SUMMARY OF FLUE-CURED TOBACCO RESEARCH
FOR THE PERIOD 1921 TO 1944

Some preliminary work was done with flue-cured tobacco in 1921. In 1922 a full-time tobacco research agronomist was employed and an organized program initiated. This work was begun, and has continued since that time as a cooperative project of the Georgia Coastal Plain Experiment Station, the Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration of the United States Department of Agriculture, and the University of Georgia College of Agriculture.

Early findings indicated that two major problems faced growers. These were: (1) Existing fertilizer formulas did not carry enough potash for best quality. (2) The root-knot nematode would make tobacco production rather hazardous unless means could be found for its control. In 1925 a tobacco pathologist was employed for full-time study of tobacco diseases. Since then two men, one agronomist and one pathologist, have worked full time on the problems of tobacco production in the Coastal Plain of Georgia. Some of the more important findings over this 24-year period are outlined in the following report.

Soils: Early tests of fertilizers and varieties were made only on the light phases of Tifton sandy loam soils. It soon became apparent that these soils were too high and dry to be considered ideal tobacco soils and that good crops of tobacco could be grown only during seasons of well distributed rainfall. In 1927 a small area of Norfolk sandy loam soil was leased for tobacco tests. Results soon verified the assumption that the high water table of the Norfolk soils made them better adapted to the production of tobacco than the higher, more rolling Tifton sandy loams.

Rotations: A series of crop relation studies, consisting of 2-year rotations of tobacco with cotton, corn, peanuts, and sweet potatoes begun in 1922, resulted in severe root-knot damage after sweet potatoes, and outstanding symptoms of potash deficiency on tobacco after both peanuts and sweet potatoes. It should be explained that potash applications were 22.5 and 45 pounds K₂O per acre, the latter being considered adequate at that time. Since the root-knot nematode was such a factor in these tests, practically all work with rotations has become a problem of the pathologist.

Fertilizers: Early work with fertilizers consisted mainly of testing formulas, rates of applications, and the comparative values of different materials as sources of nitrogen, phosphorus, and potash. While the importance of magnesium was well recognized, only a limited amount of work with this element was undertaken. Results were not consistent and could not always be explained on the basis of the work as planned. To follow up, all work with formulas and materials was discontinued and experiments were planned to study one element of nutrition at a time, keeping applications of all other elements constant.

Nitrogen: Nitrogen deficiency symptoms have been manifested by the yellowish stunted growth and firing of the lower leaves. The lemon color so desirable in flue-cured tobacco, can be developed only when the nitrogen supply of the plant is under close control. Excessive nitrogen will destroy the quality of the leaf. On the other hand, yields must be relatively high if
the crop is profitable to the grower. To obtain both yield and quality, nitrogen can be used only in limited quantities. In the early history of the flue-cured tobacco production in Georgia when the crop was topped comparatively low and kept well suckered, it was believed that 25 pounds of nitrogen per acre were sufficient. During the last 10 to 15 years the tendency has been to top extremely high or not top at all.

More nitrogen has, therefore, become necessary to produce additional growth made under these conditions. Present recommendations are that 30 to 36 pounds of nitrogen per acre be applied. Twenty years ago large quantities of organic nitrogen were used to produce the rich, orange-colored leaf so much in demand at that time. While organic nitrogen does not leach as readily as the more soluble forms of nitrogen, results from tests including organic, nitrate, urea, and ammoniacal nitrogen, show that while there may be seasonal variations in yields and quality from these forms, there is little difference in the averages over a five-year period.

Phosphorus: In 1927 rates of phosphorus tests which included one treatment receiving nitrogen and potash but no phosphorus, and one receiving no fertilizer, were started in virgin Norfolk soil. There was no difference in growth on the treatments receiving no fertilizer and no phosphorus. In the same series, treatments receiving phosphorus and nitrogen in one case, and phosphorus and potash in another case, made approximately three times as much growth as the no-phosphorus and no-fertilizer treatments. Further experiments have shown that approximately 80 to 100 pounds of available P₂O₅ are required to produce optimum yields and quality on Coastal Plain soils. All forms of readily available phosphorus tried, which include superphosphate, dicalcium phosphate, and monobasic ammonium phosphate, have been found satisfactory.

Potash: One of the most outstanding facts obtained from the first tobacco fertilizer tests at this Station, was the need for liberal applications of potash. Normal applications of potash at the time these tests were begun, ranged from 25 to 30 pounds K₂O per acre. Recommendations were made in 1924 that 50 pounds K₂O per acre be applied, but in recent years, recommended rates have been increased to range between 100 and 120 pounds K₂O per acre.

In the absence of sufficient potash, leaves of the plant have a narrow and droughty appearance. As maturity approaches, these leaves begin to fire around the margins and between the veins. Generous applications of potash increase the size and smoothness of the leaf, resulting in increased yields of better quality. Elements with which potash is combined in fertilizer materials, govern the sources from which the potash in tobacco fertilizers should be obtained. These elements will be discussed under their respective headings. It is sufficient to say here that two units of potash should be derived from muriate of potash and, if sulphate of potash magnesia is to be used as a source of magnesium, enough of this material should be applied to supply at least one unit of soluble magnesium (MgO). The remaining potash may be derived from any source other than chlorides.

Calcium: While considerable work has been done on the calcium content of fertilizers, it cannot be said that any very definite information has resulted. Omission of all calcium from treatments for 12 years, has not as yet resulted in any symptoms of deficiency in the growth of the tobacco plant. Quantities
as high as 140 to 180 pounds CaO per acre have shown indications of promoting a vigorous green late growth. Apparently the optimum rates of calcium applications in mixed fertilizers, range somewhere between 30 and 100 pounds CaO per acre.

Magnesium: As in the case of calcium, symptoms of magnesium deficiency have not developed on treatments from which this element has been omitted for 12 years. However, well pronounced cases of magnesium deficiency have been observed in the Georgia flue-cured area and it is known that most Coastal Plain soils are deficient in this element. Symptoms of magnesium deficiency are easily identified by the bleached-out, almost white, color of the areas between the veins of the lower leaves while the areas adjacent to the veins remain green. Based on the known deficiency of the Coastal Plain soils rather than any experimental data obtained in this area, it is recommended that all tobacco fertilizers contain two units of magnesium (MgO), one-half of which should be water-soluble. Sulphate of potash magnesia is an excellent source of water-soluble magnesium. Dolomite limestone may be used for the water-insoluble portion of the mixture.

