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TOBACCO SUBSTATION AT WINDSOR

REPORT FOR 1938

P. J. Anderson

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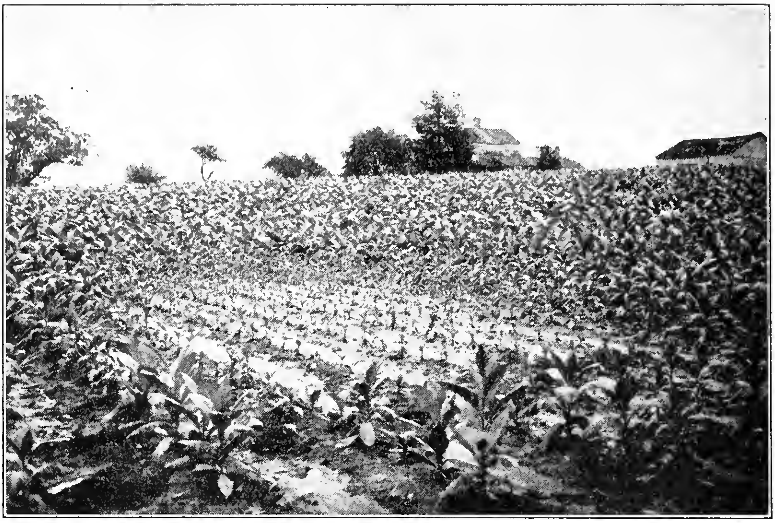

Figure 1. Drowning or "wet feet". In 1938 hundreds of acres of tobacco like the spot shown here were never harvested.

Figure 2. Hundreds of curing sheds looked like this after the hurricane of September 21.

Tobacco Substation at Windsor

Report for 1938

P. J. Anderson, T. R. Swanback and O. E. Street

This, the seventeenth, annual report of the Tobacco Substation at Windsor, is a record of the progress of the experiments during the season of 1938, a year which will probably go down in history as the most disastrous tobacco year in a generation of growers. It will long be remembered as the year of the great New England hurricane and flood which caused losses of tobacco estimated by the New England Crop Reporting Service at 5,700,000 pounds. Almost as disastrous as the hurricane and flood were the excessive rains of June and July.

From the precipitation record of the season, shown in Table 1, it will be noted that the rainfall for June at Windsor was just double the average for the last 16 years, and for July, it was two and a half times the average. It is a well known rule in the tobacco trade that the extent of rainfall during these two months determines the yield and, to a somewhat less degree, the quality of the crop. This year has provided an excellent demonstration of the rule.

A series of plots on a sandy field at the Experiment Station farm (No. V) received the same fertilization in 1936, a normal but fairly dry year, and in 1938. The average yield of these plots in 1936 was 2,087 pounds to the acre and in 1938 was 773, a reduction of 63 percent. These plots received no top dressing of additional fertilizer. Adjacent plots, top-dressed three times, produced 1,254 pounds, a reduction of 40 percent from the 1936 average.

On heavier soils the reduction in yield from leaching was not so great but, on hundreds of acres where the water stood around, the plants drowned, and either wilted and died within a short time or continued to live in a stunted condition (Figure 1). Many acres of this drowned or starved tobacco were never harvested; many more were harvested at a loss and at best can be sold for stemming prices, far below the cost of production. Even without the hurricane loss, the 1938 crop was about 50 percent of normal weight. The extent of the damage to quality can be determined only after sorting.

The hurricane of September 21 came at a time when the curing sheds were full. A farm survey in 20 Connecticut towns showed that sheds with a capacity of 6,269 acres of tobacco were totally destroyed, in addition to serious damage to 3,557-acre capacity sheds. No attempt was made to salvage the drenched tobacco in a considerable percentage of these sheds and that which was saved in others was damaged by breakage and water. Another large number on the lower levels was inundated by the flood which followed the hurricane and the tobacco in them was lost.

No serious loss to buildings or equipment was sustained at the Tobacco Substation in either case. The excessive rains of the summer, however, reduced the yield and quality of the crop so much that most of the fertilizer and cultural field tests were either ruined, or at least the results were of questionable value.

For certain types of experiments, however, the year was very favorable. Considerable and valuable data were collected on the leaching of the fertilizer elements as described in other sections of this report. It was also an excellent year for the study of diseases and nutritional disorders which were very abundant. Wildfire recurred in destructive proportions for the first time in 12 years; blackfire and several types of bedrot in the seedbeds caused considerable alarm; black rootrot and hollow stalk in addition to wildfire and blackfire were abundant in the fields; other previously little known diseases, as described later, reappeared and offered good opportunities for study.

TABLE 1. DISTRIBUTION OF RAINFALL IN INCHES AT THE TOBACCO SUBSTATION, WINDSOR, 1938

By 10-day Periods

Year	May			June			July			August		
	1-10	11-20	21-31	1-10	11-20	21-30	1-10	11-20	21-31	1-10	11-20	21-31
1938	.25	2.49	1.47	1.11	2.78	3.11	.30	2.79	5.45	.73	1.38	00

By Months

Year	May	June	July	August
1938	4.21	7.00	8.54	2.11
Av. for preceding 16 years	3.44	3.52	3.39	1.42

Requests by the growers for service in testing soils, seed germination, diagnoses of diseases and insect troubles and recommendations for combatting them increase every year. In 1938 more than 4,000 samples of soil were submitted for laboratory analyses and subsequent consultation as to fertilizer needs.

LOSSES OF FERTILIZER CONSTITUENTS BY LEACHING DURING AN ABNORMALLY WET GROWING SEASON

M. F. MORGAN[1] AND O. E. STREET[2]

The 1938 growing season for tobacco was notable for the exceptionally heavy rainfall during June and July. As a consequence, the leaching of fertilizer constituents from the soil was an extremely serious problem,

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especially on the sandy loam soils typical of most of the Connecticut Valley area. The lysimeter experiments at Windsor provided a quantitative measure of the extent of this leaching under both cropped and uncropped conditions.

At tobacco setting time, May 25-30, the soil was already well saturated with moisture as a result of a 2.18-inch rain on May 16, and a series of showers from May 22 to May 28. Further showers on June 3, 4, 6 and 8 kept the soil quite moist, and two days of heavy rains, totaling 2.77 inches, on June 12 and 13, caused approximately 1.5 inches of leaching. Doubtless this washed a considerable amount of nitrates and other soluble salts into the subsoil, but did not remove them from the soil column. (The soil column includes both the dark colored surface soil and the underlying yellow or reddish colored subsoil, to the depth of approximately 30 inches.)

After nearly two weeks of dry weather, 3.11 inches of rain on June 28 and 29 produced leaching of approximately 2.3 inches from the lysimeter tanks cropped to tobacco. This caused further downward movement of the nitrates becoming available in the surface soil, and the whole soil column began to show appreciable nitrogen losses, ranging up to 20 pounds per acre.

The dry period, June 30 to July 9 inclusive, doubtless caused some recovery of constituents washed into the subsoil by previous rains. However, the upward movement was apparently insufficient to replace former losses both in the lysimeter tanks and in the field. The tobacco plants made an unusually short growth during this time, and the leaves showed some symptoms of nitrogen depletion.

A heavy rain of 1.9 inches on July 12 caused little or no leaching from the soil as a whole on account of the accumulated moisture deficit from the previous dry period. However, further washing of nitrates and other soluble constituents from the root zone was effected, and nitrogen deficiency symptoms became more pronounced. A crop growing from July 10 to July 20 must obtain at least 40 pounds of nitrogen from the soil during this critical 10-day period in order to make normal growth, and such a quantity was no longer available in the root zone.

It is possible that slow upward movement of nitrates from the subsoil, as well as the downward extension of the tobacco roots and the further liberation of some nitrogen from organic fertilizers in the surface soil, may have permitted some recovery during the latter part of July had the weather remained normal. However, a week of almost continuous rain, from July 19 to July 24, gave a total of 5.81 inches of precipitation, causing an average leaching of approximately 4.5 inches from lysimeter tanks cropped to tobacco.

