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Fumigation of Tobacco Soils In the Seedbed and In the Field

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Fumigation of Tobacco Soils in the Seedbed and in the Field

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New chemicals and new methods of fumigating tobacco soils have received a great deal of attention in the last 10 years and are gradually changing our seedbed and field practices. Although only a relatively few growers have yet adopted these new practices, the results are so promising that the use of fumigants is spreading rapidly. The purpose of this bulletin is to present the results of experiments conducted here in recent years and describe the methods of application which seem best. Admittedly there is still much to be learned and methods will be improved by further experimentation but there is need now for a summary of our present knowledge.

The objects of fumigation are to destroy weed seeds, nematodes, harmful fungi and bacteria and some insects. Until quite recently this was accomplished in the seedbeds by forcing steam into the soil. The undesirable organisms are killed by the steam heat. Some growers, however, have used formaldehyde or acetic acid in the past. Usually these chemicals have not given satisfactory weed control but pathogenic fungi and bacteria are killed. No attempt to fumigate soil in the field was made until the last five years.

THE SEEDBEDS

Although steam sterilization[2] of the seedbeds gives quite satisfactory results, the method has some disadvantages, especially for the small grower. It requires a large steam boiler and a large metal pan which represent an uneconomical expenditure for the grower who has a small bed area. He must depend on hiring the job done by some larger operator who owns such an outfit and frequently cannot get his beds treated at a convenient time. Moreover, steam sterilizing is expensive in time and labor. It takes about a half hour to sterilize each 16 running feet of bed and requires four men to move the pan each time. With the ever-increasing cost of labor, a demand has developed for a less time-consuming method.

The first chemical to be used in this State for sterilizing the soil in tobacco beds was formaldehyde. Clinton, botanist at this Station, first used this in 1906 for the control of black rootrot of tobacco seedlings[3]. The method is described on page 14 of this bulletin. It was used by growers for many years after its introduction but the use of steam sterilization gradually supplanted it.

In 1928 Doran[4] at the Massachusetts Experiment Station demonstrated that acetic acid could be used in place of formaldehyde and was less expensive. It is effective against black rootrot, brown rootrot, damping off and bed rot. Although this method was publicized in our Station bulletins, it was used by only an occasional grower.

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[1] Tobacco Laboratory, Windsor.

[2] See Conn. Agr. Expt. Sta. Cir. 175, "Tobacco Seedbeds" for information on steaming beds.

[3] Clinton, G. P. Rootrot of Tobacco. Conn. Agr. Expt. Sta. Rept. for 1906:342-368.

[4] Doran, W. L. Acetic acid as a soil disinfectant. Jour. Agr. Res. 36:269-280. 1928.

In the tobacco regions of the southern states, uramon and cyanamide, separately or in combination, have been used successfully for killing weed seeds and pathogenic organisms in the seedbeds. During the last 10 years the writers have tested these singly or in combination in experimental plots on the Station seedbeds. Both spring application and fall treatment were tried. The results were not satisfactory for two reasons: (1) the weed seed mortality was never as high as when steam sterilization was used, (2) too much nitrogen accumulated in the soil, causing ammonia injury to the young seedlings. Even where there was no ammonia injury, the top growth became too succulent and root development was poor. Possibly our colder winters, where the frozen ground prevents nitrification and leaching, may account for the failure here of a method that is satisfactory in the warmer south.

The writers began experimenting with chloropicrin[1] in the seedbeds in 1940 and continued the tests until 1949. It has also been used by many growers. A summary of the results of the experiments and directions for application are presented on page 13 of this bulletin.

In 1945, tests conducted in the Station seedbeds demonstrated that methyl bromide gas is an excellent weed killer. No observations on its fungicidal value were made at that time. No opportunity to continue these experiments was found until the fall of 1949 when a more thorough set of experiments was undertaken. We had occasion in the meanwhile to observe good results of tests in the beds of some of the growers. Results of the Station tests in 1949-50 and methods of application are given below.

Methyl Bromide

At low temperatures or under pressure methyl bromide is an odorless clear liquid but it quickly vaporizes at temperatures above 43° F. It disperses rapidly and has remarkable penetrating powers. Its killing action is rapid and it is quickly dissipated after fumigation is completed. Thus, there is a minimum of delay in seeding the beds. The gas is three times as heavy as air. The material used in our experiments is known commercially as Dowfume MC_2, methyl bromide containing 2 per cent of chloropicrin.

Seedbed Tests of 1950

In late October, 1949, five plots, each containing 200 square feet, were treated as follows:

(1) 1 pound methyl bromide per 100 square feet
(2) 2 pounds methyl bromide per 100 square feet
(3) 3 pounds methyl bromide per 100 square feet
(4) Steam sterilized 20 minutes at 90 pounds boiler pressure
(5) Check (no treatment)

To confine the fumes, the beds were covered with sisalcraft paper, stretched tightly over the side boards with the edges buried in soil outside the boards. The gas was forced under the cover through saran tubes from one

[1] Chloropicrin is sold under the trade name of "Larvacide" and is popularly called "tear gas".

pound cans by use of a Jiffy applicator. The soil was fairly moist and at a temperature of 62° F. The sisalcraft cover was removed after 24 hours. No cover was provided to afford protection from blowing weed seeds during the winter. The beds were seeded on April 11, 1950, after stirring the soil to a depth of 4 inches.

