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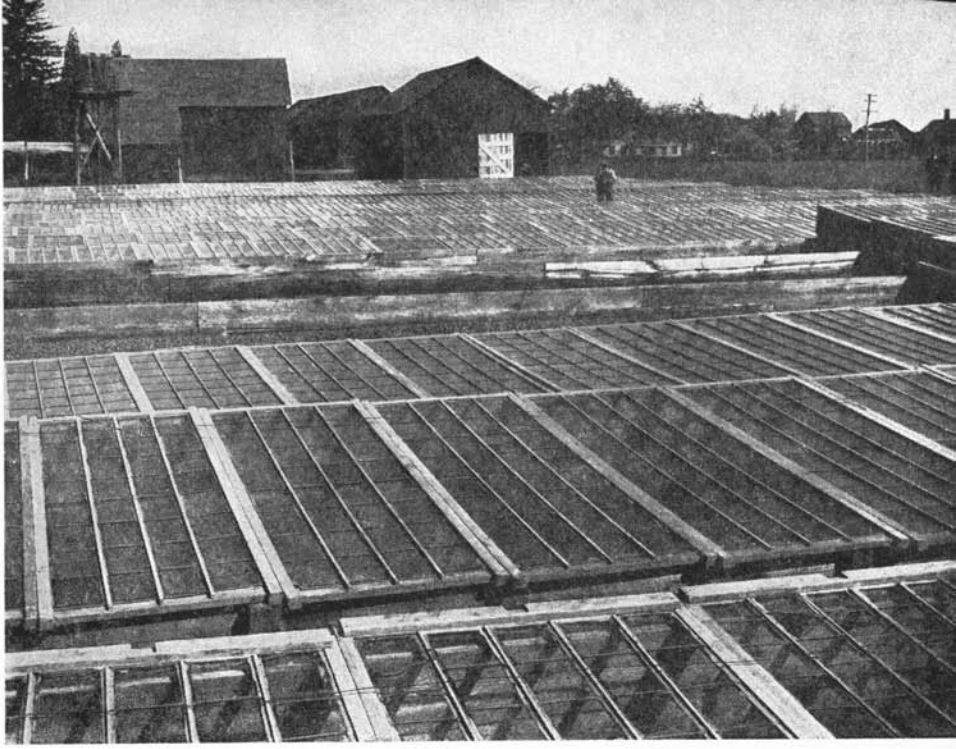

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Tobacco Seedbeds

by

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Figures 1, 2, 8 and 12, courtesy of the Shade Tobacco Growers Agricultural Association, Inc. Photograph for Figure 10 furnished by Dr. James Johnson, University of Wisconsin, Madison, Wis. Figure 16, courtesy of W. M. Kulash, Department of Zoology and Entomology, North Carolina State College of Agriculture, Raleigh, N. C.

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TOBACCO SEEDBEDS

P. J. Anderson and T. R. Swanback[1]

It is the aim of every tobacco grower to have at hand an abundant supply of hardened, healthy plants of the right size when he is ready to set his fields. Proper management of the seedbeds to produce an adequate supply at the right time is of supreme importance to successful tobacco growing. Most of the troubles and failures of seedbeds can be avoided or eliminated by proper management and application of known remedies.

Besides providing a good supply of plants, good seedbed care eliminates many disease and insect troubles in the field. Many such problems start and spread while the seedlings are still in the beds and from this source are distributed widely in the fields.

Few growers can keep in mind the mass of facts and figures involved in such operations as soil fumigation, fertilization, and preparation, dilution and rates of application of fungicides and insecticides. The following pages describe successful seedbed practices which have been developed by research at the Tobacco Laboratory and elsewhere and by growers.

LOCATION OF BEDS

Most seedbeds in the Connecticut Valley are permanently located and are not moved from year to year as in many tobacco growing sections. However, if new beds are to be started or the previous location has not given satisfactory results, the following considerations are important in selecting a new location. The site should be convenient to the farmer's dwelling, to buildings in which sash, tools and other supplies will be housed and, particularly, to the water supply. If the land is sloping, a south or east slope is preferable because it is naturally warmer and thaws out and is ready to work earlier in the spring. The majority of beds here, however, are on land so nearly level that slope is of no importance, and a hillside location is certainly not necessary.

A spot that is protected from cold winds by woods or surrounding buildings has some advantages because it is easier to keep heat in beds where there is no strong wind to suck out the warm air. Moreover, such a location is more comfortable in the early spring for the workmen. Woods or buildings, however, should not be close enough to shade the plants. Fences of boards or of several thicknesses of shade cloth on the exposed side are sometimes used to break the force of winds. Some growers locate beds under regular shade tents (Figure 1).

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[1] Tobacco Laboratory, Windsor.

Figure 1. One method of ventilating the beds. These beds are protected by a regular tent cover.

Good water drainage is important. Too often growers place beds in low, wet, poorly drained areas because plants can be grown there without much watering; in fact, some claim to grow plants without *any* watering. Usually such beds are the first to be attacked by diseases such as damping-off, mildew, bed rot and wildfire. Also, continuous rains may keep the soil so soaked that the root system is poor and growth is stunted. A sandy well-drained soil of fairly high elevation with a low water table is preferable even though it does involve more labor in keeping the plants watered.

A soil that grows good tobacco in the field is a good seedbed soil. It is customary to run the beds in an east and west direction with the slope of the glass to the south, but good plants are being grown in beds laid out in all possible directions and it is apparent that this point is of no great importance.

CONSTRUCTION OF BEDS

Most glass-covered beds are six feet wide because the standard hot bed sash fits this dimension. Some are eight feet but this size is less popular and for most operations is not so convenient. The longer sash are heavier and are apt to sag and warp out of shape. Cloth-covered beds are usually wider, varying according to the width of cloth used. The length of the bed depends on the space available (cover picture).

The side boards are one inch or, preferably, two-inch planks, as long as they can be economically purchased. The planks on the upper side of the

Figure 2. Hardening off the plants.

bed are wider, usually 12 inches, while those on the lower side are 8 or 10 inches high. Some growers prefer to make the sides higher than this by using two boards on one or both sides (Figure 2). Having one side lower than the other gives a slant to the glass so that the water will run off. The boards are nailed to 4 by 4 posts about 3 feet long set 8 or 10 feet apart in the ground on the outside. The end boards of the beds should be removable to facilitate passage of cultivators or other machinery into the beds.

Untreated lumber rots rapidly under seedbed use, and planks must be replaced after four or five years. To avoid this, many growers purchase

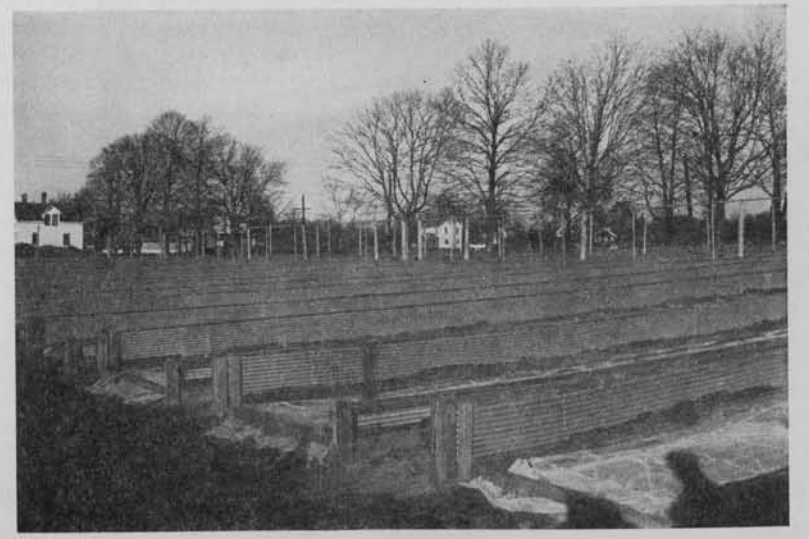

Figure 3. Tobacco beds with aluminum side walls.

lumber which has been chemically treated to make it rot-proof. A number of wood preservatives[1] have proved to be satisfactory for tobacco beds. Under no condition should creosote-treated boards be used since the fumes from creosote kill young plants. Creosote-treated posts on the outside of the boards may be used, however.