The damage to the crop caused by leaching was now beyond repair. More than 100 pounds of nitrogen, normally provided in the root zone during the latter part of the growing season, was lost from the entire soil column under tobacco during this one period of leaching. The surface soil became almost entirely exhausted of nitrates and other soluble constituents. The last increment of leaching (approximately one-half inch, separately collected) from uncropped surface soil tanks, similarly fertilized to the cropped treatments, showed concentrations of less than 5 parts of nitrogen per million. Such conditions gave little further growth, and the crop rapidly ripened during the next few days after the rains had ceased.

In summary, a total rainfall of 16.28 inches during the growing season of tobacco set on May 26 was chiefly concentrated in four storm periods

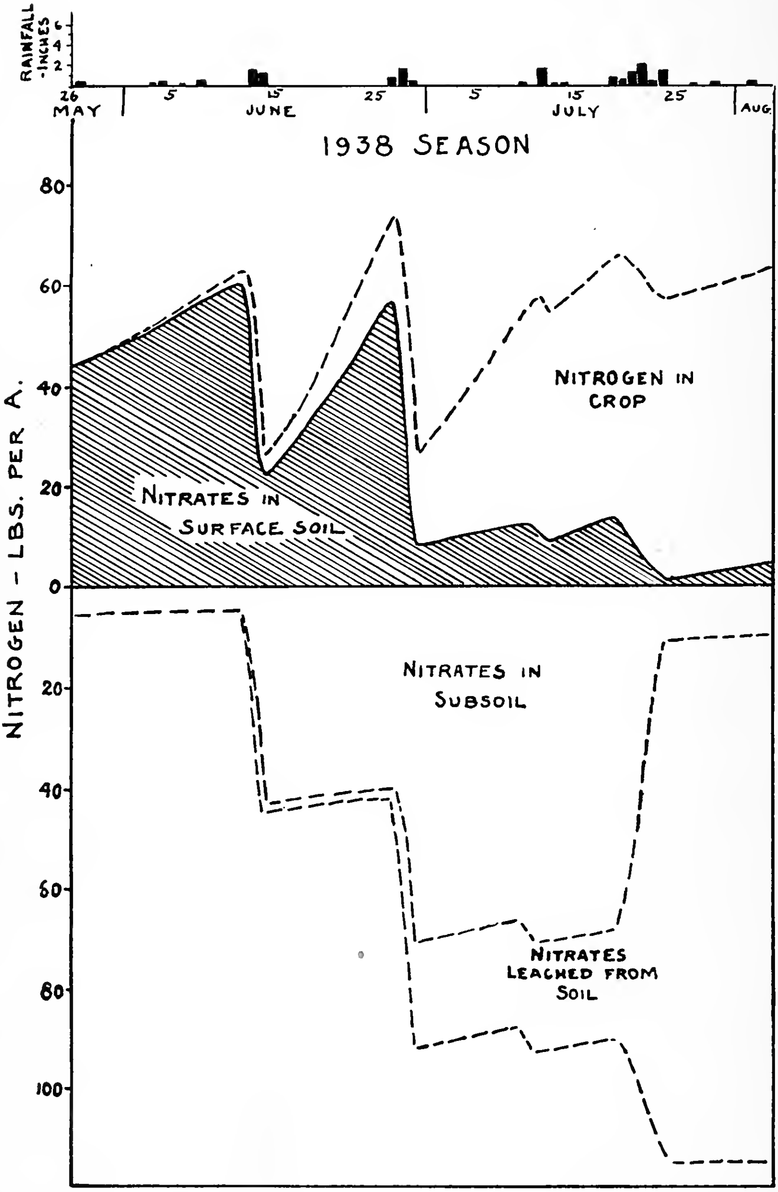

FIGURE 3. Distribution of nitrates during growing season of 1938.

ending June 13, June 29, July 12 and July 24, aggregating 13.59 inches and resulting in the leaching of 8.3 inches of water from areas cropped to tobacco. This leaching removed from 100 to 120 pounds of nitrogen per acre from the entire soil column. Under favorable conditions, soils nor-

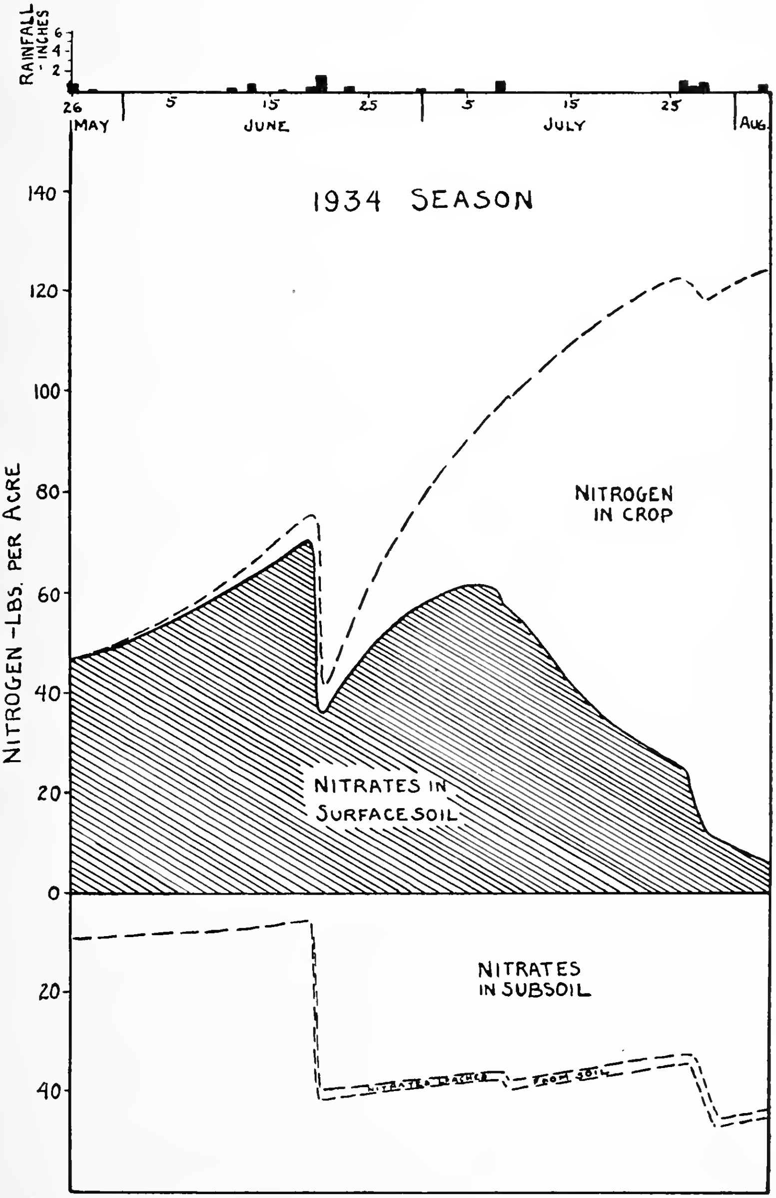

FIGURE 4. Distribution of nitrates during growing season of 1934.

mally fertilized for tobacco liberate approximately 160 pounds of available nitrogen per acre during the growing season. Hence, the crop was able to obtain only from 40 to 60 pounds of this constituent per acre, or less than half the amount ordinarily utilized by an average crop of sun-grown Havana Seed tobacco.

It is interesting to compare these conditions with those of 1934 which was a season of very favorable rainfall distribution except for a two-week dry period in mid-July. The total rainfall, from May 26 to August 4, was 7.95 inches, approximately the normal amount.

The conditions of nitrate accumulation in the soil, intake of nitrogen by the crop and loss by leaching are shown diagrammatically for the 1934 and 1938 seasons in Figures 3 and 4. These graphs show rather similar conditions during the early part of the season in both years. The leaching of June 20, 1934, and that of June 12-13, 1938, both produced depletion of nitrates in the surface soil, but since the 1934 leaching was less, there was little loss from the whole soil. The late June leaching in 1938 had no counterpart in 1934; hence there was a rapid build-up of nitrates in the soil and an ample supply to meet the rapidly increasing demands of the crop during the month of July. On the other hand, in 1938 the nitrates in the soil were consistently low and reduced to the vanishing point after the rainy spell of July 19-24. The crop reflected this inadequate supply of nitrates in the soil, and was apparently unable to utilize more than a small amount that had been washed deeply into the subsoil by previous rains.

