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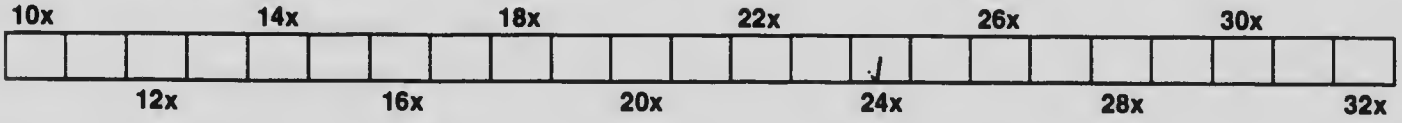

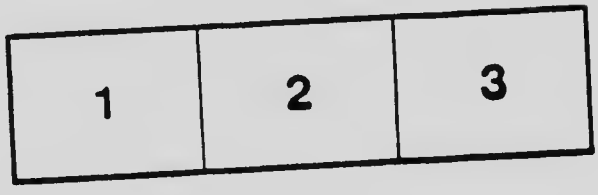


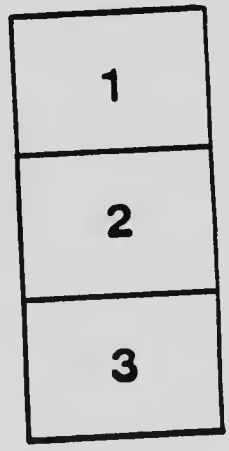


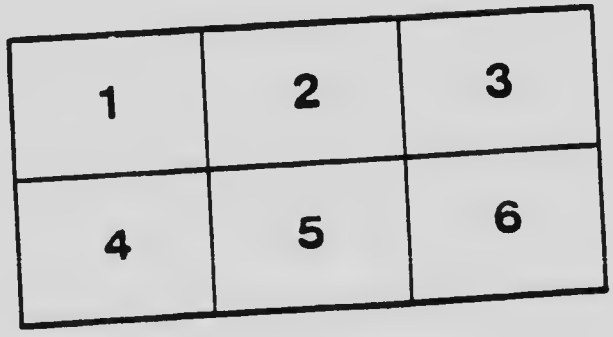

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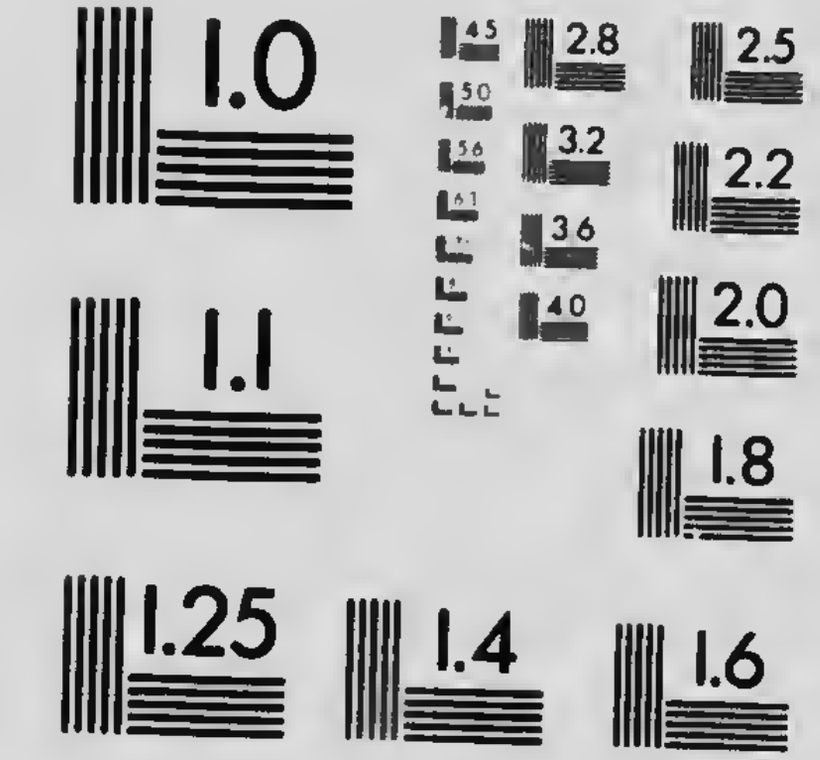


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DOMINION DEPARTMENT OF AGRICU
CENTRAL EXPERIMENTAL FARM
OTTAWA, CANAD.

TOBACCO DIVISION

# TOBACCO SEED BE

BY

**F. CHARLAN**
*Chief of the Tobacco Division*

Bulletin No. 21

Published by direction of the Hon. MARTIN BURRELL, Minister of Agri

GRICULTURE

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# BEDS

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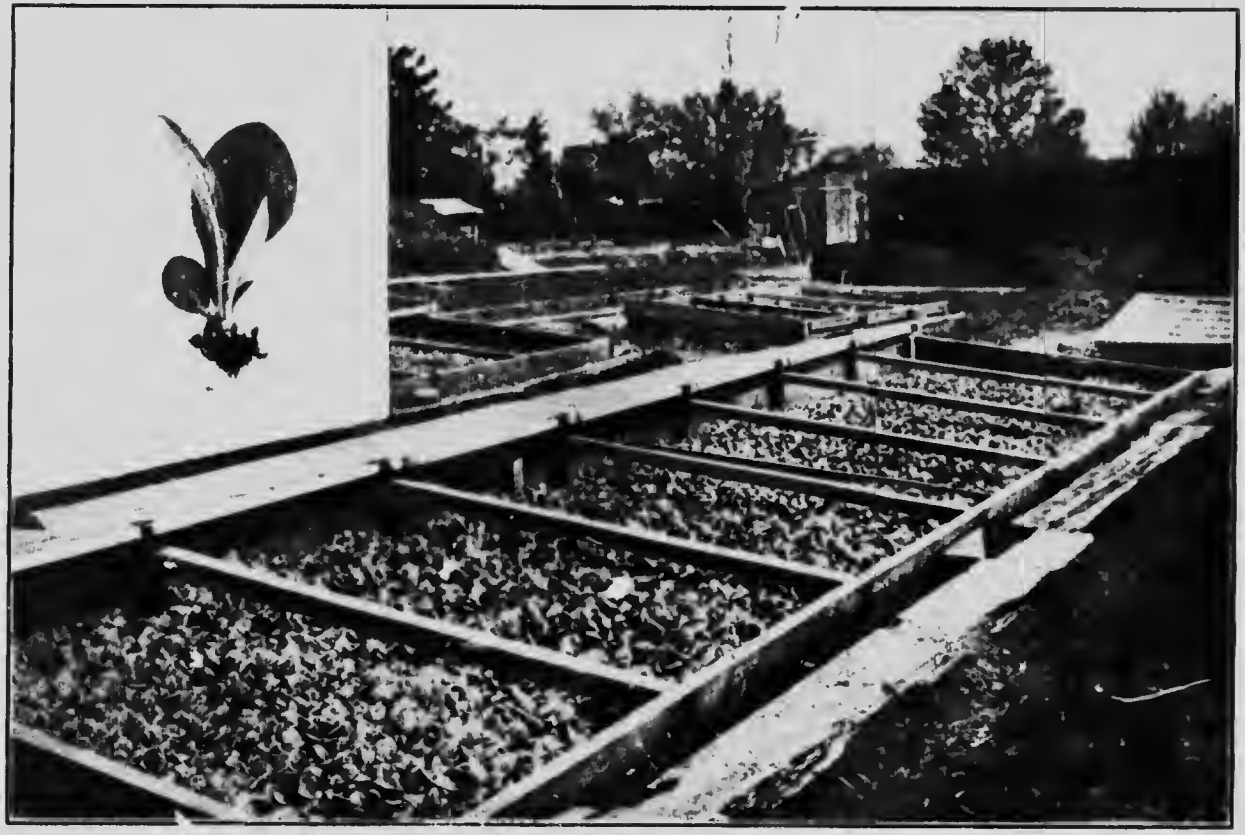

PLATE I. Seed bed of Comstock Spanish. (Sown at the rate of ½ oz. of seed per 100 square feet). Good type of plant

DOMINION DEPARTMENT OF AGRICULTURE

CENTRAL EXPERIMENTAL FARM

OTTAWA, CANADA

TOBACCO DIVISION.

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## VI.

OTTAWA, January 5, 1915.

The Honourable,
The Minister of Agriculture,

SIR,—I have the honour to transmit herewith, for your approval, Bulletin No. 21 of the second series, entitled "Tobacco Seed Beds" which has been prepared by the Chief of the Tobacco Division, Mr. F. Charlan.

The ever-increasing demand for information in connection with tobacco growing and handling is a fair indication of the development of this business in Canada in recent years.

While it would hardly be wise to expect any very great increase in the quantity of tobacco produced by our farmers in the near future, there is no reason why we should not make decided progress in the way of reducing cost of production and improving the quality of the leaf as it goes to the packer and manufacturer. In this way we might hope eventually to produce not merely, as at present, about two-fifths of all the tobacco we use but quite possibly three-fifths or even a greater proportion of the total amount consumed in this country.

With this end in mind, much experimental work with a view to the improvement of the leaf produced and to the lowering of the cost of production is under way.

The accompanying bulletin deals quite fully, as indicated by the title, with the question of starting off the crop in the spring. The young tobacco plant is subject to many diseases and is difficult to get well under way. It is hoped, therefore, that the information contained herein may help our tobacco growers to solve some, at least, of the many problems which confront them at seed time each year.

I have the honour to be, sir,
Your obedient servant,

J. H. GRISDALE,
*Director, Dominion Experimental Farms*

The Director, Dominion Experimental Farms,
Ottawa.

SIR,—I have the honour to submit herewith for your approval, Bulletin No. 21 entitled "Tobacco Seed Beds."

This bulletin is intended to take the place of Bulletin No. A1, of the series of the Tobacco Division, which has been exhausted for some time.

This work is a little more detailed perhaps than would seem to be necessary for a practical text-book. It will enable us however, to answer, merely by referring to a special chapter, and more satisfactorily than could be done by individual letters, a number of inquiries on the subject.

The most suitable methods for our climatic conditions are discussed at length and compared, when opportunity occurs, with the methods followed in foreign countries, which our farmers are a little too eager to adopt before knowing whether they are suitable or not.

It is hoped that this bulletin, in which the use of technical terms has been carefully avoided, may be of service to the beginner as well as to the experienced grower, who may be desirous of elucidating some special point.

I have the honour to be, sir,
Your obedient servant,

F. CHARLAN,
*Chief of Tobacco Division.*

## INTRODUCTION.

It is not the object of this bulletin to give a complete account of all the methods used in the production of tobacco seedlings by the various tobacco growing countries. Only a brief reference is made to the latter, and the author passes on at once to a full discussion of the methods which have been shown by an experience of six years to be the best adapted to the climatic conditions of Canada.

# I.

## TYPES OF BEDS.

The seed of tobacco is one of the smallest seeds known. It is always sown in a special bed, and the young plants are pulled out to be planted in the field, when they are of sufficient size to be extracted and handled without injury, and of sufficient strength to permit of their easily taking root under favourable conditions.

Various kinds of beds are used for the sowing of tobacco, according to the climatic conditions of the country: tropical, temperate and cold. In Canada, the climatic conditions may be said to be cold in the province of Quebec and temperate in the provinces of Ontario and British Columbia.

There are three types of beds, generally known as follows:—

Open beds.
Frame beds.
Greenhouse beds.

### OPEN BEDS.

Open beds are used only in warm climates. They merely consist of a plot of ground prepared for the purpose.

A spot is selected in a suitable place, cleared of all vegetation, and manured. Generally, this spot consists of virgin bush soil, covered with a shrubby growth, in a well protected clearing. The soil should be light, rich in humus and of a rather dark colour. It is generally burnt over to be cleaned of the weed seed and insects that it may contain. Dry branches are piled over the area which is to be seeded and fire is set to them. The fire is put out when the effect of the heat is felt down to a depth of three to four inches.

After this operation, the surface soil is very friable and in such condition that it may easily be brought into perfect tilth. The coals and the larger part of the ashes are raked off. The remaining ashes are incorporated with the loose part of the soil, to a depth of about three inches.

When any doubt is entertained as to the fertility of the soil, an application of manure should be made before burning (at least two or three months before). The manure is worked in with a spade or spread on top. Chemical fertilizers may also be applied after burning and before the final raking.

After sowing, which may be done as soon as the soil has sufficiently cooled and when the area is properly graded, the surface is protected with branches or better still, with light canvas cloth, supported on stakes.

Excellent results may be obtained with this bed. Weed seeds, insect larvæ, disease germs are destroyed by heat. However, after sowing, the bed may be attacked by various enemies: slugs, snails, aphides, moles, etc., the only purpose of the canvas covering being to protect the seedlings from the heat of the sun. However this method of sowing in the open is only used in tropical countries, and large beds are required, out of all proportion to the areas to be planted, on account of possible failures and losses of seedlings.

FRAME BEDS.

A frame may be put around the bed. This constitutes the first step towards protecting the seedlings.

