NEMATOLOGY

In August, 1935, a nematology field laboratory was established in cooperation with the Division of Nematology, Bureau of Plant Industry, United States Department of Agriculture.

Preliminary work only was done in 1935. The program for 1936 includes work on the following projects:

- Chemicals as Soil Nematicides
- Active Migration of the Root Knot Nematode Under Field Conditions
- Host Range of the Root Knot Nematode
- Distribution of the Root Knot Nematode
- Relative Resistance of Plant Varieties to the Root Knot Nematode

Nematode injury on virgin soil.
TOBACCO

The experimental work with tobacco at the Georgia Coastal Plain Experiment Station is being conducted in cooperation with the Division of Tobacco and Plant Nutrition of the United States Department of Agriculture and the University of Georgia College of Agriculture.

This work is divided into two phases as follows: first, soils, fertilizers and varieties; second, disease investigations which include both control and preventive measures. In reporting this work it is believed that it is well to include general recommendations based on all of the work to date as well as reporting the progress of the work carried on in 1935.

SOILS, VARIETIES AND PLANT BEDS

Soils: The soils of the Coastal Plain of Georgia best adapted to the production of flue-cured tobacco are the light loamy friable or "fluffy" types of the Tifton and Norfolk soil series. The best types of these two series are the Norfolk sandy loams and the light phase of the Tifton sandy loam. The typical Tifton sandy loams which carry an abundance of small iron concretions or "pebbles" are too heavy for tobacco. Regardless of the type of soil used it should be well drained, yet have good water holding capacity; be soft and friable, warm up quickly in the spring and be fairly low in ammonia reserve.

Varieties: Many varieties of flue-cured tobacco will satisfactorily produce the type of tobacco now in demand. Of these, the Bonanza, Jamaica, Yellow Mammoth, Virginia Bright Leaf and Yellow Pryor are the most popular. These varieties are much better suited to growing the thin light type of tobacco than varieties such as Warne, Gold Leaf, Acock and the Gooches.

Plant Beds: The seed bed is the foundation of the crop and the proper preparation and care of these beds cannot be too strongly stressed. Seed beds should be located on a moist, deep loamy soil. Such soils are usually found growing gallberry bushes or blackberry briars. Soils that have washed down from surrounding fields are likely to be infested with the root knot nematode and therefore should not be used. In order that plants may be produced as early as possible the beds should have a south or southeastern exposure with natural or artificial windbreaks on the north and northwest sides. All trees on the east or southeast that shade the bed should be cut so that the sun can reach the bed throughout the day. Where equipment or material is available, sterilization of the soil used for seed beds is recommended. This may be accomplished by steam or burning with wood, or any other material available. Where the soil is to be sterilized it should be loosened up thoroughly before the
heat is applied. This enables the heat to penetrate the soil and do a better job of sterilizing. If it is not practical to sterilize, seed beds should be located on new areas each year. Fertilizer should be applied at the rate of from 2 to 3 pounds per square yard on new beds and 1½ to 2 pounds per square yard on old beds that have had previous applications of fertilizer. Only tobacco fertilizers should be used. The seed should be sown during the latter part of December or early in January. One well rounded tablespoon full of good clean seed per 100 square yards is sufficient.

FERTILIZERS

Phosphorus: This element apparently is almost entirely absent in the virgin soils of the Coastal Plain area. Since phosphorus does not readily leach from the soil, those soils that have previously received applications of this element will produce fair sized plants for a few years. However, continued cultivation without applications of phosphorus will eventually result in a failure of the plants to make any growth at all. Phosphorus not only increases the growth or size of the tobacco plant, but it promotes ripening and thereby improves the quality of the cured leaf. Plants deficient in phosphorus are small in size, of a dark green color and never ripen properly. Such plants are impossible to cure. Too much phosphorus results in a premature ripening or firing of the lower leaves and often in dry weather causes the plant to ripen faster than it can be handled to the best advantage. Experiments with various rates of phosphorus show that while 40 pounds of phosphorus (P₂O₅) per acre will give practically as much yield as heavier applications, it takes about 80 to 100 pounds per acre to give the proper combination of yield and quality. Stating this in the terms of field applications means that 1000 to 1200 pounds of fertilizer analyzing 8 per cent phosphorus (P₂O₅) is required to supply sufficient phosphorus for optimum results. The superphosphates or di-calcium phosphates are satisfactory sources of this element. However, where triple-superphosphate is used the calcium requirement of the plant must be considered.

