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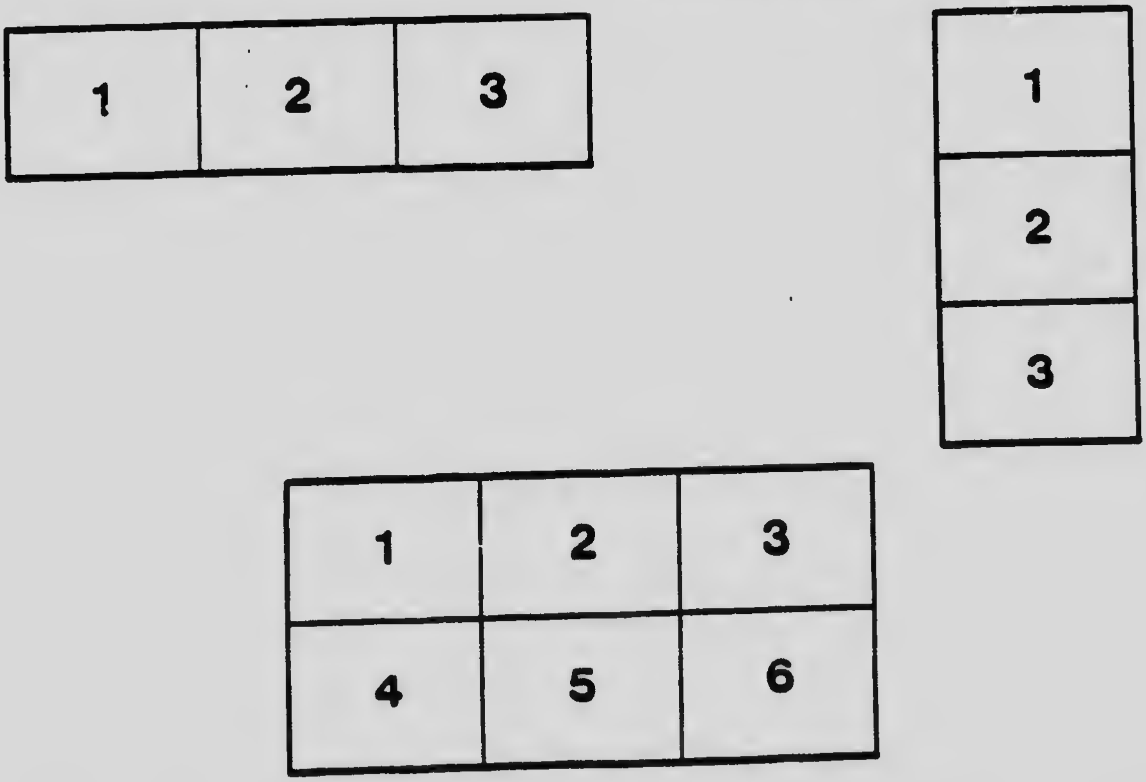
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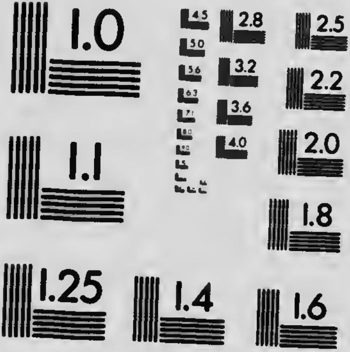

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DOMINION DEPARTMENT OF AGRICULTURE
CENTRAL EXPERIMENTAL FARM
OTTAWA - - - - CANADA

TOBACCO DIVISION

FLUE-CURED TOBACCO IN CANADA

I. GROWING FLUE-CURED TOBACCO IN ONTARIO
II. TOBACCO SOILS, ROTATIONS, FERTILIZERS
III. CO-OPERATIVE EXPERIMENTS

BY
D. D. DIGGES and H. A. FREEMAN

BULLETIN No. 38

SECOND SERIES

Published by the direction of the Hon. S. F. TOLMIE, Minister of Agriculture, Ottawa, Canada.

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OTTAWA, ONT., March 31, 1919.

The Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to submit herewith the manuscript of Bulletin 38 of the Second Series of Experimental Farms Bulletin, entitled, "Flue-Cured Tobaccos in Canada." This bulletin has been prepared by Messrs. D. D. Digges and H. A. Freeman, officers in the Tobacco Division of the Experimental Farms branch.

The growing of flue tobacco in Ontario has become, during the last few years, a well established industry but there has so far been very little reliable data available on the subject as to how far the growing of that type of tobacco may be carried on in Canada where conditions differ materially from those obtaining in Virginia or the Carolinas. The bulletin is the result of much experimental work on the tobacco station at Harrow, of which Mr. D. D. Digges is manager, and the information in that section is supplemented and widened in its scope by the report of investigations of tobacco soils in southern Ontario made by Mr. H. A. Freeman, tobacco inspector.

The bulletin should prove a valuable one to those engaged in the production of flue tobacco and I would recommend its distribution among the tobacco growers of southern Ontario at an early date.

I have the honour to be, Sir,

Your obedient servant,

J. H. GRISDALE,

Director, Dominion Experimental Farms.

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PART II—TOBACCO SOILS, ROTATIONS, FERTILIZERS.—*Concluded.*

PART III—CO-OPERATIVE EXPERIMENTS.

INTRODUCTION.

The growing of flue-cured tobacco in Canada dates back to the first experiment conducted by Messrs. Fox Brothers, in the vicinity of Ruthven, Ont., where very light sandy loams, somewhat gravelly, were first devoted to that type of leaf. From Ruthven it rapidly extended to the very light sandy loams along the lake shore, which proved very suitable for the raising of tobacco of the Bright Virginia type.

The area that can be devoted to the growing of that leaf in Canada is rather limited. In Eastern Canada we can hardly expect to see the culture of the flue-cured tobacco extended to other parts than South Ontario, as this is the only tobacco district where the season is sufficiently long and warm to allow the full ripening of the leaves before they are taken to the kiln. As to the possibilities of British Columbia for that type of tobacco they have not yet been considered. Therefore it is very probable that the growing of that type of leaf will become a specialty in the hands of the farmers who own land really suitable for this purpose. The price of land on which flue tobacco can be grown has considerably increased during the last few years, and has now reached the price paid for orchard land in the fruit belt of the Niagara peninsula.

While an overproduction of White Burley was experienced in Canada a few years ago, it can be said that, owing to the limited acreage than can be devoted to the growing of flue-cured tobacco, this need hardly be feared as far as the latter type is concerned. The growing of flue tobacco in South Ontario is therefore one of the safest undertakings.

Apart from the successful curing of the crop in order to obtain as large a proportion of bright leaf as possible, the most important problem at present is the maintenance or even the improvement of the fertility of the soils devoted to bright tobacco. Generally the fertility of those very light sands is much below the average; in fact the best land for flue tobacco in Ontario has been found where it was practically impossible to raise successfully any other crop except, in some instances, tomatoes or other vegetables, at the cost of very heavy applications of manure and fertilizers. But it is better to foresee that war conditions will not be long maintained, and that with normal prices the net return in money per acre might in a few years fall short of what it has been for the last two or three seasons, unless a serious effort is made with a view to increasing the yield per acre while maintaining the quality of the leaf.

This is the main problem which we are trying to solve at present. The objective of the grower of flue tobacco should be to obtain the best colour and the maximum possible yield at the same time. This will require the maintenance of the fertility of the tobacco land to a nice degree of equilibrium so as to prevent the leaf becoming too coarse for a successful curing.

On the other hand, the curing process by itself requires expert handling, the knowledge of which so far, at least in Canada, has been mastered by very few.

A comprehensive description of the curing process, as far as conditions in South Ontario are concerned, will be found in the first part of this bulletin. There is no absolute rule, as much depends upon the condition of the crop at the time it is taken into the kiln and the weather conditions during the process. Still, we believe it will be possible for the Ontario grower of flue-cured tobacco to derive much benefit from the comments on the methods of curing as practised at Harrow. In our opinion this is the first intelligent and practical description of the flue-curing process so far published in Canada dealing with special conditions in South Ontario.

As will be noted by the reader, the soil of the Tobacco Station at Harrow is considered a little too heavy for the growing of the brightest leaf, but, even in spite of the unfavourable weather conditions of the last few years, a comparatively large proportion of bright leaf has been obtained. If this has been possible on our Tobacco Station it can also be done elsewhere. This gratifying conclusion cannot be too much emphasized as, if the demand for Canadian flue-cured tobacco increases to the extent that the best land will not suffice to meet it, it will be necessary to grow the balance on land slightly heavier in texture, which in the hands of skilful growers will produce flue tobacco of marketable quality.

Moreover, there is not merely an active demand for really bright leaf, but other grades of flue tobacco like the semi-bright, the bright red and the red can also find a ready market in Canada. Those darker grades are used for special purposes, which require a heavier leaf, more elastic and gummy, that can hardly be produced on the lightest type of soil.

We may, therefore, look in the near future for a classification of flue tobaccos into brights, semi-brights and reds, with possibly several grades of each.

While the first part of this bulletin deals especially with conditions at the Harrow Tobacco Station, as far at least as the type of soil is concerned, the second part contains a more general description of the soils that are most suitable and of the methods to be followed for raising a crop of good quality without impairing the fertility of the land.

The experimental work along these lines has been carried on for only three years, still it was considered advisable not to wait any longer before publishing some of the results, owing to the rapidly increasing importance of the flue tobacco growing industry in Canada and the necessity of providing the farmer with some data on which he could rely for information. The same applies to the experimental work carried on at Harrow. We expect to be able, in the near future, to publish more complete results; still it was deemed advisable to provide the grower, as soon as possible, with the most urgently required information.

F. CHARLAN,
Chief Tobacco Division.

I.

GROWING FLUE-CURED TOBACCO IN ONTARIO.

By D. D. Digges, M.S., *Superintendent Harrow Tobacco Station.*

In Canada the growing season for tobacco is of short duration, and a few days lost at the time of transplanting may result either in a frostbitten crop or in one which was necessarily harvested while immature; therefore, an abundant supply of early, thrifty seedlings is of paramount importance if the tobacco grower is to reap a full measure of success with any type of tobacco. This is especially true with the flue-cured type; for, while the crop may escape frost, the climatic conditions prevailing just prior to harvesting exert a very appreciable influence on the final colour of the cured leaf. Cool nights give the leaves a tendency to thicken, and retard the ripening process, thereby making it more difficult to obtain a good cure; and cool, windy weather renders it more difficult to maintain a uniform temperature throughout the kiln, also increasing the difficulty of obtaining a satisfactory cure.

GROWING THE SEEDLINGS.

No phase of tobacco growing yields larger returns for proper care and attention than does the tobacco seed bed, for the degree of success attained in tobacco growing is largely dependent on the seedlings; and a lack of care is nowhere sooner in evidence, for without proper attention the seed bed may become a total failure within a few hours.

Locating the seed bed.—The seed bed should be located on soil with good natural drainage, both surface and underdrainage; where it will derive the fullest benefit from the sun; and, if possible, on the southern side of some building or other object which will serve as a wind-break and still not obstruct the sun's rays. A close board fence may be built around the bed with good results.

The mould.—The soil on which the seedlings are to be grown should be fertile and well supplied with vegetable matter in an advanced stage of decay. A large percentage of the failures in the production of plants, which the writer has observed, were due to the soil being too sandy and lacking in humus. Such a soil packs too tightly for the proper development of the seedlings; and, too, the light-coloured sand apparently gives up its heat more quickly than a darker soil, and the growth of the plants is checked by a lack of heat.

