprays must cover that area. Kutsaga 5 variety is moderately resistant to white mould in commercial flue-cured varieties.
Black Root Rot: *Thielaviopsis basicola*.

An infection of both seedlings and field plants, this disease has been reported from most countries of the world but only from South Africa on the African continent.

The name is descriptive. Roots of infected plants are black, either wholly or in banded parts and while small roots rot completely, larger ones carry rough black lesions. Young seedlings are killed and have the appearance of damping-off. Older plants can survive, but with a much reduced root system and are liable to make very unsatisfactory growth in the field. Some infected plants will grow normally when the temperature rises. Plants which remain stunted show wilt symptoms similar to those of other diseases and microscopic root examination may be necessary for positive diagnosis. An infected field usually presents a very uneven appearance with gradation between dwarfed and normal plant areas.

The fungus is a soil saprophyte and can persist indefinitely. Severity of attack is related to amount of inoculum present and the build-up is not easy to prevent, with such a wide host range. In contrast to diseases earlier described, black root rot is a cool-weather disease. It would appear, however, that the main temperature effect is on the host and not the parasite. Severe infections occur when conditions are not favourable for tobacco growth. A second important environmental influence is PH. Below PH 5.6 the disease ceases to be factor; it gets worse as PH increases is not a very critical factor, although high levels will lower the temperature. Other organisms appear to be associated with *T. basicola* infections but the role they play is not at all clear.

The disease was one of the first to be considered in a breeding programme. The resistance of *Nicotiana debneyi* has recently been incorporated in a commercial variety, Burley 49. But the earlier resistant varieties offer a satisfactory control in many situations, provided they are wisely used. Seedbed treatment with methyl bromide controls the disease in seedlings and other chemicals; vapam and allyl bromide have also given good results. In the field, adequate crop rotation is necessary, for even resistant varieties still build up soil inoculum and this can reach the stage where crop returns are likely to be reduced. The length of rotation depends upon the level of other factors. When PH is high (i.e. favourable) rests must be longer than when the fungus is not so well suited. Care is needed in choice of crops; small grains are most suitable. The use of lime in black-root-rot areas needs careful thought and to be aimed at keeping the PH below 5.6.
Fusarium Wilt: Fusarium oxysporum

Not a major disease, it is nevertheless widespread and can be locally serious. It is apparently associated with the important "chitri" disease of bidi tobacco in India. In the continent of Africa, only South Africa and Uganda have reported the fungus on tobacco. The absence of records from other places may be due to lack of recognition, for the causal organism is widely distributed in soil and has a comprehensive host range. Some plants can be parasitized by Fusarium spp. without showing symptoms.

Yellowing and drying of leaves precedes wilting symptoms. Indeed, the latter may be considerably delayed. Often the yellowing is confined to one side of the plant; this can be distinguished from the "half-leaf" effect of Granville wilt. The fungus, being soil-borne, enters through the roots and these will be blackened and destroyed. Removal of stalk pith reveals black or brown coloration of the woody vascular tissues. Longitudinal sections usually reveal the pith intact. Rotting is dry, in contrast to the slimy wet rot more typical of bacterial infections. Despite the apparent distinctions, there can be field confusion between Granville and fusarium wilts and positive diagnosis must be based on the presence or absence of bacterial exudate from the transversely cut stalk. Seedlings can be affected and may be a means of spread. Fusarium wilt responds to soil temperature and is most active at ambient temperatures of 82-88°F (28-32°C). Being strongly aerobic the fungus is eliminated by waterlogging. It thus prefers light sandy soils and will be most destructive in hot, dry weather.

Associations between fusarium and root-knot nematode (Meloidogyne spp.) infections have been shown for tobacco and other crops. The mechanism is not clear but it is apparently complicated.