To be satisfactory, this frame should be set down at least two or three inches into the soil. The surroundings must be kept as clean as possible, as weeds afford shelter to insects and parasites of all kinds.

Surface shelters are used to make the protection complete. They may consist of light cloth (muslin, cheese cloth), oiled paper or glazed sashes, according to the rigour of the climate.

There are also several classes of frame beds according to the method of making, viz:—

(1) Cold bed.
(2) Semi-hot bed.
(3) Hot bed.

(1) *Cold bed.*— On the spot which has been selected for the bed and which should be sheltered from the wind and well situated, generally on high and well drained ground, a wooden frame is laid. This frame should not be more than 5 feet wide; the sides are 12 and 17 or 18 inches high respectively, giving a slope of about one inch to every foot. This frame is filled with good earth to a height of four to five inches; a layer of fertile mould (vegetable earth) about one inch thick, is spread on top and the seed is sown on this layer of mould. The sides of the bed are carefully banked up and a surface shelter is put over the bed.

There are other ways of preparing the bed. For instance: instead of filling in the frame with soil brought from the out-side, the surface of the bed is turned over with a spade and the frame laid on this spaded soil and set down as deeply as possible, at least 2 or 3 inches.

The first method is the better as it insures better drainage.

The earth in the bed may be fertilized and treated as that of an open bed. This point will be discussed further on.

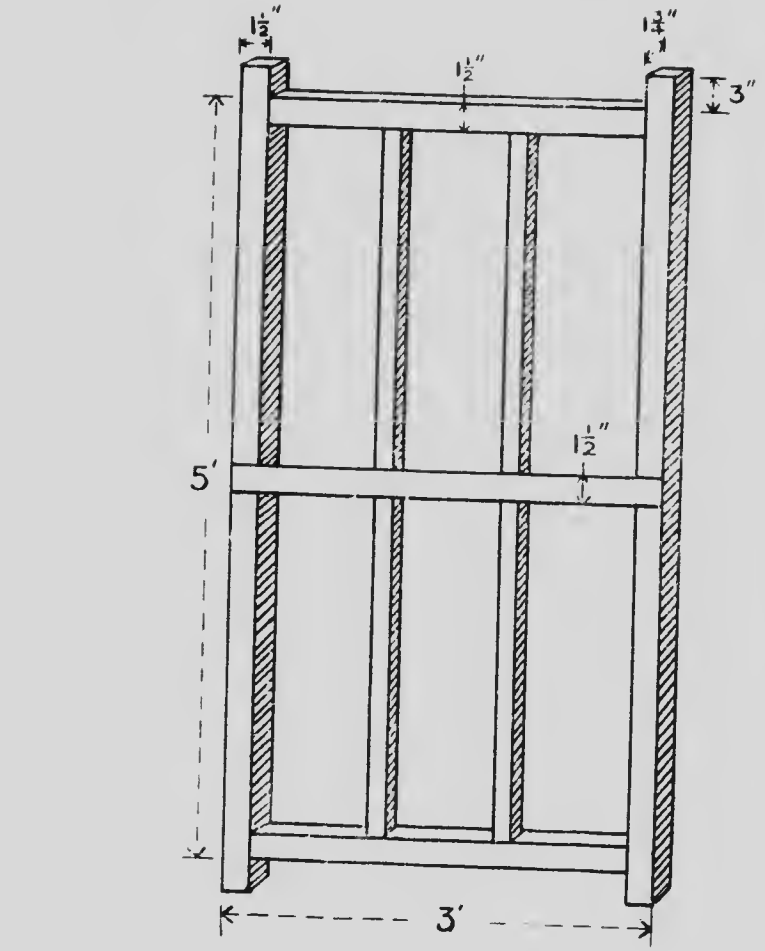
As will be seen, a cold bed does not receive any other heat than that which is supplied by the sun and which is retained by the surface shelter.

This kind of bed, established on a cold soil, as is usually done in some parts of Canada, cannot generate any heat in cloudy weather. Generally, it is exposed to the frost and, in any case, is seldom warm enough to insure a regular growth of the young plants, and at best, only during very short intervals.

Cold beds may be successfully used in temperate climates. In the province of Quebec, their use is attended by a great many risks.

(2) *Semi-hot beds.*— A semi-hot bed, like a cold bed, is enclosed in a wooden frame, but it differs from the latter in the fact that the layer of soil in which the seed is to be sown, instead of lying directly upon the earth or being composed of the latter (when the spot is merely worked over with a spade) is separated from the earth by an insulating layer, capable of giving off a certain amount of heat.

This layer is generally made up of horse manure which starts fermenting as soon as the bed is made. This layer of manure should be rather thin, only 3 to 4 inches, otherwise the temperature would rise too high and a hot bed would be the result.



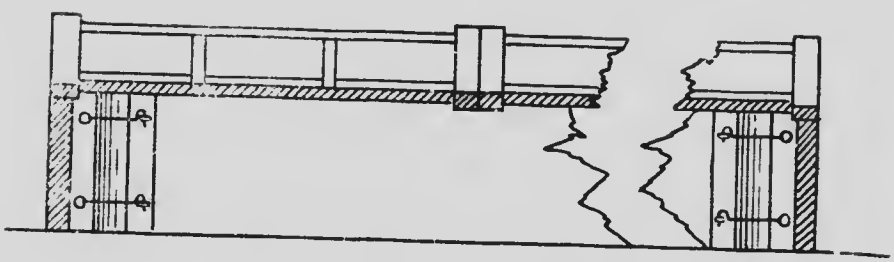



PLATE II.—Glazed sash—Assembled frame.

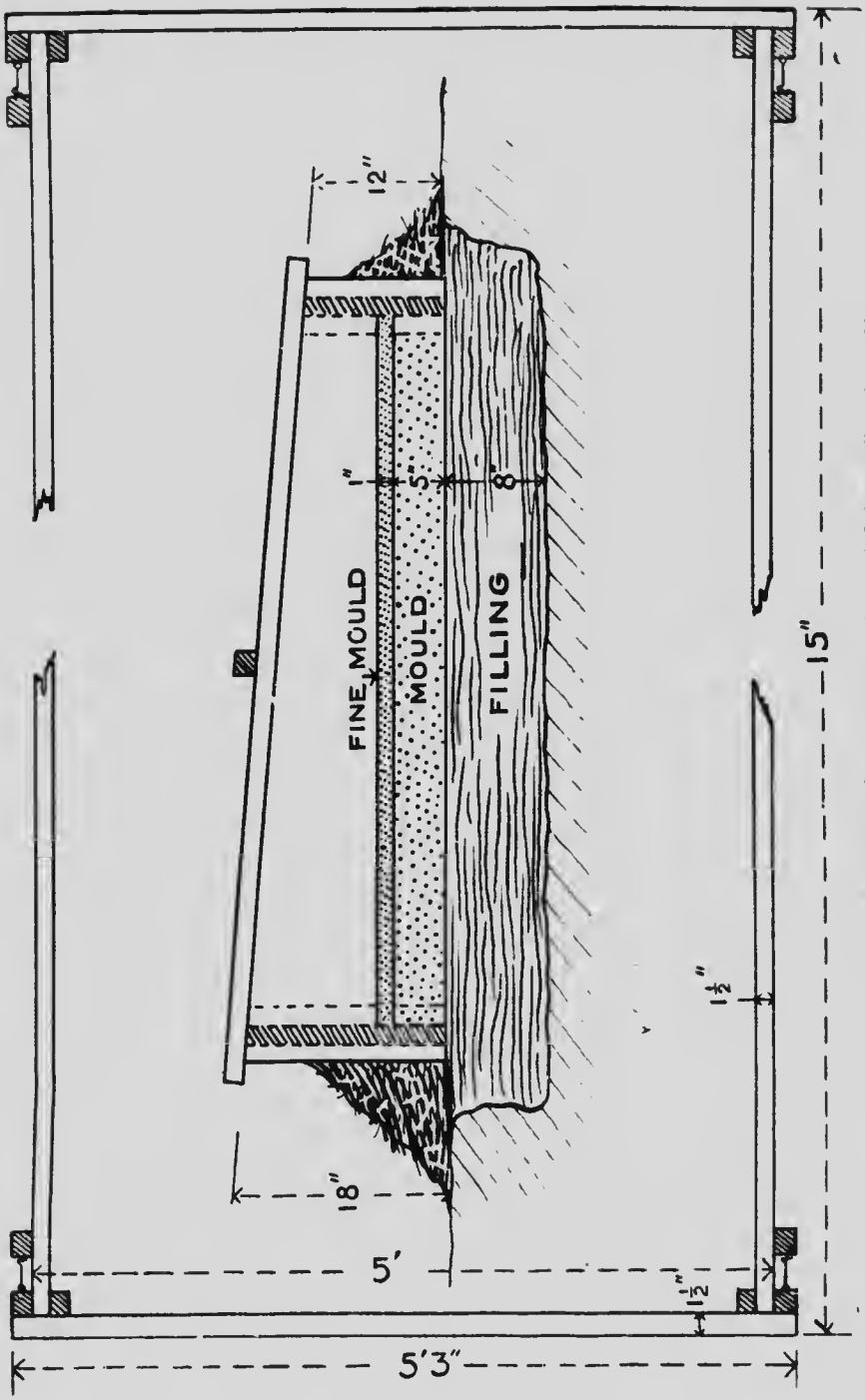



PLATE III.—Frame assembled.—Inside disposition of filling, soil and mould.

Sometimes, in order to avoid an excess of heat, equal parts of horse and cow manure are mixed together. The latter has a regulating effect; there is not so much heat given off at any time and the heat is more lasting.

It is always advisable to place the layer of manure on a pervious foundation 3 or 4 inches thick, made of branches, straw, oat chaff, tobacco stalks, etc., in order to make better use of the heat given off by the manure and improve drainage conditions.

But even this layer of manure may be dispensed with. During the last few years, this Division has experimented with a kind of semi-hot bed which does away entirely with the use of manure.

This bed consists of a layer of tobacco stalks or corn-stalks firmly packed and well levelled. This is covered with a thin layer of straw which holds the mould and prevents it from working down in the interstices, thereby causing the bed to collapse. The thickness of the layer of mould varies from four to six inches.

The latter system has, so far, given the best results in the province of Quebec. It is specially recommended by this Division. A detailed description of it will be found further on.

(3) *Hotbeds.*— Hotbeds are chiefly used by gardeners and horticulturists. They are especially useful when it is desired to hasten the growth of the seedlings; they differ from the semi-hot bed in the fact that a much thicker layer of horse manure is used, often from 8 to 12 inches. Cow manure is very seldom used in mixture with horse manure.

There are a great many objections to this bed when used for the production of tobacco seedlings. Of course, these seedlings are very early, but as a rule, they are weak, with a tendency to become yellow, and the development of mushrooms and diseases of all kinds is greatly encouraged.

Hotbeds should be used only when, owing to special circumstances, the sowing has to be delayed until a very late date in the season, but even in this case it is preferable to use a semi-hot bed and hasten the growth of the seedlings by watering with a solution of nitrate of soda some time before transplanting.

### GREENHOUSES.

Greenhouses seem to be the most up-to-date method for the production of tobacco seedlings.

In some market gardening districts, making a specialty of the production of early vegetables, especially tomatoes, gardeners have found it necessary to build greenhouses. These gardeners soon perceived, particularly in South Essex, that a large profit could be made by supplying tobacco seedlings, at prices varying from $1.50 to $2.50 per thousand, according to the season, to the growers of the neighbourhood whose bed had been a failure. A regular market has now been established, some growers are relying exclusively upon gardeners for the seedlings necessary for their plantation and this production of tobacco seedlings for sale has become a regular industry with some greenhouse owners.

Generally speaking, the construction of a greenhouse is expensive, and the expenditure involved is hardly justified when the only object is the production of tobacco seedlings. Greenhouse seedlings may be a little earlier than the seedlings grown in a semi-hot bed, but they are certainly not better and they cost more.

The results of a comparative experiment at Ottawa in 1914 on semi-hot beds and greenhouses were rather in favour of the semi-hot beds. There was a large amount of cooling off in the greenhouse during the night, the evaporation was more active during the day, it was necessary to water more frequently; in short, the semi-hot beds were at least ten days earlier than the greenhouse. It should be said, however, that the greenhouse in which we were operating was of an obsolete type. However, the conclusion from this experiment, under such conditions, is that the semi-hot beds, well protected by good glazed sashes, is the best and most economical method of raising tobacco seedlings, in good time for transplanting, and these seedlings are rooty, healthy and strong.

It may be said, however, that a greenhouse which is to be used exclusively for the production of tobacco seedlings does not require so elaborate a construction as the ordinary greenhouse. A type of greenhouse used by the Walkerville Company is shown in one of the illustrations of this bulletin (see plate IX). This is a wooden structure rather rough, covered with movable sashes which may be taken off when they are no longer necessary. Often, such houses are heated by means of ordinary stoves. There is a permanent system of water pipes for watering. The mould is treated by steam and the seed is sown on a cold frame bed. These, however, are expenses which are beyond the means of the average grower.

