Future varieties will be fundamentally different. When black root rot resistance was established and the first root rot resistant variety Havana 142 was distributed, nothing new had been added that did not already exist in the cultivated tobacco species. On the contrary, the transfer of mosaic immunity to cultivated tobacco from the wild species *Nicotiana glutinosa* and the transfer of wildfire-blackfire immunity from *N. longiflora* introduced into cultivated tobacco genes that had not existed previously in the species. Such transfers of desirable genes from distantly related wild plants means that the cultivated crops we grow are being steadily improved.

In the past, tobacco variety improvement was limited to the genes and characters found within the one cultivated species. In the future, desirable characters may be transferred from any of the 60 plant species that make up the genus *Nicotiana*.

Resistance depends on genes. In tobacco the genes for resistance may come from two sources: The many different types of cultivated tobacco and the wild plants that are related to tobacco. A vital difference exists in the quality of the resistance that comes from the two sources. The resistance obtained within the cultivated tobaccos was always a degree of resistance and never immunity. Also it was controlled by many genes. On the other hand, in the related *Nicotiana* species we found immunity; and in several instances the immune reaction has been demonstrated to be simply inherited. In a word, resistance within the cultivated species is easy to obtain, but hard to use, and it may not be adequate. Resistance in the related wild species is difficult to obtain but, once obtained, it is easy to use, and it may prove to be immunity and therefore completely adequate.

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# Crop Rotations and Tobacco

**J. G. Gaines, F. A. Todd**

Crop rotation is of unusual importance in the production of flue-cured tobacco.

Rotation crops, such as sweetpotatoes and tomatoes, encourage the early establishment of destructive soil-borne diseases. The use of small grains often prevents disease losses. Other plants, such as crotalaria, may be effective in preventing disease, but have undesirable crop effects that result in poor quality of leaf.

Cultivated plants are not alone in exerting those influences. Weeds growing between seasons may be beneficial or harmful. Nor do the responses to crops and diseases remain constant. They have less influence in some seasons and more in others. So, too, with some soil-borne diseases, which may remain localized and be more destructive in some seasons and areas than in others.

Consequently, we have to consider a complex of crops, weeds, diseases, season, and location when we evaluate rotations in tobacco culture.

It used to be the custom in the Southeast to locate tobacco fields in areas newly cleared from pine forests and to grow tobacco continuously there until the soil failed to produce good crops. Then more new ground was cleared, and the process was repeated as long as any virgin land remained. Finally, growers were forced to use rotations, primarily because of root knot.
The fact that many growers in Georgia have reduced the amount of injury from root knot enough for successful tobacco culture for 30 years points to the value of crop rotation as a practical disease-control measure.

Granville wilt, or bacterial wilt, in North Carolina has been reduced by growing corn for 2 to 4 years. Redtop (Agrostis alba), hairy crabgrass (Digitaria sanguinalis), lespedeza, soybeans, and crotalaria also could be included in the rotation. Horseweed (Erigeron canadensis), ragweed (Ambrosia artemisiifolia), jimsonweed (Datura stramonium), and horse nettle (Solanum carolinense) were susceptible to infection, but the occasional growth of these weeds in a corn rotation did not nullify the beneficial effects of corn. Four years of bare fallow failed to eliminate wilt. Crop rotation was not uniformly successful when the soils were heavily infested. Limited short rotations and the use of a tobacco variety slightly resistant to wilt have proved adequate. The growing of tomato, pepper, peanuts, and potatoes and the continuous culture of tobacco encouraged wilt.

Fusarium wilt has been controlled in Georgia by 3-year crop rotations plus the use of the slightly resistant standard tobacco varieties. Rotations that failed to control root knot also failed to prevent wilt. Two successive years of oats plus weeds effectively controlled this root knot-wilt complex. Sweetpotatoes encouraged the establishment of fusarium wilt in tobacco soils. The same fungus disease attacks both crops. Wilt was limited in small areas before 1950. The rate of spread and establishment may be governed to a large extent by whether or not sweetpotatoes are grown in tobacco soils and by the degree of susceptibility of new tobacco varieties. There is also the possibility that more virulent strains of the causal fungus may appear in some areas.

Stem rot is influenced more by season than by rotation. Over a 20-year period, in a 3-year rotation test, however, less stem rot followed cotton and tobacco than cowpeas, corn, weeds, and peanuts. The greatest amount of disease, averaging 4 percent, followed velvetbeans. As much stem rot followed bare fallow rotations as corn and weeds. More stem rot occurred after leguminous cover crops if the residues remained than if the tops were removed. Increased stem rot was associated with severe root knot in those rotations.