From a quantitative standpoint, these graphs are not strictly exact. However, they are based on unpublished data with respect to the proportions of nitrates leached from the surface soil by various quantities of water, the rate of liberation of nitrates from the soil nitrogen and from organic nitrogen in the fertilizer, and the rate of nitrogen assimilation by the tobacco crop previously determined by Morgan and Street*.

It is to be noted that 40 pounds of the fertilizer nitrogen was initially supplied in the nitrate form and that approximately this amount was washed into the subsoil by the first rainfall producing leaching in both years.

Leaching of Various Fertilizer Constituents

In 1938 field observations throughout the Connecticut Valley showed an exceptional number of cases of abnormal tobacco growth, suggesting deficiencies of one or more of the following: nitrogen, potassium, calcium, magnesium, manganese, and possibly boron. Previous lysimeter data have indicated that leachings producing considerable removal of nitrates from the soil have been associated with nearly corresponding losses of basic constituents, such as potassium, calcium, magnesium and manganese. Unfortunately, no data with reference to the leaching of boron from the soil are available since this would involve refinements in technique that have not been provided.

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*Morgan, M. F. and Street, O.E. Rates of Growth and Nitrogen Assimilation of Havanna Seed Tobacco, Jour. Agr. Res. 51:163—172. 1935.

In order that this association of nitrate leaching with losses of other constituents could be verified for the growing season period, weighed composite samples of the drainage water recovered from May 26 to July 25, the last collection during the growing season, were analyzed separately. Data for tanks with treatments of special interest are presented in Table 2.

TABLE 2. SUMMARY OF LEACHING OF VARIOUS CONSTITUENTS—WINDSOR LYSIMETERS

May 26—July 25, 1938

	POUNDS PER ACRE						
Cultural and Nitrogen Treatments	Nitrate Nitrogen	Ammonia Nitrogen	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Soda (Na_2O)	Sulfur as (SO_3)
Tanks with surface soil only (8″) no crops (Soil A, no acid adjustment)							
No nitrogen	23.8	0.6	111.8	210.7	61.2	9.8	177.9[2]
Cottonseed meal	139.4	1.2	175.3	297.1	51.5	76.0[1]	190.5[2]
Urea	177.8	21.3	176.5	269.2	68.3	6.6	137.3[2]
Nitrate of soda	192.7	0.1	111.9	190.9	19.7	370.3	190.0[2]
Tanks with partial subsoil (20″)							
Bare soil, no Nitrogen	22.0	0.3	68.3	31.5	12.9	5.7	36.0
Under tobacco							
No nitrogen	13.3	0.1	69.1	31.7	8.5	5.1	18.2
Cottonseed meal	77.0	0.3	69.3	83.8	26.2	8.6	16.0
Urea	119.0	0.7	76.1	119.9	38.5	6.2	11.0
Nitrate of soda	187.6	0.1	28.1	39.0	8.0	151.8	96.1
Tanks with complete subsoil (30″)							
Bare soil							
No nitrogen	20.8	0.4	65.9	39.9	10.1	4.7	56.4
Calurea[3]	163.2	0.3	168.8	169.7	37.1	6.9	58.2
Under tobacco (no cover crop)							
No nitrogen	22.4	0.4	56.6	31.3	10.6	4.9	47.7
Calurea	102.1	0.1	52.6	151.3	29.8	6.2	10.2
Windsor N-1 formula[4]	147.9	0.3	71.7	144.1	37.4	78.4	11.0
Divided application (167 lbs. N[5])	67.0	0.1	56.9	111.1	30.5	9.2	51.7

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[1] 56 lbs. of Na applied as sodium sulfate in order to provide same amount of sulfur on all treatments in this series.

[2] Extra sulfur and calcium added as gypsum to this series.

[3] Calurea supplies 80% of N. as urea and 20% of N. as nitrate of lime.

[4] Windsor N-1 formula supplies 80% of N. as organic nitrogen (C.S. meal and castor pomace) and 20% of N. as nitrate of soda.

[5] 73 lbs. of N. at setting time, 25 lbs. of N. 3 weeks after setting and 69 lbs. of N. five weeks after setting.

From inspection of the preceding table, it is seen that the losses due to leaching were by no means confined to nitrogen. However, under otherwise similar conditions, the losses of potash, lime and magnesia increased in proportion to the larger losses of nitrates. The nitrates leached under the nitrate of soda treatment were chiefly in the same combination as applied.

It is of interest to note that gypsum, while of relatively low solubility, was readily leached from the surface soils to which this material was applied. However, it must be pointed out that eight inches or more of water percolating through the soil represents over 200,000 gallons of water per acre, an amount capable of dissolving more than a ton of gypsum before becoming completely saturated with calcium sulfate.

The leaching of potash through the subsoils under crop was much less than from uncropped soils receiving the same treatment. This is in part due to the decreased leaching of nitrates and in part to the utilization of potash by the crop. It seems likely that even with adequate nitrates supplied as side-dressings, the potash loss by leaching would have limited the crop. This should also be true in case of magnesia, as well as of lime, in soils unusually deficient in calcium.

The data for the 30-inch tanks given in Table 2, as well as for others in the same series for which the data are not presented in detail, show that in the 1938 growing season a normally fertilized sandy loam soil in tobacco suffered leaching losses approximately as follows:

Nitrogen	100—150 lbs. per acre
Potash	50— 75 " " "
Lime	140—160 " " "
Magnesia	30— 40 " " "

The leaching losses were generally in inverse proportion to the weight of the crop, as would be expected, since the larger crop held back more of the various constituents against leaching.

During seven years previous to 1938, only insignificant leachings had passed through the subsoil at any time during the growing season, and these were almost entirely confined to the month of June. The yearly average loss of nitrogen from the entire soil column had been 2.8 pounds per acre in June, 0.3 pounds per acre in July and .03 pounds per acre in August, or a total of only 3.13 pounds per acre between setting and harvesting dates. It must be realized that two unusually dry summers were included in these data, those of 1936 and 1937, each with less than 6 inches of rainfall during the period from May 26 to August 5.

Leaching of Various Constituents Following a Season of Normal Rainfall, 1934

Let us again make comparison with the leaching in the normal season of 1934. As has been stated previously, there was little leaching from the tanks with subsoil during the growing season. However, after the tobacco was harvested, there were very heavy rains in late August and through September, on August 25, 1.58 inches; September 8, 2.73 inches; September 17, 2.21 inches; and September 29, 1.24 inches. These rains and further showers in October and November brought about much leaching, to the extent of 5 to 6 inches from the 20-inch tanks, and 4 to 5 inches from the 30-inch tanks. The soils of the surface soil tanks (8 inches) had been leached considerably during the summer, and were subjected to further leaching to the same extent as the 20-inch tanks.

The total rainfall for the six months' period ending November 25, 1934, was 23.21 inches, nearly seven inches more than fell during the growing season period May 26 to August 5, 1938. This caused about an inch more leaching from uncropped surface soils, and about two inches less leaching from cropped soils with subsoil under them in the tanks. The explanation for the difference lies in the better distribution of the rainfall in the 1934 season, the longer period for evaporation, and the greater growth of crop in the more favorable earlier season.

The 1934 data for the tanks are given in Table 3, showing the leaching of various constituents.

The drainage water was not separately analyzed for the growing season during that year. However, the leaching from the 20-inch and 30-inch tanks was insignificant prior to the August 25 rainfall; the amounts shown in Table 3 largely indicate leaching *following* the growing season. Since some leaching from the surface soil had occurred, a considerable portion represents that which had been washed into the subsoil during the growing season.

The data with respect to the uncropped surface soil tanks are not strictly comparable with those of 1938. The soils of this series had been placed in the tanks in May, 1934, and hence liberated much more nitrogen on the "no nitrogen" treatments, as compared with the fifth season with nitrogen (1938). However, when allowance is made for this difference, the leaching of various constituents is similar in both periods.

The difference in effects of the two seasons is clearly shown in the leaching from the 20-inch and 30-inch series, particularly the cropped tanks. The leachings of all constituents were very much less in the 1934 period. As in the case of 1938 leachings, when the nitrate leachings are low, the losses of other constituents are correspondingly less. This is particularly true of calcium and magnesium.