A few growers have used beds with walls made of concrete. Quite recently some growers have installed beds with aluminum side boards and have reported favorably on them (Figure 3).

BED COVERINGS

Regular hot bed sash 3 feet by 6 feet are most commonly used for covering the beds to protect the plants against inclement spring weather. A useful modification is sash with outside mullions about 6 inches longer than the others and rounded to form "handles" (Figure 4). These make it more convenient to lift and carry the sash and also aid in ventilation since the sash can be slipped down or up to leave openings at the bottom or top with the "handles" furnishing support. Sash should be kept painted to prevent weathering and warping.

Transparent or translucent plastic materials are used to some extent as substitutes for glass in the sash. Experiments conducted for many years at the Tobacco Laboratory with a considerable number of these plastics show that just as good plants can be grown under plastics as under glass. The

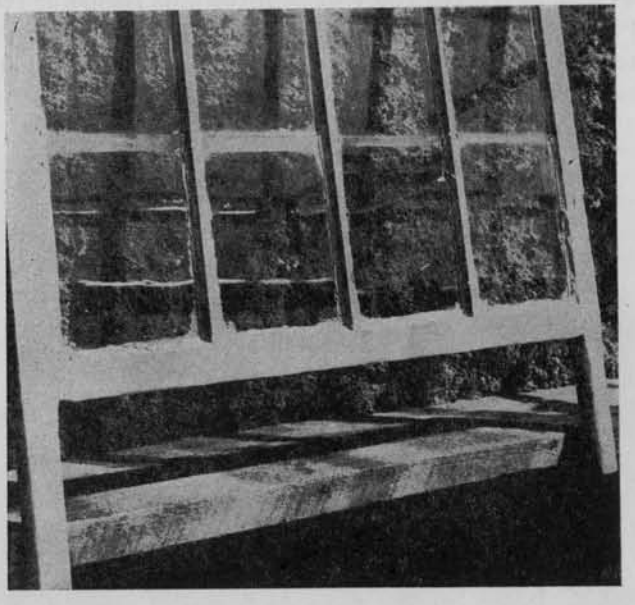

Figure 4. Seedbed sash with outside mullions extended to form handles. Bed is ventilated by pushing the sash down and resting it on the handles.

[1] See Conn. Agr. Exp. Sta. Bul. 493: 8-14, for a discussion of various preservatives.

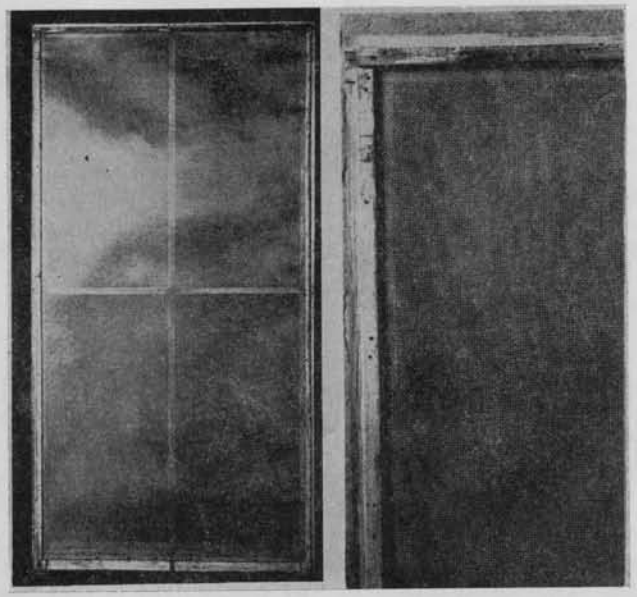

Figure 5. Sash covered with plastic reinforced by wire screen is light and durable. Enlarged corner of sash (below) shows the wire mesh imbedded in the plastic.

weakness of most of the plastics tried has been in durability. They show great variation in this quality. Some which have no reinforcing network last only one or two years; with cotton textile reinforcement, they last longer. The most satisfactory have wire screening covered with the plastic material (Figure 5). Plastic sash possesses several advantages over glass sash: (1) Plastics are much lighter weight so that they can be taken off and put on in less time and with less back-breaking labor; (2) there are no broken panes to be constantly replaced; (3) plastic materials retain the warmth in the beds more effectively because there are no openings like the cracks and holes in glass; (4) they can be handled more roughly and rapidly since there is no glass to be broken; (5) the final cost of plastic sash is less than for glass sash if the type of plastic is durable enough to last five years or more.

Cloth covers are used by a few growers. Plants grown under cloth covers are not ready for setting as soon as those grown under glass, but this is not regarded as a serious drawback. Some growers of large acreages where the setting period is extended keep a portion of the beds under cloth to supply plants for the later setting. A heavy cotton cloth of a 40 by 40 weave is made especially for tobacco seedbeds. To make it more durable and resistant to rain soaking and leakage, it may be drenched with linseed oil and then spread out to dry before being used. It may be spread directly over six foot beds and supported by wooden cross-pieces to keep it from sagging too much. Over wider beds, it is customary to stretch a stout wire down the middle of the bed lengthwise and somewhat higher than the sides so that the cloth slopes both ways from a central ridge. The cloth is secured to the side

board on one side by tacking lath over the edge of it on the outside. On the opposite board the cloth is stretched over the heads of finishing nails that are driven into the outside of the board. This allows the cloth to be easily detached and rolled back for watering, spraying, or other operations.

STERILIZING THE SOIL

Since many pathogenic organisms and noxious insects are soil borne, their injuries can be eliminated or reduced by killing them in the soil before the bed is seeded (soil sterilization). This same operation also kills weed seeds and thus eliminates the need of hand weeding. Two methods of sterilizing tobacco beds are in general use: steaming and treatment with chemicals.

Steam Sterilization

Steaming the soil not only kills germs, insects and weed seeds but also makes the plant nutrients in the soil more available and produces a more vigorous growth.

Soil may be steam sterilized either in late autumn or in spring. The advantage of fall sterilization is that it distributes the labor better by avoiding the spring rush, and also reduces the danger of ammonia injury. Spring sterilization may delay considerably the time of seeding, especially during late springs. The disadvantage of fall sterilization is that the soil may become reinfested during the winter with weed seeds, insect pests and fungi. Hence, the operation should be delayed until as late in the fall as possible.

Injury to the germinating seed sometimes results when the bed is seeded immediately after steaming in the spring. It is best to wait a few days before sowing; a lapse of 10 days is desirable, if it does not delay the time of seeding too seriously.

Figure 6. Steam sterilizing the soil in a tobacco bed. Galvanized iron pan at right is weighted down by bags of sand. Note iron pipe "handles" by which the pan is moved to the next position. Vapor is rising from the soil from which the pan has just been removed.

Of the various ways of steaming soils, the only one used in Connecticut is the "inverted pan" method (Figure 6). A galvanized iron pan, reinforced with angle irons, about 10 inches deep, 12 to 16 feet long, and just wide enough to fit inside the bed, is inverted over the soil and the sharp edges pressed a few inches into the loose earth. Steam under high pressure from a steam boiler is forced through a pipe into the end of the pan, penetrating into and sterilizing the soil. The method is too well-known to require further description except for the following precautions:

The soil should be well worked up and loose before steaming. Any manure or humus to be added should be applied in advance. Commercial fertilizers may be added before or afterwards. A moderately dry soil is more easily sterilized than one that is water-logged, because steam penetrates mud very slowly. Twenty to 30 minutes with a boiler pressure of 75 to 125 pounds is usually sufficient. If, after removing the pan, the soil is so hot that you cannot hold your hand in it at a depth of five inches, the steaming is sufficient. Otherwise the length of steaming should be prolonged. The soil should not be worked deeply after steaming because there is danger of turning up some of the unsterilized earth.