Sulphur: It has been comparatively easy to develop symptoms of sulphur deficiency on tobacco plants by omitting all sulphates from the fertilizer applications. Plants grown under such conditions develop a yellowish mosaic pattern of intermingled green and yellow areas on the lower leaves. There is some stunting of growth. These symptoms are accentuated by dry weather and, in extreme cases, there may be some firing of the lower leaves. Yields are low and the cured leaf has a greenish orange color.

Experiments indicate that there is some correlation between the amounts of sulphur and potash required for optimum growth. Mixed fertilizers with a high sulphur and low potash content, produce a small droughty-type growth that ripens rapidly. If the potash (K₂O) content of such mixtures is increased to equal that of the SO₃, this condition is avoided and normal growth and ripening occur.

From the data available, it is believed that the SO₃ content of tobacco fertilizers should be approximately 100 to 125 per cent of the K₂O content. In commercial mixed fertilizers that contain relatively high percentages of calcium, more sulphur apparently does no harm. The figures given above are minimum rather than maximum quantities.

Chlorine: Results from tests carried on over the period 1922-32 inclusive, show rather conclusively that potash salts high in chlorine would produce larger yields than sulphates of potash. However, burn tests made on the tobacco produced on these treatments, showed equally conclusively that chlorine in large quantities had a very depressing effect on the fire-holding capacity of the cured leaf. When equal parts of potash were derived from sulphate and muriate in treatments receiving 60 pounds K₂O per acre, yields dropped slightly but the leaf burn was almost as good as from the all-sulphate treatments. Based on these data, recommendations since that time have been that all tobacco fertilizers carry two units of chlorine. This quantity of chlorine will increase the yield over all sulphate mixtures but does not depress the burning quality of the leaf to any marked degree.

Boron: Ten years’ results on treatments receiving 12 ounces and 54 ounces of elemental boron per acre, have shown no benefits from the smaller
application, but have shown highly toxic effects in the form of high mortality of seedlings and stunting of early growth, from the heavier treatment. There has been no evidence of boron deficiency during this period, on treatments receiving no boron.

**OTHER MINOR ELEMENTS:** Use of reagent chemicals in an effort to determine if Coastal Plain soils are deficient in copper, iron, manganese, and zinc, has given no evidence that these elements are deficient on the location used.

**RATES OF FERTILIZER APPLICATIONS:** Experiments with rates of applications, ranging from 800 to 1,800 pounds of fertilizer on both the Norfolk and Tifton soils, have shown that the Norfolk soils will respond to somewhat heavier fertilizer applications than the Tifton soils. The amount of fertilizer that can profitably be used will depend on the natural fertility of the soil. In most cases applications should be from 1,000 to 1,200 pounds per acre of a 3-9-9 or 3-10-10 mixture.

**METHODS OF APPLYING FERTILIZERS:** A study of methods of applying fertilizers has shown that heavy applications directly under the row will cause a high death rate of seedlings in dry weather. Thorough mixing of the fertilizer with the soil in the row will reduce this loss. While placing the fertilizer to the side of the row gave the smallest death rate of seedlings, this method is not practical unless special machinery is available.

**Lime:** Applications of dolomitic (magnesium) limestone and calcic (marble screenings) limestone have been of no value when made on tobacco soils at this Station.

**Animal Manures:** Both cow and stable manure are valuable in producing high yields and better quality tobacco than can be produced with chemical fertilizers alone. On the basis of present prices of tobacco, these manures increase the gross returns about $35.00 for each ton of manure used, if not more than four tons are applied per acre. These figures are based on 11 years' results with unweathered manure.

**Spacing in Drill:** Seven years' results from spacing tests, with plants 12, 18, 24, and 36 inches in the drill and rows 4 feet apart, show that the optimum spacing is somewhere between 18 and 24 inches when plants are topped at 16 leaves. From these tests it is quite evident that an acre of soil can produce only a certain number of full-sized leaves. Close spacing should be accompanied by low topping, and wide spacing by high topping. Nothing is gained by close spacing and high topping, and the risk of drought damage is considerable.

**Topping:** During the period, 1924-27, tests were made to see how much loss of weight and quality resulted from not topping compared with proper topping and suckering. Results show average losses of 300 pounds of cured leaf per acre and 5 per cent in quality, were caused by not topping or suckering. There is also danger of severe damage from drought to plants that are not topped. However, if it is not possible to keep suckers removed, it is much better not to top the plant than to top it and allow the suckers to grow.

**Curing:** Because of variations in tobacco as it comes from the field, it has not been possible to work out a schedule of temperatures and ventilation that
is applicable to curing, except in a general way. This information is available in mimeographed form.

Studies of the comparative costs of wood, oil, and coal used as fuels for curing, have been made for several years. When both labor and fuel costs are considered, curing can be done much cheaper with coal than with either wood or oil. However, the installation of automatic coal stokers requires electric current, and coal stokers are more expensive than oil or wood burning equipment. Where electricity is not available, oil is cheaper than wood, if labor costs are included.

**Seedbeds:** Bulletin No. 38, published in November 1943, summarizes 17 years’ work with tobacco seedbeds. This publication covers, in considerable detail, seedbed soils, location, preparation, fertilizing, seeding, covers, drainage, protection from cold, top dressing, and care of the bed during the transplanting season. Bulletin 38 is available upon request.

**Varieties:** Since the beginning of variety testing in 1923, there has been a decided change in the type of tobacco demanded by manufacturers. During the period 1923 to about 1927, manufacturers preferred a well-bodied light orange leaf that could be best produced with such varieties as Yellow Pryor, Cash, and Jamaica. With the rapid increase in cigarette consumption during the boom years of 1928 and 1929, the trend turned to light, highly colored tobacco of good burning quality. This trend has continued, and at the present time, while all tobaccos are high, the companies are most anxious to buy the light, sweet, over-ripe tobaccos of good burning quality. These types can best be produced with such varieties as Gold Dollar, Virginia Bright Leaf, Yellow Mammoth, and Bonanza. Soil variations make it impossible to state definitely that one variety is superior to all others. While the 400, 401, and 402 varieties are used by numerous growers, they produce a thin papery leaf, somewhat lacking in body, when grown on Coastal Plain soils. However, all three of these varieties show definite resistance to the root-knot nematode and produce somewhat higher yields than standard varieties now in use. They are also about ten days later maturing.