Resistant varieties are again the major control. Seedbed sterilization will provide clean transplants. Field nematocide application will be assistance where root-knot is also a problem. Rotation should be practised in conjunction with use of resistant varieties but again care is necessary in choice of crops. The aim is to minimize inoculum build-up, for actual reduction is a possibility only over very long periods. Cotton should be avoided as an alternative crop for Burley, but it can be included in flue-cured cropping systems.
This disease has been called white root rot in Rhodesia. The fungus is widespread and attacks many crops, often more seriously than it does tobacco. Cold winters kill the fungus and in America it is therefore confined to the Southern States. It has been found on isolated plants in Rhodesia but does not apparently spread in the field.

The base of the stalk becomes girdled by a sunken brown lesion which may so weaken the stem as to cause it to blow over. At some stage the leaves will suddenly turn yellow, wilt and die. There will be no decay of the roots until the plant is dead. Sometimes the sclerotia, initially white and latter dark brown, will appear on the surface of the stem lesion and constitute a diagnostic feature in what may otherwise be the difficult task of distinguishing between this disease, black shank and Granville wilt. High temperature favour fungal activity and it is more likely to become apparent after heavy rain which was preceded by a period of dry weather. Greater disease severity has been noted on the lighter sandy soils. The disease has not become sufficient of a problem to warrant control measures and no resistant varieties are available.
Hollow Steak and Black Leg

Erwinia carotovora

Black leg is the seedling form of the disease and hollow stalk is seen in mature plants just after topping. The disease has been reported from most tobacco-growing countries as causing occasional severe local damage. It was not formerly of much account in Rhodesian flue-cured crops but it did prove troublesome on fire-cured crops in Malawi.

Black leg can occur during wet periods, when the bacterium gains ingress through leaves resting on the soil and passes through the petiole to the stem, causing a black rot of all the tissues through which it passes. Hollow stalk rots the pith. The bacterium can enter through any wound, but usually does so through the topping break. The depression so made can collect moisture and give ideal infection conditions. The top leaves wilt and die and this process can extend right down the plant. There may be black bands encircling the stalks. Bacteria are produced in great profusion and can continue to rot the leaf petioles during the early stages of curing.

This bacterial disease is a soft rot and very dependent upon high humidity for maximum development. Dry weather can be a complete check. Temperature does not appear to be relevant. The use of mineral oil for sucker control favours the disease and particularly if they are used undiluted. The contrasts between hollow stalk and charcoal rot should be noted. In this case it is important not to apply the oil in wet weather. In fact, where hollow stalk is a problem, damp weather is better avoided for both topping and suckering, whether mineral oil is used or not. Black leg will be favoured by dense seedbeds and anything else which raises humidity. The remedies, on occurrence, are obvious.

Frenching: Bacillus cereus

Previous reports have considered frenching to be physiological origin. No mechanism has been detailed although several theories have been put forward. The symptoms are fairly well known, for odd affected plants appear in most tobacco crops from time to time. There is marked interveinal chlorosis and a profuse growth of very narrow, quite abnormal and often fleshy leaves. The growing point can be inhibited and a rosette of growth arise from the suckers. Symptoms are more usual on young plants but they can arise after several weeks' growth. Conversely, mildly affected plants may lose the symptoms and resume normal growth.
Although frenching has been shown as non-infectious it has also been prevented by soil sterilization. Furthermore, responses to altered environmental conditions have always been erratic. The possibility of some soil toxin being responsible led to the discovery that an exudate of B. cereus produced symptoms of frenching when absorbed by tobacco. This widely occurring bacterium is non-pathogenic and apparently exerts its effects without coming into contact with the plant. Some environmental abnormality is apparently also required to produce symptoms of frenching, but whether it is the effect of this on the bacterium or on the plant absorbing the exudate is not clear. It does seem that the plant response is a disturbed nitrogen metabolism, which ties in with earlier Rhodesian observations that a dressing of readily available nitrogen could often induce normal growth in affected plants. Frenching is not, and never has been, of any marked economic significance but as a puzzling condition of widespread occurrence it has evoked a good deal of interest.