As a general statement based on the above data, the intensive leaching from normally cropped and fertilized soils during the growing season of 1938 caused losses in excess of amounts removed by heavy fall rains *following* the normal 1934 season approximately as follows:

Nitrogen	85 to 130 lbs. per acre
Potash	20 to 35 " " "
Lime	100 to 120 " " "
Magnesia	25 to 30 " " "

It is certain that the losses during the fall of 1934 represent considerably greater quantities than could have leached below the reach of plant roots during the previous growing season. Hence, it is safe to assume that the crop of 1938 was limited by the absence of more than the above amounts that would normally be available in the surface soil during the period of maximum crop demand.

It also seems reasonable to state that other soluble constituents required in small amounts for plant growth, such as manganese, iron, boron, zinc, copper, etc., must have suffered similar depletion in the soil solution. However, since no data are available and soils differ with respect to these "trace elements," it cannot be established that the soils of the lysimeter tanks suffered exhaustion in this respect sufficient to be of consequence.

TABLE 3. SUMMARY OF LEACHING OF VARIOUS CONSTITUENTS—WINDSOR LYSIMETERS

May 26—Nov. 25, 1934

Cultural and Nitrogen Treatments	POUNDS PER ACRE Nitrate Nitrogen	Ammonia Nitrogen	Potash (K_2O)	Lime (CaO)	Magnesia (MgO)	Soda (Na_2O)	Sulfur as (SO_3)
Tanks with surface soil only (8″) no crops (Soil A, no acid adjustment)							
No nitrogen	115.3	0.5	177.6	335.8	71.0	17.0	488.5
Cottonseed meal	207.5	1.0	218.8	422.3	85.4	49.5	468.5
Urea	281.8	2.2	230.3	516.9	89.9	18.5	440.0
Nitrate of soda	328.9	0.9	182.1	351.3	68.8	419.9	497.9
Tanks with partial subsoil (20″)							
Bare soil, no N.	38.5	0.2	80.6	63.7	16.2	9.7	103.1
Under tobacco							
No nitrogen	14.3	0.2	70.3	30.5	6.0	7.3	98.1
Cottonseed meal	42.0	0.2	92.9	59.5	18.7	10.0	88.9
Urea	32.4	0.3	67.2	58.2	11.4	8.6	87.4
Nitrate of soda	84.4	0.2	35.5	38.1	7.5	267.0	105.9
Tanks with complete subsoil (30″)							
Bare soil							
No nitrogen	12.3	0.2	52.3	34.3	10.8	5.5	74.7
Calurea	172.4	0.2	118.5	227.1	50.6	8.5	52.9
Under tobacco (no cover crop)							
No nitrogen	10.4	0.1	49.1	33.3	11.1	6.1	66.2
Calurea	12.4	0.1	32.0	37.4	9.8	4.2	62.2
Windsor N-1 formula	20.3	0.2	40.0	21.4	5.6	46.0	67.9
Divided application (167 lbs. N)	24.9	0.1	37.9	46.7	14.9	6.6	36.2

Utilization of Nitrogen by the Crop in the Lysimeter Tanks

The tobacco grown in the lysimeter tanks was harvested on August 9, weighed and analyzed for nitrogen content. Table 4 presents the data for representative tanks, in relation to removal of nitrogen from the soil by leaching during the growing season of 1938. These data may well be compared with those of 1934, shown in Table 5.

TABLE 4. RELATIONSHIPS BETWEEN NITROGEN REMOVED BY CROP AND LEACHING OF NITRATES FROM THE SOIL.
WINDSOR LYSIMETERS. GROWING SEASON OF 1938.

Cultural and Nitrogen Treatments	Dry wt. of crop* lbs. per A.	Nitrogen in crop		Nitrogen leached lbs. per A.	Total removal from soil lbs. per A.
		percent	lbs. per A.		
Tanks with partial subsoil (20″)					
No nitrogen	717	1.31	9.4	13.3	22.7
Cottonseed meal	3177	1.41	44.9	77.0	122.8
Urea	3106	1.53	47.4	119.0	166.4
Nitrate of soda	1692	1.43	24.2	187.6	211.8
Tanks with complete subsoil (30″) (no cover crop)					
No nitrogen	605	1.40	8.5	22.4	30.9
Calurea	3577	1.62	57.9	102.1	160.0
Windsor N-1 formula	2033	1.44	29.2	147.9	177.1
Divided application (167 lbs. N per A.)	2600	2.26	58.7	67.0	125.7

*Entire plant above ground.

TABLE 5. RELATIONSHIPS BETWEEN NITROGEN REMOVED BY CROP AND LEACHING OF NITRATES FROM THE SOIL DURING FALL PERIOD.
GROWING SEASON OF 1934

Cultural and Nitrogen Treatments	Dry wt. of crop* lbs. per A.	Nitrogen in crop		Nitrogen leached lbs. per A.	Total removal from soil lbs. per A.
		percent	lbs. per A.		
Tanks with partial subsoil (20″)					
No nitrogen	1619.2	1.210	19.6	14.3	33.9
Cottonseed meal	3916.0	2.183	85.5	42.0	127.5
Urea	3700.0	2.338	86.5	32.4	118.9
Nitrate of soda	3418.8	2.741	93.7	84.4	178.1
Tanks with complete subsoil (30″) (no cover crop)					
No nitrogen	1205.6	1.277	15.4	10.4	25.8
Calurea	5053.4	2.024	102.3	12.4	114.7
Windsor N-1 formula	5242.6	1.810	94.9	20.3	115.2
Divided application (167 lbs. N per A.)	4745.4	2.388	113.3	24.9	138.2

*Entire plant above ground.

Both the dry weight of the crop and the percentage composition with respect to nitrogen were materially less in 1938, in all corresponding treatments. The nitrogen taken up by the tobacco crop was approximately one-half that of 1934 in most cases.

On the other hand, it is seen that while in 1934 the nitrate nitrogen leaching was materially less than the nitrogen in the crop, the 1938 leaching was greatly in excess. It is obvious that in the former case the leaching represents nitrogen that was not utilized by the crop, while in the later year the nitrogen in the crop is chiefly a residue from leaching.

The nitrate of soda treatment shows the most marked difference, as would be expected. It is difficult to explain the greater leaching of nitrogen from the Windsor N-1 formula, as compared to the calurea treatment, especially in 1938. In both cases one-fifth of the nitrogen was applied in the nitrate form. However, in the Windsor N-1 formula the material was nitrate of soda, while calurea furnished nitrate of lime. Comparisons between these nitrates over a ten-year period have rather consistently shown greater crop utilization and less leaching of nitrogen from the nitrate of lime. Further, since urea produces an earlier and higher peak of nitrogen availability than does cottonseed meal and castor pomace (the organic materials in the Windsor N-1 formula), it was possible for the crop to attain a greater relative growth and intake of nitrogen before the severe leaching of the late July period. The smaller crop obtained from the Windsor N-1 formula thus permitted both a greater volume and a higher concentration of the drainage water.

It is of interest to note the performance of the "divided application" treatment. In this case only 167 pounds of nitrogen per acre was supplied, distributed as shown in the footnote to Table 2. The third application, five weeks after setting, was effective in considerably increasing the percentage of nitrogen in the crop. However, the size of the crop attained prior to that treatment was probably limited by the small earlier application.

CALCIUM DEFICIENCY

T. R. Swanback

A brief discussion of calcium was included in our published report for 1937*. The physiological functions, deficiency symptoms and effect from excesses of this element were described. It was also stated that symptoms of calcium deficiency up to that time never had been observed on any tobacco fields in Connecticut.

During the summer of 1938, however, calcium deficiency symptoms could be readily detected in numerous fields of both Havana Seed and Broadleaf tobacco. The symptoms were first observed in the latter part of July, corresponding to the time of topping the tobacco, when the season was too advanced to attempt to remedy the condition.

Examinations of the soil under calcium starved plants did not reveal unusually low pH-values (about 5.0) but there was a negative test for replaceable calcium. Inquiries disclosed that in all instances the growers had made very limited or no applications of liming materials either that season or, in some cases, for many years.

Figure 5 illustrates the deficiency symptoms. The young leaves and other organs of the terminal bud were distorted and stunted or completely aborted. Sometimes the flower buds had a brownish to blackish appearance; in other cases the tips of the youngest three or four leaves were browned and shriveled. Since flowering, or even attempted budding, never has been observed on calcium deficient plants under controlled conditions, it is evident that the withdrawal of nutrient calcium from the surface soil occurred suddenly and at a definite time during the growing period.