**SUMMARY OF FINDINGS ON FLUE-CURED TOBACCO DISEASES 1921 TO 1944**

Root knot nematode (*Heterodera marioni*) and blue mold (*Peronospora tabacina*) have been the two most important diseases affecting the Georgia tobacco crop in the last 15 years. Stem rot, or Southern root rot (*Sclerotium rolfsii*), has occasionally caused serious damage in a limited number of fields, but average losses from this disease have been slight. Disease control experiments have been confined primarily to root knot and blue mold.

**Blue Mold**

Blue mold made its first appearance in the Georgia flue-cured area in the spring of 1931, after having spread eastward from the Perique tobacco area of Louisiana, where it had developed a few weeks earlier. The fungus had been observed on native or wild species of *Nicotiana* earlier than 1931, in Texas and states farther west, and since then it has been observed a number of times in these same states. The fungus apparently is native on wild Nico-
tiana in the West from which it eventually spread to cultivated Nicotiana in the East.

The blue-mold fungus lives over from one season to the next in plant-bed soil or in soil containing diseased leaves, and readily attacks tobacco seedlings grown in the same location the following season. Fungal spores from the mold on the underside of affected tobacco leaves, may be scattered by winds for many miles in a very short period, with the result that practically all tobacco beds throughout the Georgia area may become affected each spring within 30 days after the initial outbreak in a few old beds. These old beds are, therefore, often directly responsible for the annual recurrence of the disease.

Prevention of Early Mold Attacks by Cultural Practices: Elimination of all old tobacco beds and prevention of all holdover and volunteer plants, should materially delay the initial outbreaks each winter, and possibly could, for a time, eliminate the disease entirely from the flue-cured tobacco belt. Full cooperation of all tobacco growers would be necessary, however, before eradication of the fungus could be expected, because only a very few old affected beds could initiate a widespread attack that would involve the entire tobacco area of the state in one season.

First infections each winter are observed in early sown beds, especially in old beds sown early. Observations have indicated that the disease could be delayed at least two weeks, and much of the plant loss prevented, if beds were not sown before the last week in December. The earlier the beds are sown, the earlier the mold may develop. Greatest damage is invariably inflicted in the first beds attacked, and in beds where plants are smallest. While the fungus readily attacks all ages of plants, those with six leaves and smaller are much more likely to be killed than plants nearly large enough to set. Elimination of a few early beds will help materially to protect seedlings in the majority of beds sown the last week in December.

The mold fungus, an obligate parasite, cannot develop except in the growing host plant, and then only when the plants are growing during the moderately cool seasons of the year. Aside from tobacco, the only plant crops susceptible, are pepper, tomato and eggplant. These three are usually sown much later in the season than tobacco and hence are not responsible for the initial early outbreaks each season.

Mold Control by Temperature Regulation: Under normal light and atmospheric conditions, mold causes practically no damage when the mean temperature is 70 degrees Fahrenheit, or when the temperature is kept constantly at 70 degrees Fahrenheit. This is why the disease does not develop in Georgia during the summer months. Each year the disease reaches a peak of activity when the spring temperatures approximate a mean of 57 to 60 degrees F.—usually in late February or in March. In late April and May, as the temperatures rise, activity greatly diminishes and in June the disease completely disappears.

Regulation of temperatures in tightly constructed beds covered with glass or suitable glass substitutes, has successfully controlled mold in test beds. Such beds must be provided with suitable ventilation and adequate watering, as well as an artificial heating system capable of maintaining the desired
temperature of 70 degrees or above in occasional freezing weather. Prolonged exposures of 90 degrees several hours each day, will hold the disease in check provided adequate sunlight is available. The disease is much more severe in shaded or partially shaded locations, than in direct sunlight; and also more severe in midwinter when the days are short and sunlight less intense. Exposures of 110 degrees for 4 or 5 hours, usually kill out the fungus inside affected leaves, and actually cure diseased plants. Thus it is possible by temperature regulation alone to completely control this disease. However, actual tests have demonstrated that the heat method is excessively expensive, cumbersome and impractical under Georgia conditions. Simpler and much cheaper control methods are available.

**Mold Control by Gassing Plant Beds:** Paradichlorobenzene is accepted as the most practical chemical in gassing for blue mold prevention and cure. Benzol, toluol, xylol, paraaldehyde, monochlorobenzene and orthodichlorobenzene are also effective control materials, but these are liquids and more difficult to use than crystalline materials. The No. 6 grade of paradichlorobenzene has proved most satisfactory. Aside from the paradichlorobenzene, the only material needed for successful gassing, is a heavy cloth canvas or cover for placing over the bed to hold in the vapors. This cover is essential for successful control. The treatment consists of broadcasting $1\frac{1}{2}$ to 3 pounds of crystals per 100 square yards on top of the regular cover, and of confining the vapors by covering the bed an entire night with the heavy canvas.

**Directions for Gassing with Paradichlorobenzene:** Method No. 1. From 15 to 25 pounds of paradichlorobenzene per 100 square yards and a heavy cotton sheeting (60 to 65 mesh)—large enough to cover the entire plant bed and overlap at the sides and ends—are required. A good grade of closely-woven cotton bagging may also be used where available, instead of the sheeting. This should be sewn in one piece to fit the plant bed. The regular tobacco bed cover, which is kept on the bed all the time, should be stretched flat and tight over the bed, and it should be free of holes. The crystals may then be sown directly on top of this cloth, immediately after which the heavy canvas should be carefully rolled over the top so that the material is held between the two layers of cloth. Plenty of supports must be provided to keep the cloth from sagging and touching the plants.

Three pounds per 100 square yards should be applied two to four times a week, or every night until the disease is checked, if infection has already occurred. Usually three or four successive nights of treatment are required to eliminate mold from a plant bed, although two nights a week sometimes will be sufficient. The important thing to remember about gassing is that the material should be used at night. The treatment should be started shortly before sundown; the cloth should be left on all night, and removed by 10 o'clock the next morning.