It should also be stated that the greenhouse may be utilized for storing seed plants when some difficulty is experienced in ripening these plants (late season, cold fall with danger of early frosts). The best method is to dig out the seed plants with a spade, leaving as much earth adhering to the roots as possible and store them in the greenhouse until the pods are ripe.

However, the same advantage may be secured by building, on some part of the farm, a greenhouse frame, and in the fall, when the time has come to put the seed plants under shelter, this frame is covered with the glazed sashes, which were used over the seed beds in the spring.

The real superiority of the greenhouse over the semi-hot bed is the saving of time effected by not having to remove the sashes for airing or watering. Again, there is not so much danger from sunstroke in a greenhouse if sufficient care is given to aeration, while sunstrokes are always likely to occur with the use of glazed sashes, especially when the sun comes out suddenly after a period of cloudy weather.

## II.

### THE SOIL OF THE SEED BED.

The most important part of the bed is, doubtless, the layer of soil in which the seedlings will throw out their roots and where they must find the food necessary for a rapid growth. It is important that this soil be light, rich, well tilled, and exempt from disease germs or insect larvæ.

When the seed is sown in the open, on a suitable spot, not much change is made in the composition of the soil of the bed.

A bush land is selected, generally a virgin soil of great fertility, containing a good supply of humus, of light texture, in a place sheltered from the wind but well exposed to the sun during the greater part of the day.

If the spot selected is of sufficient fertility, all that will be necessary is to make a bush fire over it as already explained.

After the coals are removed, the soil is lightly worked over with a spade, care being taken to mix the remaining ashes with the bulk of the soil as thoroughly as possible. After a good raking to complete the preparation, the bed is ready to be sown. If there is any doubt as to the fertility of the spot, it should be given a good manuring. The manure is spread on top the preceding fall, in a fairly thick layer, or worked in with a spade, always in the fall. Well decomposed manure gives the best results.

The burning is done in the spring, almost immediately before the bed is prepared.

Although this system has long been in use and often with good results in southern Ontario, it cannot be recommended on account of the fact that it is too easily influenced by climatic conditions. Even in Ontario, the temperature is seldom warm enough in the spring to allow the seedlings growing on these beds to be ready at the beginning of the transplanting season.

*Bush soils.*—The moulds generally preferred are those found in the bush and consisting of a mixture of soil and decomposed organic matter; pieces of bark, wood, dead leaves, which accumulate under the trees. These bush soils, as they are generally called, are of a spongeous nature, light, of a dark colour. They have a great power of absorption for water and keep it a long time. Some are rich in humus but the humus content is very variable and sometimes deceiving. Bush soil containing a large proportion of undecomposed vegetable matter, should be looked upon with suspicion. Such soils are better for growing mushrooms than for raising tobacco seedlings.

Sometimes these bush soils are so coarse that it is impossible to bring them to a sufficient degree of tilth. In this case, it is difficult to level properly the surface of the bed and a very irregular stand is the result. Furthermore, the care of the bed (hoeing, thinning out) is very much harder when the component elements of that part of the bed are coarse and agglomerated.

In the open bed all these difficulties are removed by burning.

When bush soils are to be used just as they are, it is better to choose those containing only a fair amount of organic matter, having a sufficient density and with such a texture that they may be easily reduced, thereby giving a very fine mould.

These bush soils, however, have a serious objection. They may contain the germ of some diseases which are transmitted to the seedbeds, and, in time, to the field One of these diseases is *Thielavia Basicola*, or "root rot," which, for the last few years, has caused considerable injury in some tobacco centres, in the United States and Canada.

When bush soils have not been burned over, it is almost indispensable to disinfect them thoroughly, either by formalin or by steam.

*Ditch mud.*- Ditch mud is generally made up of a mixture of sand more or less fine, and of accumulated silt, together with the product of the decomposition of sod and grasses growing along the ditches.

This mud may be of very great fertility, according to the quantity of plant food carried by the water in the ditch. Real composts may be obtained by mixing together all the detritus that is removed when cleaning a ditch. To secure the best results, these composts, after being carefully mixed, should not be used before several months have elapsed.

*Composts.*—This designation includes varying mixtures of soil and organic matter, generally decomposed or in the course of decomposition.

The kind most frequently met with is a mixture of light soil and decomposed manure (horse or cow manure). This mixture is obtained by piling up thin layers of earth and manure, one on the top of the other, up to a height of six to seven feet.

When it is believed that the fermentation which is taking place in this heap is over, or about complete, the heap is cut with a spade in vertical slices, and these slices are divided as much as possible and mixed over several times with a shovel, until the mixture is well disintegrated and almost homogenous in texture.

All the coarse particles are removed by sifting, leaving a fertile mould, as fine as desired. By making use of fine sieves, a very fine mould may be secured, which is particularly desirable for levelling the surface of the bed and for other uses to be mentioned further on.

With the moulds made in such composts, there is not so much danger of introducing disease germs into the beds. However, to avoid any risk, it is also advisable to disinfect them with formalin or by steam.

The ditch mud which was mentioned in a preceding paragraph may also be used for making composts. In this case, the various layers of earth do not need to be so thick.

Very good composts may also be obtained by mixing almost pure sands—in most cases very light soils—with good mixed manure (horse and cow manure), thoroughly decomposed.

The name of compost may also be given to the special mixture which has been used as mould during the past six years at the Central Experimental Farm, Ottawa, and which has invariably given excellent results.

This mixture is obtained by piling up slices of sod (earth and sod) about three to four inches thick and cut in the same way as the sod which is used for making lawns. When this sod contains a sufficient quantity of clover roots, it makes a very fertile mould. As it decays rather slowly, it should be prepared a long time in advance, at least two years.

Owing to the material employed, it might be supposed that these composts contain a larger number of weed seeds; such is not the case, however, as they are comparatively free from them. Apparently the seeds which are in the compost germinate while the latter is exposed to the air, but the germs do not succeed in piercing through the soil and perish. It is also very likely that a large number of seeds, buried at a too great depth in a comparatively damp soil, decay and are destroyed.

### FERTILIZATION OF MOULDS.

It has been seen that the fertility of the soil or "mould" put in the beds is a very important factor.

When this soil comes from a well prepared compost, it is generally sufficiently rich and seldom requires any manure or other fertilizing matter.

*Manure.*—Mention has already been made of the fact that when open beds are used, the soil of the area which is to be sown may be fertilized by the use of well decomposed manure, worked in with a spade, or by green manure spread on top. Chemical fertilizers may also be used.

*Chemical fertilizers.*—A great number of mixtures sold under the name of "special fertilizers" and prepared for the growing of tobacco seedlings, are found in the trade. Generally speaking, these mixtures contain a large proportion of potash, far too much phosphoric acid and too little nitrogen.

It is obvious that chemical fertilizers—and even the so-called guanos—cannot be relied upon to supply the bed with the proportion of humus which it should contain. This humus must come from another source, from an application of manure or vegetable matter (bush soil).

If, however, the main object of the seed bed is considered viz., production, in a limited time, of seedlings suitable for transplanting,—it is easily seen that the only element of which there should be a slight excess is nitrogen, provided that the soil is fertile, that is to say, contains sufficient proportions of potash, phosphoric acid and nitrogen. It is almost a waste of money to apply phosphoric acid and potash on the beds; better use these on the field.

Some of these special fertilizers, however, were used several times in the preparation of our beds and, as a rule, they gave satisfactory results.

The following method was adopted:

When the bed is ready to be sown, the special chemical fertilizer is spread on top at the rate of one ounce per square foot. This fertilizer is thoroughly mixed with the one-inch layer of mould on the top of the bed. This being done, another layer of good, fine mould, at least half an inch in thickness, is spread on top and the tobacco seed is sown on this mould.

If any doubts are entertained as to the fertility of the mould, a certain quantity of chemical fertilizers—from one to two ounces per square foot—should be mixed with it before filling in the bed. In this way the chemical fertilizer will be absorbed in a layer of mould five or six inches thick and will be in a sufficient state of dilution not to cause any injury.

When nitrate of soda is used alone (a nitrogenous fertilizer containing nitrogen in a readily soluble form), it may be spread on top of the mould in the same manner

as the complete fertilizer, but at the rate of one-fourth to one-half ounce per square foot of bed. As it is rather difficult to spread evenly such a light quantity of fertilizer, it is better to mix it, at first, with good mould, in the proportion of one-fourth to one-half of nitrate of soda, which gives a sufficient bulk to make spreading possible.

Later, if it is thought that the fertilizer used in this way has not sufficient action, it may be completed by watering with a diluted solution of nitrate of soda.

*Liquid manure.*- Liquid manure is a very active fertilizer. It is used in sprinklings.

The mould which it is desired to fertilize is thoroughly soaked with liquid manure, then left to itself for some time, then worked over with a shovel, heaped up again, watered and shovelled over a second time.

However, mould which has been fertilized with liquid manure should not be used for some time. The best method is to prepare the mould and do all the applications and the shovelling necessary during the fall. In districts where no very hard frosts are expected, the moulds may be treated during the winter, but the last applications of liquid manure should be made at least two months before the mould is used.

*Hen manure.*—This product of very high fertility is seldom used in Canada. There is no reason why it should not be, considering the scarcity of really good manures. It might certainly be utilized in the preparation of composts, where it would advantageously take the place of fertilizers known under the name of Guanos. In some cases, hen manure may be applied in the form of a diluted solution. This question will be dealt with in the chapter on special waterings.

## REGENERATION OF THE MOULDS.

By regeneration is meant the operation which consists of returning to the mould the plant food which has been taken away from it with the seedlings grown on the bed.

The various methods that are used for the fertilization of moulds may also be used for their regeneration. It is important to start as soon as transplanting is over and when no more seedlings are required.

At this time, the soil and mould from the various beds are put together in a heap and treated just as though they were new. When it is considered that the desired result has been obtained, the regenerated mould is put away, under shelter, if possible, to be protected from the rain.

It is very unsafe to use mould which has already given a crop of seedlings, and this should be done only when it is impossible to secure fresh mould. However, the danger may be eliminated by a suitable treatment with formalin or with steam, as mentioned further on.

*A poor method.*—In some part of the country, specially in Ontario, beds are often made after the following fashion: after setting up the frame on the selected spot, a thick layer of manure is spread, the earth is spaded until a good mixture, of sufficiently loose texture is obtained, then levelled with a rake and covered with a thin layer of mould. As a matter of fact, this is nothing else but an application of manure made just before sowing.

Where this plot is sown just as it is, a great number of plants inevitably contract diseases such as mosaic or blight disease, owing to their roots coming into contact with undecomposed bits of manure.

There would not be so much danger of developing diseases if the mould was treated on the spot with steam or formalin. But it is useless to expect good results from such a late application of manure, because the fertilizing elements of this manure have not time to become mixed with the coarse mould prepared in this manner.

Mould should be as homogeneous in texture as possible and the only way to make it so is to prepare it long before it is required.

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# III.

## SHELTERS.

To ensure regularity and evenness of growth, it is necessary to protect tobacco seedlings, in the beds, from the cold and the sudden variations of temperature. Various kinds of shelters may be used: they are divided into two chief classes: vertical and surface shelters.

*Vertical shelter.*—The object of this shelter is to protect the seedlings from the prevailing winds which, at the time when the beds are made, generally cause a considerable lowering of temperature.

When the seed is sown in forest clearings, natural shelter may be obtained in the shape of belts of trees of sufficient thickness to break the wind. However, this windbreak is generally insufficient during the early part of the spring, at least so long as the trees are devoid of leaves, and it is wise to complete it by palisades built up on the more exposed sides and of varying height according to the surface in need of protection. It has been figured that a palisade shelters from the wind an area equal to three or four times its height. In places where the winds may come from various directions, several palisades should be built at various angles, without intervals through which the wind may blow.

These palisades may be formed by simple fascines, six to seven feet long, firmly held by posts and transversal bars. A better shelter is obtained by means of board palisades, but these are comparatively expensive.

The farm buildings also constitute excellent vertical shelters for the beds which are made in their neighbourhood. However, care should be taken to establish the beds at a sufficient distance from the buildings so that rain-water or water resulting from the melting of the snow and droppings of the roof may not cause any floods in the immediate vicinity of the beds.

*Surface shelters.* Surface shelters have a double object: they prevent the cooling off of the bed and protect it from too sudden or too great variations of temperature. They may be made of many different materials.

In tropical countries, the beds established in the open are simply covered by light branches laid above the sown area. These branches moderate the strength of the rays of the sun and protect the bed from the birds and from the fowls. It is a primitive system, but quite efficient, at least so long as the seedlings are not very large.

A light cloth shelter (muslin, cheese cloth) simply stretched on bars and held up by pickets, also protects the beds from the rays of the sun more than from the cold. It is more efficient when stretched over the frames as in this way it prevents, to a certain extent, nocturnal cooling off. Thus, it protects the beds as well from the cold as from the excessive heat.

The use of cloth shelters requires some precautions. One of the most essential is the following: when the tissue of the cloth is so tight as to present a certain degree of resistance to rain-water, sufficient slope should be given to the cloth so that the

water may fall promptly outside the bed, instead of gathering in the central part of the cloth. The best method is to make a double slope by supporting the cloth by a wooden bar, placed at the central part of the bed, in a longitudinal direction. In this way, the shelter has the shape of a tent with a double roof.