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*Bulletin 410, pages 396-397.

The direct cause was excessive leaching rains. Heavy losses of calcium along with the other fertilizer elements occurred and the reader is referred to the discussion of this feature in the preceding section.

FIGURE 5. Calcium deficiency symptoms on field-grown plants.

Table 1 in the introduction presents the season's rainfall. It is the highest since this Station was established 15 years ago. During May, June and up to July 20, 14.6 inches were recorded, while the mean for this period is about 9 inches. In the next three days, following July 20, 4.87 inches of rain were recorded. It is obvious that on fields with a minimum of readily available calcium, this last rainfall in some cases removed all available calcium from the root zone, resulting in calcium starvation. The funneled arrangement of the leaves on a tobacco stalk, moreover, produce a more effective collection of rain water around the bulk of the roots.

In restoring the calcium supply of such a depleted soil, it is recommended to apply not more than 500 pounds of agricultural lime the first year in order to prevent fixation of minor elements. In addition, land plaster may be applied to the extent of 500 pounds per acre.

VALUE OF TOP-DRESSING THE GROWING CROP WITH ADDITIONAL FERTILIZER

The excessive rainfall of the past growing season was discussed in the introduction. Numerous soil samples, brought to the Station by the growers after heavy rains in June, were examined and in most cases found deficient in both nitrate and ammonia nitrogen. Similar examinations in previous years usually revealed considerable supply of ammonia nitrogen under the growing crop even after rains that were considered to be excessive. It was obvious that the unusually heavy precipitation had caused withdrawal of the available nitrogen in the surface soil.

Since nitrogen is a most important element for cigar leaf tobacco, a deficiency of this plant food at any time under the growing crop obviously must affect adversely the quality of the leaf.

Usually a top dressing was recommended, consisting of equal parts of cottonseed meal or soybean oil meal and nitrate of soda, applied at a rate of 30 to 40 pounds nitrogen to the acre.

Commonly, one such application would be sufficient. During the past season, however, many growers reported that it was necessary to repeat this operation three times.

Some interesting data on the results of top dressing were gathered from observations at the station farm. Two fields, not intended for fertilizer or nitrogen tests, were top-dressed; one, a very light soil, received in three applications the equivalent of 114 pounds additional nitrogen per acre and the other, a medium heavy soil, 90 pounds nitrogen in two applications.

The yield and grading data from these tests, together with those from adjacent fields not top-dressed are found in Table 6. From the data it is evident that the untreated tobacco can be sold only at stemming prices, while the tobacco supplied with additional nitrogen may command the regular market price. If stemming be given an arbitrary price of 10 cents a pound and the sound crop 20 cents, the crop value was increased an average of 250 percent by the addition of nitrogen.

It may be estimated that the extra cost of labor and fertilizer connected with top-dressing operations amounts to 16 or 20 dollars per acre. Since the cost of growing an acre of Havana Seed is from 200 to 250 dollars per acre, it is obvious that the price received for stemming hardly covers a third of this cost.

On the contrary, the results suggest that the added expense of top dressing at least prevented growing the crop at a loss. On soils that are prone to leaching, top dressing is thus profitable when conditions require it.

Table 6. A Comparison Between Tobacco Crops that *Were* and *Were Not* Top-dressed

Location	Top-dressed	Yield per acre	Grading (Grade index)	Remarks
Field V	No	773	Stemming	Starved, yellow
" V	Yes, 114 lbs.	1254	.341	Thin, but sound, good color
Field I	No	812	Stemming	Starved, yellow
" I	Yes, 90 lbs.	1176	.382	Good, excellent color and texture

FURTHER TRIALS WITH SOYBEAN OIL MEAL

The use of soybean oil meal as a source of nitrogen in tobacco fertilizers is ever increasing in the Connecticut Valley. Seldom has a fertilizer material established itself and won the confidence of the grower within such a short time. The reason is that soybean oil meal gives an effect similar to cottonseed meal, long in use here, and has additional features that make for favorable competition.

Soybean oil meal has been shown to produce a better quality leaf and sometimes higher yields than several other vegetable fertilizers. A higher nitrate level is maintained in the soil which is correlated with a more efficient return of available nitrogen from the original material.

It is commonly known that the fibrous contents (crude cellulose) in all plant materials decay more slowly than other constituents. The amount of fiber in soybean oil meal averages about 5.9 percent, and in cottonseed meal about 10.8 percent. It is quite possible that the higher fiber content of cottonseed meal retards the decomposition of this material and therefore may furnish available nitrogen at a lower rate than soybean oil meal. Furthermore, preliminary ammonification studies have indicated that ammonia is formed in the soil at a much lower rate when cottonseed meal is added than when soybean oil meal is applied.

The experiments with soybean oil meal were continued in 1938. Extensive tests were laid out to observe further the effect of variation in the water soluble content of nitrogen in soybean oil meal. From this series, however, reliable data could not be gathered because the crop was ruined by the heavy leaching rains.

The experiment, designed to furnish a comparison between the effect of cottonseed meal and soybean oil meal was located on a somewhat heavier soil than the experiment above. Although the crop here was greatly reduced in yield and quality, the data included in Table 7 are of some significance. This three-year summary shows a higher yield and grade index for soybean oil meal than for cottonseed meal. Over the period of three years the crop value has been about 13 percent higher for the former meal.

Table 7. Three-Year Summary of Soybean Oil Meal Test on Field I

Source of nitrogen	Acre yield				Grade index			
	1936	1937	1938	Av.	1936	1937	1938	Av.
Cottonseed meal	2250	1969	1029		.372	.360	.246	
	2283	1645	900	1682	.364	.304	.220	.316
	2298	1787	1010		.382	.319	.276	
Soybean oil meal	2113	1972	1023		.389	.361	.256	
	2218	2022	1026	1740	.376	.349	.294	.346
	2169	1888	1031		.421	.368	.300	

TIME OF HARVESTING HAVANA SEED TOBACCO. IV

The object of this set of experiments, now in its fourth year, is to determine the optimum stage of maturity at which this type of tobacco should be harvested to obtain the highest yield and best percentage of good grades. The plan of procedure and results of the first three years of the experiment have been fully described in previous reports[1] and the reader is referred to these for more complete detail. The present is a progress report to add the results of the rather abnormal year of 1938.

This year the plots were in the same position as in 1937. There was one test on Field V where the land is sandy and prone to leach; two sets on the heavier soil of Field I, one with the No. 211 strain of Havana Seed and the other with the Brown strain. In each of these, the first harvesting was made one week after topping and the later harvestings at weekly intervals. In addition to the regular broadcast application of fertilizer ten days before setting the plants, it was necessary this year to make two later applications to the growing crop on the heavier soil, and three on the lighter soil of Field V. These applications contained 30 pounds of available nitrogen to the acre on June 14, 60 pounds on June 30, and 25 pounds on July 13.

The dates of harvesting on Field V were August 4, 12 and 17, and on Field I were August 5, 12, 19 and 26. All plots were cured in the same shed on the same tier of poles. As in the preceding years, it was noticed that the earliest harvested tobacco cured most slowly and showed the greenest color when cured. The longer the tobacco was left in the field the better the color and "body" of the cured product.

The yields and grading records for the three series of plots are shown in Table 8. It will be noted at once that both yield and grading on all plots were very low compared with those of previous years. This condition held for all our plots at the Station and generally throughout the tobacco district because of the excessive rains of June and July. In the first two series, the weekly increase in yield and improvement in grading, the longer the tobacco is left in the field after topping, are quite significant and in line with all our previous results. The ratio of increase on the lighter soil of Field V, 70 pounds to the week, is much less than in previous years, but

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[1] Buls. 386: 585; 391: 73, and 410: 368. Conn. Agr. Exp. Sta.

is probably due to excessive leaching of this soil in spite of the later applications of additional nitrogen. On the heavier soil of Field I, however, there was a weekly increase of 213 pounds which compares favorably with previous results for the No. 211 strain. The Brown strain, however, does not seem to be as well adapted to withstand adverse conditions. It showed poor growth throughout the season with no improvement after topping except in the fourth week. The average yield on the Brown strain was only 1,103 pounds and the grade index .261, as compared with an average yield of 1,476 and a grade index of .382 on the adjacent plots of Strain No. 211.