Black shank also responds to crop rotation, but rotations alone are not always successful. Longer intervals are required between tobacco crops. Two years of clover, lespedeza, small grain, or grass crop followed by 2 years of corn (or cotton or harvested Spanish peanuts) have been reasonably successful. Limited rotations plus a moderately resistant tobacco variety have been adequate. Root knot sometimes influences the amount of black shank damage. At Attapulgus, Ga., the resistant Rg cigar-wraper variety develops severe black shank if root knot is present. This variety remained highly resistant in the absence of root knot. Highly susceptible varieties of tobacco, however, succumbed to black shank in nematode-free soil. Thus control of root knot alone is not enough to control black shank, unless it is combined with a variety that is moderately resistant to black shank. Growth of tobacco, pepper, tomato, and related plants encourages the development of black shank, even if resistant varieties of tobacco are used.

Nematode root rot is a little-known disease complex that also has been associated with crop rotation. Three-year rotations with small grain plus weed fallow or bare fallow were helpful in South Carolina. Corn, cotton, and crabgrass, as well as continuous tobacco culture, permitted the disease to become destructive. The oats-plus-weeds rotation helped materially in controlling the nematode root root-knot root-knot combination.

No accepted variety of tobacco has pronounced resistance to root knot,
and since the control of root knot is an important tool by which it is possible to keep other soil-borne diseases in check, rotation becomes more urgent than ever, especially in districts where black shank and fusarium wilt develop along with nematode diseases. Root knot nematodes occur over the entire flue-cured region from Virginia to Florida. Thousands of tobacco growers, particularly in the Carolinas, are faced with the grave problem of attempting to produce profitable crops on lands infested with two or more diseases. Good varieties of tobacco, which have adequate multiple resistance to these infestation complexes, are not available; existing varieties have to be supplemented by rotation. On the other hand, limited rotations are inadequate without the use of moderately resistant tobacco varieties.

To complicate matters, there are several recognized species of root knot and root rot nematodes. Some of them vary in ability to infest different crops. Closer attention than ever must be paid to them by grower and research worker alike. If previously effective crops fail to protect tobacco, one has to know that quickly so that other crops can be substituted in time. Also nematodes in time may become adapted to crops that are considered resistant.

Because root knot is more widespread than other recognized nematode diseases, extensive experiments designed for nematode control have been made at McCullers, N. C., and Tifton, Ga. A number of field crops were grown in continuous rotations with tobacco between 1925 and 1951 at Tifton and between 1937 and 1951 at McCullers. Experiments of shorter duration were conducted at both locations and at Florence, S. C. Annual records were kept of root knot in tobacco at the close of harvest. Yields, leaf grades, and occurrence of other important diseases were recorded. In general, wherever peanuts, soybeans, cowpeas, velvetbeans, and similar cultivated legumes were grown, the tops were removed in an effort to avoid the danger of adding objectionable amounts of nitrogen to the soil. Uniform fertilizer and cultural practices accepted in the respective States were followed throughout.

Leaf quality and yield usually are not affected by the equivalent of less than 50 percent severe root knot at the close of harvest. Unlike black shank, fusarium wilt, stem rot, and Granville wilt, which may cause death of the plant from a single infection, severe nematode infestation after mid-season may not cause measurable reduction in leaf grade or yield. Sometimes a root disease of 80 percent severity causes no measurable crop loss. If a well-developed root system is attacked by root knot nematodes and the roots do not break down readily, little damage may be done. Only when the weakened roots break down from secondary decay, caused by common soil organisms, do serious losses generally occur. If seedling roots are infested, marked stunting of plants may be evident from the outset. The earlier the attack the likelier is the secondary breakdown before plant maturity is reached. Usually the breakdown is slow acting, but when weakened roots are attacked by black shank and fusarium wilt, early death is more certain.

Root knot and other root nematode diseases commonly cause reductions in yield of 200 to 400 pounds an acre. Occasionally maximum losses resulting from root knot exceed 1,000 pounds an acre. Leaf grades, as well as yields, are materially reduced when a big part of the root system becomes affected by secondary decay.