A very satisfactory soil for the growing of the seedlings can be obtained from low, marshy fields. Such soil is practically full of decayed vegetable matter; but, as a rule, is waterlogged and sour. Consequently it should be hauled to a dry place the spring before it is to be used and turned several times during the summer to permit of its being thoroughly sunned and aired. After this treatment, a layer about two inches thick spread over the top of the plant bed is an excellent medium in which to grow the plants. Due to its dark colour it absorbs heat very rapidly and with its high humus content there is no danger of it becoming too tightly packed. If such a

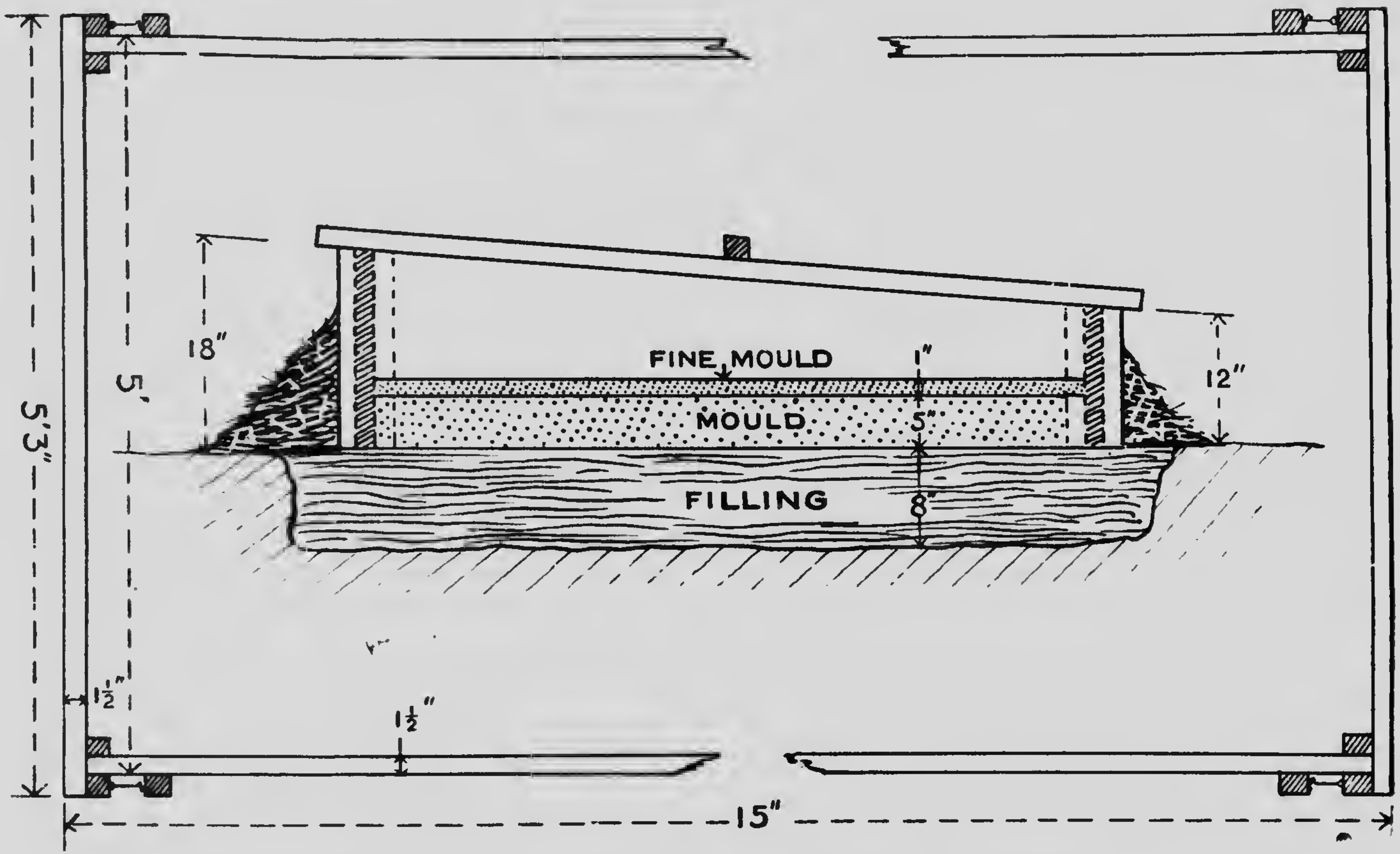

PLATE 1.—Graphic illustration of the construction of the semi-hot bed Frame assembled and in place.

soil is not available, a good substitute can be made by mixing grass sod and stable manure and turning the mixture, at intervals, until the whole mass has completely decayed.

Where efficient means of sterilizing the soil are employed the soil used in growing the seedlings should be changed every two or three years; however, if the soil is not sterilized it should be changed every year to prevent the bed becoming diseased.

Types of bed.—An ideal type of bed for producing early seedlings is one within a greenhouse. However, there are other types of bed which are almost as satisfactory for growing early seedlings and less expensive. The ordinary cold bed, in which the soil is merely well pulverized and covered with glass, is fairly satisfactory. A still more satisfactory type of bed, from the standpoint of earliness, is the glass-covered, semi-hot bed. This is made by first digging out a trench about eight inches deep and any width desired; the trench is then filled with straw or cornstalks to a depth of about six inches, after which about five inches of soil is placed on the straw or stalks and the whole well packed. The bed is then ready for sterilization, after which it may be seeded.

The results of three years' experiments have shown the glass-covered semi-hot bed to be vastly superior to the glass-covered cold bed for producing early plants; in every instance the semi-hot bed, which was steamed and seeded at the same time and with seed of the same variety of tobacco as the cold bed, produced plants ready for setting out four to five days earlier than the cold bed and in some instances eight days earlier. Even when covered with canvas, the semi-hot bed is superior to the canvas-covered cold bed, other conditions being the same.

The advantage of the semi-hot bed lies in its ability to retain its heat longer: the layer of straw breaks the conduction of heat from the top of the bed to the lower layers of soil and, as a result, the temperature of the semi-hot bed is lowered much more slowly than that of the cold bed and generally remains one or two degrees higher over night than that of the latter.

Sterilizing the Seed Bed.—After the bed has been made it should be thoroughly sterilized before seeding. The prevalence of diseases of tobacco, such as root rot (*Thielaria Basicola*) and bed rot or damping off of the plants, necessitate this treatment. Sterilization has been found to be the most effective means of controlling these diseases in the bed; the operation may be performed in a number of ways; namely, by burning the soil, by steaming the soil, or by treating the soil with chemicals. Of these methods, the first two are most satisfactory, as not only are the disease germs killed by burning or steaming but the weed seeds as well; while with the chemical treatment very few, if any, weed seeds are killed and beds so treated must be weeded several times before the seedlings are large enough for transplanting. Often the beds can be steamed for what it costs to weed them once.

If the bed is to be sterilized by burning, it should be burnt in sections; each section having a hot fire burning on it for about thirty minutes.

Under most conditions, sterilization by steam will be found most convenient. A galvanized iron pan 12 feet long, 6 feet wide, and 6 inches deep is inverted over the bed, the soil of which has been well loosened and pulverized, and after connecting the pan with a boiler the steam is turned on for thirty minutes. To be most effective the steam in the boiler should be under not less than 100 pounds pressure; for at the higher pressures the steam is drier and more penetrating. As long a time as possible [illegible] elapse after steaming before seeding, as the high temperature to which the [illegible] is raised during the steaming process renders conditions in the soil abnormal: and the young seedlings will not make a thrifty growth under such conditions.

Cold beds steamed in the fall, and well covered to prevent the wind blowing in weed seed and unsterilized soil, are just as satisfactory as spring-steamed cold beds. However, with semi-hot beds the results might not be quite so satisfactory, as they would have a tendency to settle too much during the winter and the layer of straw would lose some of its effectiveness as an insulating medium.

Not only is steaming a very effective means of controlling plant diseases but it has also proven effective as a means of hastening the development of the plants. In some cases the plants grown on steamed sections, of the same bed, were ready for transplanting from 5 days to 3 weeks earlier than plants grown on unsteamed sections; and the plants grown on the steamed sections were more robust and thrifty than those grown on the unsteamed sections of the bed.

Formalin is the most satisfactory chemical for sterilizing plant beds. The formalin treatment consists of sprinkling the beds with a solution of one part formalin to 50 parts water at the rate of ½ gallon of the solution per square foot of bed. This should be put on in two applications 24 hours apart. After each application the beds should be covered well to keep the fumes of the formalin in. About 24 hours after the second application the beds should be uncovered, and as soon as they are sufficiently dry the soil should be loosened up again to permit the fumes of the formalin to escape. The beds should not be seeded for several days after this treatment or until after the fumes of the formalin have disappeared.

Two serious objections to the formalin treatment are its failure to kill weeds and the waterlogged condition in which it leaves the soil.

The frames should be placed around the bed immediately after sterilizing. These should be at least 18 inches wide at the back and 12 inches wide at the front, and be so placed that the lower side faces the south. Good, tight frames which will prevent the access of cold air are very important in helping to force the plants.

Seeding.—For early plants, the beds should be seeded about the 10th of April with well-cleaned, home-grown seed.

Most growers seed their plant beds too heavily instead of too lightly; and while it is desirable to strike the happy medium in this operation, the thinly seeded bed is to be preferred to one which has been too heavily seeded. It is in the thickly seeded beds, due to the crowded conditions, that the most trouble from the damping-off fungus and other plant bed diseases is experienced; and the plants from such beds are generally too long and spindling to stand the shock of transplanting well. The greatest objection to thinly seeded beds is that the plants grown thereon are too short and stocky to be handled to the best advantage with the transplanting machine. With seed which has been well cleaned and which gives a germination test of about 80 per cent. one-seventh of an ounce (a slightly heaping teaspoonful) to each 100 square feet of bed will be found satisfactory. For seed giving a higher or lower germination test the amount sown should be regulated accordingly.

Sifted wood ashes is about the most satisfactory medium to use in sowing the dry tobacco seed. The use of corn meal or similar materials for this purpose is objectionable on account of the moulds which afterwards frequently appear on the bed and which grow on these materials.

Sprouting the seed.—Under some conditions a few days may sometimes be gained by sprouting the seed before it is sown. If this is done, the seed should be soaked only until the seed coat bursts and the tiny white sprout appears. Then it should be sown immediately. Soaking the seed until long sprouts appear is very objectionable. A large number of seed are killed in this way and it is difficult to obtain straight seedlings; and a crooked plant is a source of trouble all through the season.

Two serious objections to sprouting the seed are the difficulty of sowing such seed uniformly over the bed and the danger of killing a large percentage of the germs.

After the bed has been seeded it should be well firmed and sprinkled with water.

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

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

CARE OF THE SEEDLINGS.

Watering.—The beds should always be kept nicely moist after being seeded, unless the damping-off fungus appears. When the seeds are sprouting they are very easily killed by drying, and often on sunny days it will be necessary to water the bed two or three times. To permit the bed to become very dry at any time before the seedlings have covered it with their leaves is exceedingly dangerous. The beds should never be flooded but should be watered with a finely spraying nozzle. Too much water tends to give the plants an unthrifty appearance and makes conditions more favourable for the development of diseases. It is beneficial to have the chill removed from the water in sprinkling the beds.

Sprinkling the glass lightly with whitewash will serve to diffuse the sun's rays and aid in preventing the beds drying out too rapidly when the plants are very small. After the plants have covered the bed this whitewash should be removed, as the shading will have a tendency to make them too tender.

Ventilation.—A change of air is absolutely necessary for the proper development of the plants and as a means of holding diseases in check; therefore, the beds should be ventilated slightly every sunny day, and if the fair days come at too long intervals they should be ventilated a short while about noon on cloudy days. The amount of ventilation should be increased as the plants increase in size and as the weather gets warmer. However, since the temperature most suitable for the development of the plants is from 80 to 90 degrees F., except during the period of germination when it should be kept as close to 80 degrees as possible, the ventilation should be so regulated as to avoid lowering the temperature of the beds much below this for any length of time. On very close, hot days, if there is an insufficiency of ventilation there is danger of all the plants being killed by scalding.

Forcing the plants.—If the young plants have an unthrifty, pale-yellow appearance, or if it is desired to hasten their growth, they may be sprinkled with a solution of nitrate of soda, in the proportion of 2½ pounds of nitrate of soda to 47 gallons of water at the rate of one gallon per eighteen square feet of bed, with good results. However, nitrate of soda should not be used too freely or growth will be forced too rapidly, resulting in weak, spindling, watery plants which will not stand the shock of transplanting well. Generally, when the soil of the bed is fairly fertile, two or three applications at intervals of three days are sufficient. Care must be taken to sprinkle the plants with pure water immediately after applying the nitrate of soda or the sun will cause the latter to burn the plants seriously.

On fairly fertile soil no other fertilizer than the nitrate of soda is required: the potash and phosphoric acid in fertilizers are generally too slow in their action to benefit the plants appreciably.

Keeping the beds well watered is also helpful in forcing the plants.

Hardening.—About a week before transplanting, the seedlings should be hardened off to enable them to stand transplanting satisfactorily. This is accomplished by diminishing the amount of water applied and letting the beds dry out somewhat, removing the glass or canvas during the day, and even leaving it off over night if there is no danger of frost. Care must be exercised not to harden the plants too much or they will become too woody to start rapid growth in the field.

The plant bed should be well watered both before and after drawing the plants.

PREPARATION OF THE SOIL.

Practically no crop gives larger returns for labour expended in properly preparing the seed bed than does tobacco. The land for tobacco should be ploughed as early in the spring as possible and then worked up with the disc and harrows into a finely pulverized condition. After this, the soil should be harrowed after rains in order to keep the weeds in check, and to prevent excessive loss of moisture by evaporation. When the field has been put into the desired condition, the rows should be laid off and the fertilizer drilled in the row. The fertilizer should be well mixed with the soil before transplanting. The root system of tobacco being comparatively small, better results are usually obtained in hastening the growth and maturity of the crop by drilling the fertilizer than by sowing it broadcast.

In low-lying fields it is often advantageous to throw up a light ridge just over the fertilizer. The tobacco is then set on that ridge and in times of heavy rainfall there is not so much danger of the plant drowning, or of having mud washed over the heart or bud of the plant.

ROTATION.

On account of plant diseases and insect enemies peculiar to tobacco and the fact that, in any system of farming, it is necessary to grow a succession of different crops in order to maintain the fertility and humic content of the soil and thereby secure the maximum yield with every crop, a good system of crop rotation should be followed by every tobacco grower. As a rule, the quality of the tobacco produced will depend almost as much on the rotation followed between the successive crops of tobacco as upon the fertilizer used and the cultivation given directly to the tobacco.