Contrary to the results of 1937, there was an increase in yield even up to the fourth week. The leaves continued to expand each week, as shown in Table 10, adding more than an inch in average length during the last week.

Since this experiment has now been repeated for four successive years on Field V in the same location, the results are summarized in Table 9. This table shows an average gain in weight of approximately 200 pounds per week up to the end of the third week. The experiment on Field I has been continued only two years, one of which was abnormal. It is too early to draw any definite conclusions but the trends are the same as for the longer experiment.

Conclusion. All the information which we have gained from these experiments during four years leads us to believe that Havana Seed tobacco should remain in the field at least three weeks, and often up to four, in order to secure the optimum yield and grading. Although we have not extended these experiments to Broadleaf, there is no reason for believing that the same rule should not apply to this variety also.

TABLE 8. TIME OF HARVESTING HAVANA SEED TOBACCO.
YIELD AND GRADING RECORDS FOR CROP OF 1938

Strain and field	Weeks after topping	Acre yield	Percentage of grades								Grade index
			L	M	LS	SS	LD	DS	F	B	
No. 211 on Field V	1	1,186			25	10	38	8	15	4	.329
	2	1,250		1	30	17	20	14	15	3	.343
	3	1,326			28	18	32	11	9	2	.351
No. 211 on Field I	1	1,195			25	16	33	8	16	2	.331
	2	1,269			23	15	35	8	16	3	.323
	3	1,606	2	4	24	13	41	3	12	1	.369
	4	1,822	8	5	25	10	40	1	10	1	.423
Brown strain on Field I	1	1,046			10	20	21	15	30	1	.253
	2	977			8	20	20	21	30	1	.241
	3	1,046			10	15	25	18	30	2	.248
	4	1,343			15	13	45	9	18		.300

Table 9. Yield and Grade Index of Tobacco Harvested, One, Two and Three Weeks after Topping. Summary of 4 Years Test on Field V.

Crop year	ACRE YIELD 1 week	 2 weeks	 3 weeks	GRADE INDEX 1 week	 2 weeks	 3 weeks
1935	1518	1856	2003	.334	.355	.291
1936	1902	2222	2454	.427	.423	.435
1937	1766	1872	2269	.370	.402	.446
1938	1186	1250	1326	.329	.343	.351
Av.	1593	1800	2013	.365	.381	.381

Table 10. Effect of time of Harvesting on Length of Leaves. Crop of 1938. No. 211 Strain.

Weeks after topping	Percentage of leaves of various lengths 15″ (+ fillers)	 17″	 19″	 21″	 23″	 25″	 27″	Weighed average length
1	23	18	31	23	5			18.38
2	22	17	27	25	8	1		18.66
3	16	11	18	23	21	9	2	20.14
4	12	9	14	20	17	20	8	21.26

VARIATIONS IN CHEMICAL COMPOSITION OF LEAVES ACCORDING TO POSITION ON THE STALK

Cigar binder tobaccos are usually harvested by cutting the stalks and hanging them in the curing sheds with the leaves attached. After four to six weeks, when the leaves have all turned brown and are cured, they are stripped off the stalks and packed into bundles of 25 to 50 pounds without making any attempt to classify them according to position on the stalk. At a later date, however, in the warehouse or sorting shop, they are separated into grades based primarily on appearance, or the characteristics of color, texture, gum, vein, elasticity, etc. For the most part these characteristics are only an index to the position which the leaves of each grade occupied on the growing stalk.

In the Havana Seed variety there are essentially five grades: fillers, seconds, lights, mediums and darks. On a good plant of 14 leaves, (see Figure 6) in general, we may say that the two bottom leaves are fillers, the next four seconds, then two lights followed by two mediums, with the top four darks. (The grade known as "brokes", composed of damaged leaves, need not be considered in this discussion.) Sometimes the leaves in the position of "lights" are not good enough to make such a grade and are thrown into the seconds; in the same way the mediums may be included in the "darks". Essentially, then, we may say that there are two grades of leaves, "seconds" and "darks". The others merely represent transitions between these two because there is no sharp line of demarcation in the successive stages and the most experienced of sorters finds many leaves which will fit equally into either of two grades. The different grades command different prices in the trade and determine the type of cigar on which they will be used. The "filler" grade is not used for cigars at all but is "stemmed" for scrap chewing tobacco.

Corresponding to the differences in outward appearance of these grades, there are internal differences in chemical composition. In various previous reports, the writers have published contrasting analyses of seconds and darks*. These have shown uniformly that the upper leaves of the plant contain more total nitrogen, nicotine, ammonia nitrogen, and phosphorus, while the lower leaves are higher in total ash, calcium, magnesium and potash. Elements which occur in smaller amount, such as iron, aluminum, sulfur, manganese and chlorine, do not show very decided trends.

FIGURE 6. Position of the grades of leaf on a Havana Seed plant.

In order to obtain more accurate information on the distribution in the plant of four important elements with which we have been concerned in nutritional studies, a "leaf by leaf" analysis was made on tobacco of the crop of 1936 (Havana Seed No. 211).

That year, in other respects fairly normal, was somewhat dry. The plants for analyses were taken from a plot (N56-1) which received a normal

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*For an extensive series of analyses, see particularly Rpt. of the Tobacco Substation for 1927, Bul. 10: 35-50.

good fertilizer containing 200 pounds of nitrogen, 200 pounds of potash, 150 pounds of phosphoric acid and 50 pounds of magnesia to the acre[1], and produced a yield of over a ton of cured leaves per acre. After the tobacco was fully cured in the barn, 15 normal plants were taken from this plot. All the first leaves at the bottom were tied in one hand, the second leaves in another, and this was continued up to the sixteenth leaf. The midribs were removed from the leaves. The leaf blades, after thorough drying in the laboratory, were ground to a powder and analyzed by the Analytical Chemistry Department of the Station with results presented in Table 11. The trend of the elements from bottom to top of stalk is shown graphically in Figure 7.

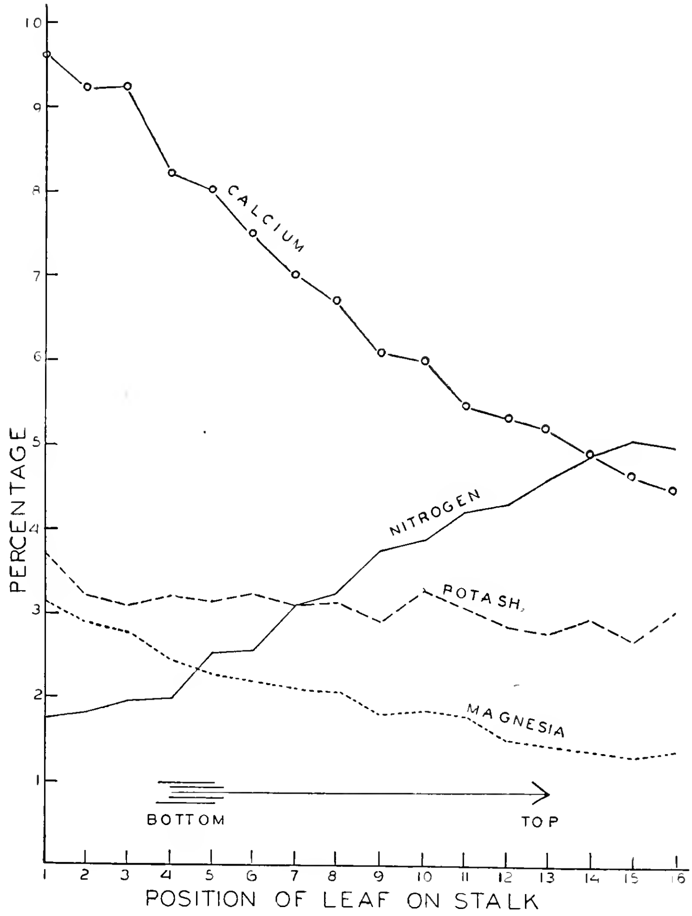

FIGURE 7. Distribution of nitrogen, potash, calcium and magnesium in the successive leaves of the stalk.

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[1] For further detail, see Bul. 410, p. 335.