Ammonia: The misuse of ammonia can destroy the quality of fine-cured tobacco quicker and more completely than either phosphorus or potash. It is therefore highly desirable to control as far as possible the amount and form of ammonia supplied the plant in the field. The absence of sufficient nitrogen produces a small thin leaf which usually cures well but does not yield profitably. Excess nitrogen produces a coarse rough plant low in quality and difficult to cure. Extremely heavy applications of nitrogen render the crop almost entirely unfit for commercial purposes. The ideal application is one that gives the maximum yield compatible with high quality. Results from tests with varying amounts of nitrogen show that the optimum applications will vary on different soils. Generally speaking, 30 pounds of ammonia (24.7 pounds nitrogen) per acre is sufficient. This is the amount contained in 1000 pounds of fertil-
izer analyzing 3 per cent ammonia. On light sandy soil the ammonia application may be increased to 40 pounds per acre. This may be done by using either higher analysis fertilizers or heavier applications of 3 per cent goods.

The materials from which the nitrogen in tobacco fertilizers is derived also have an important bearing on the quality of the crop produced. Without explaining in detail the advantages and disadvantages of the various materials (see Bulletin No. 22 for this information) it is only necessary to state here that the nitrogen in tobacco fertilizers should be derived as follows: one-third from high grade organic materials such as cottonseed meal, fish meal and high grade tankage, and two-thirds from inorganic nitrates or urea or a combination of these materials.

**Potash:** The amount of potash used and the sources from which it is derived have an important bearing on the quality of flue-cured tobacco. Extreme potash deficiency is characterized by small plants with rough crinkled leaves that fire between the veins and around the margin. Such extreme symptoms are not necessary to materially lower the quality of the cured leaf. Symptoms of potash deficiency have been observed where 1000 pounds of fertilizer analyzing 5 per cent potash was applied. Applications up to 80 pounds potash (K₂O) per acre have proved profitable and since there is little danger of applying too much potash with the formulas now available, it seems that it is advisable to apply as much as 80 pounds per acre, or 1000 pounds of fertilizer analyzing 8 per cent potash. It is entirely possible that heavier applications may be profitable but as yet no conclusive data are available along this line. Two units of the potash supply should be derived from high grade muriate of potash and the remainder from sulphate of potash or sulphate of potash magnesia, or a mixture of these materials.

**Magnesia:** Magnesia hunger or "sand drown" is not a very prevalent nutritional deficiency in the tobacco belt of Georgia but has been known to occur and should be guarded against. In order to avoid this trouble it is believed that all tobacco fertilizers should contain approximately 2 per cent magnesia, one-half of which should be water soluble. Sulphate of potash magnesia or other soluble magnesia salts, together with dolomitic limestone, are satisfactory sources of this element.

**Animal Manures:** Finely pulverized well rotted cow or horse manure may be very profitably used as a supplement to regular fertilizers under flue-cured tobacco. These materials should be drilled in the row at the rate of from two to three tons per acre and applied at least two weeks before planting. After the manure has been applied it should be covered lightly and left until the fertilizer is to be applied. The row should then be reopened and fertilizer applied as usual. Fresh raw manures should not be used.