During the growing period, differences between the plots were readily observed. The plots treated with methyl bromide grew faster and were more uniform than any of the others. Growth in the steamed plot was only slightly less rapid and uniform, while the untreated plot showed the poorest and most uneven growth. The second easily observed difference was in weed control, which was best in the methyl bromide plots and good in the steam, with no control at all in the check plot. Weeds were pulled and counted on May 27. The check plot averaged 76.4 weeds per square foot. On the treated plots, the average of weed seeds per square foot was as follows: steam, 3.9; 1 pound methyl bromide, 10; and 2 and 3 pounds methyl bromide, each 1.4. Since it is probable that some weed seeds blew in during the winter, we may consider the weed control as perfect for the treatments of 2 or 3 pounds methyl bromide to 100 square feet of bed surface. A somewhat larger weed count on the plot treated with 1 pound indicates that this rate is not quite high enough. From the standpoint of both economy and efficiency in weed control, the correct dosage apparently lies somewhere between 1 and 2 pounds to 100 square feet of surface. In similar experiments in Kentucky, South Carolina, North Carolina and Florida, it was found that 1 pound to 100 square feet was adequate for weed control[1]. The effectiveness of the gas is increased by higher temperatures and by longer exposures. Possibly if, in our experiment, the covers had been left in position for 48 hours, the 1 pound application would have been sufficient.

There was very little opportunity to determine the effect of such fumigation on diseases because the beds were free of all diseases except one. This one exception is a fairly common disease in seedbeds which we have called Pythium rootrot. A species of the fungus Pythium is associated with the deteriorated roots and is assumed to be the causal organism. Root examinations in 1950 showed that there were also many nematodes in these roots but it is not certain what part they play. In infected beds, patches of the young seedlings remain stunted and yellow and many may die. Such yellow patches were common in the untreated parts of the bed and a few of them developed later in the steamed sections. None whatever showed at any time on the sections treated with 2 or 3 pounds of methyl bromide. A few developed later in the 1 pound sections but the damage was mild compared with the untreated plot. This one disease is apparently controlled by methyl bromide and it is likely that other soil borne diseases would react in the same way but we have not enough proof of this.

Method of Fumigation

In view of the excellent results obtained both here and in other states by the use of methyl bromide, the following directions for application are suggested.

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[1] Down to Earth. Vol. 5, No. 2, 1950. Published by Dow Chemical Company.

FIGURE 1.

Seed bed fumigated with methyl bromide (top) compared with non-fumigated section of same bed (bottom).

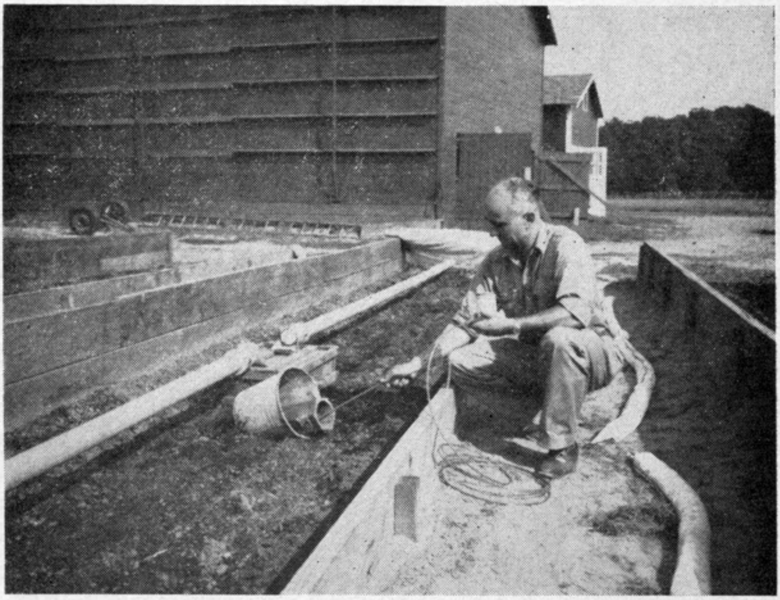

FIGURE 3.
After placing a support through the center to keep the tarp elevated, the end of the saran tube is placed in a container from which the liquid will evaporate.

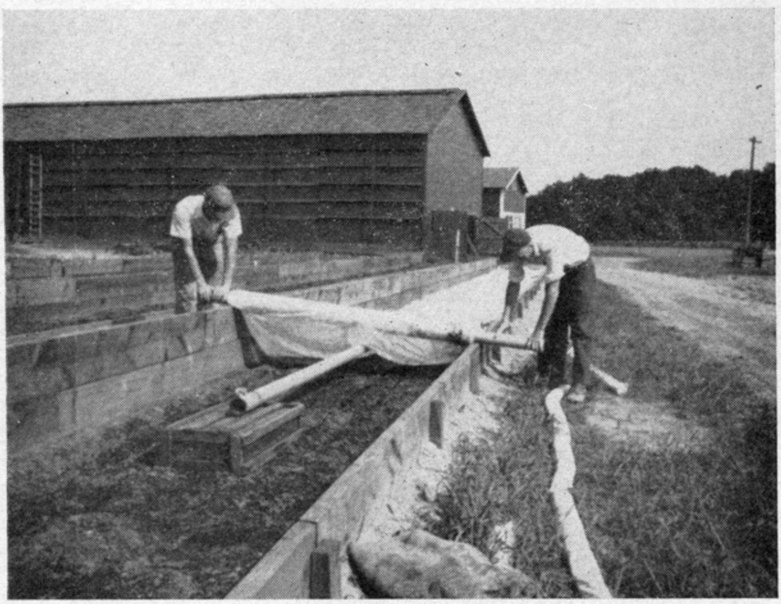

FIGURE 4.
The tarp is rolled over the bed.