Leaves harvested from these wilted and stunted plants are immature and may cure with a green or dull cast. If they are left on the stalk until ripe in appearance, they will be trashy, dark, lifeless, and of very low value when cured. Such immature leaves from severely wilted plants may contain excessive wilted plants may contain excessive nicotine and too little sugar.
Crop rotation controls nematodes by partial starvation through growth of resistant crops. Root knot nematodes require susceptible growing roots in which to develop and reproduce. The resistant crop plants are readily invaded by the nematode parasites, but the nematodes fail to mature and reproduce in them.

Two-year rotations, with tobacco grown alternately with a single resistant crop, are adequate in North Carolina and Virginia. Farther south, where the seasons are longer and conditions more favorable for year-round nematode and plant development, 3-year rotations are needed to give the same reduction. If an intermediate or susceptible crop is included in the rotation, longer intervals than 2 years are required between tobacco crops. Two years of bare fallow, used as an experimental check to compare with crops, were adequate to insure against root knot damage, but at least 3 or 4 years were needed to eliminate all infestations.

Crop rotations in which a resistant crop is grown may reduce root knot but will never eliminate it.

Rotation crops are rated according to their ability to prevent root knot in tobacco that follows them. Crops most effective in reducing subsequent nematode occurrence are regarded as most resistant.

Peanuts and oats, or other small grains, were the most effective field crops tested. Weeds were permitted to grow in the summer and fall after the small grain. Spanish (bunch) and runner peanuts were of equal value against root knot damage, but at least 3 or 4 years were needed to eliminate all infestations.

Crop rotations in which a resistant crop is grown may reduce root knot but will never eliminate it.

The bare fallow rotation (2 years of fallow and 1 year of tobacco) showed only 23 percent of slight to moderate root infestation, the lowest average of any rotation.

Crotalaria (C. spectabilis and C. intermedia) was of equal value to peanuts in other rotations. Highly effective grasses and sods were Dallisgrass (Paspalum dilatatum), the Pensacola variety of Bahiagrass (P. notatum), and centipede-grass (Eremochloa ophiuroides).

Of intermediate value in Georgia (but effective in 2-year rotations in North Carolina) were cotton, velvet-beans, and weed fallow where crabgrass grew among the weeds. In one 20-year test, excess root knot occurred in tobacco six times after two successive years of weeds, seven times after velvet-beans, and eight times after cotton. Other crops of only intermediate effectiveness at Tifton were Korean lespedeza (Lespedeza stipulacea), common lespedeza (Lespedeza striata), root knot resistant soybean, pearl millet (Pennisetum glaucum), and grain sorghum (Sorghum vulgare).

Corn was still less effective against root knot. It was followed by severe infestations in 16 tobacco crops out of 20. The test was on Tifton sandy loam soil. On Norfolk lowland sandy loam, where root knot was less destructive, corn rotations were more reliable. At no time did a maximum of 100 percent severe disease develop after corn, velvet-beans, and weeds. Cowpeas resistant to root knot were not much better than corn; the succeeding tobacco showed severe root knot 12 out of 20 years. Sudangrass (Sorghum sudanense) behaved about the same as corn.

Least effective of the rotation crops were cowpeas that were susceptible to root knot and sweetpotatoes. The only difference between the two varieties of cowpeas was that the more susceptible variety permitted maximum disease to develop within 3 years instead of 6. After that, the same amount of root knot appeared after both varieties. Severe disease was the rule after perennial lespedeza (Les-
pedezia cuneata), carpetgrass (*Axonopus compressus*), Bermuda-grass (*Cynodon dactylon*), chufa flatsedge (*Cyperus esculentus*), susceptible soybeans, tomatoes, pepper, squash, cucumber, okra, snap beans, and similar truck crops.

At McCullers, corn was slightly less effective than weeds, oats-weeds, peanuts, and cotton, but all were adequate to insure against severe losses throughout the 15-year test period. Redtop also was of value there. Thus it was easier to control root knot by rotation in North Carolina than in Georgia.

Small grains are the only reliable winter cover crops in tobacco rotations. Oats or rye, turned under in time for planting tobacco, have given slight but consistent reduction in nematode disease—not enough, however, to prevent excessive damage if tobacco was grown every year in the same field. The practice is of slight value only as a supplement to a good rotation. Winter legumes, such as vetch, Austrian winter peas, and lupine, are highly susceptible to root knot and tend to increase damage from disease.

**In Order to Determine weed influences on root knot, a number of common weeds were cultivated in 3-year rotations with tobacco.** It appeared that related species of weeds brought about different root knot responses. For example, sickle senna, or coffeeweed (*Cassia tora*), reduced root knot to a minimum, while another species, coffee senna (*Cassia occidentalis*), permitted severe disease in succeeding tobacco. The common Canada fleabane, or horseweed (*Erigeron canadensis*), was more effective than a similar fleabane (*E. pusillus*).