**Fertilizer Formulas and Rates of Application:** From the previous discussion of the elements that make up tobacco fertilizers it can be seen that such fertilizers should contain approximately 8
parts phosphorus (P<sub>2</sub>O<sub>5</sub>), 3 parts ammonia (2.47 parts nitrogen) and from 5 to 8 parts potash. The mixed fertilizer need not conform strictly to an 8-3-5 or 8-3-8 analysis but it is desirable that these proportions of phosphorus, ammonia and potash be maintained. The higher potash formulas are to be preferred over the 5 per cent goods. The rate of application of fertilizer for tobacco will vary with the natural fertility of the soil. On the light sandy Norfolk soils 1000 ot 1400 pounds per acre may be used profitably. On average soils 1000 to 1200 pounds per acre is sufficient.

**SPACINGS**

Spacing in Drill and Row: Crowding tobacco either by placing the rows closer than four feet or the plants closer together than 22 inches in the drill has no advantage. Closer spacings increase the yield slightly but reduce the quality. Where plants are crowded stems are long and spindling and leaves small and lacking in quality.

**CURING**

Curing: The schedule to be followed in curing flue-cured tobacco will vary with so many conditions that it is impossible to give one that will apply except in a general way. Such a schedule is given in Bulletin No. 22 of this Station which may be had upon request. Proper curing is easily done when uniform well ripened tobacco is harvested and close attention given it until the curing finished.

**PROGRESS REPORT ON TOBACCO TESTS BEGUN IN 1933**

As stated in previous reports, a greater part of the tobacco work was revised in 1933. A brief summary of prior work has been given in the foregoing discussion and as the time covered since 1933 has not been sufficient to justify conclusions, whatever is published regarding the new work may be considered only a report of progress.

Ammonia Tests: Farm animal manures (cow and horse) are valuable in improving the yield and quality of flue-cured tobacco. These manures may be used as a source of all the nitrogen, as the organic part of the nitrogen or as a supplement to the standard application of commercial fertilizer. Where used as the total source of nitrogen four to five tons per acre should be applied. To supply needed organic nitrogen three tons per acre is sufficient and two tons per acre serve as a good supplement to the regular fertilizer application. The manures used were well rotted, finely pulverized and were applied about ten days before the fertilizer. There was but little difference in the results from the various nitrate nitrogen materials. Cottonseed meal as a sole source of ammonia gave excellent quality but did not give as good yield as some of the manure and commercial fertilizer combination plots. No trouble was experienced from second growth on the cottonseed meal plots.
Complete Fertilizer Tests: These tests have been previously reported as "calcium and sulphur tests," which is misleading. All of the elements that are now believed to be important under field conditions are included in the fertilizer. The omission of any one of the following: nitrogen, phosphorus, potash, calcium, sulphur or magnesia, from the treatments results in distinct and characteristic symptoms. However, these omissions have not as yet destroyed the commercial value of the crop except in the cases of nitrogen, phosphorus and potash.

Formulas: The ratio of nitrogen, phosphorus and potash that should be carried in tobacco fertilizers should be approximately 8 parts phosphorus (P₂O₅), 3 to 4 parts ammonia (2½ to 3½ parts nitrogen) and at least 8 parts potash. There are indications that even more than 8 parts potash may be profitably applied.

Fractional Applications of Fertilizer: Results from these tests show that there is no particular advantage in dividing fertilizer into two applications, 60 per cent of which was applied previous to transplanting and 40 per cent 20 days later. Only in rare instances is top dressing justified or profitable. This practice often does more damage than good. However, where severe leaching has taken place early in the growing season 10 pounds of ammonia per acre from a quickly available source may be used to advantage. Such applications should be made not later than 20 to 25 days after transplanting.

