J. B. Woodward

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This volume includes Progress Reports of the following Experimental Stations of the Canada Department of Agriculture:

DOMINION OF CANADA—DEPARTMENT OF AGRICULTURE

DOMINION EXPERIMENTAL SUBSTATION
DELHI, ONTARIO

RESULTS OF EXPERIMENTS
1937-1945

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View of Grounds and Office on the Delhi Substation

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PROGRESS REPORT OF THE DOMINION EXPERIMENTAL SUBSTATION, DELHI, ONTARIO 1937 to 1945

F. A. STINSON, Officer in Charge.

Introduction

In this report it is intended to review briefly results of experimental work carried on at the Delhi Substation since publication of the previous progress report for the years 1932-1936. Investigations carried out during this period include practically all phases of producing flue-cured tobacco. A major portion of the field-plot work is devoted to study of crop rotations and methods of rebuilding and maintaining productivity of soils used for growing this crop. While experimental work is confined to flue-cured tobacco, several other crops, the chief of which are fall rye, husking corn, and clover, are grown in connection with soil productivity studies. Publications regarding some of the subjects discussed are available now and others will appear as progress of the work warrants.

Changes in Producing Areas and Production

The area planted in flue-cured tobacco in Ontario was increased from 35,700 acres in 1936 to 72,500 acres in 1945. Besides the expansion which took place in the counties of Norfolk, Elgin, and Oxford during this period, the industry was established and expanded in some of the more favourable areas of Brant and Middlesex counties. More recently this crop has been successfully produced in parts of Durham and Simcoe counties. During the same period the acreage of flue-cured tobacco grown in Essex county continued to decline.

Throughout this development, improvements in fertilizer practices and cultural methods have permitted quality leaf to mature under conditions of climate and soil hitherto considered unsuitable for growing flue-cured tobacco. On the other hand the intensive methods of cropping practised on many farms in the tobacco-growing area, have resulted in reduced soil productivity owing to depletion of soil organic matter and increased prevalence of tobacco rootrot. Meanwhile the regular introduction of this crop to new and more productive land has been a real factor in keeping up the average yield per acre in Ontario.

Tobacco Seedlings

Transplanting healthy uniform seedlings is the first step in growing a flue-cured tobacco crop successfully. Despite seasonal variations in weather, excellent seedlings may be grown any year provided good judgment is used in carrying out methods of seed-bed preparation and management which have proved sound. Seed-bed failures may be avoided and most of the diseases and so-called diseases of the seed-bed can be prevented by following closely the recommendations given here and in other previous publications issued by the Substation. Furthermore, in at least nine out of every ten instances where ordinary seed-bed losses have occured in the past, the trouble could be traced directly to over-fertilization, or improper moisture conditions resulting from faulty watering and ventilation. Information on this subject has been secured through experimentation and surveys of seed-beds throughout the tobacco-growing areas.

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Any of the various types of greenhouses in common use, when well situated with respect to drainage and sunlight, may be used with equal success to grow seedlings. Semi-hot flat beds covered with sash, serve as a useful means of supplementing the greenhouse by providing additional seedlings a little later in the season. Plants grown under cotton develop more slowly than under glass.

The use of a thin layer of muck on seed-beds is recommended to retain moisture and plant food and thereby promote abundant shallow rooting. The physical condition of muck which has been piled for a year is more suitable for this purpose than freshly-dug muck. To ensure adequate drainage the depth of muck should be limited to about one inch. Thorough loosening of the soil—preferably by spading it over before adding the muck-layer—is required to permit effective steaming.

UNIFORM BEDS OF HEALTHY TOBACCO SEEDLINGS
Excellent seedlings may be grown any year provided good judgment is used in methods of seed-bed preparation and management.

One-half hour steam sterilization per pan is recommended. Steaming is most effective when the soil is just dry enough so that it is not sticky. In order to obtain proper sterilization it is necessary to weight the pan to prevent loss of steam. Drenching walls, boards, walks, and other unsteamed portions with formaldehyde, diluted with forty parts of water, is worthwhile to prevent re-infection of the beds from these sources. The formaldehyde treatment can be applied to best advantage on a calm sunny morning just after steaming, when the greenhouse may be closed tightly for twenty-four hours. The house should be aired thoroughly to remove all fumes before seeding.