On the heavier types of soil such as are found on the Harrow Tobacco Station, a four-year rotation of corn, tobacco, some cereal, and grass has been found quite satisfactory. The corn preceding the tobacco tends to remove any surplus of ammonia (nitrogen) in the soil and thereby check the tendency of the tobacco to become too coarse and heavy. Since, on these soils, the use of clover has been found to have an adverse effect upon the quality of the tobacco a mixture of timothy and red top is seeded for hay.

On the lighter types of soil, on the Station, where the tendency is to produce a thin leaf lacking in body and weight, it is found that the above rotation should be altered in such a way that the tobacco does not immediately follow the corn, in order to obtain a leaf of better body and a larger yield.

FERTILIZING THE CROP.

No crop produced on the Harrow Tobacco Station gives larger returns, per dollar spent for the judicious use of commercial fertilizers, than does tobacco. The results of three years' experiments have always shown an increase in yield and often an improvement in quality of the leaf when fertilizers were used; and the net profit has ranged from three to four dollars for every dollar spent in fertilizer.

Due to the adverse effect of slowly available plant foods on the colour and quality of flue-cured tobacco, a commercial fertilizer containing readily available plant foods is especially adapted to, and valuable in, the production of this type of tobacco.

On most soils of the above-mentioned Station, a complete fertilizer—that is one containing nitrogen (commonly spoken of as ammonia), phosphoric acid, and potash—is needed; and, as none of these materials can substitute for another, a maximum yield cannot be obtained unless all three are present in a sufficient quantity. Moreover, since these materials not only affect the yield of tobacco but the quality as well, it is not only important to have them present in a sufficient quantity but also in the proper proportion.

On the Station, an excess of ammonia has been found to give a coarse, dark, late-maturing tobacco with a tendency to become flecked with reddish, dead spots in hot, dry seasons; while a deficiency of ammonia results in a thin, small, light weight leaf.

No decidedly adverse effects have been observed, on the Station, from excessive applications of phosphoric acid or potash; and since practically none of those materials is lost by leaching and we have found that an excess of ammonia may be overcome to a great extent by a comparatively heavy application of phosphoric acid, which material tends to increase the growth, hasten maturity, and brighten the colour of the leaf, it would seem advisable on such soils always to have an excess of phosphoric acid.

We have found, at Harrow, that the form in which the different materials are supplied has a most important bearing on the quality of the leaf. Potash should be applied only in the form of sulphate of potash, as other forms of potash generally contain chlorine, which element tends to cause the production of a chaffy leaf of poor burning quality. The ammonia should be derived from some quickly available source, such as sulphate of ammonia, nitrate of soda, or dried blood (preferably the first two). If supplied by some material such as cotton seed meal, which gives up its ammonia very slowly, the tendency is to prolong the growth of the tobacco and thereby prevent it maturing early and ripening up yellow in the field.

In determining the right quantity of each of these materials to use no fixed rule can be applied; as the fertility of the soil and the effect of previous crops on the soil must be taken into consideration. The results of experiments, on the Station, indicate that an ideal fertilizer for the growth of flue-cured tobacco would be one in which the ammonia is pr ent in such form and quantity that it would cause the tobacco to make a rapid maximum growth and would become practically exhausted when this growth had been attained, thereby giving the tobacco a better chance to ripen up yellow and uniformly.

The results of three years' experiments on the Harrow Tobacco Station, where the soil is representative of the heavier types used for the production of flue-cured tobacco, have shown that while potash is the limiting factor, on that soil, in growing tobacco, in most cases a complete fertilizer is needed to secure the maximum yield and the best quality. That is, the soil is more deficient in potash than in either of the other two materials. In some of these experiments tobacco stem ashes (in a quantity sufficient to give the equivalent of potash derived from the sulphate of potash) were used and the results indicated that the ashes were as good as sulphate of potash in producing tobacco; at least, so far as the yield was concerned. The stems might be used without burning and some ammonia as well as potash derived from them. In the latter case, the ammonia furnished by the stems should be taken into consideration in fertilizing.

These results also indicate that for both yield and quality, on the heavier soils, the following mixture is best:—

Sulphate of ammonia	140 lb. per acre.
Acid phosphate	500 " "
Sulphate of pot. sh	200 " "

This gives a total of 840 pounds of fertilizer per acre. However, the plant food contained in that 840 pounds is approximately equivalent to the plant food derived from 1,100 pounds of a ready mixed fertilizer with an analysis of 3 per cent ammonia, 8 per cent phosphoric acid and 9 per cent potash.

LIMING SOILS FOR FLUE-CURED TOBACCO.

Practically all soils contain enough lime for the direct requirements of tobacco; and if used at all, the value of the lime will depend upon its action as an indirect fertilizer.

On many soils an application of lime will result in an increased yield; however, in many cases the quality of the tobacco will be impaired. On fairly fertile soils, with a good ply of humus, the use of lime generally results in the production of a coarser, hea. odied leaf which does not cure with the most satisfactory results. This is due to the effect of the lime in causing a more rapid decay of the vegetable matter in the soil, thereby resulting in an increased food supply, which may be largely ammonia and which has the same effect on the quality of the tobacco as an excessive application of ammonia in the fertilizer would have.

On very poor soils lime may cause both an increased yield and better quality due to the liberation of needed plant food.

With soils on which the root rot is troublesome the use of lime would probably be distinctly injurious. Investigators report that an acid soil is best as a hindrance to the spread of that disease; and by liming that acidity would be corrected and conditions made more favourable for its spread.

As a rule, it would be best to apply the lime to some other crop in the rotation coming after the tobacco, and two or three years before the field is to be put into tobacco again.

About 500 pounds of air-slaked lime or 1,000 pounds of high-grade limestone per acre should be sufficient. This should not be applied more frequently than every four or five years.

TRANSPLANTING.

Transplanting should be begun as soon as all danger of frost is over, during the latter part of May, if at all favourable. As a rule the earlier the transplanting the earlier the crop will ripen and the better the conditions will be for curing.

Selecting the plants.—A careful selection should be made when drawing the plants; only the thriftiest, most robust plants, which show no signs of being diseased, should be used. It is also very desirable to have the plants straight and of a uniform size, and to have a good lot of roots remain on the plant; however, too much of the plant bed soil should not be allowed to remain on the roots. The presence of this soil in large quantities tends to retard the sending out of the new rootlets by the plant; consequently it does not start off to growing as quickly in the field and becomes more susceptible to the root rot.

Transplanting.—In transplanting, the plants should be set so deeply in the ground that only the bud and leaves remain above the surface. When much of the stalk is left exposed it generally becomes hard and woody very quickly, especially in dry seasons, the development of the plant is seriously checked and it seldom attains its full growth under those conditions.

Spacing the plants.—On fertile soil, the tendency to produce tobacco which is too heavy in body can be rectified somewhat by setting the plants close together in the row. On such soil the rows should be about three feet apart and the plants should be set about 20 inches apart in the row. On a lighter soil, where the tendency is to produce tobacco which is lacking in body, it would probably be more satisfactory to have the rows 3½ feet apart and the plants about 28 inches apart in the row.

A good uniform stand is also of importance in procuring a fine, smooth, nicely ripened crop. Where some of the plants are missing, the surrounding plants will be overfed and rendered coarse and overgrown; and on that account will neither ripen, yellow, nor cure satisfactorily.

About four or five days after transplanting the field should be gone over and reset with the best plants available.

CULTIVATION.

The first cultivation should be given as soon as the tobacco has taken root, usually from eight to ten days after transplanting, care being taken not to disturb the newly established roots. This cultivation should be fairly deep and each succeeding one more and more shallow until towards the last only the crust is being broken.

A good hoeing by hand, especially at the time of the first cultivation, is very helpful in starting the plants to grow. The soil can be loosened more thoroughly close to the plants without danger of disturbing them too much with the hoe than with the horse-drawn cultivator.

The tobacco should be cultivated as soon as possible after every rain in order to conserve the moisture, and the field should be kept as nearly level as possible for the same reason. Cultivation should be stopped after topping, as to cultivate after this operation has a tendency to keep the tobacco growing and it does not ripen up as it should.

INSECT PESTS.

The most common and troublesome insects which the Canadian tobacco grower has to combat are the wireworm, cutworm, tobacco hornworm, and grasshopper.

Wireworms.—The wireworm usually attacks the plant soon after it has been transplanted; generally starting near the roots, it bores its way into the plant and upward through the heart. Since the plants attacked do not die for some time, and, if the weather is cloudy and cool, do not even wilt, this insect is especially troublesome in securing a good stand of tobacco. The field may be reset several times, under such conditions, without any indications of damage.

The most effective means of controlling this insect consists of rotating the crops in such a manner that tobacco follows some crop, such as oats, which the insect does not use as a place to harbour; and fall ploughing followed by spring cultivation to keep down the grass and weeds and thereby starve it out before the tobacco is transplanted.

Cutworms.—The cutworm is also a serious drawback in obtaining a good stand of tobacco. This insect cuts the plants off near the surface of the ground and frequently necessitates several replantings of the crop.

The cutworm may be largely controlled either by preventive measures or by the use of poisoned baits. Fall ploughing after the 20th of September, about which date the moth stops laying its eggs, is very effective as a control measure. The use of a mixture consisting of 1 pound of Paris green, 50 pounds of bran, and one gallon of molasses is also beneficial. The bran and Paris green should be mixed while dry, then the molasses, and enough water is added to form a paste. This should be sown over the field broadcast several days before planting, care being taken first to go over the field and kill or cover up all weeds and grasses. Cloudy days are especially adapted to the use of this mixture as it does not dry out so rapidly and lose its attractiveness so soon on such days. If this mixture is applied after transplanting it is not so effective and frequently the tobacco plants are killed by coming into contact with the Paris green. The quantity of mixture given above is sufficient for one acre. Spraying the plants with a solution of arsenate of lead, at the rate of 1½ ounces of dry, powdered arsenate of lead per gallon of water, long enough before setting to allow the plants to dry, is also beneficial.

Fighting the hornworm.—Spraying the tobacco with arsenate of lead, as soon as the worms appear in appreciable numbers, is about the safest and most effective method of combatting the tobacco hornworm. Paris green is also good for this purpose; however, there is more danger of burning the tobacco with the Paris green; and too, if the tobacco is sprayed too frequently with the latter, there is a tendency for the leaf tissue to be killed just at the point where the leaf joins the stalk, and as a result the leaves break off much more easily at the time of harvest. The Paris green also washes off more readily and therefore loses its effectiveness more quickly than does the arsenate of lead.

Arsenate of lead may be applied either as a dry powder or in solution. It has been found that until the tobacco is about half grown, a solution consisting of 6 pounds of dry, powdered arsenate of lead per 100 gallons of water is most effective. The solution apparently covers the plant more completely and adheres to it longer than does the powder. After the tobacco becomes too large to get through it with the spray cart, the dust gun may be resorted to. For use in the dust gun, the dry, powdered arsenate of lead should be mixed with equal parts of dry, sifted wood ashes, or if they are not obtainable the next best carrier is dry, air-slaked lime. The powder should be applied early in the morning while the dew is on and when there is no wind blowing, at the rate of five pounds of the arsenate of lead per acre on large tobacco or three and one-half pounds per acre on small tobacco.

In purchasing the arsenate of lead, the buyer should demand the form having at least 30 per cent arsenic oxide; other forms with a smaller arsenic oxide content are too slow in their action to give the best results. It is also important that the powder does not have more than 1 per cent of the arsenic oxide in a free or water-soluble state, as a higher percentage of water-soluble arsenic oxide may cause the spray to burn the tobacco.

If the paste form is used, the amounts previously mentioned should be doubled, as this form contains only one-half the strength of the powder.

Grasshoppers.—Some years, grasshoppers are a source of considerable loss to the grower. These pests fly from one plant to another, eating small holes in the leaves, and in a short while cause the whole field of tobacco to have a very ragged appearance. Very little can be done towards combatting the grasshoppers after they reach the winged stage. Scattering the poisoned bran mixture previously recommended for cutworms, to which the juice of six oranges or lemons has been added, around the edges of the field while they are still in the hopping stage will be found very helpful. Where possible, it is also beneficial to plant several rows of corn around the tobacco field. These pests pass the winter in old fence rows, meadow lands, and weedy fields, and fall ploughing of such lands will serve to decrease their numbers appreciably.

DISEASES OF TOBACCO.

Tobacco root rot.—The tobacco root rot, caused by the fungus *Thielaria basicola* (B. & Br.) (Zopf.), is one of the most common diseases of tobacco in Canada. This disease causes the growers thousands of dollars in losses annually, due to decreased yields, inferior quality, and, in some cases, total failure of the crop.