Chemical Sterilization

Of the various chemicals that have been tried, the only one that has come into general use in Connecticut is chloropicrin (sold as "Larvacide"). It does not give quite as good weed control as steaming but in all other respects has been satisfactory. The principal advantage of the chemical 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 7. Chloropicrin should be applied three to four 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 young seedlings because the gas remains in the soil between 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 one and one-half inch layer of shredded, weed-free black humus and water it thoroughly.

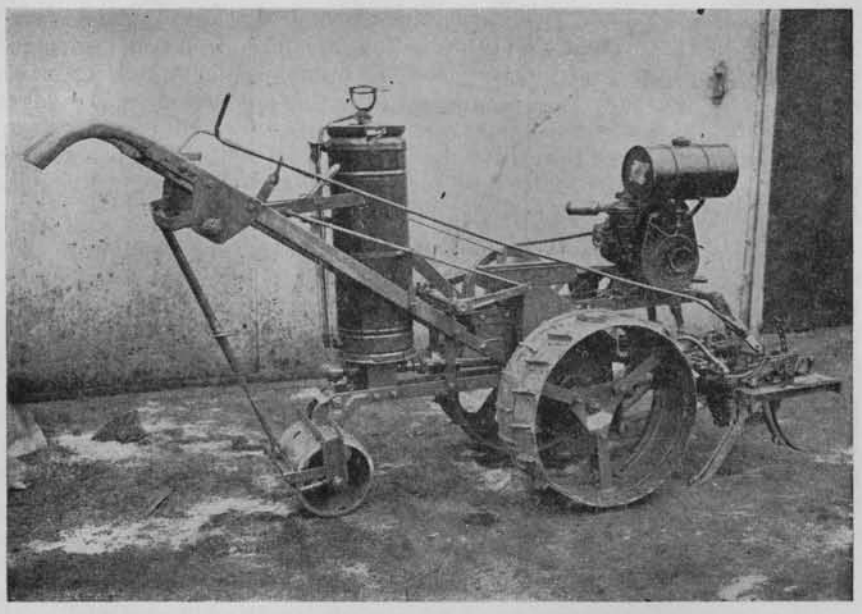

Figure 7. Continuous flow applicator for chloropicrin.

Soil fumigation with methyl bromide is a promising new method. This chemical is obtained as a liquid under pressure in one pound tin cans. One pound is sufficient to fumigate 100 square feet of bed. The bed is first covered with a rubberized tarpaulin or sisalkraft paper. The rims of the cover which lap over the side boards are then covered with soil to make a tight seal. The methyl bromide is introduced under the cover through a saran[1] flexible tube attached to an applicator which is clamped onto the can. When the liquid is released from pressure under the cover, it immediately vaporizes and penetrates the soil to kill weeds, germs and insects. The cover is left over the bed for 24 hours. The gas soon escapes and leaves no harmful residues. The bed may be seeded almost immediately. This method should be used when the temperature of the soil is above 50°F. and is most effective at temperatures of 60°F. or higher.

This method of soil fumigation has not yet been sufficiently tested here to warrant general use.

FERTILIZERS

The constant removal of thousands of seedlings with their roots and adhering soil from a small area depletes the soil rather thoroughly of nutrient elements. The seedbed is as completely robbed of its plant food every year as is the field where the crop is grown to maturity. However, the seedling roots do not forage as deeply in the soil as field plants and it is essential to have an adequate food supply in the layer close to the surface.

[1] A plastic not affected by methyl bromide.

Despite this heavy requirement of the seedlings, we have found that vastly more harm is caused each year by *over*-fertilization than by *under*-fertilization of the beds. Roots of the tiny germinating seedlings are very easily injured by too high a concentration of fertilizer salts or ammonia in the soil. Many bed failures or partial failures are traceable to such fertilizer "burn". We have never seen tobacco plants die from too little fertilizer, although the rate of growth may be slowed.

The actual nutrient requirement of the seedbed is essentially the same as for the field. No special mixtures or mysterious formulas are needed. The main difference is in the *time* of application.

Many successful growers use no fertilizer, or at most a very light application, when fitting the bed soil for seeding in the spring. The fertilizer is applied either during the previous summer and fall or after the plants have germinated and started to grow. An excellent and commonly practiced plan is to cover the beds with a heavy coat of stable manure after the pulling season is over. This may be left on the surface until fall, or even spring, or may be plowed under at any convenient time in the summer. It will be pretty thoroughly rotted before time to seed the beds the next spring. Some prefer to supplement this by an application of regular tobacco mixture or cottonseed meal in the fall, but manure alone is sufficient. If a regular tobacco mixture or cottonseed meal is used instead of manure, or as a supplement, it should not exceed one-half to three-quarters of a pound to a square yard of bed.

In some cases the growing seedlings may later show symptoms of nitrogen or potash starvation. If the difficulty is nitrogen starvation, this may be remedied by soaking the beds with nitrate of soda solution made by dissolving 2 to 3 pounds in a barrel of water; the same amount of nitrate of potash may be applied if the trouble is potash starvation. A gallon of the solution to a sash should be sufficient. The solution should be washed off the leaves by sprinkling with water after treatment. Top dressings are also made sometimes with fish meal, "Swiftsure", "Vigoro", or other quick-acting mixtures.

It is a common practice to add shredded humus or black swamp soil, covering the surface with a one-inch layer and then working it into the top soil. This excellent practice improves the mechanical condition of the soil and is beneficial, but it adds very little plant food.

If beds have been in the same location for many years, it is a good practice to renew the soil occasionally by bringing in soil from some fertile field. A complete soil test is useful in detecting deficiencies of nutrient elements in the seedbed soils.

PREPARATION OF THE SOIL

If the soil was properly cultivated, pulverized and levelled during the sterilizing operation, very little additional work is necessary to get it ready for seeding. The surface soil should be raked and pulverized to a depth of only two or three inches. Deeper cultivation should be avoided since there is danger of bringing to the surface some of the unsterilized soil. To make the surface firm, it may be rolled either before or after seeding. Rolling is

particularly essential if a roto-tiller has been used. The surface should be made as level as possible so that there will not be pockets into which the water will settle after seeding. Too, there should be no slope from one side to the other.

SOWING THE SEED

Most seedbeds are sown during the first half of April. There is nothing to be gained by seeding earlier than this, even though it can frequently be done in March during early springs.

The seed may be sown dry or it may be pre-sprouted. The only advantage of pre-sprouting is that plants can be pushed ahead and may be ready for setting in the field a few days earlier. For pre-sprouting, a weighed quantity of seed is mixed with some fine absorbent organic material, such as sifted rotted wood punk (apple tree punk is an old favorite), ground cocofibre or black swamp humus. The bulk of the absorbent should be 10 to 20 times as much as the seed. It is then placed in jars and moistened with as much water as it will absorb without an accumulation in the bottom of the jars. The jars are kept in a warm room until the seeds crack and the little white primary roots can be seen pushing out. They are then ready to distribute in the beds. Knowing the weight of dry seed added to each jar, the square feet of bed on which each should be distributed can be calculated easily.

It pays to have the seed tested for germination before the beds are sown. Percentage of germination may be learned by sending a sample to the Tobacco Laboratory at Windsor, or the grower can easily make his own tests. One hundred seeds are counted out and kept on a moist blotting paper or filter paper in an enclosed dish in a warm room for 14 days. The dishes should be at least in duplicate to get an average. As fast as the seeds show the white emerging rootlets, they are removed. The number of seeds which have failed to germinate at the end of 14 days is subtracted from 100 to give the percentage of germination. Any lot that germinates less than 70 per cent should not be used. Those that germinate above 90 per cent are excellent.