Application of too much fertilizer is one of the most common causes of poor growth in tobacco seed-beds. One hundred pounds of commercial tobacco fertilizer per 800 to 1000 square feet of seed-bed, worked into the muck after steaming, provides an abundance of plant food in suitable proportions. A light dressing of commercial fertilizer (25 to 30 pounds per 1,000 square feet) applied and well washed off the plants after the first pulling, will frequently improve those remaining in the bed.

Good tobacco seed should have a germination test of at least 80 per cent. The use of only high grade seed, such as registered seed, is recommended. Table 1 shows the number of seedlings produced in a test to compare seeding at different rates.

TABLE 1. NUMBER OF FLUE-CURED TOBACCO SEEDLINGS OF TRANSPLANTABLE SIZE PER 100 SQUARE FEET OF SEED-BED WITH DIFFERENT RATES OF SEEDING.

Area on which one ounce of seed sown (Square feet of seed-bed)	Average number of seedlings per 100 sq. ft. seed-bed	
	Before June 5	Total during season
1,400	4,119	8,000
1,600	4,179	8,764
1,800	3,736	7,847

Seeding at the rate of one ounce to 1600 square feet of seed-bed resulted in earlier seedlings and a greater number, than did seeding at either a lighter or a heavier rate. Plants from the beds with the heaviest rate of seeding were not as sturdy as the others.

Temperatures between 80 and 90 degrees F. are most favourable for growth of tobacco seedlings. If the surface of the bed is allowed to get dry or too hot before the plants appear, the stand is likely to be uneven. As soon as the plants are up, drying the bed off encourages rooting and prevents a condition known as "tipping out". From then on sufficient moisture should be provided by watering not oftener than once a day. When water is applied during the early part of the day the surface has a better chance to dry off before nightfall. This is important in the control of many seed-bed troubles.

Hardening off the plants before transplanting is recommended. This may be done by withholding water, and ventilating as much as possible for three or four days before beginning to pull the seedlings.

Flue-cured Tobacco Varieties

Varieties of tobacco differ in their adaptability to different soil conditions as well as in their time of maturity and ability to yield leaf of high quality. Unfortunately, none of the commercial varieties available is highly resistant to the black rootrot disease. The present breeding program at the Substation is directed mainly toward developing resistant varieties with the other desirable features of those in present use.

Each season from eight to ten varieties and strains consisting of leading commercial varieties, and promising introductions and developments, are tested and compared. Similar tests have been carried out on important soil types in the tobacco-growing districts during the period of this report. A comparison of average grade values, yields, and gross returns per acre, obtained with four varieties which have been tested during each of the past eight seasons, is shown in Table 2.

TABLE 2. GRADE VALUE, YIELD PER ACRE, AND GROSS RETURNS PER ACRE OF FOUR VARIETIES OF FLUE-CURED TOBACCO OVER THE EIGHT-YEAR PERIOD 1938-1945.

Variety	Grade Value (cts. per lb.)	Yield per Acre lb.	Returns per Acre $
White Mammoth	25·0	1,427	357
Yellow Mammoth	24·6	1,426	351
Gold Dollar	24·6	1,422	350
Duquesne	26·1	1,322	345

White Mammoth, Yellow Mammoth, and Gold Dollar yielded almost equally well. The leaf of White Mammoth matured slightly earlier and graded a little higher than that of the other two varieties. This variety is well adapted to the coarser and heavier-textured soils, whereas both Yellow Mammoth and Gold Dollar have noticeably heavier-bodied leaf and are better adapted to lighter types of soil. Yellow Mammoth has proved more susceptible to a crop-effect disease known as brown rootrot, than either of the other varieties.

Duquesne matures earlier than any other variety of flue-cured tobacco grown in Ontario. Leaf of this variety has consistently graded higher than that of most other varieties, although its yields are not among the heaviest. Duquesne may be used to advantage where the soil is naturally more productive than average, as under such conditions it tends to mature more rapidly, producing a higher grade of leaf than other common varieties without serious sacrifice of yield.

Bonanza is an early maturing variety but not so early as Duquesne. It has produced heavier yields than Duquesne and is also adapted to soils which are more productive than average, especially those of the fine sandy loam type. White Stem Orinoco has its best development on soils of this general character too, but in tests both yield and grade of leaf have been lower than those of Bonanza.