This fungus attacks the entire root system, especially the young fibrous roots of the plant, causing them to decay; whereupon these roots cease to function as food carriers and, as a result, the plant is starved. The degree of starvation depends upon the extent to which the plant and field are infected, the climatic conditions, prevailing at the time of transplanting, and the robustness of the plant. Some plants may die; however, with the majority, the roots apparently function just long enough before becoming diseased to keep the plant living but not long enough to enable it to make any growth. The diseased plants generally remain small until late in the season when they may begin to grow; however, such plants never attain the size which a normal plant does and usually must be harvested green.

This disease attacks the plant in both the field and the plant bed. In the plant bed, the plant usually has a yellow, unthrifty appearance and its growth is comparatively slow; however, this is not always the case. Often, upon examination, plants which have a good colour and are making satisfactory growth in the bed, will be found to be infected. In the field the plants show the same unthrifty appearance and lack of growth and often the field will have a checkered appearance, there being several small plants followed by large, healthy plants. This condition may prevail throughout the field. In either case, upon carefully pulling up the plant and examining the fine roots, it will be seen that they have turned black and are rotten.

After the plant has become infected no amount of cultivation or fertilizing appears to be of value in starting it to grow; however, if healthy, robust plants are transplanted in slightly diseased fields, which have been thoroughly prepared, and climatic conditions are favourable to quick growth, the plants are apparently capable of resisting the disease and making a normal growth. On the other hand, a continued wet spell or anything which tends to weaken or check the growth of the plant apparently lessens its resistance to the disease and the degree of infection is increased.

In controlling the disease it is necessary to produce absolutely healthy plants and transplant them to undiseased fields. The plant beds must be thoroughly sterilized before seeding, and the same soil should not be used too long for growing plants. No plants should be transplanted from a diseased bed, as the use of diseased plants will serve to spread the disease over the entire field very quickly. If the fields become diseased a good 4 or 5-year rotation should be practised. Since many legumes, especially red clover and alfalfa, are host plants of the *Thielaria basicola* they should be left out of the rotation.

Bed rot or Damping-off fungi.—The rotting or damping-off of the young seedlings in the plant bed is caused by fungi which spread very rapidly. The plants attacked by his disease usually begin to rot near the surface of the ground, though the infection may spread on up the stalk and even the leaves may become decayed. Infected plants generally bend over, wilt, and die; though some may recover, giving evidence of the attack by a brownish, deadened area on the stalk near the root. Such plants should be discarded as they seldom prove satisfactory if transplanted. This disease is most prevalent in thickly seeded beds which are very *moist* and *lack ventilation.*

Sterilization of the bed and seeding thinly are the most effective methods for preventing the disease. After it occurs it may sometimes be checked by throwing out tho infected plants, lowering the temperature by ventilating the bed well, and allowing the bed to dry out for a while. In warm, rainy weather it is very difficult to check it and at all times the best method of control is preventive.

GROWING TOBACCO SEED.

That the tobacco plant is one of the most susceptible of all plants to changes in the soil and climatic conditions has been conclusively proven by experiments and in actual field practice. Varieties which were practically ideal for the production of a certain type of leaf in one section of the country have, upon being taken to another section, where the soil and climatic conditions were different, become so changed in their characteristics such as length, breadth, and thickness of leaf, elasticity, yield, and quality, as to be practically worthless for the production of that same type of leaf. Even when this was not the result is has been clearly demonstrated by experiments that good home-grown seed germinates more quickly and produces plants ready for transplanting earlier than foreign-grown seed; and, in the field, plants produced from home-grown seed ripen more uniformly and from four to seven days earlier than those grown from unacclimated seed. Moreover, the individual characteristics of the tobacco plant are, to a large extent, inherited from the parent and may be improved or allowed to deteriorate, depending upon the care and judgment exercised in selecting the seed plants. The old theory that tobacco seed runs out or deteriorates has been disproved when careful selection is practised.

In view of these facts, and the history of the development of valuable types of tobacco by seed selection, the importance of each grower producing his own tobacco seed is clearly seen.

Selecting the seed plants.—In selecting seed plants, the grower should go over the whole field several days before topping and, with a fixed idea as to the type of plant best suited to his soil and climate and most desirable for his market, select about twice as many plants as he requires; marking them so they will not be topped. In making this selection, he should take into consideration the general character of growth of the plant, the number, shape, size, and uniformity of the leaves, the length of the internode or distance between the leaves on the stalk, the time and uniformity of ripening.

height of the plant, number of suckers produced, the colour of the leaves at the time of ripening, and, if possible, the colour of the cured leaves. Plants with long internodes or large coarse veins are undesirable. After the preliminary selection the field should be gone over at least twice more and any plants developing undesirable characteristics discarded.

Care of the seed plants.—Tobacco is naturally a self-fertilized plant and ordinarily does not cross. However, bees and other insects flying from flower to flower will carry the pollen from one plant to another; and if a poor plant or a plant of another variety should bloom out near the selected plants, there is danger of them being crossed and the benefit of the selection lost unless the seed head is protected in some way. Just before the first flowers open, each seed head should be trimmed up until only the five top branches remain; this insures the grower obtaining the seed from the earliest flowers which form, and the plant food which would be distributed over the whole seed head, were it left untrimmed, is reserved for the development of the earlier pods, which results in plumper seed of greater vitality. The seed head should then be covered with a fourteen-pound manila bag the mouth of which is tied loosely around the stalk just below the lowest remaining branches. About every ten days these bags should be removed and all suckers, late pods, and fallen blossoms taken out and the bags raised a little. When the seed pods have all formed and begin to turn brown, the bags should be removed and the seed heads allowed to ripen in the open. This causes the seed to ripen earlier and give a higher germination test.

After the greater portion of the seed pods turn brown and before frost, they should be harvested and hung up in a dry place for about two months to finish ripening and to cure. After this they may be hulled.

It usually requires from twenty-five to thirty seed heads trimmed up as previously described to produce a pound of cleaned seed.

Usually about ten leaves should be left on a seed plant.

CLEANING TOBACCO SEED.

The weight or specific gravity of dry seed is a clear indication of the amount of plant food contained in that seed for the nourishment of the young seedling while it is becoming established and developing the root system necessary for its future growth. This has been clearly demonstrated in experiments with light and heavy seed, in which it was conclusively shown that larger yields and more uniform crops of better quality were obtained from large, plump seed than from small, light seed.

While the general farmer has not been slow in recognizing the value of good heavy seed in producing his crops, using various methods of separating out the heaviest seed before planting, the tobacco grower, as a rule, has overlooked the importance of this point. And in tobacco growing, when we take into consideration the short growing season, the comparatively few plants on an acre, and the relative value per acre as compared to other crops, it is readily seen that plump, heavy seed for the production of strong, vigorous seedlings is really more important than in producing practically any other crop.

It has been found that the heaviest seeds do not always germinate first, neither do the plants from those seeds always attain the proper size for transplanting first; however, the seedlings from the heaviest seeds are always more robust and vigorous than those produced from light seeds, and, when transplanted, the most vigorous plants produce the heaviest yields and the most uniform crops.

It is practically impossible, in selecting plants at the bed, to discard all of the weak seedlings produced from small, light seed; therefore, this selection must be done by cleaning the seed before it is sown. Furthermore, the average germination percentage of uncleaned seed is about fifty while well cleaned seed should give a germination percentage of about ninety; so with cleaned seed a smaller bulk of seed is handled at the time of sowing and, as a rule, a uniform stand is more easily obtained.

After the seed has been cleaned it should be stored in a dry place, in a container into which the air can penetrate. Stored under such conditions it may be kept satisfactorily for about ten years.

TOPPING AND SUCKERING.

The natural tendency of every plant is to reproduce itself. In the tobacco plant this is demonstrated by its effort to flower out, and, after being topped, to send out suckers from the axil or junction of the leaf with the stalk, which will also flower out and form seed if the growing season is long enough.

Topping.—Usually, in seasons of normal growth, the plant will begin to show signs of flowering out about 8 to 9 weeks after transplanting. It must then be topped or the quality of the leaves will be impaired; leaving the bud until it has fully developed and begins to flower out is an unnecessary waste of plant food and also retards maturity. In topping, the grower must exercise careful judgment, taking into consideration the capabilities of the individual plant, the fertility of the soil, and the character of the season. His aim should be to leave only as many leaves as the plant can bring to their fullest development, and as far as possible to insure all plants maturing at the same time. In order to get the whole field to ripen uniformly it is usually necessary to go over the field twice, at different dates, in performing this operation. This is necessitated by replants and undersized plants which should be topped later and about two leaves lower than the earlier, more vigorous plants. Topping too low results in an unnecessary loss in yield and has a tendency to make the tobacco rough and coarse; while topping too high does not increase the yield, and gives a smaller, lighter-bodied leaf which will most likely be slow to mature. High topping may sometimes be resorted to, with beneficial results, on land which is too fertile and which produces a coarse, heavy-bodied leaf. As a rule, tobacco should be topped low in dry seasons, on poor land, and in districts with a short growing season. On fertile soils and in wet seasons it is best to top higher. Usually, on poor land, from eight to ten leaves, exclusive of three or four undeveloped leaves at the bottom, should be left; and on fertile soil from twelve to fourteen leaves.

Care should be exercised in topping not to damage the top leaves of the plant; when injured at this time they seldom develop satisfactorily.

Suckering.—Soon after topping, the plant will begin to send out suckers. These should be broken off as soon as they attain a length of about four inches. To leave them longer results in a waste of plant food which should go to the development of the plant, and if left too long they get woody, are harder to break out, and may cause more leaves to be broken from the plant during harvesting operations by weakening the attachment of the leaf to the stalk. Sometimes, when the plant has begun to ripen and a rainy season sets in, they may be left for a while longer with beneficial results, as they aid in preventing the plant starting a second growth.

HARVESTING.

Maturity.—Usually, about ninety-five to one hundred days after transplanting or about thirty or forty days after topping, the tobacco is ready for harvesting. When ripe the leaves generally become a greenish-yellow colour or become flecked with yellow spots: they are said to grain up, changing from the smooth, velvety feel of a green plant to a rougher, pebbly character, and on being folded between the thumb and forefinger break along a clear cut line with a distinct crackling sound. The plant ripens from the bottom leaves upward; and, as the top leaves are practically always greener than

PLATE IV.—Special wagon for hauling crop to shed. A strong horse can draw 75 loaded laths (about 500 plants).

the middle and bottom leaves, the ripeness of the plant as a whole must be taken into consideration when harvesting. To allow tobacco to become over-ripe before harvesting makes the leaves more brittle both at the time of harvesting and after being cured, tends to reduce the yield, and often results in an increased percentage of red leaf after curing.

Methods of harvest.—Of the various methods followed in harvesting tobacco the split stalk method has proven to be the best; both from the standpoint of economy of labour and the final colour of the cured leaf. In following this method the procedure is as follows: Several days before harvesting the tobacco laths are distributed along every fourth row in the fields; then when the tobacco is ripe it is harvested by splitting the stalk from the top of the plant to within about two inches of the ground; the plant is then cut off close to the ground and allowed to lie where it falls until sufficiently wilted to handle without breaking. After it has wilted sufficiently each harvester walks between two rows placing the plants on the lath by merely slipping the lath in between the split halves of the plant. The tobacco is then ready to be put in the curing barn.

By splitting the stalk the surface offered for the evaporation of moisture is greatly increased; and since the colour of the cured leaf depends upon the rapidity with which the moisture can be expelled, at certain times in the curing process, it is easily seen that this is an important factor in securing a satisfactory cure and in shortening the curing process. When the stalks are split there is also less danger of swelled stems.

After the tobacco has been placed on the lath it should be immediately hauled to the barn. If exposed to the sun and air too long the vitality of the leaf cells is greatly diminished and, as yellowing takes place while the tobacco is living, the tobacco will not yellow so well. On hot, sunny days there is also danger of the leaves being scalded by the heat, after which the scalded portions will always remain a dark-green, ugly colour.

Hanging in the barn.—The sticks of tobacco should be hung about eight inches apart on the tier poles, or far enough apart to prevent the tobacco touching that on the next stick. It is usually a good plan to regulate the distances between plants on the same stick after hanging, as there is a tendency for the plants to run together on the stick and they will not cure satisfactorily if crowded too much.

THE CURING BARN.

A properly constructed curing barn is a very important consideration in curing the tobacco. Since at certain times, in curing the tobacco, a close barn is desired and at all times a uniform temperature is necessary, the barn should be tightly built; moreover, it should be well provided with vents both at the bottom, near the ground, and at the top to permit of the escape of the enormous amount of moisture given off at certain times in the curing process. A barn 20 feet wide, on the gable end side, by 18 feet 11 inches long, inside measurements, and 21 feet to the eaves is a very satisfactory size. This gives five rooms or sets of tier poles to hang tobacco on. The tier poles should run lengthwise of the barn or parallel to the widest side and should be 3 feet 8 inches apart horizontally, from centre to centre, 3 feet 3 inches apart vertically, and the bottom or lowest tier pole should be at least 8 feet above the flues. Such a barn should have two furnaces for heating it, from each of which a line of 12-inch galvanized pipe should extend along each side of the barn to within about a foot of the side opposite the furnace and then return through the centre of the barn. For firing with wood, these furnaces should be about 2 feet high by 2 feet wide, inside measurement, and about 7 feet long. The furnaces should not extend too far into the barn or too much heating surface will be lost. Usually about 4 feet is far enough for

PLATE V.—Interior view of an underground system of ventilation designed by S. McKenna. This system is especially valuable in curing heavy bodied tobacco. The cold air enters the tile at *A* (Plate 5) coming up into the barn at *B* directly under the flue and is heated before coming in contact with the tobacco. Each tile shown in Plate 5 leads to a different opening in the floor, and, as there are eight of these lines of tile on each of the two sides of the barn, there are sixteen of the openings shown in Plate 6 in the floor of the barn.