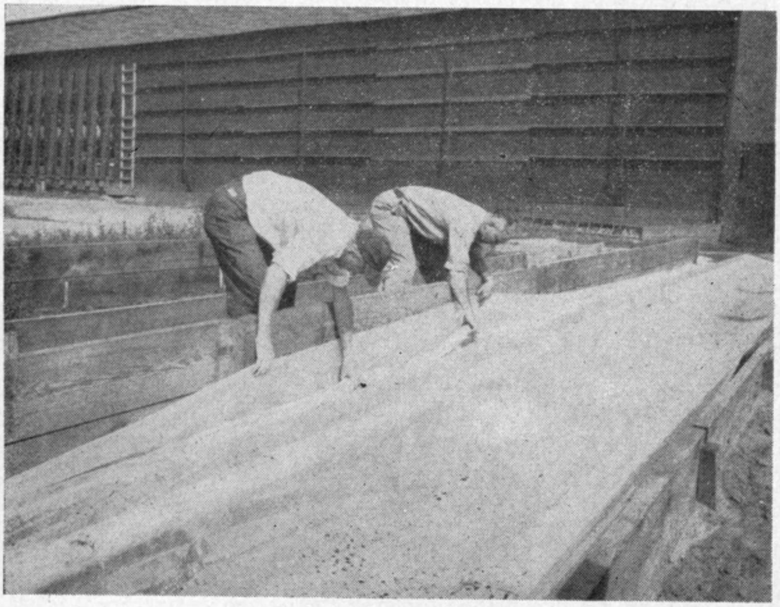

FIGURE 5.
Edges of the tarp are weighted down with sand snakes.

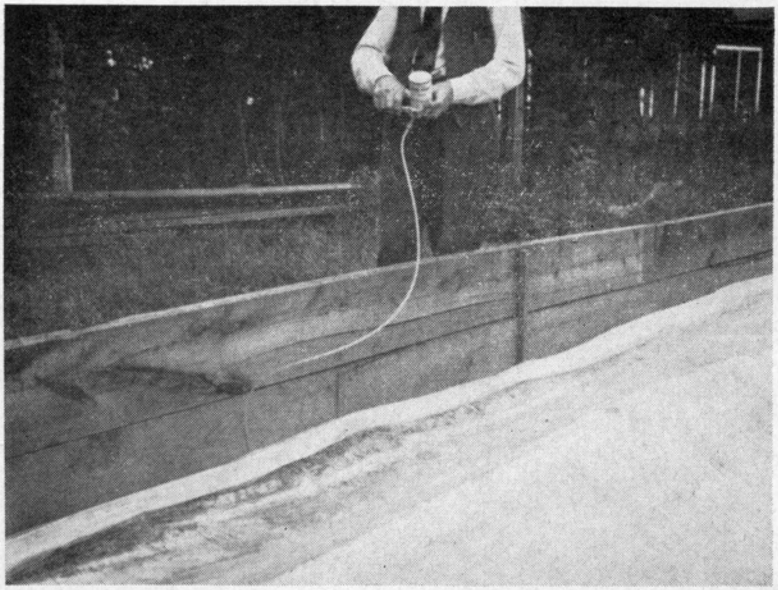

FIGURE 6.
The methyl bromide is released by puncturing the can with a Jiffy applicator. It flows through the tube under pressure and into the evaporating vessel under the tarp.

may be stretched across and over the side boards and the edges weighted down with soil outside the beds. In this case there will be little or no need of further support for the cover since the height of the side boards keeps it off the soil. If, however, the cover is not to be drawn over the side boards (the edge being anchored inside the boards), it is best to place some crates, boxes, pipe, or any other objects that are convenient along the center of the bed. In the accompanying illustration (Figure 3) crates and some lengths of irrigation pipe are used for this purpose. The edges of the plastic cover are pressed down and kept tight by the weight of "sand snakes"—canvas tubes of about 4 inches diameter and 6 feet long, filled with dry sand (Figure 5). This method allows the use of a much narrower cover than is necessary when it is stretched over the side boards. The cover should be as long as practicable—a 100 foot length is convenient.