In recent years several new varieties have been introduced in Ontario. One of these, Improved Bonanza, is a vigorous grower and produces higher-than-average yields. It matures about the same time as Gold Dollar and Yellow Mammoth. The cured leaf is bright in colour but its coarser midrib and lack of body are objectionable features. Incidentally, this variety shows no relationship to the variety commonly known as Bonanza. Virginia Wrapper appears to be similar to White Mammoth in its adaptability.

Although varieties available at present offer a suitable choice for a wide range of soil conditions, there is a distinct need for suitable varieties which are highly-resistant to black rootrot.

Crop Rotations and Soil Productivity Maintenance

The need for general improvement in cropping systems on flue-cured tobacco farms is becoming more and more evident. This phase of tobacco production is the subject of intensive study in field plot tests on the Delhi Substation.

ROTATION OF CROPS WITH FLUE-CURED TOBACCO

Several crops have been grown in rotation with flue-cured tobacco for sufficient length of time to study their effects on the crop as well as their value for maintaining soil productivity.

Keeping up soil organic matter and controlling soil-borne diseases are two of the main requirements of a sound cropping program. In selecting crops for use in rotation with flue-cured tobacco and planning the order in which they are to be grown, there are several other things that need to be considered. The effect of certain crops on tobacco planted the following season, whether or not a crop is a heavy feeder, the amount of organic matter which may be added by growing it, as well as the net returns from the crop itself, are some of these factors. In addition, it is important that the soil has adequate protection the year around from damage by wind and water.

Whereas the two-year rye-tobacco rotation, used widely at present, has a number of desirable features, it fails to provide adequately for the upkeep of soil organic matter and the control of black rootrot. Barnyard manure is useful for restoring organic matter in this rotation but its frequent application makes conditions more favourable for development of this disease. To avoid losses from black rootrot it is necessary to plant tobacco not oftener than once in three years.

On soils which have been cropped heavily with flue-cured tobacco a striking improvement is usually observed when it is preceded by two or more other suitable crops. The yields and gross returns per acre from flue-cured tobacco, listed in Table 3, show typical responses to the rotations practised.

TABLE 3. AVERAGE YIELDS AND GROSS RETURNS PER ACRE WITH FLUE-CURED TOBACCO IN TWO AND FOUR-YEAR ROTATIONS (1943-1945).

Length of Rotation	Yield per Acre lb.	Gross Returns per Acre $
Four-year	1,483	357
Two-year	1,262	295

In this test, average gross returns per acre from tobacco grown during the three seasons were twenty per cent higher in the four-year rotation than in the two-year rotation. Besides this increase there was less variation between the crops in different years where soil productivity was at the higher level.

Considerable loss of soil organic matter or humus takes place during the growing of a hoed crop such as tobacco, corn, or potatoes. This loss is less when grain crops like rye are grown and still less with hay crops such as clover or grass. Net losses are reduced, of course, by turning under stubble and by disking or ploughing under plant refuse such as rye straw and corn stalks.

As flue-cured tobacco is sensitive to the effect of the crop grown the preceding year, the arrangement of crops in the rotation is important. For instance, tobacco planted the year after corn, soybeans, or timothy sod is frequently light in yield owing to a condition known as "brown rootrot". Late maturity and low grade leaf usually result where flue-cured tobacco follows alfalfa. Similarly the ploughing under of sweet clover or red clover adds too much slowly-available nitrogen for tobacco the next year. Under average conditions, however, excellent flue-cured tobacco may be grown where the land is ploughed and seeded to rye after removing a crop of sweet clover or red clover hay the previous year.

A number of different crops were alternated with flue-cured tobacco for several years on the Substation to compare their effects on flue-cured tobacco. Tobacco grown after oats was above average in grade but lower in yield. Oats may sometimes be used to advantage before tobacco on land that has been broken out of alfalfa sod. The growing of buckwheat appeared to lower both the yield and grade of flue-cured tobacco which followed. Wherever weeds were used as a rest crop on the land for a part of the time between tobacco crops the yields were lowered proportionately. Flue-cured tobacco of excellent quality may be

expected following a crop of potatoes. Tobacco yields are not reduced by the growing of potatoes, provided there is an adequate supply of organic matter in the soil. Following tomatoes or another crop of tobacco, mosaic is likely to be prevalent.