If dry seed is used, it is first mixed with a much larger amount of some dry diluent, such as sifted sand, coal ashes or bone meal, since this insures better distribution. There is an advantage in having a white diluent since it shows plainly the part of the bed that has been sown.

A standard sowing rate is one ounce (three heaping tablespoons) of seed to 1,000 square feet of bed area. A heavier rate makes the beds too thick, with resulting spindling, weak plants. Thick stands invite diseases. The seed, with diluent, is spread by hand as evenly as possible over the bed. A measured amount of seed is sown on each bed or each portion of a bed to insure uniform stand. Some growers even divide the seed for each section into two equal lots and sow the bed twice to make it more uniform.

After distribution, the seed is barely covered by very light raking. Some, however, rake the rolled soil before sowing and then depend on watering to cover the seed. Regardless of the method practiced, it is essential that the seed be very close to the surface of the soil or only half buried. The bed

is next watered carefully with a fine sprinkler nozzle, going over it several times to avoid puddling but still wetting the soil thoroughly. Some prefer to cover the soil after sowing with a layer of shade cloth and then water. This prevents washing, holds moisture and helps to prevent the soil from drying out so quickly in spots. The cloth should be removed just as soon as the first green plants come through it. The beds are covered with sash just as soon as sown. It is a good practice to cover the sash with several thicknesses of shade cloth to furnish partial shade until the plants show green; this practice, however, is not essential to success.

WATERING

Proper watering during the early seedbed period is a "must" for good even beds. The germinating seeds are close to or even directly on the surface of the soil. If they dry out after the rootlets have started and before they get established in the soil, they die; hence, the importance of keeping the soil constantly moist during this period. Bare spots in growing beds and uneven stands are mostly due to allowing spots to dry out during this critical period, thus killing the seedlings. Under some conditions it is necessary to water the beds twice a day to prevent the appearance of dry spots. A sprinkler nozzle with fine holes is best and the force of the water must not be so strong that it will wash the seeds about and deposit them in pockets. Overwatering will have the same effect and should be avoided.

After the plants have become established and have four to six leaves, the system of watering may be changed (Figure 8). Water less often but apply more water each time. As the plants become larger, they will consume larger quantities of water. They should always have water enough so that they will not wilt. Again, overwatering should be avoided because it encourages bed rot, mildew and wildfire, and makes the plants too tender. It may also leach the nitrogen out of the soil.

Figure 8. Sprinkling. More water is required as the plants grow larger.

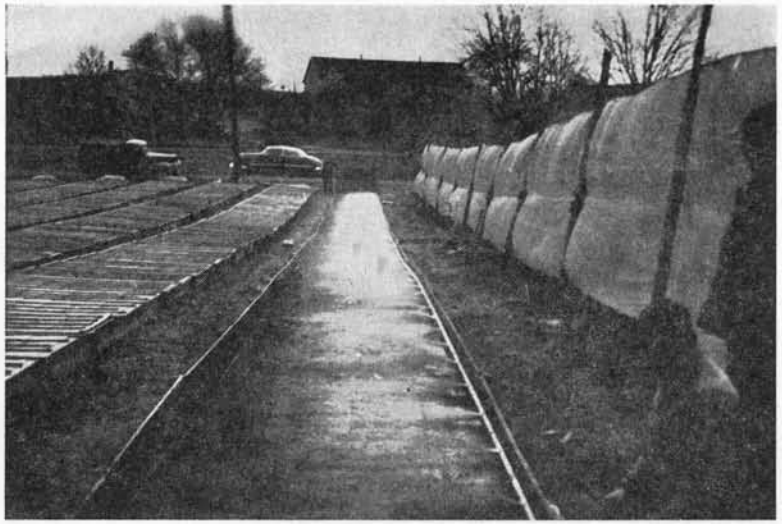

Figure 9. Automatic sprinkler system operating in beds. Fine mist coming from small nozzles in pipe at right.

Several systems of watering through a water pipe running lengthwise of the bed beneath the sash and fitted every two feet with small spray nozzles have been tried and at least one of them is coming into general use (Figure 9). This seems to be a good way of watering since it eliminates the labor and time of raising or removing the sash. Moreover, the fine mist of these small nozzles does not cause washing of the soil as larger nozzles tend to do. With this system a whole bed of any length can be watered in five minutes. Objections to some of these systems have been clogging of some of the fine nozzles and excessive water deposited in some spots.

VENTILATION

If beds are not sufficiently ventilated, the air inside becomes too humid and the plants are forced and tender. Forced tender plants do not develop a large enough root system and are not hardened sufficiently to resist the dessication they experience when transferred to the field. Moreover, the humid air favors growth of "green mold" algae and various disease-producing fungi mentioned in the next section of this circular. Too, on bright sunny days the air under the glass may become too hot for the plants to endure unless the beds are ventilated. The temperature in the bed should never be allowed to rise above 95°F.

There are many ways of ventilating beds and all have their advocates. The commonest way is by raising one end of every second sash on one side of the bed, usually the higher side. The raised end is supported above the top of the board on wooden blocks 2 by 4 by 6 inches, such blocks furnishing a choice of three heights to which the sash may be raised to give the desired size of opening. Alternatively, the blocks may be placed under the side of each sash (Figure 1) and supported on the first mullion of the next sash.

Another method is to place a loose board 4, 6 or 8 inches wide between each of the sash when the bed is first made up. These boards can then be taken out whenever ventilation is needed. If the outside mullions of each sash are prolonged to make handles, the alternate sash may be slipped down and up with the ends of the handles resting on the side boards (Figure 4).

The beds are usually opened for ventilation during the day and closed at night. During warm nights they may, however, be left open. When the plants are nearly large enough to start transplanting, it is customary to remove the sash from the beds during warm days or even at night to "harden off" the plants (Figure 2).

In the first stages before the seeds have germinated, it is usually not necessary to ventilate at all, unless there is trouble with molds. After the first tiny green leaves appear, the beds should be ventilated at least a few hours every day except on unseasonably cold windy days. More seedbed troubles arise from too little ventilation than from too much.

CONTROL OF DISEASES

Every effort should be made to keep the beds free of diseases, not only because they may kill, damage or delay the plants, but because diseased plants taken from the bed are the principal source of most field diseases. Our worst seedbed diseases are damping-off, wildfire, bed rot, mildew and calico. Ammonia injury or "yellow patch" should be added to this list although it is not caused by an organism or virus. The most effective known method of control for each of these is given below.[1]

Early Damping-Off

This is the first disease of the season, appearing about the time the seedlings have developed the first two leaves (cotyledons). Diseased seedlings have shrivelled stems and soon fall over. After lying prostrate on the soil for a day or two, they disappear. The stand becomes thinner every day and in patches there may be no plants left at all. This disease is caused by a soil fungus[2] which invades the stem and causes it to decay.

Damping-off is not serious in most beds but in certain favorable locations it occurs year after year. Control measures are not necessary for the majority of beds. In locations where damping-off is known to occur, the most effective method of control is soil treatment with formaldehyde just previous to sowing the seed. This must be done carefully because an overdose may kill the plants. A procedure which has proven successful is as follows:

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

2. Have soil pulverized and ready for sowing.

[1] For a more complete discussion of these diseases and their causal organisms, see Conn. Agr. Exp. Sta. Buls. 432 "Diseases and Decays of Connecticut Tobacco" and 527 "How to Control Tobacco Diseases".

[2] *Pythium debaryanum.*

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 three 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.

Coating the seed before sowing with fungicidal dusts gives some control although it is not always effective. In a series of trials at the Tobacco Laboratory, the three which gave best results were Arasan, Cuprocide and Fermate, in the order named. Spraying with copper fungicides as described under "Wildfire" on page 19 is beneficial but is usually too late to be dependable. Fumigation of the beds with paradichlorobenzene every second night after the seeds had started to germinate gave excellent control in experiments at the Tobacco Laboratory.