The gas is carried under the cover through small flexible saran tubes. Before the cover is placed in position, these tubes, 4 to 6 feet long, are laid with one end in a metal receptacle, such as a pan, pail or trough, near the center of the bed and the other end projecting over the side of the bed. The purpose of the receptacle is to hold the liquid until it evaporates. The end of the tube should be secured by a weight or other means, else it may be dislocated by the rush of the liquid as it comes from the can. The methyl bromide is purchased in small one pound cans. A special can opener, called a Jiffy applicator, is attached to the free end of the saran tube and the can slipped into the applicator (Figure 6). By pressing a small lever with the thumb, the can is punctured and the liquid—under pressure in the can—

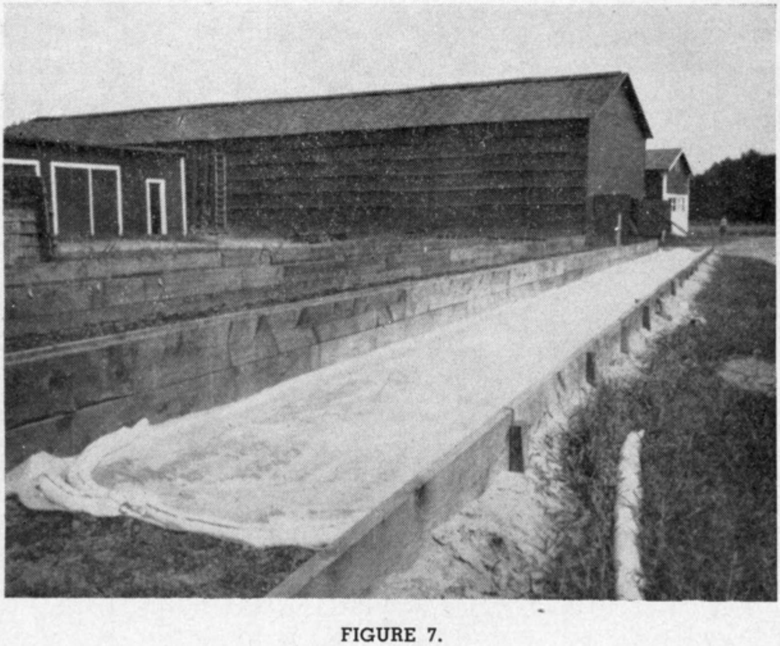

FIGURE 7.
The tarp is left in place for 24 hours.

rushes out through the tube and into the receptacle where it is immediately vaporized. The can empties itself in about a minute and then the applicator is removed and attached to the next tube where the process is repeated. After removal of the applicator, the exposed end of the saran tube should be plugged to prevent escape of the gas.

The cover should be left over the beds for 24 to 48 hours. Twenty-four hours is enough if 2 pounds of methyl bromide to 100 square feet have been used and the soil temperature is 60° F. or above. If, however, only 1 pound has been used, or if the temperature is lower, it is best not to remove the cover before 48 hours.

Chloropicrin

Chloropicrin ("tear gas", sold commercially as *Larvacide)* has been used by many growers during the last 10 years for fumigating seedbed soil. Growers usually evaluate fumigants by the amount of weed control but pay little attention to disease control. It is assumed that any material which will kill weed seeds will also destroy fungi or bacteria in the soil. Many growers have been satisfied with the weed control obtained with chloropicrin. Others have failed to control weeds. In many cases, the failure was due to faulty application, improper soil preparation, too low temperature or other traceable causes. Nevertheless, it is a common observation that weed control is not as complete as with steam.

Beginning in 1940, tests were run at the Tobacco Laboratory farm, comparing the effectiveness of different rates of application and of uramon, cyanamide and steam. Averaging results of several years, we found that the best rate of chloropicrin application (4 cc. per square foot) reduced the weed count by about 55 per cent below the untreated sections. Steam gave a reduction of more than 90 per cent.

Since other fungicides were used for controlling the various diseases, these tests did not afford an opportunity to determine the value of chloropicrin against diseases. In field tests, however, it was found to give good control of black rootrot.

The principal advantage of this method is that the soil can be sterilized in one-tenth of the time it takes to steam-sterilize it. Thus, there is a big saving in labor. Moreover, the cost of the apparatus is not as great as the cost of a steam boiler and steam pans and it can be handled and housed in less space. In small beds, chloropicrin can be applied (spot application) with a small hand applicator, a three-foot long injector built on the principle of a hypodermic needle, spacing the injections about 10 inches apart. It requires 16 to 20 pounds of chloropicrin to 1,000 square feet of bed. The volume of each injection can be regulated by a "stop" on the plunger bar and should be calibrated before starting application. For larger beds, it is more economical to use a motor-driven continuous flow applicator such as that shown in Figure 8. Chloropicrin should be applied 3 to 4 inches below the soil surface.

If chloropicrin is used, the beds should be sterilized in the fall because the soil is too cold in the early spring. In addition, there is danger of killing the