The weeds most effective in preventing root knot were no better than peanuts and crotalaria when used in 3-year rotations. Among the most resistant were coffeeweed, horseweed, ragweed, beggarweed (*Desmodium tortuosum*), and goldenrod (*Solidago microcephala*). Mexican clover (*Richardia scabra*) permitted slightly more root knot than peanuts or crotalaria but was more effective than dogfennel (*Eupatorium capillifolium*). Weeds that had intermediate value but permitted occasional excess disease were crabgrass, camphor plant (*Heterotheca subaxillaris*), bitterweed (*Helenium tenifolium*), and fleabane (*Erigeron pusillus*). Of still less rotation value were dogfennel and bull paspalum (*Paspalum boscianum*). Weeds that permitted severe disease consistently in a 7-year experiment were spiny amaranth (*Amaranthus spinosus*), slim amaranth (*A. hybridus*), cocklebur (*Xanthium chineense*), lambsquarters (*Chenopodium album*), drug wormseed (*C. ambrosiodes var. anthelminticum*), and coffee scnna (*Cassia occidentalis*).

The best natural weed fallow in North Carolina consisted of ragweed and horseweed, but crabgrass frequently predominated between annual row crops. Cultivation after a row crop or after small grain encouraged crabgrass. In Georgia, Mexican clover, crabgrass, bull paspalum, and camphor plant predominated after oats the first year, with occasional beggarweed, horseweed, and ragweed. The second year of weeds showed less grass and Mexican clover, with more horseweed, camphor plant, beggarweed, dogfennel, and goldenweed, *Aplopappus divaricatus*. The clean-cultivated cotton and peanuts discouraged all weed growth. Corn encouraged beggarweed, crotalaria, cocklebur, coffeeweed, crabgrass, and bull paspalum. Normally root knot susceptible weeds soon disappeared in a long weed rotation, but in short ones that did not occur. If soils are very fertile, a long period may be necessary to eliminate the susceptible weeds. Root knot has been observed in old abandoned barnyards 15 years later on lambsquarters and Jerusalem-oak (*Chenopodium botrys*). Such places, however, are not suitable for flue-cured tobacco.

**Conclusions regarding rotation effects cannot be drawn from short-**
time experiments—those continuing only 4 or 5 years.

At McCullers, root knot remained severe during the first rotation cycle. Then there was a steady decline in disease until a minimum occurred in 1946, 10 years later. During the following 5 years, there was a slight but unimportant increase. Those trends occurred in all 2-year rotations with oats, weeds, peanuts, cotton, and corn, but root knot remained severe throughout the 1937–51 period in continuous tobacco plots.

Striking differences occurred at Tifton between some rotation crops during the 1925–51 period. All the tested crops in 3-year rotations there permitted an increase in root knot up to or beyond the danger level. In contrast, bare fallow consistently prevented an increase in disease, and at no time was there any indication that this starvation method would fail.

The time required for nematode populations to build up to a crop-destructive level varied with the different rotations. In these 3-year rotations, maximum root knot occurred after 2 or 3 years of sweetpotatoes, susceptible cowpeas, or tobacco; after 4 years of corn-corn-tobacco; 6 years of nematode-resistant cowpeas; and 9 years of velvetbeans or native weeds; but not until 27 years after peanuts-peanuts-tobacco.

The results with the cotton rotation were quite unexpected. Like sweetpotatoes, cotton permitted a rapid increase in disease the first 2 years. Maximum root knot occurred the third and fourth years, after which there was a steady decline in nematode activity until this rotation reached the bare fallow level of minimum root knot activity 14 years later. An average of 100 percent of the tobacco plants after cotton were severely affected by root knot in 1930–31. This was in contrast to only 2 percent during the 1942–46 period.

The long-time rotation experiments have shown many successive periods of ascending and descending disease developments, plus some trends that extend over long periods. At both McCullers and Tifton there was a low disease activity in 1946, followed by a higher peak of activity in 1951. Many factors exist in the crop-soil complex. Some of them we do not understand fully. Rotation effects need to be evaluated on a basis of averages and not on the basis of results of 3 or 4 years. Any rotation is considered dangerous, however, if it permits several successive years of severe root knot.