**Virus diseases**

The number of identified virus diseases has been growing in recent years together with appreciation that the older ones are in fact complexes whose symptom expression can vary. Nomenclature has caused a great deal of confusion through failure to realize that as the same virus can cause different symptoms so similar symptoms may be caused by different viruses. Viruses are diseases of any plant age and the growth stage of infection is very relevant to the losses caused.

**Mosaic**

Tobacco mosaic virus is ubiquitous and is very well known through its employment in many basic virus and hereditary studies. It is becoming a serious disease in America and caused an estimated $2.8 million worth of damage to the 1966 North Carolina flue-cured crop. The classical symptom is the mottled leaf appearance. The light and dark blotches are usually very obvious but holding the leaves to the light quickly resolves any doubts. Dark-green blisterings may be seen on the upper surface and enations on the under surface.
Neurotic spotting is also a symptom. Mosaic scorch may develop around the veins and then become extensive, destroying much or all of the leaf. The varied symptoms are due to various TMV strains, their interactions and environmental influences on the host.

TMV is highly contagious and very easily spread by mechanical contact. The classical appearance of a succession of infected plants down a row of tobacco often reflects the passage of a worker transmitting the disease as he moves along, topping, or even cultivating. Some injury to epidermal cells seems necessary but it need only be slight. With above-ground inoculation the infection, after a brief pause, rapidly becomes systemic throughout the plant, although symptoms do not appear on leaves which are already mature. Infected leaves, if they mature adequately, will cure out thin and looking in body. Early infections are particularly serious as often causing severe stunting. Mosaic is generally a debilitating disease but it does not always behave in this way. TMV can survive for up to two years on plant debris unless the latter is frozen or completely decays. The high temperatures of flue-curing and redrying will largely or completely inactivate the virus but tobaccos not undergoing these processes retain infective potential through manufacture. Mosaic is often present in a field without realizing its potentialities as a very serious disease. This should not lead to any false sense of complacency. Control is through prevention, which can be ensured by simple if rather tedious hygiene. Destruction of all old tobacco debris with particular care to keep it well away from the seedbed site, treatment with methyl bromide, the forbidding of tobacco use (smoking and snuff) within the fences seedbed area and soap and water hand washing for all who enter it, will ensure virus-free seedlings. Similar rules regarding smoking, sniffing and handwashing whenever the plants are handled in the field should also keep the planted crop free from infection. An additional precaution is to spray the beds with milk just before pulling. Milk can also be used for rinsing workers' hands instead of soap and water. Inspection, to remove any odd infected plant that may have appeared, despite the precautions, before workers enter a field is an added safeguard. Again, rather unfortunately for effective extension work, absence of all these measures often fails to lead to infection. But since it is too late for action when symptoms appear no preventive effort should be spared. Adequate crop rotation has been shown to reduce field infection on American flue-cured crops. Resistant varieties are available in America for every tobacco type grown there, but the performance of flue-cured lines carrying resistance has not been satisfactory. The commercially released vanmor varieties have a poorer performance than the parents but they can be used if mosaic is an overriding problem.
Known by various other descriptive names such as 'curly' and 'crinkle' the disease is common throughout tropical areas but is not as yet of any serious consequence in the United States. It was first identified in Java and East Africa. A number of other plants, including common weeds, have been reported as hosts.

The symptoms vary according to the strains of the virus which are involved. In Africa, the leaf is typically puckered, often looking like a savoy cabbage and the veins on the undersurface become thickened and twisted to give a knotted appearance. Other symptoms include enations from the undersurface veins and the leaf margins may turn down to give a hooded look. Early infections cause severe stunting, with any upper leaves which may be formed being so small, curled and twisted as to be hardly recognizable as leaves. Later infections can result in the lower leaves remaining apparently symptomless, although when cured these will be of poor quality. Spread is by insect vector only. Whiteflies (Bemisia sp.) are the most commonly cited agents but other aleurodids have been shown to carry the disease. The situation varies from country to country.