Fall rye is a valuable crop to precede flue-cured tobacco in the rotation, particularly when the mature rye straw is disked into the soil. In addition to having ability to grow during late fall and early spring and to furnish a soil covering during winter, rye produces a large amount of suitable plant material which may be disked under. Fall wheat is similar to rye in some respects but it has not proved so effective in the flue-cured tobacco rotation. A comparison of the results with tobacco harvested during six consecutive years after disking under each of these crops, is made in Table 4.

TABLE 4. AVERAGE YIELDS AND GROSS RETURNS PER ACRE WITH FLUE-CURED TOBACCO FOLLOWING FALL RYE AND FALL WHEAT (1940-1945).

Rotation	Yield per Acre lb.	Gross Returns per Acre $
Fall rye—tobacco	1,247	323
Fall wheat—tobacco	1,222	313

The average yield and returns per acre were higher for the tobacco that followed rye. This crop protected the soil more completely during the winter and produced more straw to disk under when mature.

The general use of more suitable varieties of rye on flue-cured tobacco farms offers a ready means of improving cropping practices. Nine of the most promising rye varieties have been tested and compared at the Substation during the past

SECTION OF RYE VARIETY TEST

LEFT: Horton Rye. RIGHT: Rosen Rye.
Horton rye is recommended for use in the tobacco rotation. It grows more quickly than other varieties in the fall and spring and is one of the heaviest yielders of straw and grain.

five years. The Horton variety has proved outstanding in several ways. Owing to its early habit of growth, Horton furnishes more protection for the soil during winter and develops much more rapidly in the spring than ordinary varieties. Beside it is one of the highest yielders of straw and grain. There is a strong demand for this variety for use on flue-cured tobacco farms. Approximately twenty-five hundred bushels of Horton seed rye were offered for sale by farmers of the tobacco district in the fall of 1945.

Different methods of handling the rye have been compared in tests for sufficient length of time to appraise their value in keeping up tobacco production. Disking under all of the rye straw after it ripens has proved superior to ploughing it under before ripening or removing it with a grain binder. The practice of combine harvesting rye compares favourably with disking the whole crop when provision is made for a good growth of rye after disking under the straw. Fall ploughing is a bad practice and is not recommended. By delaying ploughing until the rye has made a few inches of growth in the spring the soil may be well protected against drifting and washing during the winter and spring months, and the tobacco crop is improved. Table 5 shows the average yields and gross returns per acre from ploughing in the spring as compared with fall ploughing in preparation for flue-cured tobacco. A crop of mature rye had been disked under in each instance.

TABLE 5. AVERAGE YIELDS AND GROSS RETURNS PER ACRE WITH SPRING AND FALL PLOUGHING FOR FLUE-CURED TOBACCO (1940-1945)

Season of Ploughing	Yield per Acre lb.	Gross Returns per Acre $
Spring	1,247	323
Fall	1,225	306

Ploughing in the spring after rye had made six to eight inches of growth resulted in a higher average yield and return per acre than fall ploughing, over the entire six-year period.

Fertilizers in the Rotation

Owing to the low levels of plant nutrients normally found in these soils, practically all crops respond to applications of suitable commercial fertilizers. Most crops, except flue-cured tobacco and legumes, require fairly liberal amounts of nitrogen. Where nitrogen has been added either by means of a commercial fertilizer or through the growing of clover or other legumes, the addition of potash ordinarily results in a marked increase in growth. Although response to phosphate is not so noticeable, the need for an adequate supply of this nutrient for development and maturity of commercial crops is well recognized.

Simply lengthening the rotation for flue-cured tobacco is, in itself, not an effective means of either maintaining or rebuilding soil organic matter. A satisfactory rotation should provide for methods of fertilizing and growing crops that ensure good stands and yields so that large amounts of stubble and other crop remains may be returned to the soil. Indeed, the returns of all crop refuse, either directly or in the form of barnyard manure, is most important to the future productivity of flue-cured tobacco soils. Following disking or ploughing under of relatively large amounts of mature crop residues, such as straw or corn stalks, growth is likely to be poor for some weeks unless a source of nitrogen is applied at the same time.

Experiments conducted during the period of this report have demonstrated the value of applying commercial nitrogen in the form of ammonium nitrate or calcium cyanamid when disking under mature rye straw during the summer before planting tobacco. The nitrogen added in this way aids in the decomposition of the straw and increases the growth of rye which follows. The improvement in yields of flue-cured tobacco where this practice has been followed, indicates that it is a practical and economical means of restoring soil organic matter and thereby maintaining soil productivity. When nitrogen is applied in this way it is important that sufficient potash and phosphoric acid should be provided to bring about a satisfactory balance of nutrients for the tobacco crop.