Wildfire

This bacterial disease may start at any time in the seedbed, from the four-leaf stage up to setting size. The disease usually appears in patches and under severe conditions all the young plants in these areas may be

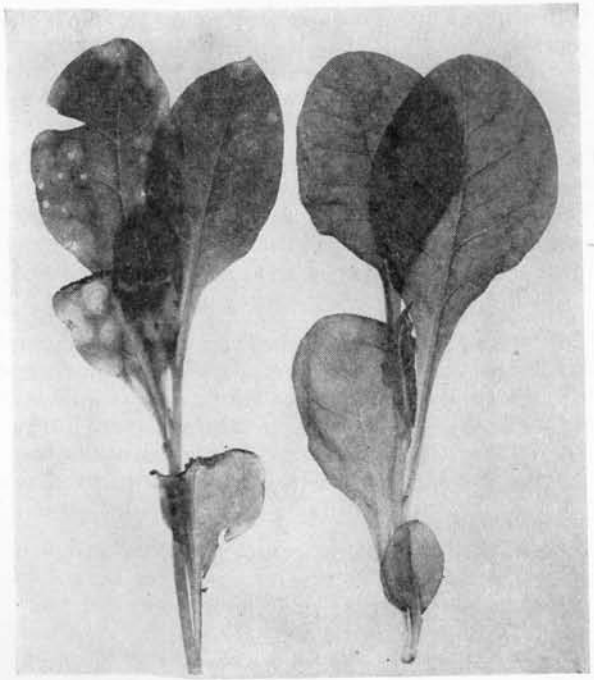

Figure 10. Wildfire. First symptoms are the yellow halo spots as shown on plant at left. Plant on right is healthy.

killed. The symptom by which this disease can be distinguished from all other leaf-spot troubles is the halo spot. This is a circular spot with the dead brown center surrounded by a wide yellow band (the halo) with a smooth regular margin (Figure 10).

Early spraying of the beds with a copper fungicide is the most important measure in preventing wildfire. Homemade Bordeaux mixture is satisfactory but bothersome to prepare. Many growers would rather purchase a fungicide that requires only mixing in water to be ready for application. A number of such materials with a copper content of 30 to 50 per cent are now marketed under different trade names.[1] Rates of dilution with water are given in the directions on the package. Copper A Compound, for example, is diluted at the rate of one pound in 10 gallons of water. One gallon of this mixture is sufficient to spray 15 to 25 sash, depending on the type of sprayer used.

The first application should be made just as soon as the plants are up and established (while they are still mostly in the two-leaf stage). If, on drying, every leaf is blue, the rate of application is sufficient. It is important that the copper spray cover the soil surface because it stops the bacteria from passing from the soil into the lower leaves. Later applications should be made at weekly intervals. After spraying with copper compounds, the leaves should be allowed to dry before replacing the sash; otherwise, there is danger of leaf burn. Copper sprays are not compatible with Fermate and, therefore, should not be mixed with it or applied on the same day but should alternate with sprays for controlling mildew.

If wildfire was prevalent during the preceding year, precautions should be taken against transferring any infected material from the sheds to the beds. If the disease occurred in the beds, it is well to drench the sash and boards with formaldehyde diluted at the rate of one part in 25 parts of water.

Frequently wildfire appears only in isolated spots in the beds. Whenever such an infection is found, all the plants in the area and those bordering on it for a foot or more should be destroyed by drenching with formaldehyde diluted at the rate of one part in 25 parts of water. Glass should be removed from the bed during this operation and left off for the next 24 hours to prevent the fumes from spreading and injuring other plants.

If the infected spots are numerous or the disease is distributed generally throughout the bed, it is best to destroy the bed entirely. This may be done by drenching with a one to 50 solution of formaldehyde on a hot day and leaving the glass on tight.

Wildfire is contagious. Tools used in infected beds should be dipped in formaldehyde before being brought into contact with healthy plants. If it is at all practicable, no plants should be pulled from beds in which wildfire is present.

Downy Mildew (Blue Mold)

This is the most troublesome disease we have in seedbeds. If it gets into the beds when the plants are quite small, it kills many of them and may even

[1] Such as Copper A, COCS, Basi-Cop, Tennessee Tribasic, etc.

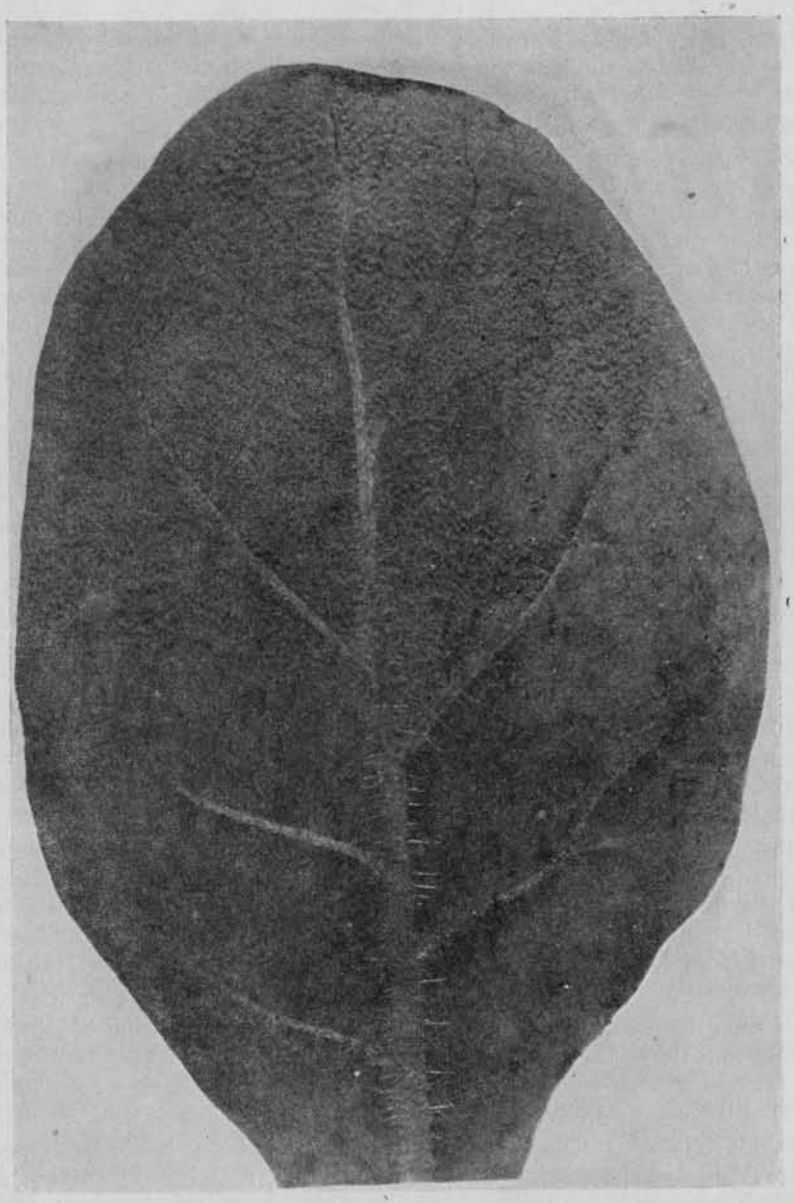

Figure 11. Downy mildew. This leaf from the seedbed shows the fungus covering a part of lower surface (somewhat enlarged).

destroy the whole bed. If the plants are large, it kills parts or all of the leaves but the plants survive and put out a new crop of leaves. This, however, may cause serious delay in getting the plants set in the field.

Mildew first causes yellow blotches on the upper surfaces of the leaves which become distorted. The sure diagnostic symptom, however, is the mold-like growth of fungus[1] which soon appears on the lower surface of

[1] *Peronospora tabacini.*

the leaves (Figure 11). This growth may have a violet color when fresh; hence, the popular name "blue" mold. It soon assumes some shade of gray or brown. If the bed atmosphere is moist, the leaves develop a wet rot; under dry conditions, they shrivel and lie like twisted strings on the soil.