**Method No. 2.** Only 8 to 12 pounds of paradichlorobenzene per 100 square yards and a somewhat smaller canvas, are required for this method. Remove all supports that hold up the cover so as to permit the regular cover to rest directly on top of the plants. This should be done only on nights of treatment. Apply only a half dose, or $1\frac{1}{2}$ pounds of paradichlorobenzene per 100 square yards, by scattering the crystals directly on top of the cloth resting on the plants. Then carefully place the heavy sheeting on top of the regular cover.
Begin the treatment just before sundown, and remove the cover the next morning before 10 o'clock. This method has some advantages over the other, in that less material is required and it is not necessary that the heavy cloth be in one piece, or that it be larger than the bed. From two to four night treatments a week are sufficient to keep mold under control.

With either method, the same heavy cloth may be used on alternate nights, on two similar beds; provided treatments are not delayed until the disease becomes severe in both beds at the same time. Gassing is cumbersome and less practical than spraying.

Warning. Paradichlorobenzene is not effective in freezing weather because the crystals do not volatilize sufficiently at very low temperatures. Also, in unseasonably warm weather, volatilization is so rapid that the vapors may cause severe plant injury if the heavy cover is kept on when the sun is shining.

Blue-Mold Control by Spraying: Several effective spray treatments have been developed within the past ten years, and during this period, spraying proved to be the cheapest and most practical method of control. Irrespective of the spray formula to be used, it is necessary that spraying be done regularly (twice a week), and that applications be started before disease development in the bed and continued until the danger of severe infection has passed. Usually 8 to 12 applications a season are necessary.

It is also important that at least three or four gallons of spray mixture be applied per 100 square yards at each application when the plants are small, and that this amount be increased to five or six gallons when the plants develop leaves larger than a silver dollar.

When mold first begins to develop, the amount of spray should be increased to the maximum, regardless of size of plants. Spray treatments will not cure plants of mold as is done by heat treatment and by gassing, but if started in time, will prevent severe attacks and avoid delay and plant shortage. This is all that is necessary, because plants not severely affected by mold, soon recover, grow normally and produce normal tobacco when set in the field. Moreover, recovered plants are resistant to a second severe attack, so that any treatment which permits slight infection but prevents plant loss and delay, may be discontinued as soon as all plants have become infected and have started to recover.

Fermate Spray for Blue-Mold Control: This is one of the simplest spray treatments known. It does not always give best control, but is effective enough under most conditions to be recommended. It may be used at the rate of three pounds per 100 gallons of water, and 1½ pounds are enough for 100 square yards one season.

Material for Mixing 25 Gallons of Spray

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Fermate</td>
<td>12 ounces</td>
</tr>
<tr>
<td>Vatsol OTC (optional)</td>
<td>4 ounces</td>
</tr>
<tr>
<td>Water to make</td>
<td>25 gallons</td>
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</table>

Fermate may be used without the Vatsol, if desired. Except in hot weather, the amount of Fermate may be increased to 16 ounces per 25 gallons of water.

Bismuth Subsalicylate: This is one of the most effective spray treatments known. About one-half pound of bismuth will be sufficient for 100 square
yards for one season. It is used at the rate of 1 1/2 pounds per 100 gallons of water. Only 6 or 8 applications a season are required, because the bismuth enables the plants to build up resistance to mold attack so that it is not always necessary to continue spraying after the plants have become attacked and have recovered.

**Material for 25 Gallons of Spray**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Bismuth Subsalicylate</td>
<td>6 ounces</td>
</tr>
<tr>
<td>Vatsol OTC</td>
<td>2 ounces</td>
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<tr>
<td>Water to make</td>
<td>25 gallons</td>
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The bismuth and Fermate sprays are the two most practical and simple mixtures to use.

**Fermate-Salicylic Acid Mixture:** A combination of small amounts of Fermate and salicylic acid, has given most outstanding blue-mold control and has consistently been more effective than larger amounts of either material used separately. This promises to be the cheapest and most effective treatment.

**Material for Preparing 25 Gallons**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Fermate</td>
<td>4 ounces</td>
</tr>
<tr>
<td>Salicylic acid</td>
<td>1 ounce</td>
</tr>
<tr>
<td>Vatsol OTC</td>
<td>1 ounce</td>
</tr>
<tr>
<td>Water to make</td>
<td>25 gallons</td>
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</table>

This mixture proved most successful when mixed at the time of spraying. The salicylic acid and Vatsol powders (wetting agent) should be pulverized to break all lumps before being mixed with Fermate. All three ingredients should then be shaken or stirred thoroughly in a small amount of water before the full amount is added. An ounce of zinc salicylate may be substituted for salicylic acid with equally good results. While this mixture may be considered cumbersome because it contains three ingredients, it is the cheapest spray tested and is more effective than bismuth subsalicylate.

Thiosan (tetramethylthiuramdisulfide) may be substituted at the same rate for Fermate in the above mixture, with either salicylic acid or zinc salicylate. When used alone, Thiosan is much less effective than Fermate, but in combination with either of these two salicylates, the Thiosan mixture rates among the very best.

The sprays listed below have been most effective when used with cottonseed or soybean oil emulsions, but these mixtures are somewhat more difficult to mix on the farm.

**Cuprous Oxide-Cottonseed Oil Mixture:** This was the original successful blue-mold control spray proved in 1935-37. Since it is more difficult to mix, it is no longer suggested as the most important spray treatment, although it was highly effective from 1935 to 1942.

**Material for Preparing 25 Gallons**

<table>
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<tr>
<th>Ingredient</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Yellow cuprocide</td>
<td>4 ounces</td>
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<tr>
<td>Vatsol OTC</td>
<td>4 ounces</td>
</tr>
<tr>
<td>Cottonseed or soybean oil</td>
<td>1 quart</td>
</tr>
<tr>
<td>Water to make</td>
<td>25 gallons</td>
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</table>
Zinc Salicylate-Cottonseed Oil Mixture: Zinc salicylate, when used in a vegetable oil emulsion, is more effective than any other oil spray mixture, and is almost as satisfactory as bismuth subsalicylate.

**Material for Preparing 25 Gallons**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Zinc salicylate*</td>
<td>2 ounces</td>
</tr>
<tr>
<td>Cottonseed oil</td>
<td>1 quart</td>
</tr>
<tr>
<td>Vatsol OTC</td>
<td>4 ounces</td>
</tr>
<tr>
<td>Water to make</td>
<td>25 gallons</td>
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</table>

*Note: The zinc salicylate should be dissolved in acetone or wood alcohol and then poured into the cottonseed oil.