PLATE VI.—An exterior view of the kiln.

Note the small tile in the wall at *C*, which is an additional means of ventilation, but insufficient when not supplemented with other ventilators.

the furnace to extend into the barn. For firing with gas the furnaces need not be so large. The foundation should be of concrete and should extend about 4 feet above the surface of the ground on all sides. In these walls it is well to place about three 4-inch tile on each side near the ground in such a manner that they will protrude through the walls and serve as a means of ventilation. Small doors should be cut in the gable ends near the top which can be opened for the purpose of ventilating; and a portion of the peak of the roof should also be so constructed that it can be raised or opened for the same purpose.

PLATE VII.—Exterior view of curing barn, showing fire-places and top ventilation.

CURING.

The most successful curer keeps constantly in mind, all through the growing season, the type of leaf which he wishes to produce and the factors which will influence the colour of the leaf when cured. He transplants, cultivates, and tops with due consideration for the soil and climatic conditions and with the fixed idea of producing a smooth leaf, not too coarse and heavy in body, and one which will yellow up nicely in the field just before ripening time. Such a leaf is about the ideal type for the best results, and unless the tobacco is grown properly in the field it cannot be cured satisfactorily. Then at harvesting time he carefully selects plants of the same colour, body, and degree of ripeness to fill his kiln. Plants which differ, to any great extent, in these characteristics will not yellow up together and as a result the temperature must be run either too slow or too fast, for a portion of the tobacco, and a uniform colour cannot be obtained. It is also essential that the kiln be filled with tobacco, all of which has been cut the same day.

General principle.—The fundamental principle underlying the successful curing of flue-cured tobacco is the proper regulation of the humidity of the air in the barn. In the humidity we find an expression of the water-holding capacity of the air, and therefore its drying capacity. The humidity is regulated by the temperature of the barn, hence the use of artificial heat, and by the ventilation. By raising the temperature the water-holding capacity of the air is increased, consequently its capacity for drying is increased; and as, in time, the air in the barn will become nearly saturated with moisture, its capacity for holding water or drying becoming greatly reduced, it is necessary to replace the saturated air with air of greater water-holding capacity, by ventilation. Hence, in the first stages of the curing process, when the curing or drying must proceed slowly, a high relative humidity or nearly saturated atmosphere, a low temperature, and very little, if any, ventilation is desired. But as the curing advances the relative humidity of the air in the barn must be lowered, by increasing the temperature and ventilation, in order to increase its drying capacity. Experiments indicate that, with light-bodied tobacco, the relative humidity of the barn should be approximately as follows:—

About 80% to 85% when starting to cure.
" 70% when the bottom leaves begin to yellow.
" 68% " the middle leaves begin to yellow.
" 65% " the tip leaves begin to yellow.
" 42% " the leaves have all become about yellow enough to fix the colour.

With heavier bodied, very sappy tobacco, the relative humidity should be lowered faster after the leaves begin to yellow than with lighter bodied tobacco, or there will be danger of the leaf having too much moisture to take a drying heat without scalding when the yellowing process has been completed. The preceding figures are only approximate and are the results of only two years' experiments; hence they should not be taken too literally.

The relative humidity of the barn is determined by computation after finding the difference in the temperature of the barn as recorded by a hygrometer, or two thermometers, the bulb of one of which is covered with a piece of muslin cloth which is suspended in rainwater.

In controlling the rate of drying, the temperature in the barn bears a close relation to that of the outside air, and the correct difference between the temperature inside and outside of the barn is influenced by the humidity of the air outside. Therefore, in warm weather or in wet seasons the temperature in the barn must be higher than in cool or dry weather.

No fixed rule or set formula can be followed successfully in flue-curing tobacco. Different types of tobacco and different climatic conditions necessitate so many changes in the temperature and humidity of the barn that it is seldom that two barns are cured under exactly the same conditions and with the same changes in temperature. However, the same general principles hold good in all cases.

Yellowing.—The first stage in the curing process is called yellowing the tobacco. During the yellowing process the colour of the leaf changes from green to yellow and certain chemical changes also take place. These changes are life processes, occurring while the leaf cells are still alive but slowly dying from starvation and if the cells are killed by drying too rapidly or by being bruised before they occur, the tobacco cures out with too much green. On the other hand, if the yellowing process is too slow, that is, if the temperature and ventilation are not increased fast enough during the latter stages of the process, a pumpkin-yellow colour will result—the tobacco will be too sappy to take a curing heat without scalding—the leaves will become splotched with red, called sponging—and may all run totally red before the curing is completed. When the tobacco begins to sponge the only remedy is to give all the ventilation possible and raise the heat as fast as possible not to scald. The main idea in the yellowing process is to change all the tobacco to a nice, flesh-coloured, not a pumpkin-coloured, yellow and at the same time to dry the tobacco out sufficiently, by gradually increasing the temperature and the ventilation, to enable it to stand a quick curing heat when it becomes sufficiently yellow. Yellowing is generally done between the temperatures of 85° F. and 110° F. While the leaf may yellow a little at temperatures up to 120° F. it is rapidly killed after the temperature passes 110° F. and should be practically through yellowing before the latter temperature is passed. Usually a slow fire should be built immediately after the barn is filled and the temperature run up to about 85° F. in two or three hours after the fire is built, if the weather is fine and warm; if cool and windy do not go over 10° F. above the outside temperature at first. Hold the temperature at 85° F. for several hours, then gradually raise the temperature, at the rate of about 5 degrees an hour, to from 90° F. to 100° F. The rate at which the heat is raised will depend on the tobacco; if it is heavy and sappy the heat must be raised more slowly than if it were lighter in body or there will be danger of scalding it; however, if the tobacco is very light it will also be necessary to go very slowly in raising the heat or the tips may dry out before they are sufficiently yellow. A good plan here is to watch the tobacco just above the point where the flue enters the firebox, which is the point at which the heat strikes hardest, and if it shows signs of drying too fast or scalding, lower the heat. The tips will begin to dry and turn up when it is scalding. As a rule the more heat, up to 110° F., the tobacco will stand in yellowing the brighter it will cure. Hold the temperature at from 90 to 100° F. until the bottom leaves are yellow, then raise it gradually to 105° F.

Usually, it is best to begin to ventilate slightly after the bottom leaves become yellow unless the tobacco is very light in body. The idea is to try to dry the bottom leaves sufficiently to prevent them sponging while the other leaves are yellowing.

When the leaves in the body of the plant become a nice flesh-coloured yellow raise the heat gradually to 110° F., at the same time increasing the ventilation. Hold at 110 until all of the leaves are sufficiently yellow to fix the colour. Generally, it is best to begin to fix the colour while the leaves still have a greenish-yellow cast and there are traces of green around the veins. Curings handled this way generally give the clearest, brightest leaf.

Fixing the colour.—The next stage is called fixing the colour, and is the most critical of all the stages in the curing process. It is at this stage that the leaf gives off its moisture fastest and it is here that the most ventilation is needed. The idea here is to stop the yellowing of the leaf and to dry the leaf as quickly as possible without scalding. This is accomplished by gradually raising the temperature from 110 to 125° F. and increasing the ventilation. A good plan at this stage is to watch the tobacco at the hottest place in the barn (where the flue enters the firebox) and at the coolest place (in the corner just over the first elbow joint) and govern the increase in temperature according to which place the tobacco is doing best. If the tobacco has the proper temperature and sufficient ventilation it will feel silky when the tails of the leaves are allowed to slide over the back of the hand; however, if it feels sticky the heat should be held steady and the ventilation increased until it does feel silky. This procedure should be repeated until the heat has been raised to 120° F. If the tobacco should begin to sweat very profusedly during this stage the temperature had best be lowered a little and the ventilation increased until the sweating is considerably decreased.

Drying the leaf.—Hold the temperature at 120 until the leaves in the body of the plant begin to feel husky or dry, then gradually raise the heat to 125° F.; now watch the tobacco at the hottest and coolest places and, if it is doing all right at the hottest place, raise the heat at the rate of 5° every two hours until a temperature between 135 and 140° F. is reached. If the tobacco begins to scald at the hottest point the rate of increase must be slower. Hold the temperature between 135 and 140° F. until the leaf is thoroughly dry.

The ventilation may be gradually decreased after a temperature of 135° F. is reached until only a little ventilation is left at the top, after a temperature of 150° F. is reached.

Drying the stems and stalks.—After the leaf is dry raise the heat 10 degrees every hour for three hours and then raise it as fast as is desired until a temperature of 190° F. is reached. This is the last stage in the curing process and is called drying the stems and stalks. The heat may be run up to 200 or 225° F. in drying the stalks; however, this is dangerous and unnecessary and raising the heat above 190° F. reddens the face of the leaf. The heat must be held at 190° F. until all the moisture has been dried out of the stems and stalks. If any moisture is left in the stems and stalks the tobacco will run red when bulked down and may even mould and rot.

The best places to look for moisture or swelled stems are just over the firebox, and in the corner just over the first elbow joint.

It generally requires from 36 to 56 hours to yellow; from 12 to 18 hours to fix the colour; and from 40 to 58 hours to dry the stalks.

With tobacco which is extremely light in body it sometimes happens that the tip leaves begin to dry at a temperature of about 90° F., before the tobacco is yellow enough to fix the colour. This is due to a lack of moisture in the barn and may be remedied by wetting the floor of the barn well. However, it is not advisable to use water very freely after the middle leaves become sufficiently yellow to fix the colour, as then there is danger of causing the yellowed leaves to sponge.

HANDLING AFTER CURING.

After the cure is completed the barn should be opened to permit the tobacco to come into condition for taking down. Care should be exercised not to take down the tobacco while it is too high in order or there will be danger of its running red or even moulding. When the leaf can be folded without breaking it is about right; however, the large part of the middle vein should not be so pliant. The tobacco should then be bulked down shingle fashion in long bulks. When shingled down in fair order and in moderate temperatures the leaf will improve considerably in colour. In leaves with a light pea-green cast or a pea-green colour along the veins this green will run out, leaving a clear lemon-yellow leaf. After about ten days the bulk should be taken down and rebuilt, in a square shape, with the tips overlapping and the butts to the outside. The tobacco is now ready for stripping and assorting.

STEAMING TOBACCO INTO ORDER.

A period of dry weather often occurs during the curing season which prevents the tobacco coming into the proper order for handling, and the curing barn may be badly needed on account of the proximity of frost. In such cases the tobacco may be steamed into order, and while the natural order is more satisfactory, steaming is not a bad substitute. In steaming tobacco in order the barn should be fairly tight, and the steam must be under a low pressure; about 25 pounds pressure is the most satisfactory. Under high pressure the steam is too hot and drying for the best results. Care must be exercised not to get the tobacco too high in order, and it must be handled as soon as possible after steaming as it will go out of order very rapidly.

VA .ETIES OF FLUE-CURED TOBACCO.

The many varieties grown and tested may be divided into two general classes, based on the shape and size of leaf, namely, the broad-leaf types and the narrow-leaf types.

As a rule the broad-leaf types were somewhat later in maturing, darker in colour when cured, and coarser than the narrow-leaf types; and when both types were planted at the same distance the broad-leaf types were the heaviest yielders.

The broad-leaf types grown included Long Leaf Gooch, Conqueror, Adcock, White Stem Orinoco, Virginia Gold Leaf, Warne, Hester, Hickory Pryor, and Critcher. Of these Long Leaf Gooch, Conqueror, Adcock, White Stem Orinoco, Virginia Gold Leaf and Hester grew very rank and coarse; and while they were heavy yielders they were too heavy in body to cure satisfactorily. However, on a very light soil these varieties, especially Hester, Adcock and Virginia Gold Leaf would probably yield better than some of the varieties now being grown and also give a product of good quality.

The Warne is about the most satisfactory variety for the general run of soils, giving a very smooth leaf of good body and a good yield; however, it has a tendency to cure up with a dull face and on heavy soils it grows rather rank.

The Hickory Pryor and Critcher are quite similar in their characteristics; both will give a cured leaf of a bright, flashy face and are fair yielders, though not so good yielders as the Warne. Of the two the Hickory Pryor is the better yielder and has the smoother leaf, and on the heavier soils gives the most satisfactory results of any of the broad-leaf types.

The narrow-leaf types grown included Flanagan and Gopher Skin. The Flanagan has a fairly smooth, medium-sized leaf of good body and cures up with a bright, flashy face. It is a fair yielder and the results of the experiment indicate that, on the heavier types of soil, if it is planted a little more closely than is customary in planting the broad-leaf types, it will yield just as well as the latter and give a brighter coloured leaf of good body.