Fertilizers for Flue-cured Tobacco

Commercial fertilizers are required in considerable amounts for economic production of flue-cured tobacco. Proper balance of nutrients available for the growing crop is essential for satisfactory growth and development, early maturity, high yield, and quality of leaf.

Extensive fertilizer experiments have been conducted on the Substation, throughout the period covered by this report, to study and compare different mixtures, rates, and methods of application. Information gathered from these experiments has formed the basis for further tests on privately-owned farms with different types of soil.

TOBACCO FERTILIZER PLOTS ON THE SUBSTATION

Results of experimental work are reviewed by the Standing Committee on Tobacco Fertilizers before formulating recommendations.

The 2-12-10 and 2-10-8 mixtures meet the requirements of this crop on the majority of flue-cured tobacco soils used at present. On soils which naturally are fairly high in productivity, the 2-12-10 provides a more desirable balance between nitrogen and other nutrients. This mixture has given excellent results on many of the soils that have been brought under flue-cured tobacco cultivation during recent years. In such soils there is usually a fairly good supply of available nitrogen, but to promote ripening, a relatively large amount of phosphoric acid is required and the extra potash has an important part in development of quality in the leaf. A 2-10-8 fertilizer is well suited for use on land which is not above average in productivity and where late maturity has not been a factor.

As soils used for growing flue-cured tobacco vary considerably in fertility, drainage, and methods of management and cropping, the amount of commercial plant food that is applied to advantage for this crop varies accordinly. Ordinarily, not more than 20 pounds of nitrogen per acre is required in the fertilizer for flue-cured tobacco. Under some conditions, less than that amount results in earlier maturity and higher quality, without a reduction in yield of marketable leaf. Where it is indicated that more than 20 pounds of nitrogen per acre is desirable to promote larger growth, the soil organic matter has usually become critically low. Under such conditions it is considered better practice to apply nitrogen to other crops in the rotation and thereby restore the organic matter supply. By this means the tobacco crop will indirectly obtain additional nitrogen as required.

About 100 pounds of phosphoric acid and 80 pounds of potash per acre are required in the fertilizer for this crop under average soil conditions. Variations from these amounts should be made when the crop response and the amount of nutrients available in the soil indicate that a change in the application is advisable. Reduced yields of tobacco have been observed where more than 120 pounds of phosphoric acid per acre was applied on the lighter types of soil. Moderate increases in the amount of potash applied usually result in improved quality and yield of leaf without any undesirable effects.

Magnesium is required for normal development of flue-cured tobacco on many soils in Ontario. The use of dolomitic limestone as filler in the fertilizer apparently meets the crop requirements for both magnesium and calcium.

The suitability of many sources of plant nutrients for use in flue-cured tobacco fertilizers has been tested and compared at the Substation. It is definitely indicated that one-quarter of the total nitrogen in the fertilizer should be supplied in the nitrate form. Higher grades and yields of leaf are obtained by using sulphate of potash and muriate of potash together as sources of potash, than by using either one of them separately.

Placing the fertilizer in bands about four inches to each side of the row of plants and slightly below the roots, with a fertilizer attachment on the transplanter, is recommended. Table 6 presents the average yields and gross returns per acre where this method was compared with the older method of applying fertilizer in the row one week before transplanting.

TABLE 6. AVERAGE YIELDS AND RETURNS PER ACRE WITH FERTILIZER FOR FLUE-CURED TOBACCO APPLIED IN BANDS, AND IN THE ROW ONE WEEK BEFORE TRANSPLANTING (1939–1945).

Method of Fertilizer Application	Yield per Acre lb.	Returns per Acre $
In bands at time of transplanting	1,439	357
In row one week before transplanting	1,400	342

Over the seven-year period, both the average yield and gross returns were higher with fertilizer applications made by the band method. Plant injury, owing to "fertilizer burn" which results in more resetting, uneven and delayed growth, is avoided by applying the fertilizer in this way. The more constant relationship between the position of fertilizer placed in this way and the plant roots also helps to make the crop more uniform. A shortage of suitable equipment for applying fertilizer in bands has limited more general adoption of the band method of application.