If it is also desired to prevent the attacks of insects, the cloth should be fixed to the frames by means of hooks. Instead of using hooks, however, the cloth may be rolled on rather heavy poles and unrolled according to the requirements. The weight of these poles is generally sufficient to insure close contact between the cloth and the frames.

Cloth shelters may be very useful in countries with temperate climates and where spring rains are not too frequent or too copious. They cannot be depended upon to give sufficient protection from very intense cold or very heavy rains.

However, cloth may, to a certain extent, be made waterproof by being impregnated with linseed oil. But this operation, whilst it makes cloth impervious to rain, takes away, at the same time, one of the main advantages of the cloth shelter, that is, its permeability to the air.

Oiled cloth covers should be handled in the same manner as glazed sashes, as they are almost as waterproof as the latter. They protect the bed very well from cooling off during the night; on the other hand, the coat of oil which insures their impermeability, catches the dust; they very soon take a dark and dirty colour and the quantity of light received by the bed is decreased in proportion. As a matter of fact, in spite of their strength, oiled cloths can only be used one season, owing to the dirt which they collect.

In some districts, always in countries with a temperate climate, oiled paper is used instead of cloth.

This paper, after receiving two or three coats of linseed oil, takes a special texture and becomes almost translucid. It stands the water very well; as regards the absorption of light it comes about half way between cloth and glazed sashes. It does not last very long however, as it soon becomes dry under the action of the sun and loses a part of its transparence. Like oil cloth, it gets dirty, but it costs so little that it may be renewed each season over the same frames.

Of all shelters, the glazed sash is by far the most air-tight. It is also the one which permits the absorption of the greatest quantity of heat; as a matter of fact, on a sunny day, no matter what the external temperature is, a glazed sash bed must be closely watched to prevent the temperature from rising to a dangerous degree.

The glazed sash, owing to its impermeability, reduces evaporation to a minimum, hence the atmosphere of the beds gets saturated with moisture, it becomes warm and must be renewed frequently. But it absorbs the heat of the sun with such rapidity that the bed may be aerated almost at any time. Therefore the seedlings are placed in the best possible conditions of growth, viz., sufficient temperature and good ventilation.

In order to avoid sunstrokes which may occur under a very hot sun, when the sashes are closed or insufficiently raised, the glass may be whitewashed with lime-water, which is made adherent by the addition of a little coal oil. Light cloth, such as muslin or cheese cloth, may also be spread over the glazed sashes in order to lessen the absorption.

The objection to glazed sashes is that, while they absorb the heat of the sun very easily during the day, they may, unless sufficient precautions are taken, let the bed

cool off very rapidly by radiation in a clear night. Whitewashed sashes do not permit such a loss of heat, but ordinary sashes should be covered during the night by cloth thick enough to protect the bed from the cold as well as from nocturnal radiation.

The weight of paper or cloth shelters is almost insignificant, but the weight of glazed sashes becomes an important item when the covered surface is fairly large. Therefore the size of the sashes should be such that they may be easily handled by one man. Experience has taught us that the handiest sash is one 3 feet wide by 5 feet long. It is easily handled, of a comparatively light weight, and, owing to its small size, may be constructed with sufficient rigidity. A too large sash has a tendency to warp when handled often and there is a great risk of breaking the panes of glass and undoing the joints.

A model of glazed sash recommended is shown on plate 2.

The frame part, including the frame, covers exactly fifteen feet square (3 feet by 5 feet).

The pieces of wood are 2 inches and 1½ inches thick. The corners are mortised or reinforced with iron squares. The two large sides of the frame are connected by a wooden lath, 2 inches by 1 inch, which increases the solidity.

The extension on each side of the frame makes it possible to get an opening of 2 or 2½ inches wide, simply by sliding the sash. This opening is sufficient to obtain a light ventilation which, without unduly lowering the temperature of the bed, is an excellent precaution against sunstrokes.

*Straw mats.*—Straw mats are straw shelters, one to two inches thick, made of long straw, as little broken as possible.

The straw may be laid and fixed on light frames, but the most practical method is to bind it by means of strings so as to obtain a kind of mat that may be rolled or unrolled over the bed. The closer the rows of strings, the stronger the mats are. There should be five rows of strings on a bed five feet wide.

Mats make an excellent insulating material. In some countries, they are laid directly over the frame during the night and during cold days; as soon as the fine weather has returned they are taken off to let in the light and thus avoid the "spindling" of the seedlings.

When the mats are to be laid directly over the bed, they must always be kept in good order, otherwise bits of straw drop off during the handling and soon dirty the beds. This defect may be remedied, however, by placing a sheet of light canvas between the mat and the bed. Of course the objection disappears when the mat is laid over a glazed sash.

*Frames.*—The tightness of the frame is an important point. Unless the frame is quite tight, the surface shelter is of little use, no matter how well built.

The size of the frame and the size of the sash are regulated by practical considerations. The length may vary according to the surface to be planted, and the quantity of seedlings required; it should not be so long as to cause a waste of time in watering, or the general work of caring for the bed. The width should not, as a

PLATE IV.—Assembled frame, showing height of banking

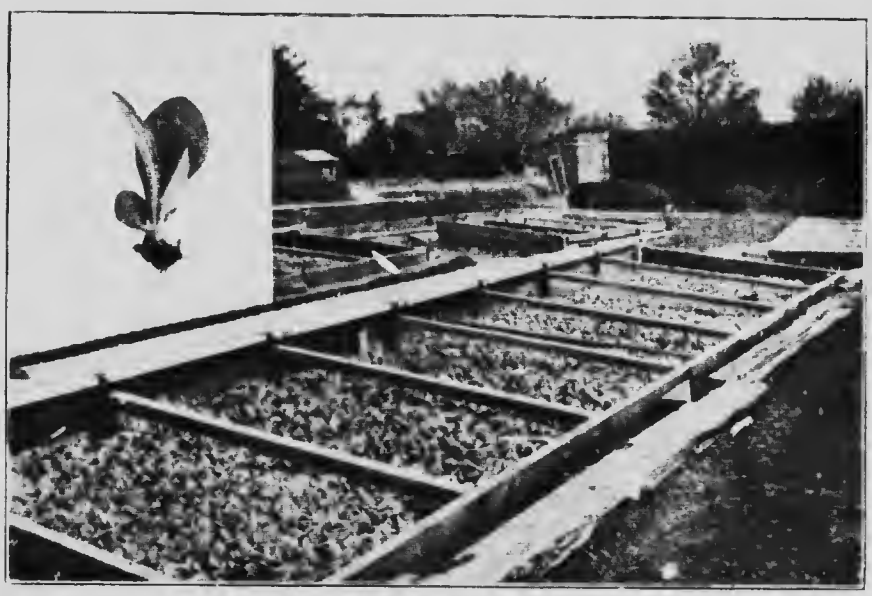


PLATE V.—Seed bed of Comstock Spanish, sown at the rate of 1½ oz. of seed per 100 square feet.

rule, exceed five feet. When a glazed sash is used, the width of the bed is regulated by the length of this sash; in any other case, the width should be such as to permit of convenient access to all parts of the beds for watering and all other work such as hoeing, thinning and pulling off.

The frame used on our experimental stations is 15 feet long by 5 feet wide. This choice was regulated to a certain extent by the size of the materials that are found in the trade. A bed of this size, if everything goes well, supplies a sufficient quantity of seedlings for one acre of land.

A very useful frame is shown in plates II, III and IV. It is made of boards 1¼ to 1½ inches thick which are fixed together by means of hooks, when the beds are being prepared. As soon as transplanting is over, the frame may be unhooked and put under shelter. This is very easily done, as the frame, when taken apart, takes up very little space. The earth from the various beds is put into one heap, treated in preparation for the following year or spread on some part of the farm, when it is desired to use new material.

This type of frame is certainly much easier to handle than the solid frame; it lasts longer, stands handling better, and is exposed to the weather only during a limited time. Another advantage is that it can be very easily cleaned when the soil is treated for diseases.

*Note.*—In a preceding chapter, mention was made of the temperature kept in a semi-hot bed under glazed sashes and in a cold bed in a heated greenhouse. An examination of the curves given in the diagram annexed to this bulletin shows that almost every night, during the spring of 1914, the minimum temperature was lower in the greenhouse than under the sashes. The latter were covered with comparatively light canvas, which prevented the loss of heat by radiation to a greater extent than the coat of whitewash on the panes of the greenhouse. If woollen blankets or mats had been used instead of this comparatively light canvas cover, the difference in favour of the ordinary beds would have been much greater.

### HOW TO USE SURFACE SHELTERS.

During the first few days after sowing, the surface shelter may be left constantly over the beds, as light is necessary only when the young plants are up.

Care should be taken however to see that the temperature does not rise too high under the glazed sashes, (not above 80 degrees F.) and if necessary, the beds should be lightly aired.

As soon as the seedlings start to develop (when they are about to have four leaves) an endeavour should be made to give as much air and as much light as possible, the first in order to keep the plants healthy, the latter to prevent spindling.

The main object of a surface shelter is to regulate the temperature of the bed. The more pervious to light, the better the shelter is, and this is the reason why glazed sashes or oiled cloths are specially recommended in cold districts, where shelters have to be kept a long time over the beds. In almost all tobacco districts of Eastern Canada, there is such a lowering of temperature during the night, right up to the time of transplanting, that the danger of frosts is always present. The beds should therefore be sheltered during the night until transplanting is over, and the glazed sash covered with canvas.

On the other hand, in May, the shelters should be raised during the day as often as possible, and even completely removed, so as to give the seedlings a good chance of hardening off early.

*A bad practice.*—Some growers, in an endeavour to protect their beds, cover them with rough canvas (burlap) or a heavy paper immediately after sowing.

This is a very objectionable method as the seedlings get caught in the meshes of the burlap, if the tissue is loose, or strike themselves against it, if the tissue is closed, and get stunted in their growth.

Generally these covers, and specially the paper ones, give rise to a large quantity of moulds which may completely infest the soil.

# IV.

## SEED SOWING AND MAINTENANCE OF THE BED.

### CHOICE OF SEED.

The quantity of tobacco seed required even for a large plantation is so small that the grower who does not purchase the best quality of seed, regardless of the price, is absolutely without excuse.

In the first place, deal only with reliable seedmen, use only seed which has kept its germinating power and make sure of this by testing. To test tobacco seed, use the following method: place a certain number of seeds between two sheets of blotting paper, moisten the sheets lightly, and keep in a room at a fairly regular temperature (near a stove). The right proportion of humidity may be kept by adding a few drops of warm water from time to time. The percentage of germination may be ascertained at the end of seven or eight days or sometimes ten days, according to the temperature and the degree of humidity, by counting the number of germinated seeds.

The seed of tobacco keeps its vitality a very long time (ten years or more). There is no objection therefore to purchasing a four or five years' supply of good young seed. There is even an advantage in doing so, as the successive crops will have a certain degree of uniformity and may be marketed at a more profitable price. Again, if the grower is a good observer, he may, by watching his crop, improve his method of cultivation and care from year to year according to the experience gained.

The younger the seed of tobacco, the quicker it will germinate. This does not mean that fresh seed has a higher vitality than seed four or five years old, but it means that when two beds are sown, one with seed from the previous year and the other with seed four or five years old, the former germinates first.

### ARTIFICIAL GERMINATION.

Tobacco seed may be sown in its natural condition (dry), or swollen or germinated.

The use of dry seed is recommended except in special cases, as it is more resistant, than germinated or swollen seed, and not so likely to suffer during the first few days following sowing.

Sowing with swollen seed, and, to a greater extent, with germinated seed, enables one to obtain an almost immediate germination, thus gaining a few days.

This has not been found necessary, however, even in the colder parts of the province of Quebec.

The seed which it is desired to have germinated before sowing is put in a small bag, made of thick cloth, and soaked in lukewarm water, then drained and stored in a part of the house where the temperature is kept as near as possible to 80 degrees F. The bag may be opened from time to time to see the condition of the seed.

The seed may also be mixed with vegetable mould, which has been gathered in the hollow part of a tree, and kept in a moderately damp place as above. The time to sow is when the majority of the seed has burst and when the white plantule appears.

In some parts of Canada, seeds are germinated to an exaggerated extent before sowing. This is not a good practice. The seed showing a small white speck or slightly

swollen, germinates very quickly when placed in a good bed, whilst over developed germs may easily be injured by the handling of the seed during the work of sowing. Furthermore, the seeds contain only a limited supply of food, and there is danger of exhausting this supply by over germination before sowing.

The most favourable temperature for the germination of tobacco seed is about 80 degrees F. An endeavour should be made to have the beds at this temperature during the greater part of the day, but not much above it. The cooling off which occurs during the night is dangerous only when the temperature goes down near the freezing point.