The Gopher Skin has a smaller and a little rougher type of leaf than the Flanagan. It cures up bright and is a fair yielder but the leaf is not of quite as good a quality as that of the Flanagan.

II

TOBACCO SOILS, ROTATIONS, FERTILIZERS.

H. A. Freeman, M.S., *Tobacco Inspector.*

SCOPE OF THE WORK—METHODS.

In 1916, in response to many inquiries, and on account of a serious lack of data regarding the physical and chemical nature and composition of Canadian tobacco soils, as well as a lack of data regarding their correlation, fertilizer needs, and extent, it was proposed to investigate the soils of Canada now producing tobacco and any proposed tobacco soils, in order to secure this information. These investigations are being conducted on the flue-cured, White Burley, and Quebec cigar tobacco lands. A large number of samples are taken over the entire area, as an isolated soil analysis is seldom satisfactory because there is no standard of comparison. We get the bulk of our knowledge by comparison, and for this reason extensive and general analyses of all tobacco soils in Canada are being made. Such a system will give general standards that will be valuable in every comparison.

Soil samples are taken according to the method of the Official Agricultural Chemists bulletin 107, Bureau of Chemistry (1). Physical analyses are made the basis of the survey, and the method used is that given in bulletin 84, Bureau of Soils, United States Department of Agriculture (2). The methods used in the chemical analyses are given as official by the Association of Official Agricultural Chemists (3). Inquiry and observation are made on fields showing better adaptability than other fields of apparently the same nature.

GENERAL DISCUSSION.

Since the investigation of soils during the last fifteen years have shown the distribution of crops to be so dependent upon physical characteristics of soils and upon climate, it is readily seen that data regarding this phase of the soil are very necessary if we are to advise with very much accuracy regarding soil questions. The physical analysis is recommended as most valuable for soil survey work. In fact it should form the basis of the survey because it alone takes account of those physical functions—the regulation of the water supply, and therefore the temperature, the air supply, ease of cultivation, and crop adaptation—that play so large a part in determining the value of the soil for the production of any crop.

The tobacco plant probably more than any other is localized according to climate and soil. Each distinct soil formation, aided by climatic conditions, gives peculiar qualities to the cured tobacco leaf as to texture, flavour, colour, and special fitness for varied uses, and for different markets. The same soil often has the capacity of producing imperfectly all the classes of tobacco, but such soil is not found to be favourable for yielding the highest excellence in any of the classes. So controlling is the character of the soil that one part of a farm may produce the finest grade of tobacco, and the other part will grow only the commonest article.

The Bureau of Soils of the United States Department of Agriculture (4) have shown very conclusively that it is possible to locate a soil that is adapted to the production of a certain type of tobacco by a study of the physical and chemical composition of the soil. The production of a very good cigar leaf tobacco in Texas is the result of such a survey. In a soil survey of the Connecticut Valley by the Bureau of Soils, soils were observed as being adapted to produce certain qualities of leaf of the same variety of tobacco diff[illegible]g markedly in texture and colour. Practical results since secured by growers h[illegible] shown the deductions of the Bureau to be very valuable, and in most instance[illegible]ect. Experiments conducted by the Connecticut Statio[illegible] have also shown the [illegible]e of a careful soil survey of any proposed tobacco districts.

Hall and Russell (5) have shown that there is a close relation between the mechanical or physical analyses of soils and their suitability to potatoes, barley, fruit and hops.

ORIGIN OF THE FLUE-CURED TOBACCO SOILS.

The soils now producing bright tobacco in Canada belong in the glacial lake and river terrace soil province. At the close of the glacial epoch the lakes in this part of the United States and Canada were very numerous, and the water level of those which remain was very much higher, and covered areas that are now from a few feet to two hundred feet above their present shore line. These soils are derived from glacial material and debris which has been reworked and redeposited along lakes and rivers. They vary from beach sands and gravels to heavy clay soils.

CLASSIFICATION.

"The (6) texture of the soil is expressed in the mechanical analysis of a separation into seven grades, the sizes of which are arbitrarily fixed. The results of the analyses show the percentages of sand, silt, and clay.

When, aside from texture, the physical and chemical properties of the soil and its method of formation are alike, we have what we call a soil series extending from the coarse gravelly or sandy soils on the one side to the finer silt and clay soils on the other, and in such a series the texture of the soil determines the distribution of crops. Such soils are given a soil generic name (generally the name of the place where first noted) with qualifying textural terms." We have for example Leamington sand, Leamington fine sand, and Leamington fine sandy loam as prominent types in the Leamington series.

"In the classification of soils, the texture is used to determine the place in the series, and the structure and colour to determine what series the soil can be correlated with. In the flue-cured tobacco section only one soil series has been found which we have arbitrarily designated as the Leamington series.

The results of the physical analyses of a few typical soils of the district are given in Table I.

BRIGHT OR FLUE-CURED TOBACCO LANDS.

TABLE I.—Showing Mechanical Analysis of the Soils now producing Flue-cured Tobacco in Canada, and giving their Soil Classification.

Lab. No.	Depth.	Locality.	Loss on Ignition.	Gravel, 2-1 mm.	Coarse Sand, 0·1-0·5 mm.	Medium Sand, 0·5-0·25 mm.	Fine Sand, 0·25-0·1 mm.	Very fine Sand, 0·1-9·05 mm.	Silt, 0·05-0·005 mm.	Clay, 0·005-·00 mm.	Classification.
	Inches.										
500	0-6	Wm. Mills, Ruthven, Ont	1·79	1·87	2·17	41·66	37·17	5·42	7·02	3·47	Leamington sand.
501	6-24	Subsoil to 500	0·89	1·96	3·37	40·40	39·93	5·77	5·47	3·41	.. ..
502	0-6	Wm. Mills, Ruthven, Ont	1·31	1·73	3·48	49·99	29·09	3·36	8·50	3·95	.. ..
503	6-30	Subsoil to 502.	0·93	2·36	3·49	55·45	27·02	2·37	5·66	4·61	.. ..
504	0-6	Conover Leamington.	1·68	4·99	11·41	52·29	13·71	2·81	8·45	6·32	.. ..
505	6-30	Subsoil to 504.	1·21	6·08	16·89	59·01	4·00	1·50	7·70	6·26	.. ..
508	0-6	Fred. Wright, Harrow	1·99	2·11	3·87	65·72	14·29	1·81	6·43	5·76	.. ..
509	6-30	Subsoil to 508	1·06	2·70	3·58	66·89	14·29	1·74	5·99	5·09	.. ..
510	0-6	J. Henry, Leamington.	2·02	2·76	5·19	64·45	12·46	2·05	9·56	3·46	.. ..
511	6-30	Subsoil to 510	0·98	2·75	6·16	64·65	11·88	1·58	9·32	3·63	.. ..
513	0-6	W. S. Corcoran, Arner.	1·65	2·62	4·38	60·20	14·49	2·56	11·08	4·47	.. ..
512	6-30	Subsoil to 513.	0·97	1·94	6·01	63·63	13·61	2·41	7·13	5·22	.. ..
518	0-6	Wm. Patez, Ruthven	1·61	4·14	11·13	63·44	20·92	2·82	12·05	4·11	.. ..
519	6-30	Subsoil to 518.	1·11	4·29	10·03	65·93	2·11	2·79	11·82	4·96	.. ..
522	0-8	W. A. Barnett, Harrow	2·20	1·69	4·56	67·82	7·51	2·23	8·21	7·99	.. ..
523	8-30	Subsoil to 522.	1·62	2·12	5·51	69·00	6·12	1·77	7·48	7·88	.. ..
525	7-30	Subsoil to 524	1·21	0·79	1·67	55·15	20·88	4·19	13·21	4·19	.. ..
528	0-6	Fred. Wright, Harrow	1·79	2·69	4·38	64·35	12·09	1·82	8·67	5·97	.. ..
529	6-30	Subsoil to 528.	0·72	2·77	5·23	64·53	16·23	1·44	5·98	3·75	.. ..
530	0-7	East of Ruthven, 2 miles.	1·55	1·18	3·76	65·32	11·49	2·20	10·89	5·11	.. ..
531	7-30	Subsoil to 530.	0·68	0·66	2·61	77·09	10·31	1·42	5·14	3·66	.. ..
532	0-6	Chas. Stockwell, Leamington	1·54	0·95	1·65	55·00	22·97	4·69	9·46	4·61	.. ..
533	6-30	Subsoil to 533	0·83	0·48	0·89	55·77	28·44	4·09	7·85	2·83	.. ..
534	0-7	Wm. Mills, Ruthven	2·72	1·22	3·24	39·21	39·39	5·63	10·78	5·46	.. ..
536	0-7	A. Fox, Leamington.	2·11	1·72	6·68	76·83	2·49	1·06	7·49	3·66	.. ..
537	7-30	Subsoil to 536	0·94	1·72	4·56	79·70	3·37	1·09	5·10	4·47	.. ..
538	0-6	Maidens, Leamington	2·39	1·27	2·69	59·00	17·77	3·32	9·99	6·18	.. ..
539	6-30	Subsoil to 538	1·09	0·57	2·68	66·59	14·37	2·72	7·46	6·92	.. ..
543	0-36	W. S. Corcoran, Arner	2·06	2·11	3·70	61·41	12·69	2·10	10·10	4·83	.. ..
545	0-36	Alfred Thompson, Harrow	2·21	5·12	9·63	61·74	5·25	2·06	10·59	5·65	.. ..
546	0-24	A. Fox, Leamington	1·75	15·08	27·54	38·74	3·82	3·09	7·22	5·03	.. ..
514	0-6	Harrow Station, Plot 11, Harrow..	2·45	1·99	2·72	24·73	23·87	17·46	22·56	6·74	Leamington sandy loam.
515	6-30	Subsoil to 514	1·56	2·19	3·30	27·.6	24·39	15·13	17·78	9·83	.. .. ..
516	0-6	Fox, 3rd Concession, Leamington.	8·46	2·04	4·16	42·84	9·56	5·05	23·08	13·13	.. .. ..
517	6-30	Subsoil to 516.	1·98	3·72	19·84	53·00	6·71	3·72	11·39	10·31	.. .. ..
520	0-7	Harrow Station, Plot 4, Harrow..	2·20	2·46	15·01	51·20	7·10	3·66	13·98	6·36	.. .. ..

TABLE I.—Showing Mechanical Analyses of the Soil, etc.—*Continued.*

Lab. No.	Depth.	Locality.	Loss on Ignition.	Gravel. 2-1 mm.	Coarse Sand. 0·1-0·5 mm.	Medium Sand. 0·5-0·25 mm.	Fine Sand. 0·25-0·1 mm.	Very fine Sand. 0·1-0·05 mm.	Silt. 0·05-0·00 mm.	Clay. 0·005-00 mm.	Classification.
	Inches.										
521	7-30	Subsoil to 520	1·45	4·35	16·86	50·22	6·08	2·87	14·02	5·79	Leamington sandy loam.
524	0-7	Harrow Station, Plot 7, Harrow..	2·75	0	2·25	49·63	19·77	4·58	12·19	11·63	" " "
526	0-7	Harrow Station, Plot 14, Harrow..	2·56	1·22	1·67	25·36	37·20	14·40	14·05	6·09	" " "
527	7-30	Subsoil to 526	1·29	0·96	1·20	26·00	36·21	16·72	9·18	9·44	" " "
535	7-30	Subsoil to 534	1·86	1·11	1·23	33·00	33·00	11·77	11·39	8·35	" " "
606	0-20	Farnham Station, Farnham, P.Q.	9·18	2·02	3·42	25·51	18·78	10·47	21·52	18·29	" " "
591	0-20	Harrow Station, Harrow, Ont.	2·83	0·69	1·48	30·42	33·60	9·45	17·22	7·14	" " "
544	0-36	Harrow Station, Plot 13, Harrow..	2·83	0	0·17	13·71	42·94	22·47	12·37	8·34	Leamington fine sandy loam.

It can be seen from these analyses that our flue-cured tobacco soils have a high proportion of medium sand and a low silt and clay content. In the case of soil Nos. 516 and 517 a rather large amount of silt and clay for the usual tobacco land is found. This field produced a very green and gummy tobacco that would not yellow on the hill nor in the kiln. This was probably due in part to the nitrogen content of the soil, which was found fairly high, but was no doubt due largely to the rather high clay and silt content of this soil. Practically all samples selected so far, which represent some of the best and most successful tobacco farms in the district, have shown these soils to be of the Leamington sand type. Some of these farms have been under observation for several seasons, and have shown good adaptability to flue-cured tobacco for different seasons. The Harrow Tobacco Station farm is a little heavier in type than the average. It has been found that a longer time is required to mature the tobacco on this land than on the average bright tobacco soil, also that the plant has a tendency to get large and remain green instead of ripening and getting yellow in the field. This type of soil does not seem well adapted to the production of the best colour, but the yield and body are generally good. Soil No. 606 produced a very heavy, rank growth of flue-cured tobacco that was so green and coarse that it had to be air-cured. The fertility of this particular soil is good, and the drainage is good but the silt and clay content is too high to be adapted to the production of good quality flue-cured tobacco.