TABLE 11. CHEMICAL ANALYSES OF INDIVIDUAL STEMMED LEAF SAMPLES OF HAVANA SEED TOBACCO ACCORDING TO POSITION ON STALK. FROM 15 PLANTS. (N56-1, 1936)

Position of leaf, counting from bottom	Percentage of			
	Total Nitrogen	Potash (K_2O)	Calcium (CaO)	Magnesium (MgO)
1	1.72	3.68	9.62	3.11
2	1.67	3.23	9.22	2.84
3	1.95	3.09	9.39	2.75
4	1.94	3.31	8.37	2.50
5	2.52	3.19	8.00	2.44
6	2.52	3.26	7.51	2.25
7	3.06	3.05	7.05	2.10
8	3.29	3.13	6.83	2.03
9	3.76	2.93	6.13	1.72
10	3.91	3.33	5.99	1.81
11	4.20	3.06	5.54	1.70
12	4.32	2.82	5.10	1.65
13	4.59	2.75	5.23	1.54
14	4.79	2.82	4.82	1.45
15	5.00	2.65	4.61	1.34
16	4.92	3.03	4.58	1.39
Composite of midribs	3.59	9.28	4.73	2.10

Nitrogen. There is a gradual and regular increase in the percentage of total nitrogen leaf by leaf from bottom to top. The uppermost leaves contain about three times as much nitrogen as the lowest. Since this increase is accompanied by a corresponding increase in the nitrogenous alkaloid, nicotine, the upper, darker leaves make a "stronger" smoke and must be more thoroughly fermented before they are satisfactory for cigars. In an investigation of flue-cured tobacco, Darkis *et al** found in that type a quite different curve with a higher nitrogen content at the bottom, diminishing up to the center of the plant and later increasing toward the top. This different curve in flue-cured tobacco is probably explainable on the basis of the differences in cultural practices, particularly the low fertilizer nitrogen level of flue-cured tobacco, and the practice of picking the leaves at successive levels at intervals of several days instead of harvesting the entire plant at one time. During such an interval, the nitrogen content of leaves in any particular position could be materially changed by translocation.

Calcium is higher in the lowest leaves and decreases regularly in each successively higher leaf until the percentage at the top is about one-half that of the bottom leaves. This trend agrees in general with previous analyses which have been made here on darks and seconds as well as with the results obtained by Darkis and his co-workers. The larger percentage of calcium in the older leaves may be explained on the basis of the relatively higher percentage of cell wall materials and the longer period of precipitation of the calcium into insoluble salts, a form unsuitable for translocation.

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*Darkis, F. O., Dixon, L. F., Wolf, F. A. and Gross, P. M. Flue cured tobacco. Ind. and Eng. Chem. 28: 1214. 1936.

Magnesium follows the same course as the calcium. It is highest in the lower leaves and diminishes regularly toward the top of the stalk until it is about one-half as abundant in the topmost leaf as in the bottom leaf.

Potash also shows a tendency to decrease toward the top of the plant but the trend is not so definite. The differences between bottom and top leaves are not so marked as we have found in previous analyses of seconds and darks (see Tobacco Station Bul. 10) but this may probably be explained on the basis of the rather dry growing season. A wet season is always reflected in higher potash and lower calcium.

Composition of the midribs. At the bottom of Table 11 is presented an analysis of a composite sample of all of the midribs stripped from these same leaves. The percentage of nitrogen and magnesia is about the same as the average for the blades of the leaves. The potash is extremely high, showing a heavy translocation of this readily soluble element from the blade to the midrib during curing. The calcium is as low as in the top leaves, showing that there has been no translocation of this element into the midribs.

TOBACCO DISEASES IN 1938

P. J. Anderson

Diseases caused by fungi and bacteria and malnutritional disorders were unusually abundant, widespread and destructive this season. The frequent and excessive rains were undoubtedly responsible. Not only were the usual diseases more prevalent, but new and unusual ones that had not been noted for many years appeared in 1938.

Downy Mildew

This disease, which was unknown in New England previous to 1937, was common again in seedbeds in the spring of 1938. The first infected bed was observed on May 11, just two weeks earlier in the season than in 1937. Within the next week mildew was seen and reported in numerous beds from various towns and continued to be prevalent throughout the seedbed period. During the first two weeks of June it spread in the fields, especially in the shade tents. This caused considerable apprehension, but the disease disappeared during the hot days of the middle of June and there was no further trouble.

Extensive experiments to control downy mildew were conducted during the winter in the greenhouse and during the spring in the beds. The results will be published in a separate bulletin before the opening of the seedbed period of 1939. Very briefly, they were as follows:

1. All copper sprays including the various forms of red copper oxide failed to give satisfactory control. In numerous cases also the copper oxide caused severe burning of the leaves.

2. Benzol vapors completely controlled mildew in the beds where the beds were tight enough to prevent too much escape of the gas.

3. Wet cloth covers were found to be more effective than glass sash for building up the gas concentration. Wet cloth over the top of the sash was also very effective in this respect. The number of pans used in a bed depends on the tightness of the cover. One pan of at least 8 inches diameter to every third sash is sufficient for reasonably tight beds, but more must be used in more loosely covered beds.

FIGURE 8. Wildfire on a mature leaf of Broadleaf. Such dead spots ruin the leaf for cigar purposes.

4. Paradichlorobenzene at the rate of one-eighth to one-quarter ounce per square yard of bed and distributed each night on shelves attached to each side of the bed, or in the pans such as used for benzol, gave complete control. This method, however, is in need of more extensive trial before it can be recommended for general use.

Recurrence of Wildfire

From 1920 to 1925 wildfire was the most important and destructive tobacco disease in this section. During the next 10 or 12 years, however, it became less prevalent each summer until only two or three affected farms were reported annually. The damage on these was so light that wildfire was no longer considered a major problem. Even during the wet year of 1937 it caused little injury and it was hoped that we would have no further trouble with it. In late May of 1938 the seedbeds on one farm in West Suffield were found to be severely diseased. A shade field of 30 acres set from these beds became so badly diseased that the plants were harrowed up and the field reset with healthy plants from another farm.

FIGURE 9. Hollow Stalk Disease. Bacterial decay runs from the pith into the bases of the leaves causing them to collapse.

During July and August wildfire was found in an increasing number of fields and spread rapidly with the frequent rains, becoming most serious just before harvest. The worst center of infection was in the Havana Seed section of Suffield but other cases were reported from a number of towns. Many growers, becoming alarmed at the rapid spotting of the leaves, harvested the tobacco before it was fully mature in order to save any of it. This meant loss in crop weight in addition to damage from spotting. Badly spotted leaves such as those shown in Figure 8 are worthless for cigar tobacco.

A year of heavy infection, such as 1938, naturally increases the opportunities for infection centers the following year. The season of 1938 showed rather definitely that the strain of wildfire bacteria either had not lost its virulence during the preceding decade of relative inactivity or else has regained it, and we may anticipate further trouble in 1939 if weather conditions are favorable.

Since the center of wildfire infection is the seedbed, growers should make every effort to keep the beds healthy by sterilizing and spraying and should not set fields from diseased beds.

Hollow Stalk

This bacterial disease has been mentioned and described in several of our previous reports*. Its severity is quite dependent on weather conditions. During dry years it is often difficult to find a plant affected by hollow stalk. During 1938 it was more prevalent than any year since we have been keeping records of tobacco diseases. It was localized, however, causing very severe damage on some farms and being entirely absent on others. Some fields were observed where 10 percent of the plants were affected. A diseased plant is usually a total loss (See Figure 9).

The disease usually appears first at about the time for topping. The bacteria which cause the malady (*Bacillus aroideae*) are spread from plant to plant most effectively on the hands of workmen and gain access to the pith through the fresh wounds caused by breaking out the tops or the suckers. During wet weather, they spread with great rapidity in the pith, which furnishes an ideal food for them, and within a few days reduce it to a watery jelly. With the recurrence of dry weather, the watery, rotten pith dries and shrivels, leaving the stalk hollow—hence the popular name for the disease. But the progress of the rot does not stop at the pith. From here it passes by natural channels into the bases of the leaves, causing them to droop and hang down around the stalk (Figure 9) or to fall off entirely leaving the stalk bare. Even if the stalks are harvested in the early stages, the leaves do not cure well in the shed.

There is no known remedy for hollow stalk. The spread in the field may be reduced, however, by restricting the operations in an affected field to periods when the leaves are dry. Also the workmen should avoid touching or working with affected plants while topping or suckering.