### SOWING.

It is difficult to spread tobacco seed very evenly over the bed, on account of its fineness. It should therefore be mixed with some inert matter such as wood ashes, burnt fine sand, black earth, etc., in the proportion of one part of seed to one hundred parts of sand. A good medium is semonla, a non-hygroscopic, non-agglomerating substance, which spreads easily and which, having about the same density as tobacco seed, permits of obtaining an homogeneous mixture. It is recommended by some authors to sow tobacco seed with the chemical fertilizer used for fertilizing the bed. We do not think this practice should be encouraged.

The mixture is sown by hand, lengthwise and crosswise, or by means of a pepper holder, with large holes. The colour of the mixture, being generally different from that of the bed, may be used as a guide.

In any case, growers should endeavour to obtain a stand of equal density, not too close, so that the seedlings may grow under good conditions, form the necessary root hair and not become spindly.

After sowing, a light quantity of very fine mould (black earth) is spread over the top of the bed, and the latter is packed gently by the hand or by means of a light board. The use of mould, however, is not indispensable.

### THICKNESS OF SEEDING.

Care should be taken not to use too much seed for the size of the bed.

It has been clearly shown by our experiments, that the best quantity of seed to use for all seed leafs tobaccos is about one-seventh of an ounce per hundred square feet of bed. This is of course for good seed, having a germinating power of about 95 per cent, but in any case, no more than one-sixth of an ounce of tobacco seed should be sown per hundred square feet.

The proportion should be the same for all other types of tobacco, including the White Burley. An exception should be made, however, for the varieties "Nicotiana Rustica", the seeds of which are much larger and much heavier than those of the group of varieties known under the name of "Nicotiana tabacum."

When a certain number of beds are used, it is very seldom that all of them give equally good results and yield seedlings ready to be transplanted at the same date. It is advisable to sow the beds at intervals of a few days, or to sow them all at the same date, but with dry, swollen or germinated seed so that transplanting may be carried on continuously and so that plenty of seedlings may be had without any interruption.

The grower is the best judge in such cases; he has other means at his disposal to hasten or retard the growth of the seedlings in an average season if the beds should have been sown a little too early or a little too late.

*Watering.*—Watering should be done with a great deal of moderation. The beds should not be drenched, but simply kept moist. When the grower judges that the time has come to water the beds, he should do so chiefly during the hot hours of the day, keeping the sashes open as little as possible; lukewarm water should be used and applied by means of a watering can, the spout of which is perforated with very small holes. By so doing, he will avoid uncovering the roots of the seedlings; if, however, some up-rooting is observed, a little mould should be spread in order to cover the roots. Later on, when the seedlings have become stronger, when they are being hardened off by raising the sashes during a part of the day and when the evaporation becomes more active, a larger quantity of water may be applied to the bed. But in this case, it is better to give several sprinklings, taking care, however, not to sprinkle too late at night; lukewarm water should always be used and no more water should be applied at any time than is strictly necessary to maintain the humidity of the beds. In this way losses of heat are avoided, while the seedlings are provided with all the water that they require. Again, if too large a quantity of water were applied at any one time, it might interfere with the fermenting of the layer of manure supporting the mould in a hot bed or in a semi-hot bed.

*Note.*—Pure water only should be used for watering, except in special cases, mentioned further on. It should be slightly warmed by being exposed to the sun, or to some other source of heat.

*Airing.*—Beds should be aired as much as possible, and the sashes should be raised whenever it is possible to do so without exposing the beds to an undue amount of cooling off.

When the beds are protected by rather loose canvas, an exchange takes place between the atmosphere of the beds and the out-side atmosphere which, to a certain extent, may be considered as a real ventilation. However, it is a good plan to lift the canvas and uncover the seedlings whenever the weather in favourable.

The more impervious the surface shelter is, the greater will be the aeration required. A close atmosphere in the bed is very injurious to the seedlings; it is important, therefore, to keep the glazed ashes up, almost all the time, except during very cloudy weather and during the night.

Some of the plates in this bulletin show how a good aeration may be obtained when glazed sashes are used.

By raising lightly the sashes on the lower part of the frame, a good temperature is obtained and sunstrokes are avoided.

In plate VI-a the top part of the frame only is raised. This allows of a rapid exit of hot and impure air. If the opening is not very large, the bed does not cool off noticeably.

Another way of arranging the sashes, by which a regular draught of air may be created upon the bed is shown in plate VI-b. This arrangement is recommended specially during hot days, and when the sun is very strong.

It is also possible, as shown in other plates, to slide the sash one way or the other, to make sure that all part of the beds are at the same temperature.

Again, during the hot hours of the day, it is always possible to cover the sashes with light cloth, thus largely reducing the quantity of heat absorbed.

A

B

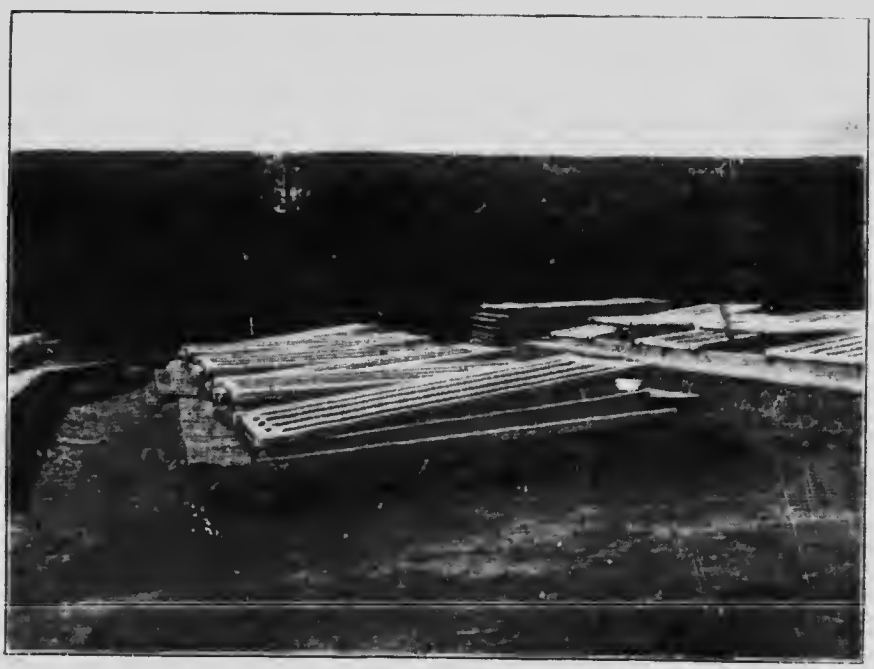


PLATE VI.—Seed for aeration.

(*a*)—Warm air escaping by the opening at the upper part.
(*b*)—A double draft established by lifting the sashes both ways

By combining the use of the sashes and that of the cloth, it is possible, near the end of the growing period, to keep the bed at a lower temperature than the outside atmosphere. In this way, growth is retarded instead of being hastened.

*Weeding.*—Unless the soil has been steamed a number of other plants will appear on the bed, no matter how carefully the latter has been prepared. It is necessary therefore to weed the beds in order to free the young tobacco seedlings and give them a chance to grow unhindered. The weeding, which should be preceded by a watering if necessary, is done by hand or with the point of a knife during the hot hours of the day. Care should be taken not to lay bare the roots of the tobacco seedlings, and a light quantity of mould should always be spread after this work. Weeding should be done at proper intervals, until the tobacco seedlings cover the whole surface of the beds and have become strong enough to prevent any other plant from growing in their midst.

However, there is a method by which weeding may be reduced to a minimum. When glazed sashes are used, the bed is prepared fairly early and heated, while kept moist at the same time, until all the weed seeds that are in the mould have germinated. When the weeds are well up, they are destroyed by raking, the bed is put again in proper condition and sown with tobacco.

*Moulding.*—This operation consists of spreading an even and thin layer of very fine mould on the whole surface of the bed after sowing, or after watering, thinning or weeding, so as to cover the roots of the seedlings which may have been laid bare.

The mould which is to be used for this operation should be prepared in advance.

When the beds have been treated with formalin or by steam, the mould which is used for covering should, of course, be submitted to the same treatment.

*Thinning.*—No matter how carefully sowing may have been done, it often happens that the stand of the seedlings on the beds is not quite uniform, and that they are much too thick on some parts. It also very often happens that too much seed is sown, causing a very thick growth of seedlings.

The beds should be thinned early, before the plants have made much growth; the strongest seedlings are kept, and these having more space, develop rapidly and produce an abundance of roots. By this means, the production of slender, elongated, or "spindly" seedlings, too weak to stand the handling before transplanting, and taking root with difficulty, is avoided.

An instance will show the importance of this work; on one of our beds, the seedlings were so thick that they were yellowing in spots, just as though they were diseased. After a good thinning, everything was normal, the remaining plants became green again, grew in regular manner and no disease appeared.

Thinning, like weeding, should be preceded by a light watering, facilitating extraction, and followed by a sprinkling of vegetable mould. The latter is particularly important.

*Nursing.*—This operation is practised when the seedlings are too thick. Some of the strongest ones are removed and planted on another semi-hot bed or in good garden earth. By this means, a small number of excellent seedlings may be obtained and they may be reset with a part of the soil in which they were growing. However, this method has the objection of necessitating a great deal of labour. The use of such seedlings

is not recommended for the production of seed, specially in the case of light varieties, as it would soon result in a deformed type, no longer answering the needs of the market for which it is grown. The best way is to have a thin stand on the beds so as to secure strong and uniform seedlings.

*Hardening off and acclimatization.*—This operation consists of preparing the young plant for the conditions in which it will be placed in the field.

As a general rule, the soil of the field is very different in composition from that in the bed, so, in order to correct the transition to a certain extent, it is recommended to leave as much as possible of the mould adhering to the roots; care should be taken therefore to avoid shaking the seedlings.

Seedlings are hardened off chiefly by decreasing the proportion of humidity in the bed and increasing the length of the exposure to the sun and to outside temperature. Hence, during the period of acclimatization, which may last from eight to fifteen days according to the requirements of transplanting, the beds should be kept covered as little as possible and watering should be decreased.

Hardening off is not so easy as is generally supposed.

For instance, if, in an endeavour to reduce the proportion of humidity, watering becomes insufficient, the growth of the plants will suddenly come to an end and the stems of the young seedlings, instead of remaining white and tender, will take a green colour and harden rapidly. Seedlings of this kind will stand drought better perhaps than tender seedlings, but they will not produce so many leaves. The removal of the shelters, especially when a first lot of seedlings has already been extracted from the beds, may have the same results. While reducing watering, evaporation should be decreased by sheltering the beds with light canvas cloth, in case the work of transplanting should take longer than was anticipated.

Lastly, if the seedlings, in spite of all these precautions should show a tendency to harden or to spindle, or to make an excessive growth, it would be better to have them extracted at once and keep them in the manner indicated in the following paragraph.

### EXTRACTION AND CHOICE OF THE SEEDLINGS.

Stocky seedlings with a tender green foliage, a white stem and abundant root hair are the best for transplanting. A good height is from three to four inches. Yellow or spindly seedlings or those showing green or yellow streaks (a symptom of disease) should be discarded.

Before extracting the plants, the beds should be well watered so as to avoid breaking the roots or disturbing the soil too much; care should be taken also not to shake off the earth adhering to the roots as this earth will facilitate the recovery of the seedlings when transplanted.

The extracted seedlings are placed together loosely, in a slightly slanting position, in a basket or any other vessel with a wide opening and a flat bottom, covered with a damp cloth and kept in a cool place, cellar or silo, until the time when they are to be used. They may be kept in this condition for a fairly long time, but it is better to use them as soon as possible, in order to prevent wilting or yellowing.

Upon no account should the seedlings be watered after being pulled out, as they would rapidly decay.

After extracting, a good quantity of mould should be spread on the bed so as to cover the roots of the remaining plants which have been slightly raised. A new extraction may be made a few days after the first one.

Extractions should not be made in too [illegible] succession. It is wise not to make more than two extractions from any [illegible] for transplanting. A third extraction may be made a little later for resetting. [illegible] for this work, it is better to use seedlings coming from a bed which has not been called upon to supply too many plants.

No matter how carefully the extraction is made, the roots of the remaining seedlings are always disturbed.

It has been observed on our plantations that the number of diseased plants is always in proportion to the number of resettings, and this observation was made in a season when, owing to the insufficiency of our beds, the seedlings came from a third and sometimes a fourth extraction.

The best plan, therefore, is to make thin sowings, at various dates, so that all the plants from one sowing may be ready at the same time, and to sow a sufficient number of beds so as to supply as many and even more seedlings than are required for transplanting. A bed one hundred feet square, may, with a fair degree of success, easily yield from eight to nine thousand seedlings.

Sometimes, towards the end of the transplanting period, the grower may be compelled to use seedlings that are a little "spindly." Such seedlings should be set a little deeper than the others, so as to provoke the growth of adventitious roots, and restore to the plant, to some extent, the strength which it has lost during the last few days that it was on the bed.

### DATE OF SOWING.

The date of sowing varies according to the date at which transplanting is to be done, and the length of time which is required by the seedlings to take a sufficient development.

In the province of Quebec, and when semi-hot beds are used, it would be useless to sow before the middle of April. During the last few years, our beds were seldom sown before the 20th of April, and the seedlings were always ready to be transplanted by the end of May. Hence, seedlings can be grown in less than forty-five days.