Usually mildew first appears in Connecticut about May 15 but during early springs it may attack earlier in the month. It spreads rapidly by means of spores that are blown about in the air. When it is found in one bed, it almost always shows up quickly in the other beds in the neighborhood.

Fungicides for Control

Any of several fungicides may be used to control mildew. Fermate is most commonly used. It is easily applied, cheap, generally available and gives excellent control, if properly applied. It is mixed in water at the rate of one pound (about 4 pints) in 50 gallons when the plants are small. For larger plants or in locations where mildew has become general, this may be increased to two pounds.

Fermate is a fluffy blackish powder not easily mixed with water. Mixing is facilitated if the required amount of powder is first shaken vigorously with a small amount of water in a closed container and then added to the larger amount of water in the spray tank.

Since the action of Fermate is preventive rather than curative, it should be applied to the leaves before infection is expected. The beds are sprayed regularly twice a week, beginning about the first week in May and continuing until setting in the field is completed.

Any type of spray pump may be used which gives a moderately high pressure and fine distribution of the spray. A good coverage is indicated when every leaf shows black droplets of Fermate (Figure 12). It requires 3 to 5 gallons of spray to cover 100 square yards of bed, depending on the type of sprayer used and the size of the plants. Applications should not be delayed for inclement weather unless it is actually raining at the time. It is not necessary to leave the beds uncovered until the spray has dried. The beds should not be watered, however, until the spray has dried.

There is little danger of spray injury from Fermate, although heavy application under certain weather conditions may cause the bud leaves to become strap-shape. The plants quickly outgrow this and there is no permanent damage.

Karbam is another proprietary fungicide which contains the same effective compound (ferric dimethyl dithiocarbamate) as Fermate. It mixes with water more easily than Fermate. It may be used at the same dilution as Fermate and controls mildew equally well. Nu-leaf is a similar fungicide containing ferric dimethyl dithiocarbamate and may be used in the same way.

In several years of tests at the Tobacco Laboratory, Dithane Z-78 has given as complete control of mildew as has Fermate. The directions for preparation and application are the same as given above for Fermate. The compound has not caused any leaf burn. Parzate contains the same effective ingredient as Dithane Z-78 and controls mildew to the same degree.

Figure 12. Pulling the plants. Black Fermate spots on the leaves show that these plants have been properly sprayed to prevent blue mold and bed rot.

Each of the fungicides noted above may also be obtained in a dry mixture suitable for application as a dust (Fermate and Karbam, 15 per cent; Dithane and Parzate, 10 per cent). Experiments at Windsor showed that Fermate dust was as effective as the spray. With equal distribution, there appears to be no reason why any of these fungicides should not be applied in dust form. The choice of methods depends on which the grower considers more convenient and the equipment he has available.

Fumigation

Fumigation of the beds with crystals of paradichlorobenzene[1] was the method commonly used for combating mildew before the Fermate spray method was developed. The action of PDB differs from that of the fungicides discussed above in that it stops the fungus after the plants are already diseased while Fermate and the others are preventive. The PDB method is, therefore, preferable if mildew is already present in the bed. Wise growers keep a supply at hand as a second line of defense. If, for any reason, they have failed to stop mildew with the spray program and the disease appears in the beds, then they use PDB. Some growers still depend on the PDB method alone but most of them consider the spray method less troublesome.

The fungicidal (or fungistatic) action of PDB is dependent on the concentration of fumigating gas in the seedbed air produced by vaporization of

[1] PDB, Dichlorocide or Parabaco.

the crystals. Adequate concentration can be built up only in tight beds where the air does not leak out too rapidly. Thus, the key to success is to keep the sash and side boards free of cracks or holes which would allow the gas to escape.

The crystals are exposed in the beds during the night when the sash are closed and are removed in the morning before the sun warms the bed air to a degree which causes too rapid vaporization. On cloudy days, however, PDB may be left in the beds all day. The crystals are placed in screen wire baskets supported above the plants. A common practice is to attach these flat shallow baskets to the side boards alternately on the top and bottom. Baskets should not be over six feet apart and the rate of application not less than one-quarter ounce to the square yard of bed.

If mildew is already present in the beds, the treatment should be repeated for several nights in succession, or until no fresh growth of mildew can be found. If, however, mildew has not yet been found in the beds, treatment on alternate nights is sufficient.

There is danger of injury to plants if the beds are kept closed during sunny warm days without removing the crystals. The initial injury appears as fading of the green leaves to yellow, and stunting, or slow growth of plants.

During cold nights when the temperature is below 45°F., the crystals do not vaporize fast enough to produce a lethal concentration of the gas and the treatment is not effective. Under these conditions it is best not to remove the crystals too early in the morning but to wait until the bed temperature gets up to 80°F.

Benzol is sometimes used for fumigation. It is applied in much the same way as PDB except that liquid benzol is vaporized from shallow pans, such as 8-inch pie tins. When the weather is cool or during cold nights, it is more effective than PDB, because benzol vaporizes more readily at lower temperatures. The pans are supported above the plants, one to every two sash, on wire standards. The benzol is poured about one-quarter inch deep in the bottom of the pans. Although more effective than PDB, the benzol method has certain disadvantages. Tipping of the pans or falling of water drops from the sash splashes the liquid out of the pans on to the leaves. Every drop kills a spot on the leaves and entire patches of plants may be killed. Another disadvantage is the extreme flammability of benzol, which involves danger of fires where it is stored.

Bed Rots

Bed rot attacks plants in the later seedbed stages, from the time they are half grown until they are pulled, with greater frequency as the plants grow and become more crowded. Beds that are too thick, too little ventilated or overwatered are most often affected, but the disease is not confined to such beds.

Four different kinds of bed rots occur here, each caused by a different species of parasite[1] and having slightly different symptoms. The general

[1] *Rhizoctonia Solani, Pythium aphanidermatum, Botrytis cinerea* and *Bacillus aroideae.*

Figure 13. A bed rot spot. Arrows point to plants where the fungus is advancing up the bases of the leaves from the rotted stalk.

effects on the plant, however, are about the same and since all seem to respond to the same treatment, they will be considered collectively here.

Patches of plants, from a few inches to several feet in diameter, wilt and then collapse in a wet rot (Figure 13). Close examination of the plants shows a brown rot area on the stalk at the surface of the ground. The rot progresses up the stalk and into the leaves. When the plants are dense, the rot may run from plant to plant through the leaves. Fungous growth may or may not be found on plants and soil, depending on the species of the parasite and moisture conditions. Finally, the whole mass of plants sinks to the ground and dries out as a parchment-like brown or bleached mat over the soil. Under wet conditions the spot spreads centrifugally and kills all the plants as it goes. With a return of dry conditions, it stops and there may be no further trouble. Around the edge of the patch there are usually some plants that do not die but survive with brown lesions on the stalks. Such plants often die when set in the field and are the start of stalk diseases, such as wet stem rot and sore shin.

The first line of defense against bed rot is the sterilization of the soil by steaming or by chloropicrin. This kills the parasites that are in the soil at the time but does not prevent reinfestation. Avoidance of overcrowding, overwatering and too little ventilation also helps prevent the disease.

Regular spraying of the beds with Fermate, as outlined for mildew, gives almost complete control. Bed rot rarely occurs in beds that have been so treated. Spraying with Bordeaux or the copper sprays discussed for wildfire control also reduces bed rot but is not so effective as Fermate.

Mosaic or Calico

Mosaic (calico) is not a destructive disease in the seedbeds. It is rarely seen on the plants at this stage and never kills them or causes serious dam-

age. However, even a few mosaic-infected plants may cause spread of the virus throughout a bed when plants are pulled or weeding done. When these plants are transplanted to the field, they never recover from calico even though they had no visible symptoms when taken from the beds. Keeping mosaic out of the beds is the most important measure in reducing losses which frequently become serious in the fields.