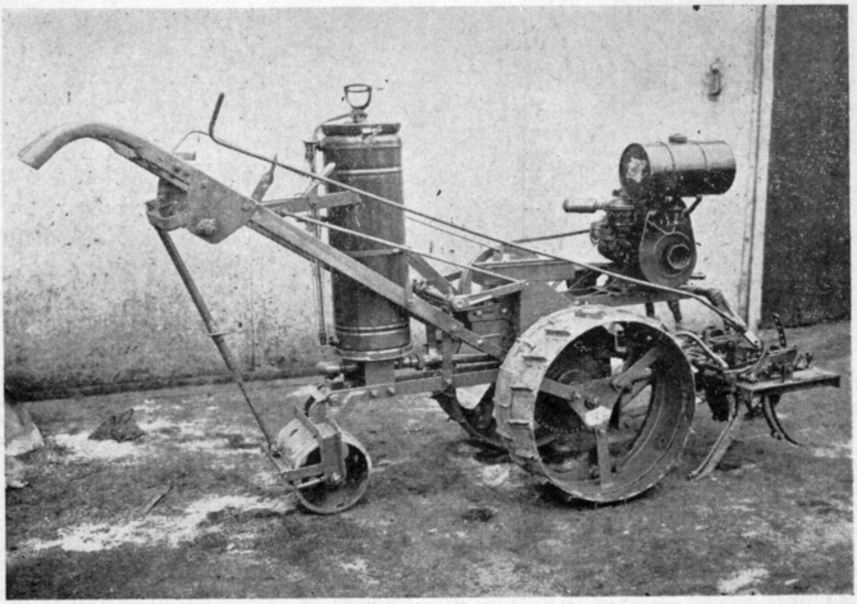

FIGURE 8.
With this motorized applicator for chloropicrin the beds can be sterilized in one-tenth the time required for steaming the soil.

young seedlings because the gas remains in the soil between spring application and seeding. The soil should be fertilized and pulverized before treatment. In dry weather it should be thoroughly watered a week or two before sterilizing. This causes weed seeds to begin germinating and makes them easier to kill. The soil should be moist but not muddy at time of treatment.

As soon as possible after fumigation, the soil should be raked level and watered so that it is wet to a depth of one inch. This seals the top and holds the gas in the soil. The seal can be improved by spreading several thicknesses of old shade cloth over the surface before watering. Another very effective method is to cover the surface with a 1½-inch layer of shredded, weed-free black humus and water it thoroughly.

Formaldehyde

Formaldehyde was the first chemical fumigant used on tobacco in this State and was applied to seedbeds for many years before the other methods described above came into general use. It is particularly effective against soil borne diseases such as rootrots, damping off and bed rot. Its advantage is that it requires no outlay for apparatus as do the two methods described above. The cost of the chemical is also somewhat less than that of chloropicrin or methyl bromide. The labor cost is less than that of steaming. Although most of the weed seeds are killed with formaldehyde, many hard weed seeds survive. This is its main drawback and the one that induced growers to change to steam sterilization. Also, the length of time necessary between treatment and safe seeding of the bed was considered a disadvantage by those who are accustomed to sterilize the beds in the spring.

Formaldehyde is used in tobacco seedbed practice in two different ways. First, it may be used as a drench to destroy all disease organisms and a large part of the weed seeds. Secondly, it may be used as a sprinkle to prevent only early damping off. These are two quite different practices, require different amounts of formaldehyde and should not be confused with each other. Directions for each procedure are given separately below.

Formaldehyde Drench for General Sterilization

This procedure involves a complete soaking of the soil and a long delay before seeding. The solution is made by adding 1 gallon of 40 per cent formaldehyde to a 50-gallon barrel of water. After working up and levelling the soil, it is soaked at the rate of ½ gallon to each square foot of surface. If there is a tendency for the solution to run off, it should be added more slowly. After treating, the seed should not be sowed until the odor of formaldehyde has gone. Usually this requires a delay of 10 days or more. This may be hastened somewhat by working the soil over every few days as it begins to dry.

Formaldehyde Sprinkle for Controlling Early Damping Off

This is applied just before the beds are sowed. The rates and method are quite different from those for the general drench. The following directions must be followed carefully because an overdose may kill the plants.

1. Stir 1 pint of formaldehyde into about 1 gallon of water in a sprinkling can.

2. Have soil pulverized and ready for sowing.

3. While raking over the soil the last time just before sowing, sprinkle the above amount of solution evenly over an area of four or five sash (72 to 90 square feet). Mix thoroughly into the top 3 inches of soil with the rake.

4. Level the surface and sow the seed as usual.

The formaldehyde fumes remain in the soil long enough to kill or prevent growth of the fungus during the period when the seedlings are becoming established, but are not concentrated enough to injure the plants.

Acetic Acid

Acetic acid may also be used as a drench and is as effective as formaldehyde. The solution is made by mixing 8 pounds of acetic acid (56 per cent) in a barrel of water and proceeding as indicated for formaldehyde. Acetic acid is usually less expensive than formaldehyde but is not always as readily obtainable.

FUMIGATION OF FIELD SOILS

Up to the present the chief reason for fumigating the soil in tobacco fields has been to destroy nematodes. This is a quite recent development in Connecticut, the first tests having been started some five years ago. Previous to that time it was not known that nematodes were damaging Connecticut tobacco. In 1946, the writers[1] first published the fact that two types of nematodes damage tobacco here. These are the root knot nematode[2] and the meadow nematodes[3]. The root knot nematode has appeared in only a few fields and it is probably not a threat in this State at present. However, it is possible that it may become widespread and destructive at some future time just as it is now in southern tobacco growing states.

We are more concerned with the meadow nematodes and some others which cause similar damage to tobacco roots. They destroy the small roots, causing them to turn brown in the rotting process. This causes the above ground parts of the plants to be stunted and sickly. Previously, this field trouble was commonly known as brown rootrot. Although not every field is infested, it is widespread in the tobacco growing regions of the State and has at times caused large losses and even abandonment of some fields. Extensive investigations in the last 30 years failed to determine the cause of brown rootrot until the association of nematodes with it was recently established. Even now there is some uncertainty as to whether all brown rootrot is due to nematode infestation but this has little bearing upon the control question. As soon as it was found that nematodes were associated with this trouble, experiments were started with the object of testing the value of soil fumigants[4].