Of course an earlier stand would be obtained if the beds were sown sooner, but this is not an advantage as it is difficult, at the beginning, to maintain a favourable temperature in the beds while keeping up sufficient aeration. Under such conditions, the growth of the seedlings is very slow.

It is preferable to sow a little later, when the outside temperature is not so cold. As soon as they are up, the seedlings grow quickly and if they should be a little late towards the end of the growing period, they may always be forced by means of glazed sashes, or by more copious waterings, or, if necessary, by the use of solutions of nitrate of soda or hen manure, which are mentioned further on.

Generally speaking, in a normal season, the grower may, to a large extent, control the date at which seedlings suitable for transplanting may be obtained. He has very efficient means at his disposal: sashes and watering (with pure water or with water to which plant food has been added), he may therefore accelerate vegetation or retard it almost as he desires.

However, it is somewhat easier to push the growth of the seedlings that are a little late than to retard seedlings that are too early.

ACCIDENTS.

*Sunstrokes.*—Sunstrokes are always a possible danger when glazed sashes are used. To avoid them, the sashes should be raised slightly during the hours of sunshine or covered with light canvas cloth, reducing the quantity of heat coming into the bed.

Whitewashing sashes with lime gives almost the same result. Even in this case, it is wise to give a little aeration.

As a rule, glazed sashes should be raised as soon as the sun is fairly well up.

*Spindling.*—Spindling is unavoidable when the stand is too thick. The only treatment is to thin out well. Unfortunately, when the stand is uniform, spindling is observed only when the growth is fairly well advanced, and in this case, it is difficult to thin.

Spindling may also be caused by a lack of sunlight. In this case, the bed should be uncovered during longer intervals. Light canvas cloth, with a loose tissue, should be used, instead of heavy and comparatively thick cloth, and if the temperature does not allow of this substitution, glazed sashes should be used, admitting a maximum of sunlight while maintaining a maximum of heat.

*Yellow plants.*—A good many causes are responsible for the yellowing of the plants.

Lack of light and insufficient ventilation are the main causes and also the ones easiest to remedy.

Generally, seedlings have a tendency to yellow when the stand is too thick. In this case, thinning out is the remedy.

Sometimes, the yellowing of the seedlings is caused by a lack of plant food in the mould, and the plants not only turn yellow, but they make a slow growth. In this case the beds should be watered with a diluted solution of nitrate of soda or hen manure. These solutions are prepared and used as follows:

*Hen manure* (formula A. L. Fisher).—In a barrel of soft water, put three bushels of hen manure, and let this mixture ferment for about ten days. Take one part of the mixture for nine parts of water. This one to ten solution, used once a week for watering, stimulates the growth and soon restores the healthy colour of the seedlings.

*Nitrate of soda.*—The following formula was successfully used by Mr. O. Chevalier, on our station of St. Jacques l'Achigan. One quarter of a pound of nitrate of soda is dissolved in two gallons of water. This solution may be used for watering as soon as it is ready. For best results, a watering with pure water should be given after the watering with the solution of nitrate of soda, in order to wash the leaves, and remove the excess of solution that might remain.

J. Johnson, of the Wisconsin Experimental Station, recommends for the same purpose, a solution of 2 to 3 pounds of nitrate of soda in a barrel of water. This quantity of water is for two hundred square feet of beds, which represents a normal watering.

*Mushrooms.*—The mushrooms generally originate in the manure that is used in the making of the hot bed. The best way to prevent their appearance is to spread, on the top of the layer of manure, a good quantity of hard kitchen salt. A raw product, very cheap and very suitable, is found in the trade.

Mushrooms should be removed as soon as they appear and before they become full grown, especially before they decompose in the beds, after scattering their spores. They are only really dangerous when they develop in very large numbers, in which case the beds may have to be abandoned on account of the disorders which they cause.

Mushrooms are not so likely to appear when a foundation of tobacco stalks or corn-stalks without manure has been used. It is advisable however, to sprinkle a little kitchen salt upon the layer of straw on which the mould is to be laid.

## INSECT ENEMIES.

Young tobacco seedlings are often attacked by insects, particularly in warm districts, when the beds are not protected by frames, or when the frame is poorly made and not sufficiently tight. They may also come from the mould itself, where they are present in the stage of larvae. The evolution of the larvae is greatly facilitated by the temperature of the bed. Slugs and snails are nocturnal enemies. A good way to get rid of them is to place on the beds, at dusk, pieces of fresh willow bark or slices of carrots under which they gather during the night. Early in the morning, they may be picked from under the shelters and destroyed. Another good plan is to put a little quick lime or kitchen salt around the bed; little rows of hair or cotton also hinder their march. In any case, the surroundings of the bed must be kept very clean, as weeds often shelter insects during the day.

Beds are also attacked by aphides. When the sun is fairly hot, they gather under shelter. Pieces of damp bark may be placed, under which they may be found and destroyed.

Earthworms may be hunted and destroyed at sunset or during the night, when they come out of the bed, care should be taken to avoid making any noise; in full daylight, a good plan is to shake the beds by striking the frames or by means of sticks, put underneath the frames. Another very good way to get rid of earthworms is to mix a little soot to the top layer of mould.

In warm countries a small beetle of the altise family (flea beetle), sometimes causes considerable injury. This beetle fears dampness and may be killed by repeated waterings. Spraying with nicotine solution has given excellent results; this seems to be the best treatment. The following mixture may also be used as a spray: 3 ounces flower of sulphur, 4 ounces copper sulphate finely crushed, 14 pounds air-slaked lime, 2½ ounces Paris green (formula J. G. Smith and C. R. Blacow).

Moles and mole-crickets sometimes cause considerable injury. Fortunately these pests are seldom seen in Canada.

There is not much danger from moles when the bed frame is made sufficiently tight. They may be caught with traps, or removed with a spade, just as they start to work, about noon or at sunset. The mole-cricket may be asphyxiated by flooding the tunnel with water, to which one-twentieth part of oil has been added. Coal tar may also be used; a small liquor glass of it being poured at the opening of every tunnel.

PLATE VII.—Seed bed aeration. (Period of acclimatization.) Bed sown with ½ oz. of seed per 100 square feet. Vertical shelter.

PLATE VIII. Seed bed aeration. (Sliding sashes both ways.) Kind of canvas used at night.

# V.

## DISEASES OF TOBACCO SEEDLINGS.

A scientific study of the disease of tobacco plants would be out of place in a practical bulletin of this kind. This subject, which is not as yet completely elucidated, is one which should more properly be dealt with by a botanist or a pathologist.

It will be sufficient for the grower to know that these diseases are caused by the development of organisms on the young stems or the roots of the tobacco plants. These organisms, which belong to an order of inferior cryptogams or mushrooms, hardly visible to the naked eye, find a suitable medium for their growth in overheated beds, kept too damp, insufficiently aired and where the stand is too thick.

For the sake of convenience, these diseases will be divided into two groups: (1) the diseases affecting the visible parts of the plant, from the collar to the leaves; (2) those affecting the subterranean parts of the plant, viz., the roots.

(1) *Damping off.*—In the first case, some seedlings are seen to wither suddenly, in a few hours time, on one or several parts of the bed, generally in the dampest parts, and on those where the stand is the thickest. The seedlings that are infected wilt rapidly, they collapse as it were on the top of the bed, forming a matted mass. This disease has been called damping off. Three different organisms, all three attacking the aerial parts of the plants may be responsible for this disease: Pythium Debaryanum, Sclerotinia or Rhizoctonia. The latter, however, attacks the root and stem indifferently.

The injury is specially visible at the collar (the part of the plant between the root and the stem); the collar becomes dark, like brown cork, and hard. As a rule, the roots of the affected plants have not as much hair as have those of normal plants.

A careful examination of the surface of the bed will show a net of white filaments (mycelium) surrounding the young stems of the dead seedlings.

When the plants are already fairly developed when the disease appears they do not necessarily perish. A sort of canker forms above the collar. This canker, easily seen with the naked eye, enables one to recognize the disease at extraction time. When the disease is caused by Sclerotinia, the canker sometimes develops on a higher part of the stem; in this case it is easier to make a diagnosis. All diseased plants should be discarded, and it will be better to give up the bed entirely if there is a large proportion of diseased seedlings, as they would surely prevent the grower from securing anything like a full crop.

(2) *Root Rot.*—It is not always easy to ascertain the presence of this disease, as it generally starts on the underground parts of the plant. The destructive agent is generally *Thielavia Basicola.* The presence of Rhizoctonia has sometimes been observed, but the latter attacks more particularly the parts of the plant above the ground. This disease is called "Tobacco root rot."

The seedlings which are attacked grow very slowly; this slowness is sometimes attributed to the lack of plant food in the mould, to the lack of heat or to the insuffi-

ciency of water. Sometimes the stem shows a tendency to harden and the foliage becomes dark. When this symptom is observed, as indicated by G. P. Clinton, the seedlings should at once be taken out and their roots carefully examined; this examination will show the real cause of the trouble.

In the case of damping off, it often happens that the seedlings die upon the bed; with the tobacco root rot, the infection may not be observed on the beds if it is not very severe, and it is carried with the seedlings on the field, where it does considerable damage for several years in succession. As a matter of fact the infection by *Thielavia Basicola* renders the land unsuitable for the profitable growing of tobacco, for a number of years.

In the more frequent cases (general infection or infection localized to a part of the bed) the seedlings that were thought to be normal are found to have practically no roots. In the majority of cases, the main root is destroyed as well as the secondary roots, only the adventitious roots are left, which have developed in the immediate neighbourhood of the collar, under the pressing requirements of the plant, and have helped the latter to live. Instead of roots, one sees dark stubs, last remains of the roots that have been destroyed.

It seems almost unnecessary to dwell on the necessity of discarding such seedlings as well as all the seedlings coming from the infected seed bed.

Sometimes, a more careful examination is necessary, the root system is not entirely destroyed, but a good part of the root hair has disappeared. Sometimes the latter subsist but the extremity of the young roots appears to be burnt. This is a mild form of *Thielavia Basicola*, perhaps the most dangerous of all, as, being unnoticed, it is often carried from the bed to the plantation.

Such seedlings, transplanted in a healthy and fertile soil, will give a crop but they will inevitably ruin the soil by spreading the germs of the disease and making it unsuitable for the profitable production of tobacco for years to come.

*Bacterial Canker.*—Some investigators claim to have found a soft bacterial canker on the young seedlings. This canker, which often appears on the European tobacco fields (G. Delacroix) propagates through the vessels and develops particularly on the stem, at the axis of the leaves and on the leaves, at the point of intersection of the ribs. It appears in the shape of dark and soft spots of a livid hue, which, on drying out, form a real ulcer. It has never been observed as yet in Canada.

*Mosaic disease.*—Mention should also be made of the mosaic disease which, up to the present, has been thought to be caused by a purely physiological disorder. On the seed beds, it appears in the shape of light streaks or light swellings on the green parts of the plant. Generally the roots of affected plants are poorly developed. Suspected seedlings should be discarded. Better give up the entire bed if possible.

### PREVENTIVE TREATMENTS—REMEDIES.

How can the grower prevent or check diseases which threaten to destroy the crop at the very beginning of the growth?

As regards the mosaic disease, it is very difficult, in the present state of our knowledge of the subject, to recommend any efficient treatment. This disease is supposed to be caused by trouble of nutrition, arising out of sudden variations in the

conditions of growth. To avoid these variations is therefore the first consideration, but this is a difficult matter as it is almost impossible, in the majority of cases, to keep the humidity, the temperature and the aeration of the bed always as regular as they should be. Outside atmospheric variations will always exert a considerable influence, which, in most cases, will decide the final results. It must not be forgotten that the mosaic disease occurs only very occasionally on the seed beds, and that it may, according to the season, be the logical consequence of the measures that should have been taken to prevent the more frequent and more serious diseases mentioned in this chapter.

*Predisposing causes.* For all other cases, it may be stated, in a general way, that the main causes favouring the appearance of diseases on the beds are the following: excess of moisture, lack of air and light, too high temperature, too thick a stand, infection of the moulds.

The germs of diseases may be contained in the mould that has been put in the bed or they may be accidentally introduced during the period of growth. They are always very dangerous but the damage caused is much larger when they find favourable conditions for their development and when the young plants, on the other hand, hindered by unfavourable conditions, can only offer a minimum of resistance.

*Remedies.* This is specially the case as regards the diseases constituting the group designated under the name of "damping off". Very often the disease may be checked by decreasing watering, by giving more aeration and by thinning. The conditions thus created are most unfavourable for the growth of the mycelium and the injury may be completely checked.

The following mixture for use as a spray is recommended by Smith and Blacow:

3 ounces flowers of sulphur.
4 ounces copper sulphate finely crushed.
14 pounds air-slaked lime.
Or a solution of formalin of $\frac{3}{100}$.