The crops of tobacco on the Leamington sand type showed no very marked variation that could be attributed to textural differences of the soil.

In mechanical composition, Canadian flue-cured tobacco soils are much coarser textured than the flue-cured tobacco soils of the south (7). The silt and clay content of the Ontario and southern soils is practically the same. Since the extreme heat and consequent excessive evaporation experienced in the south is not common to Ontario, practically the same water relation to growth should exist in the coarser textured soils as obtains on the finer textured southern soils.

The loss on ignition, which represents the organic matter, humus, etc., is quite low in our soils. Much increased yields would no doubt result if the humus content was increased without increasing the nitrogen content too much. Rye turned under and proper rotation of crops are the best means of supplying this organic matter.

THE PROPER SOIL FOR FLUE-CURED TOBACCO.

Judging from observations and data on growth and production extending over the past four years, and on physical analyses, the proper soil for flue-cured tobacco in Canada should be a loose, porous sand, containing 40 to 70 per cent of medium sand, and not more than 8 to 10 per cent of clay with the best results in favour of a clay content of 3 to 8 per cent. The surface soil should be 6 to 10 inches deep underlaid by a sand to sandy loam subsoil preferably yellow, to a depth of at least three feet, and the natural drainage should be good. Tobacco cannot be profitably produced on poorly drained soil of any kind.

Soil adaptation is a very important factor in the satisfactory production of flue-cured tobacco of good quality. It is an influence of fundamental importance in determining the colour of the leaf produced as well as such other points of quality as fineness, richness and body. Tobacco grown on soil that is not suited to it is not likely to grade with any other established type, and likely to sell as nondescript.

The mechanical and chemical condition of the soil is often indicated by its colour. Light-coloured soils generally produce bright tobaccos, and dark soils darker shades of tobacco. Soils containing a large proportion of clay or having a large moisture-holding capacity produce heavy tobacco which cures to a dark-red or brown. Sand soils produce tobacco which cures yellow in colour. Very rich soils usually produce a large leaf of poor quality.

FERTILITY STUDIES.

Chemical analyses field experiments, and co-operative fertilizer tests are being carried on with a view to determining and increasing the fertility of the tobacco soils and securing profitable yields.

Every soil contains two kinds of plant food, usable, that which the plant can get without difficulty; and unusable, such as enclosed in rocks, particles and compounds. A great mass of people still believe that all that is necessary to know how to handle a soil is to have its chemical analysis made or plant food content determined. The chemist can only determine the total or arbitrarily available, usable plus unusable, plant food in the soil. The soil analysis often indicates in what direction improvement lies, whether any element is deficient, the potential food supply, and is valuable for comparative relations as to fertilizer needs, etc. Carefully conducted field experiments must give the final answer to most soil problems of fertility.

Table II gives the chemical analyses of a few of the typical flue-cured tobacco soils.

	No. 500.	No. 501.	No. 502.	No. 503.	No. 504.	No. 505	No. 506.	No. 507.
Phosphoric acid	0·11	0·08	0·09	0·05	0·11	0·08	0·06	0·03
Nitrogen	0·02	0·03	0·06	0·04	0·04	0·04	0·03	0·05
Potash	0·016	0·019	0·13	0·21	0·21	0·22	0·08	0·10
Lime	0·12	0·08	0·08	0·11	0·07	0·67	0·06	0·06
Magnesia	0·06	0·06	0·03	0·14	0·10	0·02	0·08	0·08
Alumina and Iron Oxide.	2·10	2·12	1·46	1·63	4·10	4·15	2·10	3·19
Insoluble and soluble Silica	95·22	95·86	97·79	94·47	95·48	94·75	95·88	95·01
Loss on ignition	1·79	0·80	1·34	0·93	1·68	1·24	1·17	0·94

	No. 508.	No. 509	No. 510.	No. 511.	No. 512.	No. 513.	No. 514.	No. 515.
Phosphoric acid	0·10	0·08	0·08	0·08	0·08	0·03	0·03	0·08
Nitrogen	0·02	0·05	0·04	0·02	0·06	0·04	0·03	0·01
Potash	0·21	0·18	0·10	0·12	0·08	0·13	0·25	0·33
Lime	0·07	0·12	0·08	0·06	0·06	0·04	0·03	0·14
Magnesia	0·05	0·13	0·06	0·07	0·04	0·03	0·09	0·21
Alumina and Iron Oxide	2·15	2·39	1·90	2·12	0·88	3·90	3·62	4·35
Insoluble and soluble Silica.	94·75	95·33	94·46	95·92	97·01	95·07	93·16	93·00
Loss on ignition.	1·99	1·06	2·02	0·98	1·65	0·97	2·45	1·56

	No. 516.	No. 517.	No. 518.	No. 519.	No. 520.	No. 521.	No. 522.	No. 523.
Phosphoric acid	0·12	0·08	0·06	0·05	0·09	0·08	0·08	0·05
Nitrogen	0·28	0·03	0·03	0·02	0·06	0·03	0·06	0·02
Potash	0·74	0·81	0·10	0·11	0·22	0·22	0·20	0·26
Lime	0·29	0·30	0·08	0·09	0·04	0·05	0·09	0·10
Magnesia	1·14	0·20	0·02	0·05	0·06	0·08	0·08	0·09
Alumina and Iron Oxide	5·10	3·25	2·21	3·01	2·90	3·20	4·00	4·62
Insoluble and soluble Silica.	85·07	92·85	95·69	95·30	94·45	94·70	93·12	93·26
Loss on ignition	8·46	1·98	1·61	1·11	2·20	1·45	2·20	1·62

DESCRIPTION OF SAMPLES.

No. 500—Surface soil, 0-6 inches, dark sand, from farm of Wm. Mills, Ruthven.

No. 501—Subsoil, 6-24 inches, light yellow sand.

No. 502—Surface soil, same farm, dark sand, 0-6 inches.

No. 503—Subsoil to 502, 6-24 inches, light yellow sand.

No. 504—Surface soil, 0-5 inches, Conover's farm, Leamington, dark brown sand.

No. 505—Subsoil to 504, yellow sand.
No. 506—Harrow Experimental Farm, surface soil, light brown soil, 0-9 inches.
No. 507—Subsoil to 506, 9-24 inches, yellow sand.
No. 508—Surface soil, 0-6 inches, brown sand, farm of Fred. Wright Harrow.
No. 509—Subsoil to 508, 6-24 inches, medium light grey sand.
No. 510—Surface soil, 0-10 inches, light grey sand, Joe Henry's farm, Leamington.
No. 511—Subsoil to 510, 10-24 inches, light yellow sand.
No. 512—Subsoil to 513, 6-24 inches, yellow sand.
No. 513—Surface soil, 0-6 inches, dark brown sand, farm of W.S. Corcoran, Arner.
No. 514—Surface soil, 0-7 inches, chocolate coloured sandy loam, Harrow Experimental Farm, plot 11.
No. 515—Subsoil to 514, 7-24 inches, dark grey sand.
No. 516—Surface soil, 0-15 inches, black sand loam.
No. 517—Subsoil to 516, 15-24 inches, light yellow, sandy loam, farm of Fox, 3rd concession, Leamington.
No. 518—Surface soil 0-6 inches, rather rolling and compact soil, farm of Wm. Patez, Ruthven, dark sand soil.
No. 519—Subsoil to 518, 6-24 inches, yellow sand.
No. 520—Surface soil, 0-8 inches, brown sandy loam, Harrow Experimental Station, Plot 4.
No. 521—Subsoil to 520, 8-24 inches, light brown sandy loam.
No. 522—Surface soil, 0-6 inches, medium dark sand, W. A. Barnet's Farm, Harrow.
No. 523—Subsoil to 522, 6-24 inches, yellow sand.

From a chemical standpoint bright tobacco soils are rather weak, but most of them are very responsive to artificial fertilizer, manure and clovers. It can be seen that there is a fairly close relation in plant food constituents contained in each soil.

ROTATION OF CROPS.

The maintenance of fertility and the best conditions for growth in the soil are greatly dependent on a proper system of rotation.

[illegible]he present time when tobacco is in strong demand, and flue-cured tobacco lands ar[illegible] at from two to six hundred dollars per acre, there is a strong tendency tov[illegible]ling that it is a distinct loss to fail to take a crop of tobacco from the land each year. Good practice and experimentation have always shown that it pays to rotate from the standpoint of soil fertility, disease and insect pests, and total profit to the grower over any fair period of time. Wherever any one crop is grown continuously on the same soil, over a more or less extended period, crop yields always decrease, and all of the diseases common to the plant become more and more prevalent making it in the end unprofitable, if not impossible, to secure satisfactory yields.

For the production of tobacco of the best quality it is essential that the soil be liberally supplied with vegetable matter or humus in an advanced stage of decay. Humus increases the friability and water-holding capacity of the soil, and increases the yie[illegible]nd the quality of the tobacco. It has been found by experiment that a maxim[illegible] yield of the best quality tobacco could not be obtained on soils which were very low in humus no matter how much commercial fertilizer was used. This humus is best obtained by following a rotation in which grass and green cover crops are included. It has been found by experiment and practice that clover crops or even clover sod turned under has a strong tendency to produce a dark-coloured coarse flue-cured tobacco. The same is true of a very large application of barnyard manure. On rather infertile, light, sandy soils a crop of clover turned under occasionally might be of benefit, and the same is true of applications of two to three tons of barnyard manure. Even then it would be better to grow the clover or apply the manure after the tobacco and in a regular rotation rather than immediately before it. As a rule the supply of humus had best be maintained by ploughing under cover crops of rye and sods of timothy and red top grass.

The rotation should be so planned that there is always a crop on the land in winter. This prevents leaching of plant food out of the soil during winter and blowing in the spring. Rye is one of the best winter cover crops for this purpose on flue-cured tobacco lands.

On soils possessing good physical qualities for the production of flue-cured tobacco, but having too great a tendency to produce a rather large, coarse tobacco due to high content of readily available plant food, it would be best to follow tobacco immediately after corn. Corn is a gross feeder and removes large quantities of ammonia that often cause a dark, coarse tobacco.

Soils that are diseased with root rot should not have clover and certain other legumes grown on them as the disease lives on the clover roots as easily as on tobacco roots, but it is not able to live on the roots of the grasses and grains. Rotations in which grasses and grains enter help to keep up the humus supply, and prevent disease.

A four-year rotation of (1) corn, (2) tobacco, (3) grain, and (4) grass would be satisfactory. In this rotation rye should be sown after both corn and tobacco and turned under in the spring in order to keep up the humus supply of the soil. The tobacco would be fertilized with a commercial fertilizer. Manure would be applied to the young grass in the fall after the grain had been harvested.

An excellent rotation in the sections producing early tomatoes would be (1) tobacco, (2) tomatoes, (3) corn, the tobacco to be fertilized with commercial fertilizers and the tomatoes with commercial fertilizers and manure. The corn following the tomato crop would feed on any coarse material left of the manure, and remove any excess of ammonia in the soil leaving it in excellent shape for the tobacco crop. Rye should be sown in the fall after each crop and turned under in the spring. Vetch could be sown with the rye following the tobacco and tomato crops with good results. The three crops recommended being clean cultivated the soil should always be in good tilth and free from weeds.

A three-year rotation for the soils very light in colour and low in humus would be (1st year) tobacco, land manured and fall ploughed and seeded to rye; (2nd year) rye turned under, corn grown, fall ploughed, rye sown; (3rd year) rye turned under, grain spring sown, land fall ploughed, and rye sown. In this rotation the tobacco crop should be fertilized with commercial fertilizer. Rye could be used as a winter cover crop each year, and turned under in the spring provided the grain was to be used for feed. In case of wheat being grown after corn in the rotation it could act as a winter cover crop leaving the rye to be grown for two winters as a cover crop. The objection to rye being fall sown and turned under in the spring before spring sown grain is that it is very hard to kill out all of the rye, and any remaining plants head out and are harvested with the grain. If the grain was used for feeding purposes this would not be a serious objection, but it would not be satisfactory for seed grain. If the rye is not present in too great quantity, it could be pulled out at heading time.

FERTILIZERS FOR FLUE-CURED TOBACCO.

The flue-cured tobacco soils respond readily to fertilizers, and fertilizers give very good returns in increased yields of tobacco if properly balanced and used in sufficient quantity.

A complete fertilizer—that is one containing each of the three materials, ammonia (nitrogen), phosphoric acid, and potash, is needed. These can be bought ready mixed, or the ingredients can be bought and mixed at home.

Broadly speaking, each of these elements has a special effect on the quality of the leaf, and in limiting the yield. Too much ammonia if used with an insufficient amount of potash, and especially of phosphoric acid, will make the tobacco coarse, dark, and late in maturing. If sufficient ammonia is not used, the tobacco will be small, thin and poor, although the colour may be good.

Potash, like ammonia, improves the yield and body of the leaf. This element should be much more liberally used, as soon as the price of it becomes normal, than has been the custom in the past.