Fertilizer Placement Tests: The placing of fertilizer in a band directly beneath the roots of tobacco seedlings caused a heavy mortality of plants. The same was true where the fertilizer was only slightly mixed with the soil around the roots. The best stands and highest per acre values were obtained where the fertilizer was placed 2½ inches on each side of the root crowns. The local method in which the fertilizer was thoroughly mixed in the soil with a shovel plow before listing the row also gave good yields and a good quality but was slightly inferior to the side placements. These tests are conducted in cooperation with the Bureau of Agricultural Engineering of the United States Department of Agriculture.

Potash Sources: These tests are a continuation of those reported in Bulletin No. 22 and the results are closely in line with previous findings.

Phosphorus Sources: There is little difference in the results from superphosphate, triple superphosphate, and di-calcium phosphate. Basic slag and finely ground raw rock phosphate are too slowly available to promote desirable growth and ripening.

Boron Tests: Boron applied at the rate of 4½ pounds boric acid per acre showed no toxic or beneficial results. An application of 42½ pounds of boric acid per acre was decidedly toxic and caused heavy loss of plants and approximately 60 per cent reduction in the value of the crop.
TOBACCO DISEASES

The 1935 tobacco crop was freer from disease losses than usual, in both plant bed and field. Weather conditions generally were favorable for good growth. The combined effects of slight disease damage and of a good growing season were primarily responsible for the highest production on record in the Georgia-Florida flue-cured belt, the average yield being 940 pounds per acre.

Seed bed diseases were of little importance, insofar as loss of plants was concerned; but downy mildew (blue mold) made its seasonal appearance and caused some delay in many beds just before time for transplanting. Although this disease was first observed in early March, it spread less rapidly than in previous seasons, with the result that many fields had been set before symptoms developed in all seed beds. This mild outbreak was associated with an early and abrupt spring season with only a few cloudy or foggy days. Warm weather in late March was unfavorable for spread of the mildew fungus (Peronospora tabaeina) and was responsible for the fact that it was less severe than in any season since 1932. Plants actually killed by mildew represented only a negligible percentage of the total. In a few of the earliest beds attacked, however, up to 30 per cent of the small seedlings were killed.

Damping off (Rhizoctonia sp. and Pythium sp.) caused a destruction of 40 per cent of the small seedlings in two observed beds during January. At this time symptoms were apparent in 25 per cent of the seed beds around Tifton. On the whole these diseases did not become serious generally, the average loss being negligible.

Associated with the early spring season, root knot (Heterodera marioni) appeared in many old beds and in some new locations late in the transplanting season. This disease has seldom caused actual damage to seedlings in plant beds, its principal importance being the danger of infested beds becoming sources of contamination for tobacco fields. The limited number of nematodes carried to the field in infested roots during 1935 did not have any great influence on the current season’s crop.

Root knot and sore shin (Schlerotium rolfsii) were the two most important field diseases in 1935. The combined losses due to these troubles probably did not exceed 5 per cent. Frog eye leaf spot (Cercospora nicotianae) developed to a slight extent in most fields late in the season, while mosaic became general on the suckers after the plants had been topped, but apparently neither of these diseases resulted in commercial losses.

OVERWINTERING OF TOBACCO MILDEW (“BLUE MOLD”)

Mildew has been first seen in tobacco beds each spring in or near Berrien County or along a latitude close to the center of the Georgia-
Florida flue-cured belt. It has not been seen in the more southern areas until at least two weeks later. Conditions have been more favorable for overwintering of the fungus in the central and northern half of the belt.

The disease was first seen in 1935 in an old tobacco bed but soon afterwards it could be found alike in both old and new locations. Since 1931 this mildew has been observed to appear first either in old beds or on holdover and volunteer plants, except in 1933 when it was first seen in a new bed. While it is apparent that this fungus overwinters in occasional old tobacco beds as well as on holdover and volunteer plants, the practice of sowing new beds each year and of destroying all holdover plants may not be expected to completely eradicate the fungus. However, observations indicate that the above practice diligently carried out would delay the initial outbreak each spring and do much to avoid early spread of the disease.