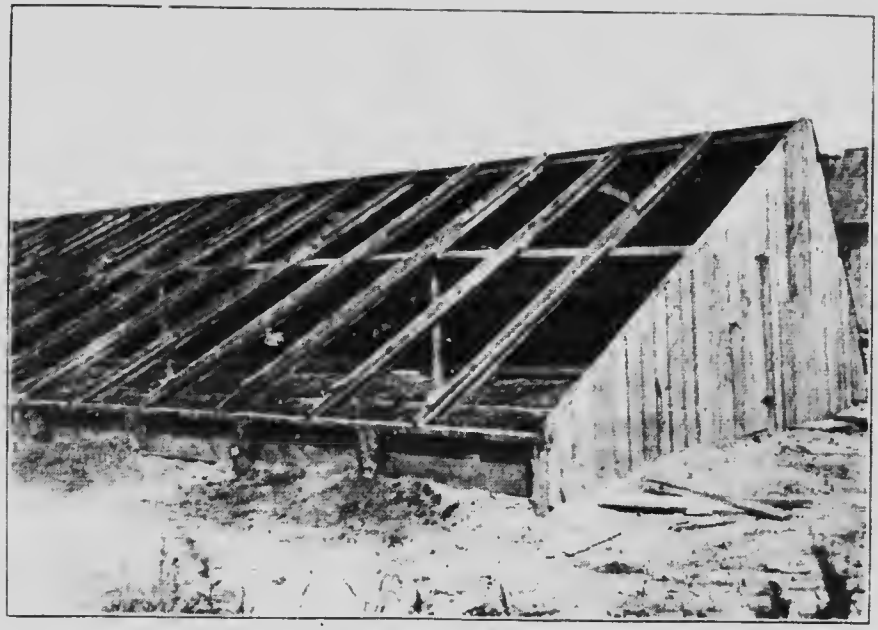
Good results have been obtained by Mr. Chevalier at Farnham, P.Q., with a solution of formalin, $\frac{1}{100}$. It is very probable that a solution of $\frac{2}{100}$ could be used safely.

The method is as follows: as soon as damping off is observed on a part of the bed, cut, with scissors, all the seedlings that are on this part, taking in, at the same time, one or two inches all around, on the healthy parts of the bed. On this clear spot spread the Smith Blacow mixture by means of a very fine sieve or apply a good quantity of formalin solution ($\frac{2}{100}$). It is necessary to cut a little more than the affected part, so as to be quite sure of removing all diseased parts. In any case, the seedlings would not survive the application of the formalin solution or of the disinfecting mixture.

Such treatment can only be applied when the attack is comparatively light, limited to certain spots, and when the bed is accidently invaded. When the whole of the mould is infected, the treatment is useless as the extirpation of the disease would involve the practical destruction of the seedlings. The only remedy in this case is a preventive one: the disinfection of the soil.

In any case, thin seeding is an absolute necessity and too much importance cannot be laid on this point. Too thick a stand of seedlings may by itself cause serious

A



B

PLATE IX.—Bed in greenhouse. (*a*)—Outside view. (*b*)—Inside view.

disorders. The young seedlings are smothered between the earliest ones and, being unable to clear themselves, they decay and fill the bed with refuse constituting an extremely favourable medium for the development of fungi.

After the thickness of the stand, the excess of humidity is perhaps the next cause. As a matter of fact, damping off is generally observed on the parts of the bed where dripping occurs (under glazed sashes) or in such parts where evaporation is the least active, near the frames. Therefore, the sashes must be perfectly tight and they should be given a sufficient slope so that rain water or water which has condensed on the inside surface of the glass may easily run off. Watering should be moderate.

*Tobacco Root rot.*—As will be seen, the treatment of a bed that has been attacked by damping off is, to a certain extent, practicable, but with tobacco root rot, the only remedy seems to be the control of aeration and of watering. Even then, however, injury can only be slightly reduced, and, in any case, it would be extremely unwise to use seedlings coming out of a bed attacked by root rot.

On the bed where the top layer consists of a sandy soil, having easy access to air and quick to dry off, it has been observed that *Thielavia* attacks specially the deep parts of the roots (root hair) and that the neighbouring parts of the collar are seldom attacked. This does not make any difference from a practical point of view, as the attacked seedlings must be destroyed, but it is a proof that the excess of humidity and lack of air are predisposing causes.

It is also advised to avoid the use of mould containing undecomposed organic manure. Mention of this fact has already been made in a preceding chapter.

There is only one preventive remedy for tobacco root rot: viz., the disinfection of the mould.

This treatment is very efficient with any form of rot, while the remedies indicated above are only good for "damping off" and are absolutely useless for tobacco root rot.

### DISINFECTION OF THE MOULDS.

The disinfection of the soils used in the beds is done by means of heat or of chemical agents which destroy the germs of fungi and are eliminated quickly enough not to hinder the growth of the seedlings.

*Treatment by heat.—1. A direct fire.*—The most simple process consists of burning, as already mentioned. The operation should not last too long and the fire must not be too intense, otherwise the supply of humus in the top surface of the soil would be completely destroyed. As a matter of fact, the top part of the bed is practically cooked while the lower part, down to a depth of three to four inches, is heated to a sufficient temperature to destroy all the germs of diseases or weed seeds without losing any of its humus contents. By mixing thoroughly the top layer and the inferior layer, down to a depth of about three inches, one secures a bed of healthy soil of sufficient fertility.

It is better to select a spot with a rather light soil as clay soils have a tendency to bake, owing to their conductibility. The burning should not be done before the soil is sufficiently dried, as a damp soil, submitted to heat, might bake just like a soil containing too large a proportion of clay.

*2. Heated pans.*—In some parts of the United States, a movable pan of strong wrought iron is used under which a good wood fire is made (Wyatt system). The soil which is to be treated is laid upon this pan to a height of about six inches and the fire is regulated in such a manner that a temperature of from 250 to 280 degrees F. may be obtained but never more. To avoid the excessive heating of the parts in direct contact with the iron it is advisable to stir the soil continually with a shovel. In this way, all the parts of the soil may be submitted to the required temperature. The process lasts from three-quarters of an hour to an hour, according to the intensity of the fire and the nature of the soil.

This pan is placed over one bed, while the soils of two adjacent beds are being treated. The soil of the bed over which the apparatus is placed may also be considered as having been treated. Thus in two hours' time, one may sterilize an area of bed equal to three times the area of the pan.

The size of the pan may vary, but the empty pan should be of convenient weight, so that it may be easily handled by a couple of men. A handy size is 4 to 5 feet wide by 8 feet long.

When judiciously employed, these two methods give excellent results but some experience is necessary to learn not to go beyond the critical temperature and it is only by practice this experience may be acquired.

*3. Ovens.*—During a visit at the Royal Institute of Seafati (Italy), the author has seen a real oven in which the soil is submitted to the action of the heat without coming into direct contact with the fire or with an overheated pan as in the preceding methods. Inside the oven are several tiers of strong iron pans on which the soil which is to be treated is placed. Hot air and gases rising from the fire circulate between these pans. The fire may be easily regulated so as to obtain a temperature of 230 to 250 degrees F. The operation is stopped when the bulk of the soil has been kept at the required temperature for a sufficient length of time, about one hour. The doors of the oven are opened, the iron pans are taken out like drawers and loaded again. Thus everything is ready for a second operation. Once the fire is lit and the temperature regulated, all that it is necessary to do is to empty the pans and fill them up again, taking the necessary precautions to avoid reinfection.

Apparently, the plant utilized at Seafati for the treatment of the soils was not built specially for the purpose. However, if we consider the reactions taking place in the soils undergoing such treatment, it is quite possible that where a large quantity of tobacco is grown, the building of a special oven might be a profitable expenditure.

*4. Steam.*—Of all the treatments employed to this day, the treatment of the moulds by steam at a high pressure is perhaps the one which gives the most uniform results. In this treatment the soil which it is desired to disinfect, is kept for half an hour at least in a current of steam, at a temperature of 230 to 240 degrees F., which result may be obtained by using a box with vertical sides, the bottom of which is covered with a system of pipes perforated with rather fine holes and through which steam is admitted. This method requires a number of handlings and admits only of the treatment of a small quantity of soil at a time; hence it is comparatively expensive. For the last few years, growers in the United States as well as in Ontario have been using a great flat, galvanized iron box, of a sufficient weight to resist the pressure of the steam. This box is put over the bed which is to be disinfected.

The height of the box is about 8 inches and it is pressed down about two inches deep in the soil. The steam is admitted by means of a pipe, one inch in diameter, blocked at the end and perforated with small holes near the end, on a length of about 1½ to 2 feet.

When the bed is covered with this box, the steam, which is introduced under a pressure of 100 to 150 pounds, spreads to a greater or lesser depth in the soil through which it condenses.

It is considered that the steaming is sufficient when the heat is felt at a depth of about three to four inches in the bed. This result is obtained by keeping the box on the bed for at least half an hour and keeping up at the same time, a pressure of at least sixty pounds.

The steam treatment may be applied after the bed has been made ready for sowing, and the sowing done as soon as the temperature of the soil has become normal again. At first, steam is introduced gradually by slowly opening the valve, in order to avoid raising the box, which might occur if steam were introduced too freely.

The size of this iron box varies according to that of the beds, and for convenience in handling. If heavy sheet iron is used, a box 5 feet wide by 8 to 10 feet long would be quite heavy enough. For beds 5 feet wide by 15 feet long, a box 5 feet by 8 feet is advised. This box [illegible] cover the bed in two applications.

The length of the treatment depends upon the nature of the soil to be disinfected and the pressure obtained. If the soil is particularly compact, the treatment should last about an hour; it should also last an hour if the pressure should drop rapidly to 50 pounds. In order to obtain good results, the soil should be treated when it is in good condition to be sown, that is to say sufficiently moist, but not too damp, and sufficiently friable.

When steaming, the steam box should be set as close as possible to the frame of the bed so as to avoid leaving an untreated strip. The handles for carrying the box should stick out as little as possible so as to permit of close contact between the frame and the box.

*Formalin treatment.* Of all the chemical products that have been used with a view to destroy injurious organisms, the only one which has so far given satisfactory results is formalin.

The formalin treatment may be applied in the fall on the soils of the various beds, or in the spring, on the bed, after the latter has been made ready for sowing.

The first method offers the advantage that very strong solutions may be used and several treatments given in succession as one has plenty of time to get rid of an excess of formalin. The soil is worked over with a shovel to facilitate the escape of fumes which might hinder germination. With the second method, the mould is treated on the spot and there is less danger of reinfection. Both methods have been tried on our stations and the second is considered to be the better.

Much time has been given to the study of the disinfection of the moulds by James Johnson, Wisconsin; G. P. Clinton, Connecticut; A. D. Selby, Ohio; and W. W. Gilbert; they conclude that the use of formalin in solutions of 1/500 does not offer sufficient guarantee and J. Johnson recommends the use of a 1/50 solution. As far as we are concerned, we have always obtained good results with a solution composed of formalin

1/50 but probably the moulds that were submitted to this treatment were not badly infected. In doubtful cases, and especially when lush soils are used, it is better to employ a solution of 1/20.

The method is as follows:

One gallon of commercial formalin (40 per cent) is mixed with fifty gallons of water. This solution is spread on the bed at the rate of about half a gallon per square foot of bed.

The best way is to prepare the quantity of solution necessary for the treatment of the bed some time before the application is made. The solution is applied in sufficient quantity to saturate the five or six inches of soil, then the soil is covered with a cloth during at least twenty-four hours. When the bed appears to be drained, the rest of the solution is applied and the bed is kept covered during another twenty-four hours.

After giving time for the fumes of the formalin to act, the bed is aired. Formalin fumes evaporate rapidly if the bed is kept at a sufficient temperature by means of glazed sashes. These sashes are laid in such a way as to create a current of air which drives out the fumes of formalin as they come out of the soil. Some of our beds have been sown four days after the last application of formalin, and if a delay of eight days is given, germination is not retarded to any appreciable extent.

### COMPARATIVE VALUE OF STEAM TREATMENT AND FORMALIN TREATMENT.

In our opinion, both treatments are equal and give results equally satisfactory when well applied.

On farms where a generator can be had, the steam treatment is to be preferred, but as germination is very slow in the soils that have been steamed, as well as the growth of the seedlings at first, the soils should be treated a long time beforehand, preferably in the fall, and aired by being turned over with a shovel or a rake. If no generator is available, formalin may be used at least fifteen days before the date agreed upon for sowing. The solution should have a strength of 1/20 and should be applied at the rate of one half gallon per square foot of bed.

For the semi-hot bed which has been described in another chapter, the fine mould which is put on top of the bed must be treated separately. However this is not a very serious complication.

The cost of the operation is about the same in both cases, about $1 per hundred square feet of bed. This is certainly not prohibitive, and even with new moulds, which are supposed to be clean, it is safer to apply this preventive treatment.

The chief advantage of steam treatment is that it kills not only the germs of fungi but all the weed seeds that may be contained in the soil. Weeding being no longer necessary, a saving of from $4 to $5 per hundred square feet of bed is realized. With the formalin treatment the proportion of weeds is reduced, but weeding is still necessary. It has been shown, in a special chapter, how this operation may be reduced to a minimum.

*Note.*—The moulds that have been treated should be handled with the greatest precaution so as to avoid reinfection.