The symptoms are usually not very prominent in the seedbeds and only careful examination will reveal them. The younger leaves become mottled, with irregular areas of light yellowish green alternating with dark green patches. The bud leaves may be distorted and irregularly wavy on the surface. The dead fleck spots and rust which characterize the disease in the field are not found in the bed.

Mosaic is extremely infectious. When, in handling infected plants, the juice gets on the hands of a workman, he need only touch or rub his fingers over the leaf of a healthy plant to infect it. Once a plant is infected, it never recovers, since it has no way of eliminating the virus.

Although the methods of dissemination in beds and field are well known, the means by which mosaic first gets its start each spring are not so obvious. Its method of overwintering, however, gives some clue. In cured or dried leaves the virus will remain infective almost indefinitely. Its longevity is probably the most important fact to be kept in mind in connection with the prevention of mosaic. It will even survive in manufactured tobacco, such as cigars, cigarettes and chewing tobacco, although in smaller amounts than in barn-cured tobacco. The chewing and smoking of tobacco by workmen while handling the plants in the beds is often a source of early infection.

In some badly infected beds growers have used tobacco refuse, raked from the floor of curing sheds, as fertilizer. In some sections of the country, perennial weeds belonging to the tobacco family are sometimes infected, and the virus is transferred to tobacco plants while weeding. This does not appear to be a common source of infection here, however.

No spray or dust is effective in controlling mosaic. Control measures must start with an understanding of the nature of the disease and, particularly, its method of dissemination as described above. Methods should aim at preventing the introduction of the disease into the bed.

The following preventive measures have been found useful and are offered as suggestions to growers whose crops are troubled with mosaic.

1. Tobacco refuse from curing sheds, sorting rooms or other sources should be kept entirely away from the seedbeds. Sometimes tools or bed sashes, which have been stored in sheds without being carefully cleaned, may carry bits of diseased leaves to the beds.

2. Men who are weeding, pulling or setting, or handling the crop in any way should be discouraged from using tobacco. This applies to the use of the leaf in any form, but particularly in chewing and pipe tobacco.

3. Plants should never be set from a bed known to contain the disease. Mosaic plants are difficult to detect in the seedbed. If only a few are found, it is quite certain that there are many other diseased ones which have not been "spotted". Rather than risk spreading the disease to the field it is

better to sacrifice the whole bed. Second and third pullings from a bed are much more likely to have mosaic than the first ones, because of spread while pulling.

Ammonia Injury (Yellow Patch)

Sometimes excess ammonia in the soil kills or stunts young plants in the early seedbed stages and may ruin entire beds. This malnutrition disorder is difficult to diagnose, requiring soil analysis and microscopic root examination before absolute confirmation. Sometimes the seed does not germinate at all; usually, however, the seedlings come up and struggle along for a while before disappearing. As most commonly found, the disease occurs in patches of a few inches to a foot or more in diameter where the plants die off before they are a quarter of an inch high. First they turn yellow and then fall over and disappear, leaving ragged bare spots scattered over the beds. Those surviving are likely to be stunted and grow slowly. Microscopic examination of the affected plants shows that the stems are sound and normal but the roots are brown and dead without any fungous mycelium or signs of disintegration. These symptoms distinguish this trouble from the various forms of rootrot and damping-off with which it can easily be confused.

Ammonia injury occurs most often on bed soils that have been steamed in the spring. A soil test shows huge quantities of ammonia liberated from such organic materials as fish meal, cottonseed meal and manure during the process of steaming. Cold, wet springs, which are not favorable for nitrification, also seem to cause accumulation of ammonia in the soil.

Control lies primarily in avoiding the application of nitrogenous materials, such as those listed above, just previous to steaming. It is also well to delay seeding as long as possible after steaming in order to permit the ammonia to be converted to nitrate. Steaming the beds in late autumn instead of in the spring will also often eliminate the trouble.

When it is found that plants are dying from ammonia injury, the trouble may be alleviated by soaking the soil with calcium chloride solution made by adding 2 or 3 pounds of calcium chloride to a barrel of water. Apply one gallon of solution to a sash.

CONTROL OF INSECTS[1]

There are four kinds of insects that may injure plants in the seedbed: springtails, cutworms, flea beetles and aphids. The first two may cause serious damage or complete destruction. The other two do not kill the plants but get their start in the seedbed from where they are carried to and widely distributed in the fields causing great losses. Therefore, it pays to destroy all of these insects in the beds.

[1] The reader is referred to Conn. Agr. Exp. Sta. Bul. 379 "Insect Pests of Growing Tobacco" for a more complete description of the species and nature of their injury.

Springtails[1]

Springtail damage is found only very early in the season (April) when the plants are in the two-leaf stage. In its mildest form it appears as semicircular notches eaten in from the rims of the leaves (cotyledons). These notches are the best diagnostic symptoms. In more severe form the cotyledons and tips of the stalk are completely devoured and only the bare stalks are left. All the plants in great patches may thus be destroyed, leaving conspicuous bare areas or a very thin stand of surviving plants.

Because of their small size and dark color, the insects are difficult to see unless one gets very close to the soil. They are only about one twenty-fifth of an inch long and have dark purple globular bodies dotted with yellow. They jump and disappear like fleas and are hard to catch.

They may be controlled by spraying the beds with nicotine sulfate diluted at the rate of one pint in 100 gallons of water. The spray should be applied on bright days and glass covers should be kept on to confine the fumes. Nicotine vapor, such as that used for fumigation of greenhouses, should also be effective.

Cutworms

Several species of cutworms feed on tobacco. At least two of these species, the dark-sided cutworm[2] and the W-marked cutworm,[3] cause damage in the seedbeds. The first species infests isolated spots in the beds while the second often invades in large numbers and makes a clean sweep of the plants.

Figure 14. Seedbed plants damaged by the dark-sided cutworm.

[1] *Sminthurus hortensis* Fitch.
[2] *Euxoa messoria* Harr.
[3] *Agrostis unicolor* Wlk.

The earliest symptoms noticed are crescent-shaped notches eaten in the leaves when the plants are still in the four- or six-leaf stages (Figure 14). As the worms grow, they eat out the whole sides of leaves, and then whole leaves or entire plants. On larger plants they eat out the buds, leaving the plants worthless, because when set in the field they do not grow up in single stalks but are multiple branched. This species does not often cut off the stalk at the surface of the ground like more common species in the field.

The worms may be found coiled up just under the surface of the ground or under the leaves in contact with the ground. They feed mostly at night and remain in hiding during the day. They are dark gray with paler stripes on the back and sides. In the early stages of injury the worm is very small, less than a half inch long. It may become fully grown, 1½ inch long, before the plants are large enough to set.

The W-marked cutworms sometimes invade beds in advancing hordes from outside territory where they have spent the winter. The worms advance over a bed, eating entire plants and leaving the ground practically denuded. They are dull brown, gray or blackish, often with a tinge of green, and marked longitudinally with dots and dashes.

Methods of control are the same for all cutworms, whether they are of the two species mentioned or other species which probably infest the plants in the beds. The plants may be dusted with a 10 per cent toxaphene dust at the rate of about one pound to 30 sash, or until there is a white coat of dust on all plants.

An older but still popular method is to apply a standard poisoned bran bait, such as is used in the fields. The bait may be made by mixing 100 pounds of bran and 4 to 6 pounds of paris green with enough water to moisten. The bran and paris green are first thoroughly mixed together and then enough water added so that the material sticks together in small pellets. This is scattered over the bed or concentrated in places where there are few plants. This method is subject to the serious objection that the poison pellets burn spots in the leaves. This does not usually kill the plants, however.