MILDEW ("BLUE MOLD") CONTROL IN HOTBEDS

Temperature studies in flue heated and electrically heated beds were continued in 1935. Results again showed that where minimum temperatures of 70° F. were maintained in glass covered beds, mildew was effectively controlled. High temperatures of 110 to 120 degrees carefully maintained for short periods each night for two or three nights in succession were sufficient to halt sporulation and further development of the fungus. This has been the only treatment thus far attempted that effectively checked the disease after it had already affected the plants.

Since this mildew has caused serious losses in only one year since its establishment in 1931, the adoption of expensive control measures would hardly be warranted just now. The practice of sowing more beds and of properly caring for them has sufficed to guarantee a normal supply of plants. During the last four seasons the need for protection from freezes has been more pressing than protection from mildew.

SPRAY TESTS FOR MILDEW CONTROL

A spray mixture consisting of 1 pound or 1½ pounds of red copper oxide, 1 gallon of cottonseed oil and ½ gallon lethane spreader in 100 gallons of water has proven superior to any other spray materials tested. Semi-weekly applications of this copper oxide-cottonseed oil emulsion successfully prevented serious outbreaks of mildew in 1935 while adjoining beds not treated were severely infected. Although sprayed beds became diseased, mildew did not become severe enough in them to delay transplanting. Beginning two weeks in advance of the outbreak and continuing until after the first pulling of plants, spraying was continued throughout the course of the disease. The treatment served as a deterrent rather than as a cure. It did not cause injury to foliage, in healthy or affected beds, and seedlings could be safely set in the field within 24 hours after having been sprayed. Stand of plants in the field
was slightly improved by applications of this mixture, a decided advantage being shown over applications of other copper containing sprays which sometimes resulted in poorer stands where seedlings were pulled and set soon after being treated. In this respect the copper oxide-cottonseed oil spray has proven superior to copper-soap and copper-lye-soap described in an earlier report.

A copper ammonia mixture commercially sold under the name of "Blue Devil" has been compared with other materials for the control of mildew. As has been observed from the use of most other copper containing sprays, this product showed slight value as a preventive and none as a cure. When applied in sufficient amounts to cover tender foliage it sometimes caused serious burning.

Except for growers experienced in this practice, spraying is not recommended at the present time.

ROOT KNOT CONTROL IN PLANT BEDS

Chloropierin applied to the soil at the rate of 750 and 1500 pounds per acre successfully controlled root knot in seed beds heavily infested with root knot nematodes. However, the higher application was necessary to eradicate all of the nematodes in the first 12 inches of soil. The lower rate permitted a small percentage of nematodes to survive, making additional treatments necessary the following season. Not many weed seeds were killed by chloropierin. Nut grass was eradicated by the higher application but not by the lower. The very high cost of this chemical (over $1.00 per pound) makes its use for such purposes prohibitive on a commercial scale. Because of high costs involved chemical soil treatments are receiving minor attention in plant bed tests for control of root knot.

The steam sterilization method, although considered too expensive for use by most growers, has been the most effective method tried for the combined purpose of eradicating nematodes, disease causing fungi, and weed seeds. As long as virgin lands remain that are suitable for seed beds, the practice of sowing new beds promises to be the most feasible one for root knot prevention. Where virgin lands have been scarce, two year rotations with fallow or velvet beans have shown some promise.

CULTIVATION PRACTICES IN RELATION TO ROOT KNOT

A field test is being continued to find out whether by cultivation practices root knot can be controlled where tobacco is grown every year. In 1935 increases in production up to 200 pounds per acre were realized where the tobacco stalks had been plowed out immediately after harvest the preceding season and where fallow cultivation was practiced every two weeks during late summer and fall. Cover crops of rye sown in late October or early November and turned under in early February slightly increased the yield. These increases in yield were associated with corresponding decreases in root knot. In addition, the quality of tobacco was improved by
these sanitary measures. Early tobacco planted in this series produced approximately 150 pounds per acre more than that set three weeks later. In other seasons still greater differences have been observed, but these increases due to the early plantings were not associated with nematode infestations. A comparison of ridge and flat methods of transplanting and cultivating tobacco has shown no marked influence on root knot damage.