Phosphoric acid should be used in good quantity as it increases growth and hastens maturity, and also strongly tends to brighten the colour because of its decided effect in ripening the leaf. On account of this effect, acid phosphate should be used liberally in the tobacco fertilizer on the better improved soils, which, from an accumulation of nitrogenous materials might tend to produce a dark, coarse leaf. It should not be used excessively on light, unimproved soils because on such soils there is a natural tendency to "firing," and such a tendency would be increased by an excessive application of acid phosphate, though increasing the ammonia supplied in the fertilizer or otherwise would help to overcome this difficulty and increase the growth. This largely explains why turning under a clover crop, or two or three tons of well-rotted stable manure on very sandy soils may sometimes result in positive benefit.

Potash and acid phosphate, as a rule, may be used freely on flue-cured tobacco without injury to the quality, but it requires a nice adjustment of the ammonia supply to give the best results. Ammonia in the soil comes almost entirely from decaying vegetable matter or manure, and the quantity to be used in the fertilizer should give due consideration to the amount that can be expected from sources in the soil.

Fertilizers for flue-cured tobacco should be applied in the row because with ordinary amounts better immediate effects are realized. When heavy applications are used in the row it should be thoroughly incorporated with the soil by running a small plough or double shovel with small teeth along the row before it is bedded, or applied two or three weeks before planting time.

Sulphate of potash, 50 per cent is recommended as the most desirable source of potash, 16 per cent acid phosphate as the most desirable source of phosphoric acid, and sulphate of ammonia, 24 per cent, or dried blood, 1? per cent ammonia (13 per cent nitrogen) as the most desirable source of ammonia for flue-cured tobacco.

From the results of co-operative fertilizer tests conducted on the Leamington sand type, which constitutes the majority of the flue-cured tobacco farms, the following amounts of fertilizers have given the best results in yield and profit when applied in the following amounts per acre:—

100 to 150 pounds of sulphate of ammonia.
400 to 500 pounds of 16 per cent acid phosphate.
100 pounds of sulphate of potash.

At normal pre-war prices an application of sulphate of potash at the rate of 200 to 250 pounds per acre would be profitable.

Soluble fertilizers, such as mentioned are recommended for quick-growing crops like tobacco because they are quickly and highly available for the plant. The high availability of soluble fertilizers is believed to be largely due to the fact that they dissolve in the soil water and spread over the surface of the soil particles before becoming insoluble, thus they offer a much more extensive surface for contact with plant roots than would food particles applied in insoluble form.

DOES TOBACCO EXHAUST THE SOIL?

This is a question often asked. It is true only when the crop is removed from the land without returning what is taken away. This practice will exhaust anything. It is true that tobacco requires plenty of easily available plant food in the soil because it is on the land for a short time, and makes a very rapid growth producing a comparatively large amount of dry matter. The subject should be considered from the standpoint of what is removed from the soil by the sale of the crop, and what is required in the soil to produce the crop. The roots and stubs remain in the soil, and the stalks should be returned to the land so that the only loss in plant food from the farm is that sold in the crops. Samples of leaves and stalks of Warne and Hickory Pryor collected as harvested from various plots and farms were analyzed for their nitrogen, phosphoric acid, potash, lime and magnesia content. The average content of these ingredients in 1,000 pounds of flue-cured leaf (7 per cent moisture) and 552 pounds of stalks (5 per cent moisture) are given in the following table:—

FLUE-CURED TOBACCO.

TABLE III.—Showing pounds of plant food removed from the soil by a 1,000-pound per acre crop of flue-cured tobacco.

Plant Foods.	1,000 lbs. leaf.	552 lbs. stalk.	Total.
Nitrogen	45	18	63
Phosphoric acid	6	3	9
Potash	58	20	78
Lime	45	6	51
Magnesia	21	4	25

To replace the amount of plant foods removed from the soil in the 1,000 pounds of leaf (and the proportion holds the same for a greater or less number of pounds) would require 200 pounds of sulphate of ammonia, about 50 pounds of 16 per cent acid phosphate, 120 pounds of sulphate of potash, and about 100 pounds of ground limestone. It is always advisable to use phosphoric acid, and potash in excess of the plant's requirements because practice and field experimentation have shown over and over again that the practice is profitable. Phosphoric acid and potash are held by the soil particles and do not wash out of the soil very readily, so if these two ingredients are applied in excess of the plant's needs they are held in store for future use, and not lost.

III.

CO-OPERATIVE EXPERIMENTS.

H. A. Freeman, M.S., *Tobacco Inspector.*

EXPERIMENTS WITH FERTILIZERS.

During the past two years the writer has been conducting fertilizer experiments on the tobacco soils of the flue-cured district.

The soils on which these experiments were conducted are of the Leamington sand type, and known as the typical flue-cured or bright tobacco soils of Essex county.

Fields of as uniform fertility and contour as could be obtained were selected. In each field one-tenth acre plots were staked out. All plots were ploughed, disced, harrowed, etc., the same way. The different fertilizers were applied in the row to the various plots in the spring on the same day, and when planting time came all plots were planted the same day. They were cultivated alike, harvested and cured together in the same kiln. The tobacco from each plot was kept separate, stripped and graded into bright, red and dark tobacco. Each grade was weighed and the yield per acre calculated. One plot in every ten to which no fertilizer was applied was used as a check.

The object of these experiments was to determine the best formula and most economical fertilizer for the production of a good yield of flue-cured tobacco of good quality.

In order to fertilize any crop intelligently three things must be known: what the plant requires, what is deficient in the soil, and the best source of plant food to supply the deficiency. Physical and chemical studies of the various types and classes of tobacco soils in Canada are supplementing field trials, manurial and fertilizer experiments.

The experiments have been running two years and are to be continued. A fertilizer test should be run several seasons to determine many points, yet two seasons may be sufficient to show fairly accurately what fertilizers are needed and whether profitable on a tobacco crop.

The amounts of fertilizers used in the various mixtures were sulphate of ammonia, 100 to 250 pounds; acid phosphate, 16 per cent, 200 to 600 pounds; sulphate of potash, 50 to 400 pounds.

The yields increased with every increase in the addition of sulphate of ammonia, but the per cent of bright leaf decreased with greater application than 150 pounds unless an application of at least 300 pounds of sulphate of potash and 500 pounds of 16 per cent acid phosphate were used.

Yields were increased by applications of acid phosphate up to 500 pounds per acre; heavier applications did not show a profitable increase.

The sulphate of potash gave substantial increases for every addition up to 400 pounds per acre, with no deterioration in quality of the cured leaf. At prices paid for the potash, which was $400 per ton, the large applications did not pay, as was to be expected, but cheaper potash is sure to come and the larger applications will then be profitable. One hundred pounds combined with 500 pounds of 16 per cent acid phosphate and 150 pounds of sulphate of ammonia made a very profitable return, being on the average of from three to four dollars for each dollar spent for the combination due to the fertilizer alone.

Much larger quantities of commercial fertilizers than are at present generally used could be very profitably applied to the flue-cured tobacco soils.

It would be better as a rule to buy the fertilizer ingredients and mix them at home. If this is not done only high grade, ready-mixed commercial fertilizers should be used.

From the standpoint of colour and quality of the cured leaf, and profit, the mixture that gave the best results at the present prices of fertilizers consisted of 100 to 150 pounds of sulphate of ammonia, 500 pounds of 16 per cent acid phosphate, and 100 pounds of sulphate of potash.

At pre-war prices of fertilizers and flue-cured tobacco, the mixture that gave the best results from the standpoint of colour, quality and profit consisted of 150 to 200 pounds of sulphate of ammonia, 500 pounds of 16 per cent acid phosphate, and 250 to 300 pounds of sulphate of potash.[1]

FERTILIZER AND CLOVER ON FLUE-CURED TOBACCO.

Although turning under a heavy crop of clover on fairly well improved land on which a crop of flue-cured tobacco is to be grown the same season is not recommended, it was thought worth while to try the effect under our climatic and soil conditions.

Four one-tenth acre plots were staked. The fertilizer was applied in the amounts given in table IV, in the row. It was desired to see if good applications of fertilizer would improve the dark colour of the leaf that was to be expected and at the same time improve the yield. Fertilizers were applied singly and in combination.

The soil on which this experiment was run is of the Leamington sand type, low in organic matter, but typical of the soils of the bright tobacco district, level and possessing excellent drainage.

Table IV.—Showing yield of red, dark, and total pounds of flue-cured tobacco per acre. Also the kind and amount of fertilizer applied per acre.

Plot No.	Lbs. red tobacco.	Lbs. dark tobacco.	Lbs. Total.	Sulphate Ammonia	Acid Phosphate	Sulphate Potash.	Fertilizer applied.
1	450	790	1,230	None.	None	None	No fertilizer.
2	1,240	200	1,440	None	600	None	Acid phosphate.
3	1,040	270	1,310	None	None	400	Sulphate of potash.
4	1,330	270	1,600	200	600	400	Complete fertilizer.

Very large yields for flue-cured tobacco were obtained on these plots. The crop was set in the field rather late.

The leaf produced was rich and waxy, possessing good body, texture, elasticity and aroma, but the colour was very poor, being mostly red to mahogany with a fair per cent of dark and green tobacco.

Plot No. 1 yielded at the rate of 450 pounds of red and 790 pounds of dark and green grades, making a total of 1,240 pounds per acre. The quality of the leaf was very poor.

Plot No. 2 yielded at the rate of 1,240 pounds of red and 200 pounds of dark and green grades, making a total of 1,440 pounds per acre. The plot was fertilized at the rate of 600 pounds per acre of acid phosphate. The phosphate increased the total yield

[1] Note.—Mr. Fred Wright and Mr. W. S. Corcoran of Oxley have given much painstaking and encouraging help in conducting these experiments.

and increased the percentage of red to dark tobacco very much over the no fertilizer plot. The quality of the crop was much superior to that from No. 1 and was more mature.

Plot No. 3, yielded at the rate of 1,040 pounds of red and 270 pounds of dark and green grades making a total of 1,310 pounds per acre. The plot was fertilized with sulphate of potash at the rate of 400 pounds per acre. The yield was increased over the no fertilizer plot. The percentage of red to dark grades was not as good as the result obtained on the phosphate plot. The body of the leaf was good, maturity was not as well advanced as on the phosphate plot although potash showed a very beneficial effect on yield and quality.

Plot No. 4, yielded at the rate of 1,330 pounds of red and 270 pounds of dark and green grades making a total of 1,600 pounds per acre. The plot was fertilized with a mixture of sulphate of ammonia, 200 pounds, acid phosphate 600 pounds, and sulphate of potash 400 pounds. The yield from this plot exceeded all others and the quality of the cured leaf was superior to all other plots.

The experiment indicates that a satisfactory crop of flue-cured tobacco of good colour can hardly be expected on land of fair improvement or better, where a crop of clover is turned under preceding the tobacco.

It also indicates the need of these soils for nitrogen, phosphoric acid, potash and humus, and also that when applied in good quantity much increased yields can be expected.

The tendency of the fertilizer to improve the quality and hasten maturity even when large quantities of nitrogen or ammonia are present is also indicated.

More complete data and experiments conducted for a longer period are necessary before drawing conclusions definitely.

THE PROPORTION OF STALK TO LEAF.

The striped leaf and stalks from twenty-four plots in co-operative fertilizer tests each year for the past two years were weighed in order to determine if any correlations of leaf to stalk could be noted. Growing, topping and harvesting were done as is practised by the growers of the flue-cured district under ordinary field conditions.

The percentage of leaf to stalk was very close each year for all plots regardless of the fertilizer applied, or the yields obtained. Yields of flue-cured tobacco on the plots varied from 1,600 pounds to 400 pounds per acre but the proportion of stalk to leaf remained practically the same.

The Warne and Hickory Pryor varieties were grown in these experiments, and percentage of stalk to leaf remained practically constant for both varieties.

In no case did a plot show less than 50 per cent of stalk to leaf, nor more than 60 per cent. Most of the plots were very close to the average of 55·2 per cent.

The soil on which these experiments were conducted is typical of the district in physical and chemical character and composition.

In the flue-cured belt of the south, Davidson (8) gave the percentage of stalk to leaf as 35·2 per cent.

By comparing 353 pounds of stalk for each 1,000 pounds of flue-cured tobacco leaf produced in the south with 552 pounds of stalk for each 1,000 pounds of flue-cured tobacco leaf produced in Canada, it is seen that an extra 200 pounds of stalk to each 1,000 pounds of cured leaf is produced, in this country.

The moisture content of the cured leaf is taken as 7 per cent and the moisture content of the stalk as 5 per cent which is the per cent given by Davidson for the cured product.

There seems to be little reason why the percentage of stalk to leaf should be higher in Canada than in the south, and it is believed that the explanation will be found in the practice of too late, and too high, topping of flue-cured tobacco in the former. If this be the case, the Canadian grower is fertilizing, producing, harvesting and curing 200 pounds more than necessary of practically worthless stalks for each 1,000 pounds of cured leaf, a large part of which could be converted into leaf by earlier and lower topping, with improvement in the quality of the total 1,000 pounds of leaf produced.

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