Emulsifier B-1956, a commercial liquid preparation, may be used instead of Vatsol in any of these formulas. One-tenth of a gallon of B-1956 to each gallon of cottonseed or soybean oil, will make a self-emulsifying vegetable oil that will need no further addition of an emulsifier.

By using two or three applications of zinc salicylate at double the above strength, it is possible to check mold development with this mixture, provided spraying is started just as the very first symptoms begin to appear in the plant bed. Otherwise, plants should be sprayed at regular strength every three or four days.

Salicylic Acid-Cottonseed Oil Mixture: This mixture is slightly more effective than the original copper-oil spray, but under some conditions it causes more plant injury. A double strength of this mixture applied just before the critical time, or just as mold first begins to appear, will effectively prevent further damage. Usually three applications over a period of ten days, are sufficient, but the mixture should not be used on small plants because of the danger of injury. Regular strengths should be used twice a week during the blue-mold season.

**Material for Preparing 25 Gallons**

<table>
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<tr>
<th>Ingredient</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Salicylic acid*</td>
<td>1 or 1 1/4 ounce</td>
</tr>
<tr>
<td>Self-emulsifying cottonseed oil</td>
<td>1 quart</td>
</tr>
<tr>
<td>(90% oil and 10% B-1956 emulsifier)</td>
<td></td>
</tr>
<tr>
<td>Water to make</td>
<td>25 gallons</td>
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</table>

*The acid should be dissolved in wood alcohol before mixing with the oil.

Benzyl Salicylate-Oil Mixture: This is the simplest oil mixture to use and also is very effective and safe. A stock solution of benzyl salicylate, cottonseed oil and B-1956 emulsifier may be prepared in advance and used at the rate of one quart to 25 gallons of water. The oil in each of the oil mixtures, should be thoroughly emulsified by pumping it through the spray nozzle after mixing with a small amount of water.

**Material for 1 Gallon of Stock Oil Solution**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Benzyl salicylate</td>
<td>1/4 pint</td>
</tr>
<tr>
<td>Cottonseed oil</td>
<td>9/10 gallon</td>
</tr>
<tr>
<td>Emulsifier B-1956</td>
<td>1/10 gallon</td>
</tr>
</tbody>
</table>
A stock mixture without the emulsifier, can be made merely by pouring \( \frac{1}{4} \) pint of benzyl salicylate into a gallon of oil. This can then be used with Vatsol OTC as follows:

**Material for 25 Gallons**

- Benzyl salicylate-oil mixture ........................................... 1 quart
- Vatsol OTC ...................................................................... 4 ounces
- Water to make .................................................................. 25 gallons

**Blue-Mold Control by Dusting:** More recent tests have shown that Fermate dust is as effective against blue mold as Fermate spray. The dust can be readily prepared by mixing Fermate and Pyrax in the proportion of 15 pounds of Fermate to 85 pounds of Pyrax, making 100 pounds of diluted mixture.

The dust should be applied with a rotary hand-crank duster of sturdy construction, with a delivery pipe long enough to reach several feet into the bed. It should also be applied uniformly and with enough force to blow it evenly on all the tobacco leaves. Enough should be applied each time to show a visible dark deposit on the leaves. From one to one and one-half pounds of diluted dust are sufficient for dusting 100 yards of bed one time when the plants are small, but this amount should be increased to two or three pounds per application when the plants are half large enough to set.

Dusting should be done twice a week regularly, preferably at a time of the day when there is the least amount of wind. Early in the morning when the air is still and the plants wet with dew is usually considered the best time to dust, although tests have shown that dusting when the leaves are dry is also effective. The dust can be blown directly through the cloth so that it will not be necessary to remove the cover except on wide beds. Beds more than four yards wide cannot be dusted without removing the cover and walking on the plants.

Dusting is considered the easiest method of controlling blue mold. While it requires about twice as much Fermate as spraying, it does not require as much labor and time, especially where it is not necessary to remove the cover. As in spraying, applications of dust should begin before mold appears and be continued regularly every three or four days without interruption until the danger from mold damage is past. Small plants in the four-leaf stage have been dusted safely with Fermate.

**Control of Root Knot and Weeds in Tobacco Beds**

Several relatively inexpensive chemical soil treatments have been found reasonably effective in destroying both weed seeds and root-knot nematodes in tobacco plantbed soil. Uramon, Cyanamid, sodium nitrite, ammonium thiocyanate and “D-D” mixture (dichloropropylene-dichloropropene mixture) are among the most promising materials thus far tested. Sodium nitrite and Uramon are effective weed eradicants and give reasonable root-knot control, but they do not always give the highest plant yields. The other materials are most effective when used in combination with each other.
Cyanamid is an excellent weed killer but is not reliable against root-knot. "D-D" mixture successfully eradicates root-knot nematodes but is of little or no value against weeds. A combination of the two, however, is highly effective against both weeds and root-knot.

**URAMON AND CYANAMID TREATMENT FOR Weed AND Root-knot Control:**
An application of 100 pounds of Uramon plus 50 pounds of Cyanamid per 100 square yards of plantbed area, effectively controls weeds, insures a higher yield of usable plants during the transplanting season, and gives reasonably good root-knot control. The material should be broadcast in late September, or approximately three months before time for sowing the seed. The area should be thoroughly pulverized two weeks before time for the application and leveled to the proper contour. The best time to apply the materials is when the soil is moist, just after a rain. Since October usually is a dry month, late September is considered a better time to plan for the treatment. This treatment has consistently insured highest yield of tobacco plants per square yard.

Both the Uramon and Cyanamid should be broadcast at the same time and worked into the soil together. It is important to broadcast them uniformly and to mix the material thoroughly into the first 5 or 6 inches of soil. Any machinery or any method which will do this thoroughly, will be satisfactory. Disking several times with a heavy-duty disk is preferred. Where light-weight or horse-drawn disk harrows are used, it has been found advisable to disk the bed twice immediately after broadcasting; then turn about 6 inches deep with a one-horse turnplow, after which the bed is again disked twice. Whatever method is used, the bed should be dragged or smoothed carefully at the end of the operation. It should then be left undisturbed until time for sowing. The soil should not be harrowed deeper than one inch at the time of applying the fertilizer or at the time of sowing.