Two types of nematocides were used in these experiments, ethylene dibromide (sold as *Dowfume W40,* containing 20 per cent of ethylene dibromide, and as *Iscobrome,* containing 10 per cent) and a mixture of dichloropropane and dichloropropene (sold as D-D mixture and as *Dowfume N).* The first field tests (1946) were on diseased shade fields, one affected by root knot, the others by meadow nematodes. The objects were to compare the two types of nematocides, rates of application and, also, fall application with spring application.

All treatments were spectacularly successful. When the untreated plants were a foot high, tobacco on the fumigated plots was three or four feet high, darker green with larger leaves, and did not wilt on hot days as the untreated plants did. Examination showed extensively developed white roots on treated soil but, on the affected plots, the usual brown bush of dead roots had appeared. On a badly infested shade field, untreated plots produced no leaves large enough to harvest while a normal crop was harvested on the treated areas.

Although both chemicals were satisfactory, in all comparisons the plant growth was better where ethylene dibromide was used. Fall treatment gave

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[1] Anderson, P. J., and T. R. Swanback. Root nematodes. Rept. of the Tobacco Substation for 1946, Conn. Agr. Expt. Sta. Bul. 504:19-22.

[2] Heterodera marioni.

[3] Pratylenchus pratensis and others. Dr. G. Steiner, Chief Nematologist of the Division of Nematology, United States Department of Agriculture, also identified Tlyenchorynchus claytoni, Dorylaimus sp. and others as probable causes of rootrot from root specimens sent from Connecticut.

[4] It is of some interest that 25 years ago, although we did not know the cause of brown rootrot, experiments at this Station showed that it could be partially controlled by fumigating the soil with formaldehyde. (Conn. Expt. Sta. Bul. 311:254.)

FIGURE 9.
Nematode control in the shade tent. Stunted plants on untreated plot in foreground never grew large enough to harvest. Larger plants in background on plot treated with ethylene dibromide produced a normal crop.

somewhat better results than spring application of the nematocide. Optimum rates of application found in these tests were 25 to 30 gallons of *Iscobrome* or one-half that amount of *Dowfume W40* while D-D gave best results at 300 pounds to the acre. Field tests of 1947 and 1948 confirmed for the most part the results of 1946. Moreover, many growers either fumigated small areas as a trial or treated whole fields during these years. In at least 90 per cent of the cases the tobacco was improved greatly. Failures were mostly due to wrong diagnoses of the cause of poor growth. Non-productive areas in the fields due to improper drainage, erosion, black rootrot, or a variety of other causes are not improved by fumigation.

Within this short period of years field fumigation has become an established practice in tobacco production. Hundreds of acres are being treated every year. This is done mostly by custom operators, probably because of the cost of the fumigation machinery which would be used only a few days on one farm. However, some growers own their own machines.

Measurement of the Benefits of Fumigation on Havana Seed Tobacco

Although it had been demonstrated in numerous trials that fumigation with ethylene dibromide resulted in remarkable increases in growth, very few quantitative measurements were recorded. Therefore, a test was laid out on the Tobacco Laboratory farm in 1949 to measure the actual increase in yield and to see whether there is any improvement in grading of the cured tobacco. Open field Havana Seed tobacco was grown on 10 plots, each approximately $\frac{1}{10}$ acre in size. Five of the plots were treated with *Dowfume W40* (20 per cent) at a rate of 15 gallons to the acre. Applications were made 18 days before setting the plants, using a shank type applicator (Figure 10) which deposited the liquid 6 inches below the surface in rows 10 inches apart. The other five plots were not treated. The field was only moderately infested but for several years had developed poor growth in spots where root examinations showed an abundance of nematodes.

More vigorous growth on the treated plots was quite apparent throughout the summer. After the tobacco was harvested and cured in the usual way, the leaves from each plot were weighed and sorted separately. Every treated plot had a higher yield and better grading than its adjacent control plot. The average acre yield for the treated plots was 2,001 pounds; for the untreated, 1,806, an increase of 195 pounds or about 11 percent[1]. The average grade index for the treated plots was .461 and for the control .415, a grading improvement of about 11 per cent where ethylene dibromide was used. On the basis of the price received for the 1949 crop, this would mean an increase of $190 to the acre. Since the cost of fumigation was about $40 an acre, this would still leave a gain of $150. This figure represents the gain on a field only moderately infested. It could be much greater on badly infested fields and less on more lightly affected fields.

Effect of Fumigation on the Soil

Even on fields which are apparently not affected by brown rootrot, it is often observed that fumigation improves the growth of tobacco. There are two possible reasons for this. It may be that there is *some* nematode injury even on plants that appear to be perfectly normal and these nematodes are killed by the fumigation. Another possible cause is that the chemical treatment induces some other beneficial change in the soil. The second possibility has not been investigated except from the angle of nitrogen changes. The dark green color of the leaves on treated plots suggests increased nitrogen feeding. In order to see whether there is any change in the nitrogen supply in the soil, samples were analyzed for ammonia and nitrates at weekly intervals in the treated and untreated plots described above in the Havana Seed tests. The field was fumigated on May 12, fertilizer applied on May 21, and the plants set on June 1. The first sampling was made a week before setting. The results presented in Table 1 show that, within a week after setting, the amount of ammonia increased and continued to rise for four or five weeks until it was 10 times as much as on the untreated soil. Later in the season it dropped but the ammonia content was never as low as on the control. The behavior of the nitrate was different. For the first four weeks it was lower on the treated than on the control plots but by the last of June it had increased beyond the controls and remained well above them during the remainder of the season. With this more abundant supply of both ammonia and nitrate during the weeks of the most rapid growth of the crop, it is not surprising that it should be reflected in the darker green color and larger size of leaves, even if the elimination of nematodes is left out of the picture.