A good rotation crop may lose its value temporarily if grown too often. In the 1925–51 peanuts-peanuts-tobacco rotation, root knot damage was negligible for the first 15 years, but remained excessive after 1946. In additional rotations, begun in 1944 where peanuts had not been grown before, infestations were reduced by peanuts between 1946 and 1950 but were increased to the destructive level in 1951. When one rotation crop permitted excess disease damage, the substitution of another one reduced disease.

Extended rotation experiments have shown that certain crops, notably oats and peanuts, have outstanding value and wherever possible the rotation should be varied. Behavior of the tobacco will indicate when the rotation crop should be changed. A number of crops, which are not highly effective in nematode control when used alone, can be used in combinations to good advantage.

For example, in the effective peanuts-oats-tobacco rotation for controlling root knot, corn can be substituted in place of peanuts. The substitution would make a better rotation in an area where Granville wilt is present, because peanuts are susceptible to it and corn is not. The crop sequence that places the most resistant crop immediately in advance of tobacco generally is to be preferred. Thus cotton-peanuts-tobacco is more effective than peanuts-cotton-tobacco.
Where it is practical to utilize a number of crops on the farm, it is desirable to change their sequence in succeeding 3-year cycles. For example, corn-oats-tobacco might be followed by cotton-peanuts-tobacco, and that in turn by peanuts-oats-tobacco. Millet, corn, and grain sorghum may be substituted occasionally with safety. Another plan might be to grow corn-oats-tobacco in succeeding cycles until that rotation begins to show excess root knot, and then change to another three-crop system. It is important to remember that any systematic two-crop or three-crop system, continued for long periods without change, may become less effective. For example, after 15 years in one location, peanuts-oats-tobacco rotations permitted severe root knot development. The expert grower will watch his tobacco crop closely each year and adjust his rotation to check disease build-up before it becomes destructive. He will also consider rotation in its relation to soil fertility.

When tobacco fields are abandoned and permitted to revert to weeds and finally to broomsedge and pines, the soil again becomes suitable for flue-cured tobacco. No better plants are known to condition the soil for tobacco than the original native vegetation. Early growers felt that cropping practices that kept the soil close to its virgin state were best for producing good leaf quality. That was sound reasoning. Of the crops compared in rotation tests, the best leaf quality followed small grain, cotton, corn, and some nonleguminous weeds. Quality was almost as good after harvested Spanish peanuts.

While crotalaria is an excellent rotation crop for nematode control, its use in a tobacco rotation is limited to poor and sandy or low and wet lands that have insufficient organic matter. With soils of average fertility, one crop of crotalaria may cause poor quality in the following tobacco crop.

In a time when emphasis is placed on increasing soil fertility to insure bountiful yields of food and fiber, it may seem a paradox that the best flue-cured tobacco can be grown only on relatively infertile soils. One important reason is that flue-cured leaf of the desired composition, texture, and aroma can come only from relatively healthy plants that receive limited amounts of nitrogen. To promote best yields, sufficient readily available nitrogen is essential during the period of most active growth. After that the supply must diminish.

Legumes, used as main crops or cover crops, are apt to cause too much nitrogen to be available late in the season, particularly if they are grown immediately preceding the tobacco. In the heavier soils, excess nitrogen may occur 2 years following legumes. This organic nitrogen causes the cured tobacco to be dark and thick; chemically the leaf is high in nicotine and low in sugar. It is not suited for cigarettes.

Consistently high yields followed oats or other small grain plus weeds, harvested Spanish peanuts, and nonleguminous weed fallow. Highest dollar returns followed those crops. Optimum yields as well as good leaf quality also followed ragweed and horseweed. Still higher yields occurred after leguminous crops such as crotalaria, beggarweed, and runner peanuts, but the tobacco was of poorer quality and dollar returns usually were reduced. Any increase in yield at the expense of quality is always undesirable.

The 1927-46 average yield of tobacco after weeds and harvested peanuts at Tifton exceeded 1,450 pounds an acre. Similar high yields, as well as top quality, followed oats during a 15-year period. As long as they effectively controlled root knot, the crops remained in this favorable position, whether they were grown in a two-crop system or included in sequence with still other crops.

All yields were approximately 200 pounds an acre less at McCullers than at Tifton. But at both locations total
production was approximately 500 pounds less an acre after continuous tobacco than after good rotation crops. Yields after root knot susceptible cowpeas averaged 100 pounds an acre more than continuous tobacco. Thus almost any rotation proved better than none.