**"D-D" Mixture and Cyanamid for Root-knot and Weed Eradication:**
This treatment is highly effective against both nematodes and weeds. One-half gallon of liquid "D-D" mixture plus 100 pounds of Cyanamid are sufficient for 100 square yards of bed. They should be applied in late September or early October. The Cyanamid should first be broadcast and worked into the soil as described above. Approximately 2 cubic centimeters of "D-D" mixture should then be poured into small holes punched approximately 12 inches apart and 7 inches deep, after which the holes should be filled firm with earth. No further attention need be given the bed until time for sowing.

**Uramon and Ammonium Thioycyanate:** This combination, used at the rate of 50 pounds of Uramon and 50 pounds of Ammonium Thioycyanate per 100 square yards, is as effective against root-knot and weeds as Uramon and Cyanamid, but does not always insure the highest yield of plants per square yard. They should be applied in late September. The Uramon should be broadcast first. The Ammonium Thioycyanate is dissolved in water and then sprinkled over the soil uniformly with a sprinkling pot. The materials should then be worked uniformly into the soil in the same way as Uramon and Cyanamid.

**Sodium Nitrite for Weed and Root-knot Control:** This material has been highly effective against both weeds and root-knot nematodes in the light sandy soils of Georgia. However, its continued use in the same location for
more than a few years, is not advised because of excessive sodium residues that often result in poor stands of tobacco plants.

This material should be broadcast and worked into the soil in the same way and at the same time of the year as Uramon and Cyanamid, using 100 pounds per 100 square yards of area. It is much more expensive than Uramon and this, together with the fact that it does not always insure good stands, will make it less acceptable when more dependable materials are available.

Field Crop Rotations for Root-Knot Control

THREE-YEAR ROTATIONS: During the past 20 years, a continuous 3-year crop rotation test showed that more root-knot developed in tobacco planted after nematode susceptible cowpeas (Clay and Whippoorwill), sweet potatoes, and corn, than after other principal crops grown in South Georgia.

In this test, only two crops were grown in each rotation, tobacco being grown on the same land only one year in three, while another single crop was grown in each of the other two years. Tobacco grown after nematode-resistant cowpeas (Brabham and Iron) and after continuous tobacco culture, showed almost as much root-knot over the 20-year period as that after susceptible cowpeas. Less disease occurred after cotton, velvet beans and weeds; but even in these rotations the disease was very severe in some seasons. By far, less root-knot developed after peanuts (harvested Spanish) than after any other field crop. In only one year out of 20, was root-knot severe after peanuts. Bare fallow was even more effective than peanuts.

This test showed that in most systematic rotations, there was a tendency for root-knot to increase in severity as the rotations were repeated on the same land. This increase occurred after a few years in some rotations, but required more than ten years in others. Once maximum disease was reached, however, it did not consistently remain serious in all rotations, even where the same practices were followed through the years.

TWO-YEAR ROTATIONS: Two-year rotations, in which tobacco was grown every second year, were much less effective than three-year rotations. Maximum disease was reached in a few years time, even where peanuts and other resistant crops were grown. Crotalaria was superior to peanuts in preventing root-knot development where two-year rotations were tested.

COMBINATION CROP ROTATIONS: Further tests conducted from 1930-1939, indicated the advisability of planting a different crop on the same land every year. For instance, peanuts the first year, followed by oats and weeds the second year, with tobacco the third year, was a superior rotation to two successive years of peanuts followed by tobacco. Therefore in a three-year rotation, the use of three different crops will be preferable to two; and in a four-year rotation, four different crops grown over the four-year period, are preferable to either two or three different crops. Four-year rotations, involving the growth of cotton, peanuts, oats and tobacco, in the order named (or corn, peanuts, oats and tobacco), were more successful than three-year rotations, both from the standpoint of root-knot control and improved production of all the crops in the rotation.

INFLUENCE OF CROP ROTATIONS ON LEAF QUALITY: Highest leaf quality followed cotton, weeds and corn, with quality after Spanish peanuts and
cowpea hay, slightly inferior. Poorer quality occurred after velvet beans and bare fallow. A comparison of several legume crops, including Ootootan soybeans, Biloxi soybeans, Spanish peanuts, runner peanuts and Crotalaria, where all the crop residues were turned under, indicated higher leaf quality after Crotalaria than after the other legumes, but even then the quality was below average. While runner peanuts and Crotalaria are highly effective in rotations for controlling root-knot, these crops should not be used consistently in the rotation unless they are grown two years in advance of the tobacco crop. A first-hand knowledge of the fertility and productive capacity of the land will usually be sufficient to determine whether a soil-building crop can safely precede tobacco. It may sometimes be advisable to plant tobacco after soil-building crops on very thin sandy soils.

 Influence of Cover Crops on Root-Knot: Leguminous cover crops, such as Austrian winter peas and vetches, have not proved successful in tobacco rotations. Cover crops of oats or rye almost invariably increase the yield and dollar return of tobacco, but this increase is not always associated with a reduction of the root-knot disease. Cover crops of oats have been observed to increase root-knot in legume rotations but not in non-legume rotations. In both instances, however, the oat cover crop significantly gives an increased yield of tobacco and a corresponding increase in acre value. Oat cover crops are, therefore, profitable where they can be fitted into the rotation.

 Best results have been secured where the cover crop was sown in late September or early October, and turned under not later than the tenth of February. Cover crops encourage the propagation of cutworms, and if grown immediately in advance of tobacco, it is advisable to apply cutworm bait liberally at the time of transplanting tobacco seedlings.

 Use of Hay Mulches for Control of Root-Knot: Subsoil application of several tons of legume hay or mixtures of legume hay and pine straw per acre, have significantly increased tobacco yields on land very heavily infested with root-knot and meadow nematodes (Pratylenchus sp.). Applications have not greatly increased yields in disease-free lands.

 Three to four tons per acre of peanut hay applied in the drill in deep furrows directly underneath every tobacco row, or three tons each of peanut hay and pine straw applied in the same manner, have given equally good results. The organic matter was applied in October in deep middleburster furrows and immediately covered with enough soil to pack the hay and straw in the bottom of the furrow. Best results have been secured when there was enough rain during early winter to keep the soil moist and to partially decompose the organic matter.