**EFFECT OF CROP ROTATION ON ROOT KNOT**

**Three year rotations with individual crops:** The first field test, begun in 1925, consists of nine 3-year rotations of tobacco following two successive years of common field crops and one rotation of tobacco following two years of bare fallow. Root knot nematodes have not become sufficiently numerous in the peanut rotation (where peanuts are harvested) to noticeably affect succeeding crops of tobacco. The peanut (both runner and Spanish) has been much more effective than any other common field crop in preventing this disease. The practice of fallow cultivation for two seasons has been as effective in this respect as peanuts. Severe infestations in tobacco roots under these two systems have amounted to only 2 per cent or less since 1925. But infestations in tobacco after native weeds (crab grass, Florida pursley and beggarweed) and velvet beans have averaged between 12 and 15 per cent; and severe root knot after corn, cotton, sweet potatoes, Brabham cowpeas and continuous tobacco have exceeded 45 per cent.

Corn and cotton rotations have proved erratic and have not resulted in consistent root knot prevention. In 1935 tobacco grown after either of these two crops was free from excess nematode development.

Root knot damage was much less severe than usual in nearly all field plots and commercial fields in 1935, so that the results obtained in this single season are not indicative of the average. Excellent crops of tobacco have been grown in some seasons when as many as 50 per cent of the root systems were severely infested with nematodes late in the season.

**Influence of length of rotation on root knot:** Nematode activity has been more pronounced in two-year rotations than in longer ones. But, while two-year systems with weeds have been unsuccessful, tobacco grown every other year in rotation with either peanuts or crotalaria has been commercially free from serious root knot damage. Other crops tested have been less effective in two-year rotations.

Three-year rotations with native weeds have successfully prevented marked increases in nematode activity, where the principal weed involved was Florida pursley (Richardia scabra). But where Bull grass (Paspalum boscianum) and crab grass predominated, weed rotations of any length were much less effective. The most successful and at the same time practical three-year systems were
those with harvested peanuts and those with oats and weeds—when susceptible grasses were less numerous than Florida pursley and beggarweed. The growth of either cotton or corn the first year, harvested peanuts the second and tobacco the third has resulted in successful prevention of root knot the past four years.

Four-year rotations have been most effective and have resulted in cleaner tobacco than three-year systems. The growth of cotton, corn, harvested peanuts and tobacco over a four-year period and in the order named, promises to be a safe rotation in which both cotton and corn can be included. From a standpoint of improving crop production in general it has been found advantageous to change the crop on the same land each year.

**Weed and Forage Crop Rotations:** Within the past three seasons additional rotations have been started that involve the growth of tobacco in three-year rotations with 38 common weeds and forage crops. Among the several grasses being tested, Bull grass, a common weed in many tobacco fields, has been observed to be most susceptible to root knot. Tobacco grown after this grass in soil previously infested with nematodes has failed due to root knot. Crab grass, Sudan grass, Carpet grass and Bermuda grass are also susceptible to root knot but to a lesser degree. A continuation of these systems for several years will be necessary before the effects of these grasses can be determined definitely.

Lespedeza, both annual and perennial, although not always seriously affected by root knot, has already proven entirely too susceptible to be safe in tobacco rotations. The smaller and more common species of coffee weed (Cassia tora) was more resistant than the larger species (Cassia occidentalis). Ootoan soybeans, like Iron and Brabham cowpeas, was moderately susceptible to root knot, and adequate prevention has not resulted from the use of this crop.

*Root knot control by crop rotation. Tobacco on left followed two successive crops of sweet potatoes. Tobacco on right followed two successive crops of root knot resistant weeds.*