While low yields were associated consistently with very severe root knot, highest production did not necessarily accompany the most effective rotation. Although control of root knot was commercially perfect after bare fallow, yields here were fully 200 pounds an acre less than in good crop rotations. These lower yields were associated with lack of organic matter and poor physical condition of the soil. In the absence of sufficient organic matter, cover crops of rye or oats have increased yields 100 or more pounds an acre without affecting leaf grades. On the other hand, lower yields comparable to those after bare fallow followed heavy sods of Bahia and Dallis grass where the sod had not completely decomposed.

In summary, nematode root diseases are serious problems throughout the flue-cured area, Virginia to Florida. They increase in seriousness with the more southern latitudes, being most destructive in Florida and least in Virginia. The basic system of crop rotation is adjusted to control nematode diseases, to maintain the soil in proper condition for production of quality flue-cured tobacco, and to aid in the control of other diseases, such as black shank, Granville wilt, and fusarium wilt.

For nematode control the small grains, especially oats, are helpful. Native weeds are good. Harvested Spanish peanuts are effective in most areas, but not if peanut-infesting nematodes are abundant.

Over long periods, a mixed rotation is better than any set system followed year after year, and almost any rotation involving nonlegumes is superior to continuous tobacco. There is also the possibility that as new varieties of rotation crops are released, their resistance to nematode diseases may differ from the old, and their value in the rotation will vary accordingly.

Maintaining the soil in proper condition to produce good tobacco involves careful watch over organic nitrogen residues in the soil. Crotalaria and runner peanuts, excellent nematode-controlling crops, must be used sparingly and only on the very poor soil types. Harvested Spanish peanuts gave the best results of any legume, but when used excessively they sometimes caused depressed stalk and leaf size and lowered quality of the top leaves. From the viewpoint of quality, small grains and native weeds have been best. It is noted, however, that such a native legume as beggarweed may become troublesome in a weed rotation because of excessive residues of organic nitrogen.

Rotation serves a double duty in relation to the control of black shank, Granville wilt, and fusarium wilt. It reduces the build-up in the soil of the organisms causing these fungus and bacterial diseases, and it reduces the nematode population, thus preventing root-infesting nematodes from opening the way to invasion by parasitic fungi and bacteria.

This over-all protective effect from rotation is not realized if the varieties of tobacco grown are highly susceptible to the other diseases. If nematode diseases are the major problem, rotation alone is adequate, but in the presence of black shank and wilt, it is necessary that rotation be combined with the use of resistant varieties. Rotation alone gave uncertain control of black shank in the 1930's, when only black shank susceptible varieties were grown. Even 5- to 6-year rotations were not completely successful. By contrast, in 1951 tobacco following 1 or 2 years of a rotation crop withstood black shank almost perfectly when the moderately resistant varieties Oxford 1 and Dixie Bright 101 were planted.
same situation now exists with respect to Granville wilt and the resistant varieties now available. Short rotations plus wilt resistance are highly effective in controlling the disease.

The fusarium wilt situation appears to be about the same, with rotation and resistance supplementing each other. An added factor here is that sweetpotatoes are subject to the same wilt and are unsafe to include on land to be used later for tobacco.

Lastly, it is a good policy not to grow rotation crops closely related to tobacco, and those include tomatoes, pepper, eggplant, and Irish potatoes.

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Soil Fumigation To Control Root Ills

J. G. Gaines, T. W. Graham

The Coastal Plain from Virginia to Florida is a center of tobacco production. Its light, sandy soils and mild, humid climate are ideal for growing cigarette tobacco of high quality. But the soils and climate likewise are favorable for the development of soil-borne diseases, especially the ones caused by nematodes.

Many farmers do not have enough good tobacco soil to permit the long rotations required for control of root diseases. They need a safe and efficient soil treatment that will enable them to use shorter rotations.

Early experiments with chloropicrin, urea, and formaldehyde demonstrated that some diseases can be controlled by adding chemicals to the soil. But they were either too expensive and cumbersome to apply, or they adversely affected growth and quality of leaf. Cheaper and more practical chemicals later became available. They are not safe enough to be recommended without qualification, but some of them are being used increasingly on tobacco farms in the Southeast.

Gaseous chemicals, whose vapors penetrate to all parts of the soil, have been more satisfactory than those that require mechanical mixing. Such gas-forming chemicals are called soil fumigants. The present materials are liquids that volatilize when they are exposed to the atmosphere. One in common use is ethylene dibromide. Dowfume W-40 is one of several com-