So-called starter solutions used in the transplanter barrel have failed to improve the flue-cured tobacco crop in tests conducted over a period of years. Such solutions have frequently been harmful owing to the "fertilizer burn" resulting from their use.

Cultural Practices

Fairly shallow ploughing (four to five inches deep) in the spring, followed by cultipacking, in preparation for flue-cured tobacco, has proved most practicable. In preparing the soil, after ploughing, the spring-toothed harrow or cultivator causes less pulverization of the soil than the disk harrow and thereby leaves it in better condition to resist drifting and washing. On sloping land it is worthwhile to run the rows across or around the slopes rather than up and down. Run-off of water and loss of valuable soil during the growing season may be reduced greatly in this way.

Field and laboratory tests at the Substation have showed that excessive cultivation results in needless loss of soil organic matter. However, thorough cultivation soon after transplanting, to discourage weed growth and loosen the soil, is important. Any cultivation required to control weeds after the tobacco plants begin to develop should be shallow enough to avoid root injury.

Spacing flue-cured tobacco at 23 to 24 inches in rows 40 inches apart appears to be most desirable under average conditions. Variations in soil productivity may influence the distance of planting to some extent. Topping at a medium height when the first flowers begin to appear on the crop has given best results. Weather conditions and fertility of the soil should be considered in determining the height of topping. Suckering thoroughly until the third priming has been taken hastens maturity and improves the grade and yield of leaf. The effect of suckering on grade value, yield and gross returns per acre is illustrated in the results shown in Table 7.

TABLE 7. AVERAGE GRADE VALUES, YIELDS, AND GROSS RETURNS PER ACRE WITH DIFFERENT AMOUNTS OF SUCKERING FOR FLUE-CURED TOBACCO (1937–1939).

Amount of Suckering	Grade Value per pound cts.	Yield per acre lb.	Gross Returns per acre $
All suckers removed until third priming taken	29·6	1,705	505
Suckered once	28·0	1,642	459
No suckers removed	27·5	1,542	424

Results obtained during this three-year period definitely indicate the importance of suckering regularly.

Considerable loss in yield, as well as lowered grade, may result from priming the leaf before it is mature. In tests to compare the effects of harvesting under various weather conditions it was found that following a period of cloudy weather quality improved with each day of sunshine which passed before priming. Experimental evidence points to the importance of promoting earlier maturity in order to avoid the necessity of harvesting during prolonged periods of cool, cloudy weather which frequently occur later in the season.

Curing Tobacco

The temperatures and ventilation required in properly curing flue-cured tobacco depend on a great many factors. Weather conditions, including changes in direction and speed of wind and variations in temperature, are among these factors. Tight kiln construction and insulation help to reduce the effects of weather on conditions within the kiln. Provision for adequate controllable ventilation at both the top and the bottom of the kiln is important.

There has been a recent trend toward the use of heating equipment which does not require hand firing. The main advantages from using such equipment are in the maintenance of uniform temperatures in the bottom of the kiln, wider distribution of heating units over the floor of the kiln in some instances, and considerable saving in labour.

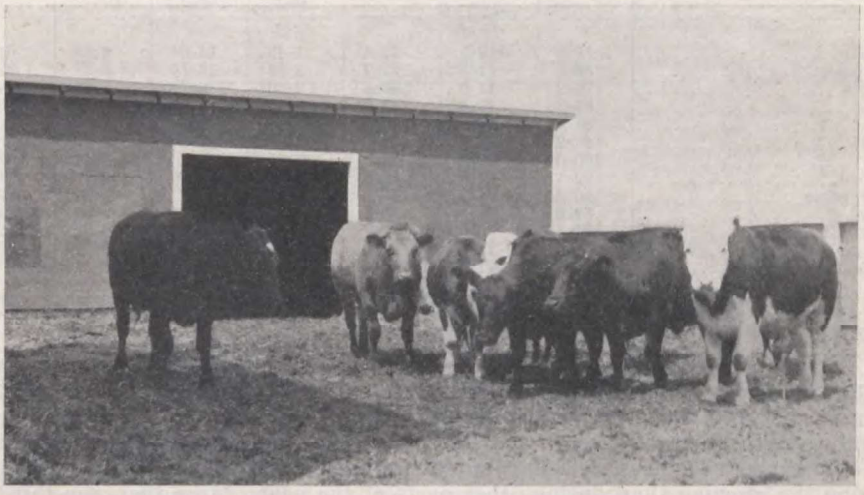
The exchange of air, necessary to remove moisture in curing, depends on the principle that warm air rises. Cooling of the air as it evaporates moisture from the leaf interferes with this rise and prevents obtaining uniform temperatures from the bottom to the top of the kiln. In normal curing, the temperature at the third tier of leaf remains at from 25 to 30 degrees lower than that at the bottom tier for several hours after the temperature has been raised. Variations in temperature of as much as 40 degrees F. from bottom to top of the kiln are not unusual. Inability to secure uniform drying conditions throughout the kiln is a common cause of loss from improper curing. This is the chief weakness in all present flue-cured tobacco curing equipment.