Flea Beetles[1]

These are small black shiny oval beetles about one sixteenth of an inch long which jump out of sight very quickly when disturbed. They feed from the under side of the leaf making small "shot holes" when they eat clear through (Figure 15). Often, only the lower tissues are eaten away but the overlying tissue dies, leaving ragged dead patches on the leaf. Flea beetles first appear in beds about the middle of May. During some years the leaves may be pretty well riddled before the close of the setting season unless measures are taken to destroy the beetles. The tiny larvae also feed on tobacco roots. Infested plants taken into the field furnish an effective vehicle for distributing the pests to the growing crop where they do the most harm.

There are a number of insecticides that can be used successfully to kill flea beetles. DDT is perhaps the most certain. The plants may be treated

[1] *Epitrix cucumeris* Harr.

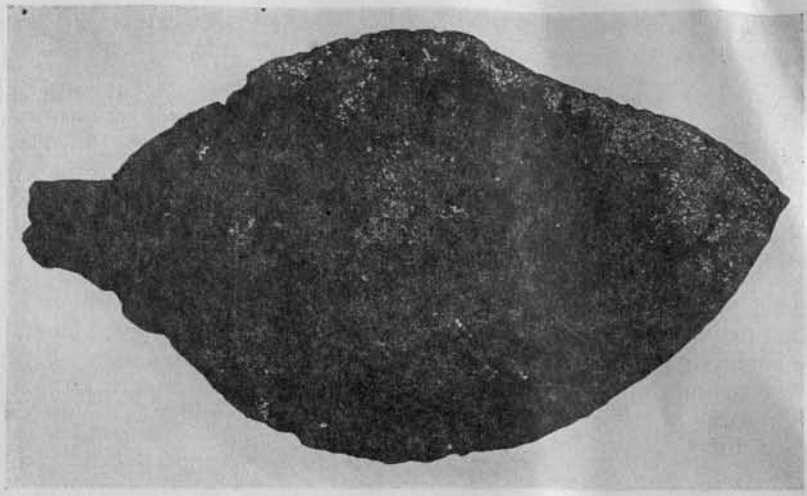

Figure 15. Flea beetles pepper the leaf with tiny holes.

with a 5 per cent DDT dust. Since at this stage the beds are usually sprayed twice a week with Fermate, it saves time to add the DDT to the Fermate spray. One pound of a 50 per cent wettable DDT (or equivalent if a 50 per cent powder is not available) in 50 gallons of the Fermate spray mixture is sufficient. A 1 per cent rotenone dust may be used instead of DDT. Marlate or Lindane are also effective.

Aphids[1]

Aphids do not cause serious damage to the plants while in the beds but even a light infestation which would ordinarily escape notice can be the

Figure 16. Aphids on lower surface of leaf in various stages of growth suck the sap out of the leaf cells. White cast skins also adhere to the sticky leaf.

[1] *Myzus persicae* Sulzer.

means of distributing this pest to all the fields on the farm. In the field, aphids may cause great damage.

These tiny yellowish green plant lice, usually intermingled with shiny white casts, can often be found on the under surface of the leaves (Figure 16). If the infestation has been present more than a few days, they become very numerous and secrete a sticky "honey-dew" which drops on to the lower leaves and may become black. They suck juice from the leaves and, in the field, the leaves fade and become "papery". This stage, however, is rarely reached in the beds.

This pest is most effectively controlled by the use of parathion. The plants may be dusted with a 1 per cent parathion dust or sprayed by adding one pound of 15 per cent wettable powder to 100 gallons of water, Fermate or other spray solution. One pound of 20 per cent Lindane in 100 gallons of the spray or tetraethyl pyrophosphate, diluted according to the manufacturer's directions[1], may be used instead of parathion.

PULLING THE PLANTS

When the seedlings have grown to a height of four to six inches (Figure 12), they are ready to be set in the fields. Before transplanting, however, they should be "hardened" in order to help them withstand better the change from the sheltered life in the beds to the more severe weather in the field. This is done by keeping the glass off the beds night and day as much as possible for a week or more, closing them only for frosty nights or heavy storms (Figure 2).

Before pulling, the beds are heavily watered until the soil is muddy and the plants can be pulled with no snapping of roots. If there is plenty of humus in the soil, each plant will come out with a ball of soil clinging to the roots. Only the larger, stronger plants are taken. Grasping the tip of the tallest leaf between thumb and finger, a sideways pull removes the seedling without seriously disturbing adjacent plants. The most convenient receptacle for plants after pulling is an oblong half bushel basket, which is a convenient size for the dropper to carry in his lap on the setter. This saves extra handling of the plants, necessary when larger baskets are filled with plants as they are pulled.

After the stand of plants is thinned out by a pulling, the remaining plants have a tendency to fall over or tilt. If they are left exposed to the weather, such plants develop crooked stems as the growing buds turn upward. Crooked plants are unsuitable for setting. If, however, the glass is put back

[1] When parathion and tetraethyl pyrophosphate were introduced as insecticides, it was known that both were highly toxic to humans. Both could be absorbed through the skin and through the mucous membrane in the eyes, mouth and lungs. Suitable precautions to be taken in handling and application were included on the labels. However, in 1949, there were three deaths of operators applying parathion sprays to agricultural crops. In each case, parathion poisoning resulted from violation of the precautions to be taken.
It is increasingly obvious that if these poisons are to be used, complete supervision is required by trained, responsible persons to enforce all of the safety measures. Unless such supervision can be given, these chemicals may be considered too dangerous to use.
The safety measures include (1) protection of the eyes, lungs and skin from concentrated powders or liquids during weighing and dilution; and (2) protection of the eyes, lungs and skin from exposure to diluted spray mist or dust cloud. At least one of the deaths was caused by the clothing of the operator being wet constantly by the spray drift.

on the beds immediately after pulling, the stalks straighten out more quickly and are straight for setting.

In order to stimulate growth of the smaller plants left after pulling, it is a common practice to topdress the plants several times during the pulling period with fertilizer. "Swiftsure", fish meal, nitrate of soda or nitrate of potash are most often used. This is often not necessary but is a good practice if the beds are not furnishing plants fast enough. The fertilizer should be completely washed from the leaves into the soil by sprinkling them thoroughly after such treatment. A thrifty bed may be pulled over every three or four days.

DESTROYING THE PLANTS IN THE BEDS AT SEASON'S CLOSE

After the last re-stocking of the fields, there are usually numerous plants left in the beds for which the grower has no further use. If allowed to grow in the beds all summer, they become diseased and infested with insects. Many field infestations can be directly traced to such neglected beds. It is, therefore, best to destroy these plants just as soon as the grower is sure he will have no further need for them. This may be done by pulling or hoeing them out. A better method is to kill them with formaldehyde or other chemicals. This not only kills the plants but also destroys any insects or pathogens that may be present. The formaldehyde is diluted at the rate of one gallon in a barrel of water, the plants are thoroughly sprinkled with the solution and then the glass sash put tight on the beds to confine the fumes. It is best to do this on a bright hot day.

CARE OF BEDS BETWEEN SEASONS

From the last of June until the following April, no tobacco plants are raised in the beds. This is the period when the fertilizer, manure and humus should be applied as described in the section on fertilizers. Also, the soil should be sterilized either in the spring or fall.

It is important that weeds be kept from growing in and around beds and shedding their seeds in the bed soil. The beds may be kept fallow by hoeing or cultivating at frequent intervals during the summer. Many growers prefer to keep weeds down by planting the beds to some crop which can be clean cultivated. Squash, cucumbers, tomatoes, cabbage and other vegetables are thus used and furnish extra food for the farmer's table. Some growers set the seedbed area to tobacco, spaced as in the open field, thus increasing the tobacco harvested. This is a questionable practice, however, because these plants may serve to carry over diseases or insects into the next crop of seedlings. The grower is tempted to use weedicides, such as 2, 4-D, to keep the area free of weeds. Some unfortunate experiences, such as accidental escape of 2, 4-D from the aisles into the beds, have discouraged this practice. No doubt a safe use of weedicides can be devised, however, and will ultimately become standard practice. For the present, caution is advised.