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1 For a full discussion of this experiment and tabulation of full data, see Down to Earth 5: (No. 4) 18-19. 1950.

TABLE 1. AMOUNT OF AMMONIA AND NITRATE FOUND IN SOILS AFTER FUMIGATION. (Parts per million). 1949.

Date	Control		*Dowfume W40*		*Dowfume N*	
	Ammonia	Nitrate	Ammonia	Nitrate	Ammonia	Nitrate
May 26	5	37.45	10	30.15	5	16.44
June 1	25	74.41	5	43.62	Trace	16.85
" 8	5	47.41	10	43.69	25	33.86
" 15	5	144.72	25	104.88	100	58.68
" 22	5	83.16	50	147.66	50	106.14
" 29	5	108.09	10	168.00	100	94.29
July 6	..	94.66	..	151.69	..	103.23
" 13	5	187.17	10	170.79	25	147.99
" 20	..	118.24	..	210.81	..	165.92
" 28	5	105.97	10	111.45	25	134.59

In the application of any untried chemical to the soil, there is always the danger of some adverse effect on the succeeding crops through accumulation of residues or disturbance of the biological balance in the soil. Up to the present no such after-effects have been observed in Connecticut tobacco fields. Ethylene dibromide is quickly dissipated and leaves the soil and, therefore, the chance of accumulation of harmful residues is remote. The effect of ethylene dibromide on the biological balance in the soil is still in need of thorough investigation but we know of no investigations here or elsewhere which indicated any harmful effect to succeeding crops from its use.

Effect of Fumigation on the Cured Tobacco

That fumigation increases the vigor of the plants and the size of the leaves, resulting in increased yields, has been thoroughly demonstrated. But does it have any other beneficial or harmful effects? Some shade growers report that the leaves from fumigated fields are too dark in color. Other do not find this fault. Since the soil tests described above show that there is a larger supply of ammonia and of nitrate nitrogen in the fumigated soil, one might expect to find more nitrogen in the leaves and a consequent darker color. The obvious remedy for those growers who find this fault is to reduce the quantity of nitrogen applied in the fertilizer. A 10 per cent reduction has been arbitrarily suggested.

In order to see whether there is actually a higher percentage of nitrogen in leaves from fumigated plots, as well as to determine other chemical differences due to fumigation, samples of cured leaves from the Havana Seed plots discussed above were submitted to the Analytical Chemistry Department for analyses. A summary of their analyses is presented in Table 2. The samples from plots treated with D-D and controls are from another field on the farm. These analyses show a 5 per cent increase in total nitrogen through fumigation with ethylene dibromide and a 16 per cent increase in ammonia nitrogen. This might easily account for the darker color.

TABLE 2. AVERAGE PERCENTAGE OF ELEMENTS IN CURED TOBACCO SAMPLES FROM FUMIGATED AND UNFUMIGATED PLOTS.

	Soil fumigated with:			
Elements	Ethylene dibromide (10 samples)	No treatment (8 samples)	D-D (2 samples)	No treatment (2 samples)
Total nitrogen	4.24	4.04	4.71	4.64
Nitrate nitrogen	.42	.82	.53	.64
Ammonia nitrogen	.73	.63	.66	.62
Nicotine	4.74	4.66	4.03	3.99
Potassium	3.50	3.50	2.25	2.36
Calcium	5.04	4.62	3.85	3.95
Magnesium	1.07	1.05	1.19	1.17
Chlorine	.07	.19	.63	.26
Bromine	.10	.01	.004	.005

Most of the other differences are too small to be significant. The chlorine figures, however, are worth noting. When ethylene dibromide is the fumigant, the chlorine percentage is lower than the control, probably due to substitution of more bromine for chlorine. When D-D is the fumigant, the chlorine content is 2½ times more than the control. In previous investigations here it has been shown that more than .4 per cent chlorine in the leaf is detrimental to the fire-holding capacity of the leaf. Therefore, the .63 per cent chlorine found in D-D-treated tobacco would naturally give it a lower burn. This was found to be the case when burn tests were made, as described below.

To determine whether the fire-holding capacity of the cured leaves is affected by fumigation with ethylene dibromide, samples of dark and light grades from each of the 10 Havana Seed plots were subjected to burn tests. Leaves were ignited by contact with an electrically heated filament and the number of seconds they continued to glow measured by a stop watch. Forty tests were made on each plot, a total of 200 tests for the treated and 200 for the controls. The average duration of burn for the fumigated tobacco was 28.8 seconds; for the control leaves it was 24.8 seconds. In a similar test on shade tobacco in 1947 (40 tests on treated tobacco and 40 on controls), it was found that the duration of burn on the ethylene dibromide treated plots was 38.5 seconds and on the controls, 18.6 seconds. Thus, there appears to be no impairment of burn but even an improvement when ethylene dibromide is used.