Besides resulting in heavy losses in value of leaf, owing to failure to cure all leaf adequately, the present method of curing also involves a definite fire hazard. Based on reports from insurance companies, annual losses from kiln fires in Ontario run as high as one-half a million dollars. In addition to this, the total loss through inability to preserve weight and quality in curing is doubtlessly much higher than this figure.

There is a decided need for a curing system that will permit more uniform and adequate curing and at the same time remove the present fire hazard.

Production of Barnyard Manure

Winter feeding of steers was undertaken at the Substation during the fall of 1944 to study the economy of producing barnyard manure on flue-cured tobacco farms by feeding home-grown roughage and grain for production of meat. Ten steers of beef type were fed for a six-month period during each of the two following winters. Seven Yorkshire pigs, averaging one hundred pounds each, were placed in the feedlot along with the steers in the winter of 1945-46. The steers were fed all the clover, alfalfa, and mixed hay they would consume, and



STEERS IN THE FEEDLOT ON THE SUBSTATION

Steer feeding is practised to study the economy of producing manure while feeding home-grown feed.

up to 28 pounds of ear corn per day, per steer, during the latter part of the feeding period. Ear corn was fed sparingly at the start and gradually increased to full feeding about six weeks before the end of the period. Fresh water and salt were available at all times. About one ton of straw per steer was used for bedding during the six-month period. The hogs were free to salvage, but were given no extra feed.

By feeding in this manner an average gain of 325 pounds per steer was made in each of the two feeding periods. The hogs made an average gain of 112 pounds each in 124 days. Approximately eight and one-half tons of good quality barnyard manure was obtained per steer in each feeding period. From the results so far this would appear to be a promising method of economically producing barnyard manure for upkeep of the land.

Seasonal Conditions

Daily records of temperatures (maximum and minimum), rainfall, snowfall, and sunshine have been kept during the past eleven years. Data on rate of evaporation during the growing season were obtained in 1945. Seasons in which rainfall is below average in June and August and slightly above average in July, appear to be most suitable for production of heavy yields and high quality flue-cured tobacco at Delhi. Such conditions prevailed during 1938, 1939, and 1941. June rainfall was exceptionally heavy in 1940 and 1945, whereas July of 1936 and 1940, respectively, were the driest on record. Yield and quality of flue-cured tobacco, produced in the seasons of 1936, 1940, and 1945 were below average.

Monthly meteorological data for the past eleven years are summarized in Table 8.

TABLE 8. MONTHLY AND ANNUAL RECORDS OF TEMPERATURE, PRECIPITATION AND SUNSHINE AT THE DOMINION EXPERIMENTAL SUBSTATION, DELHI, ONTARIO. 1935-1945 (11 years)*

Month	Temperature F			Precipitation			Bright Sun (hr.)
	Highest	Lowest	Mean	Rain (in.)	Snow (in.)	Total Precip. (in.)	
January	56·0	−19·5	21·4	1·49	14·07	2·89	64·8
February	56·5	−21·5	22·9	1·69	14·73	3·17	93·1
March	76·2	−11·0	32·3	2·20	8·70	3·06	123·7
April	84·3	10·5	43·0	3·05	2·98	3·35	160·5
May	87·5	23·0	54·3	3·51	.....	3·51	211·9
June	93·2	32·3	65·6	3·37	.....	3·37	246·8
July	105·0	39·0	70·3	3·44	.....	3·44	283·2
August	92·5	33·0	68·8	2·77	.....	2·77	254·2
September	90·5	24·9	60·5	3·38	.....	3·38	177·0
October	82·0	17·5	49·2	2·85	·14	2·86	143·1
November	71·5	10·0	37·7	2·27	6·52	2·92	82·4
December	64·6	−18·0	26·5	1·51	11·96	2·70	62·5
Annual	105·0	−21·5	46·0	31·53	59·10	37·42	1,903·2

*Meteorological records taken in co-operation with the Meteorological Division of the Department of Transport.