 Fertilizer was applied on each side of the row the next spring. A fresh bed was thrown over the row and tobacco was set directly over the organic matter. The soil had to be several inches deep over the material to insure good stands of tobacco. Poor results were invariably encountered when the organic material was not buried deeply in the soil.

 Normal crops of good quality leaf have been produced by this method on land where tobacco has been grown for 15 consecutive years, and where untreated plots were damaged 50 percent or more by disease.
A SUMMARY OF SHADE TOBACCO RESEARCH
FOR THE PERIOD 1938 TO 1944

The Shade Tobacco Experiment Station, located near Attapulgus in Decatur County, Georgia, is a substation of the Georgia Coastal Plain Experiment Station. It was established in the late fall of 1937, primarily for work on shade tobacco problems. The original property, consisting of a 425-acre tract and several farm buildings, was purchased from the Mitch Hines estate. Many improvements have been made during the past eight years. Practically all original buildings have been replaced with modern structures and several others added.

The original experimental work consisted of preliminary fertilizer tests and a seed production project. Since then the experimental work has been expanded considerably to include the study of field fertilizers, seedbed fertilizers, seedbed weed control, control of diseases in the field, breeding for disease resistance, and truck-crop rotations in connection with shade tobacco production. A small group of horticultural tests was set up two years ago, which will be expanded in the near future.

Agronomy

Agronomy work, since the establishment of the station in 1937, has included nutrition tests, method of fertilizer application, seedbed fertilizer tests, and tobacco production.

Nutrition Tests: The nutrition tests were designed to determine the most profitable applications of nitrogen, phosphorus, potash, calcium, magnesium, sulphur, boron, and chlorine for shade tobacco production. Included in this group are tests to determine the relative values of several organic nitrogen carriers and the relative efficiency of certain combinations of organic and synthetic nitrogen. Other tests have been made to determine the best single phosphorus source. Briefly, the results obtained during the 7-year period covered by these tests, are as follows:

Nitrogen: The most profitable rate of nitrogen application has been 200 pounds per acre. Lower rates appeared inadequate except in years of low rainfall during the growing season. Higher nitrogen rates were toxic, retarding plant growth and causing difficulty in securing a stand of plants.

Phosphorus: Relatively high phosphorus rates have produced better results than the medium or low rates of application. The optimum for phosphorus has proved to be around 300 pounds $P_2O_5$ per acre.

Potash: Potash applied at the rate of 200 pounds $K_2O$ per acre, has given best results. Insufficient potash has produced very poor grading quality, mediocre burn, and caused some reduction in yields. Excessive potash tended to produce similar results. Increasing the potash rate up to the optimum of 200 pounds $K_2O$ per acre, has shown a corresponding increase in grading quality and fire-holding capacity; while increasing the phosphorus rate up to the 300-pound $P_2O_5$ per acre optimum, caused a significant increase in yield. Potash produces grade quality, primarily, while adequate phosphorus is essential to good yields.
**Calcium:** The optimum rate for calcium (CaO) appears to be around 300 pounds per acre, while magnesium, applied at 80 pounds MgO per acre, has given best results. These rates of calcium and magnesium applications appear to be essential to heavy yields and good quality. Either, or both, of these nutrients applied at excessive rates have caused marked reduction in grading quality and some reduction in yields.

**Sulphur:** The minimum sulphur (SO₃) rate used in the fertilizer formula has proved to be the most desirable. Sulphur applied at rates exceeding 175 pounds SO₃ per acre, have been detrimental to yields, grade quality, and burn of the leaf. High calcium rates have shown considerable tendency toward counteracting excessive sulphur applications.

**Boron:** Including small amounts of boron in the fertilizer formula has failed to increase the yield and grade quality, or to improve the burn of the leaf. Applications of four pounds of boron (elemental boron) per acre, appeared excessive.

**Chlorine:** Applying chlorine at the rate of 20 pounds per acre has shown no significant advantages over “no chlorine” treatments. This rate, however, failed to reduce the burn of the leaf.

**Forms of Nitrogen:** Deriving all nitrogen from cottonseed meal has given slightly better results than various combinations of cottonseed meal nitrogen, nitrate nitrogen, and urea nitrogen. Results indicate that little or no benefit is derived from nitrate nitrogen when included in the mixed goods and applied three weeks prior to transplanting. Urea nitrogen has worked well when included and applied with the mixed goods. Good results have been obtained when 25 per cent to 40 per cent of total nitrogen was derived from urea with the remaining 60 to 75 per cent nitrogen coming from cottonseed meal.

**Manure Tests:** Stable manure has given best results when applied at rates of 10 to 12 tons per acre. This organic has been successfully substituted for the oil-seed meals in comparative treatments. It has been found, however, that rates as heavy as 18 tons manure per acre, drastically reduce fire-holding capacity.

**Single Nitrogen Sources:** Tung oil meal and cottonseed meal were approximately of equal value and superior to whale guano, castor pomace, soybean meal, and peanut meal as single nitrogen sources.

**Single Phosphorus Sources:** Basic slag has proved superior to steamed bone meal, dicalcium phosphate, and superphosphate, as single phosphate sources. Superphosphate was the poorest source tested, probably due to its sulphur content. The excellent showing of basic slag in these tests is thought to be due, in part, to its high basic character.

**Summary:** A summary of the work on the nutrients discussed above indicates that the optimum shade tobacco fertilizer formula (for Tifton fine sandy loam) should carry approximately 200 pounds nitrogen (N), 300 pounds phosphorus (P₂O₅), 200 pounds potash (K₂O), 300 pounds calcium (CaO), 80 pounds magnesium (MgO), and 125 pounds (or less) sulphur (SO₃) per acre. Boron and chlorine should be excluded from the formula.

**Methods of Fertilizer Application:** This group of tests included several treatments to determine the relative values of different methods of fertilizer
application. Treatments differed only in placement of the fertilizer with reference to the plant, and time of application with reference to the date of transplanting.

Applying the fertilizer in equal parts 8 inches to each side of the row center, three weeks before transplanting, has been superior to splitting the fertilizer application, broadcasting, or applying all fertilizer in the drill. The all-in-the-drill (three weeks before transplanting) method of application was decidedly inferior to the other methods mentioned.