Some less extensive tests during these same years showed that D-D reduced the fire-holding capacity of the leaves.

Chemical analyses show that the bromine content of the leaves is increased by fumigation. Tobacco from untreated soil normally contains about 100 parts per million of bromine. Samples from treated plots were found to have about 1,000 p.p.m. As far as could be judged, this larger amount of bromine had no ill effect on the tobacco.

To see whether there was any effect on the taste or aroma of tobacco, cigars wrapped with shade leaves from treated and untreated plots were given to a number of smokers with the request that they state their preference. They were not told which had been treated. About the same number preferred the treated cigars as those who chose the control, showing that no serious change in taste could have resulted from the use of ethylene dibromide.

How Often Should a Field Be Treated?

Obviously the answer to this question depends on how quickly the nematode population builds up again sufficiently to stunt tobacco growth. In 1950 the Havana Seed plots which had been treated in the spring of 1949 were again set to tobacco without further fumigation. The increase in yield over the control plots was about the same as for the preceding year and was no less than on plots treated in 1950 and growing their first crop after fumigation. Thus, on this field the benefits of fumigation persisted at least two years. We have seen shade fields where the plants were distinctly larger and greener than the controls the second year after treatment. On the other hand, some growers have fields that have gone back to their original poor condition the second year. In Florida, it is customary to fumigate every year. Apparently each farmer must decide how often he should fumigate from his experience on his own particular farm.

Spring vs. Fall Fumigation

Soil may be treated either in the spring or in the fall. Experiments of the last few years show that either gives successful results, with somewhat better control from fall applications. The choice of time will be influenced by the convenience of the grower. He usually has more time to devote to such operations in the fall than in the spring.

Application Suggestions

It is not advisable to fumigate when the soil temperature is below 50° F. because fumigants do not volatilize readily at low temperatures or when the soil is muddy. Temperatures above 60° F. are best.

The soil should not be disturbed for 10 days after fumigation, or 14 days if the soil temperature is below 60° F. This allows the maximum effect of the fumigant. Light rain, immediately or within the first few days following application, may have a beneficial "sealing" effect. On the other hand, a heavy rainfall on treated land will definitely prolong the time required between treatment and planting, since it carries the chemical to greater soil depth. It is suggested that treated land be worked as soon as possible after heavy rainfall to facilitate aeration of the soil, but not sooner than 7 days after application.

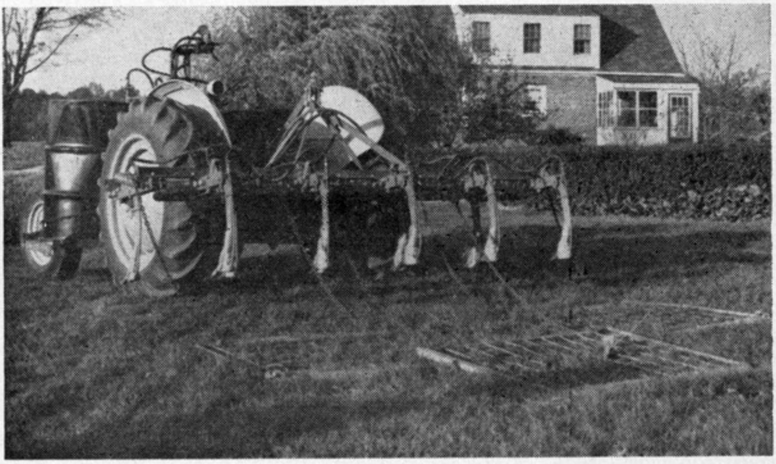

FIGURE 10.

Field fumigation equipment attached to tractor. Pump draws fumigant from barrels attached at side of tractor and drives it down into the soil through the tubes on the back side of each of the ten shanks. Grill work drags drawn behind level the soil.

The most common type of machine for applying the chemical is the shank type shown in Figure 10, attached to a tractor. This applicator is provided with strong narrow teeth or shanks which make the furrow. Attached to the back side of each shank is a small tube through which the liquid flows and is deposited to a depth of 6 to 8 inches in the soil. A motor-driven pump draws the fumigant from the tank and forces it down through the tubes back of the shanks. The drags which follow behind the machine fill in the furrows and level the soil, thus helping to prevent too rapid escape of the fumes. The shanks are spaced 10 inches apart, a distance which seems most suitable for fumigating the entire top soil.

In other tobacco sections row fumigating machines are used. These fumigate only the strips of soil where the rows of tobacco are to be set. This method has given satisfactory results in the south. It has not been used in Connecticut.

Another type of machine may be attached to the plow. It deposits a stream of fumigant on the sole of the furrow where it is immediately covered by the soil from the next furrow. These may operate by gravity or they may be operated with force pump. By another method the power take-off on the tractor provides the power for spraying the liquid in the furrow. This machine has given satisfactory results but is said to be not quite as effective as the shank type. It has the disadvantage that frequently the soil is too cold in the early spring when plowed. The advantages are that it does not involve an extra operation and it does not require elimination of stalks, roots or debris. Too much debris on the surface may prevent effective work with a shank type machine.