The above table shows that temperatures at Delhi have varied over a range of 126·5 degrees F. during the past eleven years. During this period a temperature of more than 96·5 degrees F. was recorded in one month only and a lower temperature than 20 degrees below zero F. occurred only in one month. The normal precipitation at Delhi is well distributed throughout the year, with slightly more during the growing than during other parts of the year. More than one-third of the annual sunshine normally occurs during June, July, and August. This combination of abundant precipitation and sunshine provides good growing conditions for a wide variety of agricultural crops.

Monthly precipitation during the past eleven years is shown in Table 9.

TABLE 9. MONTHLY PRECIPICATION AT THE DOMINION EXPERIMENTAL SUBSTATION, DELHI, ONTARIO. 1935—1945 (11 YEARS).

YEAR	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1935	2·59	2·76	2·23	1·48	3·19	3·67	2·44	2·68	2·52	1·45	4·22	1·59	30·82
1936	2·67	2·42	3·36	2·40	·67	2·39	·52	1·43	4·73	2·82	3·00	3·95	30·36
1937	8·13	2·81	·95	9·90	2·99	3·71	3·97	3·54	2·43	3·41	1·59	1·76	45·19
1938	2·23	5·58	2·96	2·26	2·98	1·68	4·71	2·77	3·80	1·16	2·67	2·91	35·71
1939	2·77	5·79	3·73	4·13	·95	2·27	4·08	1·76	2·46	3·42	1·03	1·61	34·00
1940	2·12	2·51	2·49	2·80	5·60	5·62	1·28	3·85	2·63	1·71	5·47	4·38	40·46
1941	2·70	1·63	1·99	·73	3·26	2·13	4·47	1·56	1·06	4·07	2·30	1·89	27·79
1942	2·88	3·08	3·85	1·79	4·41	1·72	7·90	1·26	4·78	5·30	3·74	4·95	45·66
1943	2·63	2·75	4·08	4·37	5·89	5·16	4·09	5·15	·92	2·49	2·40	·69	40·62
1944	1·07	2·55	3·36	3·00	3·73	2·54	1·73	4·78	5·74	·41	2·13	3·26	34·30
1945	2·04	2·97	4·64	4·03	4·97	6·21	2·63	1·71	6·16	5·24	3·62	2·74	46·96
Average	2·89	3·17	3·06	3·35	3·51	3·37	3·44	2·77	3·38	2·86	2·92	2·70	37·42

Although the data presented in Table 9 show that total annual precipitation has varied considerably, ranging from 27·79 inches in 1941 to 46·96 inches in 1945, there has been no prolonged period of drought during the growing season other than that in the summer of 1936.

Data regarding the frost-free periods are presented in Table 10.

TABLE 10. THE OCCURRENCE OF FROST AND FROST-FREE PERIODS AT THE DOMINION EXPERIMENTAL SUBSTATION, DELHI, ONTARIO. 1934—1945 (12 YEARS).

(Freezing temperature 32 degrees F. or lower)

Year	Spring Frost	Fall Frost	Frost-free Periods
	Date of last frost in spring	Date of first frost in fall	Days frost-free
1934	May 26	October 1	128
1935	May 24	September 28	127
1936	May 21	September 24	126
1937	May 11	September 20	132
1938	May 25	October 2	130
1939	May 14	October 1	140
1940	May 12	September 26	137
1941	May 14	October 17	156
1942	May 11	September 29	141
1943	May 19	September 12	116
1944	April 30	October 12	165
1945	May 24	October 4	133
Average	May 17	September 30	136

Date of latest spring frost on record	May 26
Date of earliest fall frost on record	September 12
Shortest frost-free period on record	116 days
Longest frost-free period on record	165 days

Whereas the average data of last killing frost in the spring was May 17, a killing frost occurred as late as May 26. A killing frost in the fall was recorded

as early as September 12 although the average date for this twelve-year period was September 30. The average number of frost-free days in the period covered in records at Delhi was 136. The frost-free period varied in length from 116 to 165 days. Frost injury to flue-cured tobacco frequently occurs in the fall at temperatures slightly higher than 32 degrees F.

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