Two sets of tools should be used, one for handling moulds that are awaiting treatment and the other for the moulds that have been disinfected.

# VI.

## MAKING OF THE SEMI-HOT BED.

In the preceding chapters, the methods of producing tobacco seedlings have been indicated in a general way.

The method of making a semi-hot bed without manure will now be described in detail. This kind of bed is specially recommended by the Tobacco Division.

*Selection of the spot.*— A sheltered spot on fairly high ground easy to drain and exposed to the south, is selected. If necessary, it should be enclosed with palisades, 6 to 7 feet high, in such a way so as to break the wind, without cutting off the rays of the sun.

*Trench.*— On this spot, a trench about 5½ feet wide, 8 inches deep and 16 feet long is dug.

*Foundation of stalks.*—This trench is filled with tobacco stalks or cornstalks well packed, laid crossways, and in a layer as even as possible, so that the surface of the bed may remain uniform if this foundation of stalks should settle under the weight of the soil.

*Setting of the frame.*—On this foundation of packed stems, the portable frame illustrated on plate III is set up and hooked with the hooks well stretched so as to be as rigid as possible, then a bed of straw is laid, on which the mould will be put. The frame is banked with the soil taken out of the trench and covered with glazed sashes.

*Heating of the bed.*— Two or three days of good sunshine, even supposing that the outside temperature is very low, are sufficient to thaw out or heat the layer of stalks or straw laid in the trench. At this point, the mould which has been prepared the previous fall and carefully kept under shelter is laid to a depth of about five inches, the sashes are placed and the bed is left exposed to the sun.

To prevent the cooling off of the bed during the night, the sashes should be covered with cloth or blankets. The latter are removed as the sun reappears.

*Disinfection of the mould.*—A solution is prepared containing 1 gallon of formalin and 50 gallons of water or exactly 1 gallon of formalin and 49 gallons of water. As soon as the solution is ready, it is applied to the bed at the rate of half a gallon per square foot. The application is stopped as soon as the soil is saturated, then the surface of the bed is covered with cloth or strong paper to prevent too rapid an evaporation of the formalin. After about twenty-four hours this shelter is removed and a second application of formalin is made, until the whole quantity of solution prepared for the bed has been entirely used.

The solution of formalin should be kept in closed vessels.

*Airing and drying off.*—Twenty-four hours after the last application of formalin, the cloth is removed definitely and the sashes are raised two or three inches on the highest part of the bed in order to air the bed while keeping it warm at the same time.

If necessary, the top of the bed should be lightly raked so as to hasten the evaporation of the fumes of formalin. Care should be taken to dip the rake in the disinfecting solution.

In clear weather and when the temperature of the bed may be carried to 80 or 85 degrees F., the evaporation of formalin takes place very quickly and may be over in two or three days. If there is no hurry, however, it is better to put off sowing until a week after the last application of formalin.

*Fertilization.*—When the formalin treatment has been applied and after the mould has been raked, the chemical fertilizer may be spread.

After carefully levelling the top of the bed, the special chemical fertilizer or the mixture of nitrate of soda and vegetable mould is spread by hand or by means of a sieve, at the rate of 1 ounce per square foot. It is incorporated by the rake to a depth of about an inch, and a layer of mould, also disinfected, is spread to a height of one-half to one inch. The sashes are replaced and the bed is ready to be sown as soon as the smell of formalin has completely disappeared.

*Note.*—To obtain good results from the use of chemical fertilizer, one should strictly adhere to the following rules: (1) Never apply more chemical fertilizers than is recommended (see page 19); (2) Mix the chemical fertilizers thoroughly with the top layer of mould to a depth of about one inch; (3) Apply at the least half an inch of mould after the fertilizer is put in. If the mould is very fertile, better put one inch.

Efflorescences may occur but they are seldom dangerous. They are caused by the evaporation of the solutions of the chemical fertilizers at the top of the bed. They may be removed by local waterings, washing the excess of mineral matter down to a depth where it no longer causes harm. It is only when excessive quantities of chemical fertilizers are used that efflorescences may cause injury on account of their caustic action and burn the young seedlings.

As will be seen, the preparation of the semi-hot bed, including the disinfection of the mould, requires some time. About eight days are necessary for the treatment wth formalin and another eight days for the setting of the frame and the heating of the bed of stalks and the mould. This work should be started at the beginning of April. At Ottawa, we generally start from the 4th to the 6th of April and the beds are ready to be sown on the 20th.

In any case, there is no danger that the fermenting of the layer of manure that is used in the hot and semi-hot beds will be over before the date of sowing; on the contrary, the more time elapses between the first placing of the glazed sashes on the frame and the date of sowing, the warmer the bed will be.

*Sowing.*—Sowing is done with dry seed from the 20th to the 25th of April, at the rate of $\frac{1}{4}$ of an ounce of seed per hundred square feet. The seed is mixed with fine sand just a little damp and which has been sterilized by heat. The quantity of sand to be used is about two hundred or three hundred times the bulk of the seed.

The seed may be sown with a pepper holder or by hand. Both methods give results equally satisfactory. When a pepper holder is used, less sand is required than when the seed is sown by hand, but care should be taken to keep the mixture continually stirred, as sand and seed have a tendency to separate from each other, owing to the difference in weight.

The mould on the top of the bed should be slightly damp.

After sowing, the surface is lightly packed by means of a small board fitted with a handle. The sashes are put in place and covered during the day with cheese cloth or muslin and during the night with a heavier cloth or blanket.

Watering should be very moderate at first. A thermometer is placed under the sashes. The sashes should be raised as soon as the temperature goes above 85 degrees F. The seedlings are up from eight to ten days after the date of sowing, according to the season. For the care of the bed after this period, the reader is referred to the recommendations made in the preceding chapters.

A

B

PLATE X.—Small special greenhouse. (*a*) Inside view. (*b*) Outside view.

## APPENDIX.

### COMPARATIVE TEMPERATURES OF HOT BEDS, SEMI-HOT BEDS AND GREENHOUSES.

An experiment was made in 1914 to ascertain the comparative value of the semi-hot bed that has just been described. The outside and inside temperatures, maximum and minimum, were recorded on three different beds: a hot bed, a semi-hot bed without manure and a cold bed in a heated greenhouse.

The following observations will be noted. The differences between the maxima temperatures in the hot bed and semi-hot bed are very light. It may be concluded that the layer of manure which is placed under the hot bed is not of very great use. As a matter of fact, in order to avoid the risk of disease, one must, before sowing the hot bed, wait until the manure has practically ceased to ferment. The heat given up by the manure has been used chiefly for thawing out the soil and it has been seen that this thawing out may be obtained without any cost, simply by using glazed sashes over the bed.

Again, the differences between the minimum temperatures are also insignificant. This is a proof that the foundation of tobacco stalks on which the mould is laid is sufficiently insulating and quite as useful as a bed of manure which has almost ceased to ferment.

It will be noted that a sudden lowering of temperature generally occurs during the night under the sashes. However, after a certain minimum point, which evidently varies with the outside temperature, is reached, it seems that the bed does not cool off any more or in any case that it cools off very slowly, opposing a greater resistance to the cold, as the difference between the minimum temperature under the beds and the minimum temperature outside increases. It is obvious that in this case the heat supplied comes from the foundation and from the mould itself as well as from the layer of hot air stored under the latter.

An important point is that the semi-hot bed without manure does not suffer any more from the cold than a hot bed.

The spring of 1914 was moderate. It will be noted, however, that the great difference observed in the coldest nights between the inside minimum temperatures and frost temperatures leaves a good margin of safety; this margin has never been less than 20 degrees F.

On the other hand, the bed in the greenhouse is the one that has been exposed to the lowest temperatures.

The six-inch layer of soil on which the seed was sown was placed directly on a foundation of boards, perforated with many small holes in order to permit of sufficient drainage. With the heating apparatus, it was easy to keep the temperature of the greenhouse sufficiently warm during the day but the body of the bed, under the influence of watering and evaporation, must always have been at a lower temperature than the temperature indicated by the thermometers in the greenhouse.

On a clear night, under the influence of radiation, the greenhouse, although the panes had been whitewashed, cooled off more rapidly than the beds under movable sashes, covered with cloth. It would have been necessary to activate the fire between midnight and the early hours of the morning in the greenhouse, but this would have required a close watch that could be dispensed with when hot beds or semi-hot beds are used.

RECORD of Maximum and Minimum Temperatures Seed Beds Experimental Farm (1914)

| | Hot bed. | | Semi-hot bed without manure. | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | | B | | C | | Greenhouse | | Outside temperature | |
| | With 8" manure. | | With fertilizer | | Without fertilizer | | | | | |
| 1914. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| | 80 | | 76 | | | | | | | |
| 26 | 69 | 55 | 64 | 54 | | | | | | |
| 27 | 78 | 64 | 82 | 63 | | | | | | |
| 28 | 92 | 72 | 90 | 71 | 83 | | 84 | | | |
| 29 | 58 | 52 | 62 | 50 | 91 | 68 | 82 | 60 | | |
| 30 | 90 | 50 | 90 | 50 | 90 | 50 | 80 | 51 | 44 | |
| May 1 | 82 | 50 | 82 | 52 | 82 | 52 | 82 | 43 | 85 | 38 |
| 2 | 75 | 55 | 72 | 50 | 72 | 50 | 83 | 42 | 80 | 38 |
| 3 | 82 | 55 | 84 | 54 | 83 | 54 | 95 | 42 | 85 | 38 |
| 4 | 80 | 58 | 80 | 47 | 80 | 54 | 87 | 47 | 78 | 34 |
| 5 | 79 | 63 | 86 | 61 | 83 | 60 | 91 | 54 | 87 | 43 |
| 6 | 83 | 59 | 85 | 57 | 83 | 53 | 85 | 57 | 80 | 51 |
| 7 | 76 | 62 | 78 | 60 | 76 | 59 | 86 | 53 | 77 | 43 |
| 8 | 83 | 56 | 80 | 52 | 83 | 50 | 85 | 51 | 86 | 47 |
| 9 | 85 | 57 | 85 | 52 | 86 | 51 | 85 | 47 | 86 | 40 |
| 10 | 80 | 57 | 78 | 55 | 78 | 57 | 80 | 50 | 80 | 45 |
| 11 | 78 | 55 | 78 | 50 | 70 | 50 | 85 | 50 | 80 | 46 |
| 12 | 82 | 57 | 79 | 60 | 80 | 50 | 89 | 42 | 78 | 35 |
| 13 | 85 | 50 | 87 | 46 | 87 | 41 | 84 | 50 | 76 | 48 |
| 14 | 82 | 54 | 86 | 51 | 79 | 46 | 85 | 44 | 70 | 30 |
| 15 | 76 | 55 | 79 | 50 | 75 | 50 | 86 | 51 | 70 | 35 |
| 16 | 82 | 54 | 83 | 49 | 77 | 48 | 85 | 43 | 75 | 31 |
| 17 | 83 | 56 | 82 | 52 | 87 | 50 | 82 | 46 | 72 | 38 |
| 18 | 84 | 59 | 82 | 53 | 85 | 53 | 85 | 45 | 85 | 39 |
| 19 | 89 | 61 | 89 | 57 | 90 | 56 | 84 | 51 | 89 | 48 |
| 20 | 88 | 62 | 88 | 58 | 92 | 57 | 91 | 59 | 89 | 58 |
| 21 | 94 | 66 | 91 | 62 | 95 | 62 | 86 | 58 | 89 | 47 |
| 22 | 93 | 70 | 93 | 68 | 96 | 65 | 92 | 58 | 93 | 58 |
| 23 | 80 | 63 | 80 | 60 | 79 | 60 | 89 | 61 | 95 | 53 |
| 24 | 90 | 55 | 91 | 54 | 92 | 52 | 74 | 52 | 70 | 49 |
| 25 | 90 | 58 | 91 | 54 | 92 | 52 | 89 | 45 | 79 | 37 |
| 26 | 92 | 70 | 95 | 68 | 96 | 67 | 92 | 47 | 86 | 38 |
| 27 | 95 | 63 | 96 | 62 | 97 | 62 | 95 | 54 | 93 | 70 |
| 28 | 100 | 66 | 99 | 65 | 102 | 62 | 95 | 62 | 93 | 58 |
| 29 | 98 | 50 | 98 | 48 | 100 | 49 | 95 | 58 | 86 | 57 |
| 30 | 90 | 60 | 92 | 60 | 91 | 61 | 91 | 51 | 85 | 48 |
| 31 | 91 | 60 | 91 | 58 | 92 | 58 | 90 | 48 | 85 | 47 |
| June 1 | 93 | 59 | 94 | 55 | 94 | 54 | 87 | 53 | 91 | 47 |
| 2 | 80 | 50 | 80 | 52 | 85 | 46 | 85 | 53 | 80 | 38 |
| 3 | 76 | 49 | 76 | 51 | 76 | 52 | 84 | 40 | 78 | 38 |
| 4 | 82 | 59 | 83 | 55 | 84 | 51 | 85 | 53 | 72 | 48 |
| 5 | | 50 | | 49 | | 49 | | 45 | | 47 |