**SEEDBED FERTILIZER TESTS:** A series of seedbed fertilizer tests was set up in 1940. The object of this work was to determine the effect of different amounts of nitrogen, phosphorus, and potash on seed germination and seedling growth.

A 4%-nitrogen formula applied at the rate of one pound per square yard, produced earlier plants than higher or lower rates. The toxic effect of heavier rates delayed germination and retarded early seedling growth. One pound per square yard of a formula carrying 6% phosphorus (P₂O₅), produced earlier plants and a greater number per square yard than other rates. Potash applied at the rate equivalent to one pound of a 3%-potash formula per square yard seemed to be the optimum rate for earliness and total yield of plants per square yard.

The foregoing indicates that best results on seedbeds can be obtained with a 4-6-3 or similar grade of mixed goods, applied at the rate of one pound per square yard of seedbed area. Sources of nutrients for seedbed fertilizers:

- **Nitrogen:** 37 1/2% from cottonseed meal (6% N)
  62 1/2% from sulphate of ammonia
- **Phosphorus:** 100 % from superphosphate
- **Potash:** 100 % from sulphate of potash

**SEED PRODUCTION:** Approximately one-half acre has been planted annually to the Rg shade tobacco variety for seed production, since 1937. These seed are produced, primarily, for distribution to growers in the Georgia area.

All seed are produced under cloth to reduce the chances of crossing with undesirable varieties. Plants of undesirable, off-type character are topped out before the seed heads form, thus preventing cross pollination with plants saved for seed. The bulk of the seed crop is not bagged; however, a few plants of outstanding type are bagged and used as foundation stock for the succeeding crop. This method of selection insures desirable plant type from year to year.

Tobacco seed production has been an important part of the Station’s program since its beginning. Seed of good quality and desirable type have been grown and distributed to growers in this area each year.

**Shade Tobacco Diseases**

Diseases in 1944 did not cause serious damage to shade tobacco. During the past seven years, root-knot (Heterodera marioni) has been the most important field disease, but this usually caused very little visible damage except in sandy or loamy soils. Black shank (Phytophthora parasitica var. nicotianae) caused only negligible damage, because the resistant Rg variety was almost universally grown. Black shank was often observed in a limited
number of tobacco roots, but the infection was seldom observed to spread up into the stalk or to measurably affect growth. Frog-eye leaf spot (Cercospora nicotianae) and brown spot (Alternaria longipes) have sometimes been important leaf diseases affecting leaves on the upper half of the stalk, making early harvesting necessary in some fields to prevent excessive spotting and reduction in quality. Early in the field season, blue mold (Peronospora tabacina) often causes leaf spotting and flecking severe enough to ruin the wrapper value of occasional leaves on the lower half of the stalk. This spotting has been most prevalent in fields set unseasonably early, especially early fields set before the seedlings were affected by mold in the plantbed. Less spotting has been observed in fields set with mold-recovered plants, or from beds that had already been attacked.

During the past seven years, blue mold has not been a destructive plantbed disease in the shade area of Georgia. Usually the disease does not develop in most beds until the plants are large enough for transplanting. The only inconvenience to growers has been an occasional delay of a few days in transplanting. It has not developed each season until approximately one month after development in the flue-cured area, less than 100 miles away. It is usually not severe enough to justify expensive or elaborate methods of control, and in some seasons no control is required. Bismuth subsalicylate and Vatsol spray mixture and Fermate spray have proved safe and practical as control measures. Dusting beds with a 15-85 Fermate dust also is satisfactory and practical.

**Root-knot and Weed Control in Plantbeds:** A combination application of 100 pounds of urea and 50 pounds of Cyanamid per 100 square yards of plantbed, has given satisfactory weed and root-knot control in shade tobacco beds. The materials were broadcast at the same time and disked thoroughly into the soil some time in November or at least 60 to 90 days before time for sowing the tobacco seed. Success of the method depends entirely on the thoroughness of mixing the chemicals into the surface 5 or 6 inches of soil. The treatment is about as effective against root-knot as the steam pan method but slightly less effective against weeds and grass.

**Root-knot Control in Shade Fields:** While root-knot is generally present throughout the shade area, the need for control is most apparent in the light sandy or loamy soils. Excellent disease control has been secured in Faceville fine sandy loam soil, where root-knot was severe, by the use of soil fumigants and heavy applications of certain kinds of organic matter.

Soil fumigation, with either tear gas (chloropicrin) or D-D mixture (1, 2-Dichloropropane — 1, 3-Dichloropropylene), has effectively controlled root-knot under field conditions and has given good indications of preventing blackshank. The field use of both these fumigants is not considered very practical, since they are liquids, unpleasant to handle and must be applied by special technique several inches beneath the surface and then immediately covered with soil to prevent excessive loss through evaporation. Best results were obtained when the soil was treated two or three months before time for setting plants into the field. Approximately 160 pounds of tear gas or 200 pounds of D-D mixture were sufficient for one acre. Cost of the latter is around $40.00 per acre or about one-third the cost of tear gas. Since there is some question as to the effects of these fumigants on the smoking quality of leaf tobacco, it is not considered advisable to recommend their use at this time.
Very good root-knot control was obtained with 2,000 and 3,000 pounds of urea per acre, broadcast or drilled in tobacco rows in November or several months in advance of planting. Broadcast applications were disked and turned so as to thoroughly incorporate the urea into the first seven inches of soil. Drill applications were mixed somewhat deeper and in an area extending 12 inches on both sides of each tobacco row. Cost of this treatment is at least twice that of D-D mixture. At times a slightly lower leaf quality develops after urea treatments.

Applications in the drill of 18 tons of stable manure per acre, have given outstanding root-knot control and produced reasonably good leaf quality in shade tobacco grown on Faceville fine sandy loam soil. Best results followed applications made in November or several months before time for planting. The compost was scattered evenly in deep furrows under the tobacco rows and covered with two or three inches of soil. The following spring, fertilizer was applied to the sides of the row and a fresh bed prepared so that the tobacco plants could be set directly over the manure which was not disturbed at any time after it was applied. Four tons per acre of low grade dry peanut hay applied in the same way and at the same time as the stable manure also gave excellent disease control, although a slight reduction in leaf quality was sometimes noted. Quality appeared to be improved by applying 4 tons per acre of partly decomposed pine straw or forest litter in addition to the peanut hay. All of the above treatments gave normal or high yields.