The spread and severity of leaf curl is entirely dependent on the insect vectors and the supply of infected plants on which they can feed. Destruction of all living tobacco material at the end of each season is vital and some countries enforce a 'close season' by regulation because it is essential that all producers in an area should comply. It is considered that this policy has been responsible for keeping the disease down to negligible proportions in Rhodesia. Insecticides can be used against the vectors but systemics are necessary because whiteflies and related genera are highly mobile by comparison with aphids. Again, there is no control, only prevention.

First reported from Rhodesia, this disease is a very serious potential threat to crops in East and Central Africa. It is not apparently recognized elsewhere. It is not always easy to distinguish between the two conditions. Both cause stunting but whereas in rosette a number of small leaves are produced, with negligible internodes, to give the named appearance, bushy top includes a proliferation of small shoots from excessive axillary bud development.
Rosette infections late in growth may be visible only a very marked hooded appearance of the leaves. There are two viruses involved in both diseases, of which *Myzus persicae* is the most common. The control is prevention and the methods are those described for leaf curl. Aphid control has been described under cucumber mosaic virus. Early planting to enable good growth before large build up of aphid colonies has been an important control factor in Rhodesia. Indeed, late plantings are so regularly infected that oriental tobacco, which was planted late in the season, has either had to be abandoned in flue-cured areas or planted early. Crop loss is related to the age of the plant when infected; the first three weeks after planting in the field are particularly critical.
The Application of Fungiocides

The fact that a particular chemical has been found to control or prevent a disease does not necessarily mean that it will do so regardless of the manner and time of application. Manufacturers' instructions are usually very explicit and must be followed if full benefits are to be obtained from what is often an expensive exercise. It is normally necessary to ensure even leaf coverage of the particular compound. Operating pressures in excess of 40 lb per in\(^2\) (2.6 kg per cm\(^2\)) are needed to ensure droplets of sufficiently small size but above 70 lb per in\(^2\) (4.5 kg per cm\(^2\)) there is danger of damaging the tissues unless very fine nozzles are used. Flat-fan nozzles will give a better distribution than hollow-cone nozzles and it pays to give some attention to nozzle arrangement and ensure the necessary slight overlap. Lower-pressure sprayers such as stirrup pumps do not give satisfactory cover. Many spray compounds form only fine suspensions in water and it is vital, by suitable agitation, to ensure that these are maintained. Sometimes dusts can be as efficacious as sprays and many suitable machines are available for their application. Dusting when the leaves are damp will cause adequate adherence to the leaves. The development of electrostatic techniques could have shown high-density adherence of electrostatically charged dusts to an almost equal extent on upper and lower leaf surfaces. Such deposits have been resistant to the washing effect of rain. Some deposits could be too long-lived for field use but there would seem no such objections on seedbeds.

Disease Identification

Investigation of a field or seedbed disease problem is rarely as simple as might be imagined from reading the catalogue of maladies given above. The simultaneous presence of more than one disease or one disease exhibiting a range of symptoms are unhelpful complications. Positive identification of the organisms present (except viruses) can usually be made fairly simply but it is still necessary to ensure the correct determination of the major problem. There are, however, a number of aids to identification, and obvious symptom expression is only one of them. In established areas it will be known which pathogens have previously been present, thus narrowing the field. Other factors which can distinguish between organisms might be listed as:

1. Variety used.
2. Growth stage of plant when attacked.
3. Maturity of leaves first attacked and subsequent spread.
4. General pattern of attack and how this is related to present and past temperature and humidity conditions.
5. Crop spacing and scale of growth.
6. Soil type, moisture content and fertilizer application.
7. Relationship of attack and spread to any management operations such as cultivating, topping and sucker ing.
9. The presence of symptoms other than the obvious ones, e.g., on the roots or in the stalk.

In most countries phytopathological laboratories are available to identify diseased specimens. Many will ask for additional information of the type listed here and often it is not adequately given. Correct identification of the most important features in a particular instance may, however, depend on such knowledge. Certainly the desirability of control measures and their extent will be very much concerned with the general state of the crop and its environment.
Bibliography

3. Crowe, T.J and Shitaye O/Kedhīn Crop Pest Hand Book