Rootrots

Very few observations were made on brown rootrot this year. There were many patches of poor growth in the fields caused by drowning and leaching and it is not easy to distinguish such plants from those affected with brown rootrot. Consequently the symptoms were ascribed to the effects of excessive rains although some of them may have been brown rootrot cases.

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*See especially Conn. Sta. Bul. **364**: 779 and Bul. **410**: 409, for descriptions and photographs.

On the other hand many more fields than in any recent year were affected to various degrees with black rootrot. In 1938 this was not due to the higher reaction of the soil, but to the cold, water-logged condition of the ground during June and July. The rootrot-resistant type of Havana Seed tobacco was much superior to the common non-resistant types. For further discussion of the resistant strain, No. 211, see page 20.

Malnutritional Disorders

Naturally in a year of excessive rainfall and leaching of the plant nutrients, we would expect considerable damage from shortage of some of the mineral elements.

Nitrogen hunger, as evidenced by the general pale color of the entire plants and reduced growth, was common throughout the Valley and is well recognized by most growers. The later addition of more nitrogen to the growing crop partially corrected this condition (see page 18 for experimental data). Some growers made as much as three additional applications of nitrogen with profit. Such a practice can be recommended only for exceptional years.

Calcium hunger was observed in many fields this year for the first time in the experience of the writer. Observations on this deficiency are written up in a separate article of this report (see page 16).

One very severe case of **potash hunger** in the seedbeds was observed in Windsor. The plants were stunted, the leaves had recurved margins and tips, and developed numerous small dead spots causing the owner to fear that a parasitic disease had invaded his beds. Applications of nitrate of potash, dissolved in the water with which the bed was sprinkled, gradually overcame this trouble and the plants developed normally when set in the field.

Magnesia hunger was observed in many fields.

Ammonia Injury in the Seedbeds

The killing or stunting of young plants in the early seedbed stages due to excess ammonia in the soil is not uncommon and many cases have been brought to our attention in recent years. A severe case involving all the beds on a large tobacco farm in East Windsor was made the subject of close study in 1938 because the beds were almost a total loss. When first seen, the young plants in the four-leaf stage were dying off in numerous patches of a few inches to a foot in diameter. The plants first turned yellow and then fell over and disappeared, leaving large, round bare patches all over the bed. The grower, in addition to a heavy application of manure in the fall, had fertilized the soil heavily in the spring with fish meal, just before steaming. The seed was sowed about a week after steaming.

A soil test showed so much ammonia in this soil that it could not be measured by the Morgan soil testing method. No nitrate or calcium was disclosed by the test. Such a condition arises from ammonification of nitrogenous materials like fish meal caused by steaming. Examination of these plants under the microscope showed the stems to be sound and normal but the roots 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 might at first be confused.

The control lies primarily in avoiding the application of nitrogenous materials such as fish meal, organic meal or manure, just previous to steaming. Also it is well to delay seeding as long as possible after steaming in order to permit the ammonia to be converted to nitrate. In less severe cases it has been found that the injury may be overcome by applications of nitrate of lime and of land plaster which neutralize the effect of the ammonia.

Blackfire in the Seedbeds

Blackfire is a bacterial disease which causes considerable damage both in the seedbeds and in the fields of the more southern tobacco states, but has never been serious in New England. Almost every year the writer has observed occasional fields where, late in the season, blackfire spots could be found on some of the leaves, but the damage has been negligible. These field occurrences have been noted and the disease described and figured in some of our annual reports*, but it has not been observed in the seedbeds.

This year, however, blackfire was found in a dozen beds in widely separated towns and was sufficiently virulent and striking to cause considerable apprehension and some damage. A careful study of the disease was made and its progress watched with the results described below.

Symptoms. In all cases studied this year, the disease occurred in small spots or patches of a foot or more in diameter and was not scattered generally over the beds as it is said to be in the South. It started from a focus and spread centrifugally, involving all the plants in its path. Sometimes only one affected patch was found on a farm, sometimes a dozen. In the first case reported, May 10, the seedlings were about an inch tall; in later cases they were larger.

The characteristic symptom of this disease is the occurrence on the leaves of numerous little dark dead spots, the number of each leaf ranging from a half-dozen to 50. In early stages, the color of these spots is black, or a very dark green, and the affected tissue is water-soaked. As they dry out, the color blanches through various shades of brown and gray to almost white. The young black spots vary from pin-head size up to a quarter of an inch across but frequently they coalesce to form larger, irregular patches. The spots are always much smaller than those found on mature leaves in the field. They are irregular in outline (Figure 10), only rarely perfectly round, with no definite margin or halo. They are sunken and at first give one the impression of flea beetle injuries, but closer examination shows that the leaf tissue is not eaten but is collapsed and sunken, with the epidermis intact. As the spots get older and dry after a few days, the tissue becomes brittle and easily cracks and falls out, leaving irregular, ragged holes (Figure 11). As the disease progresses,

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*See particularly Conn. Sta. Bul. 367: 120 and Bul. 386: 593.

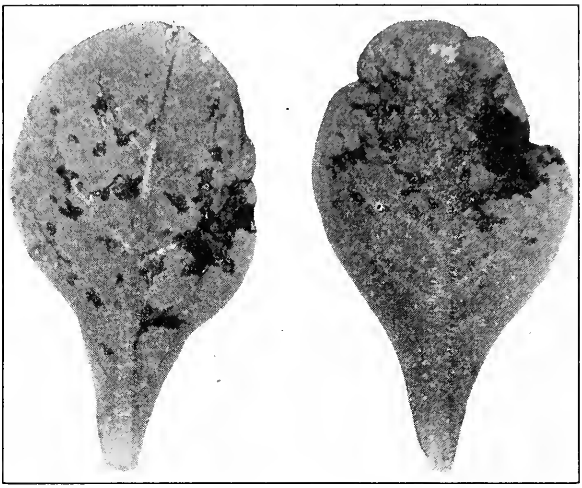

FIGURE 10. Blackfire or angular leaf spot in the seedbed. Spots at first are dark and watery.

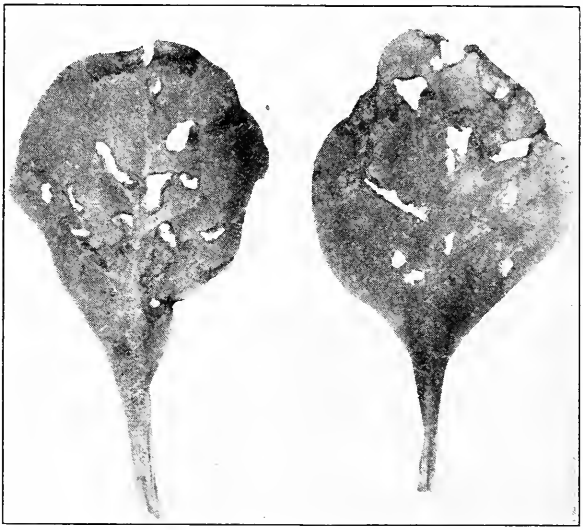

FIGURE 11. Blackfire in later stages. The spots have dried and fallen out, leaving ragged holes.

the leaves become somewhat distorted and the margins and tips turn downward. In severe cases in 1938 the plants were badly stunted but were not killed.

When examined under the microscope, the leaf tissue was found to be collapsed and disintegrated in a soft rot and was teeming with motile bacteria.

Cause. Blackfire, or angular leaf spot, as it is also called, is produced by invasion of the leaf tissue by these parasitic bacteria, *Bacterium angulatum* Fromme and Murray*. There are various ways in which they may be introduced into the beds. In Virginia, it has been shown that they may live over from one season to the next on the seed, dry tobacco leaves, refuse, or plant-bed covers. In Kentucky, Valleau has shown that chewing tobacco used by workmen about the beds is a prolific source of infection. There is also some evidence that the bacteria may winter over in the soil.

In the field, the most important factor in spreading blackfire from plant to plant is prolonged periods of rain. In the beds also, frequent watering, the prevalence of high moisture conditions and the operations of weeding and pulling the plants, when wet, undoubtedly spread it quite effectively.

Control. Blackfire has never been of sufficient importance here to warrant special control measures. If it should become more prevalent it will be necessary to take precautions to keep it out of the seedbeds, since it has been shown in other sections that the principal source of field infection is the setting of diseased plants from infected beds. Such control measures would be essentially the same as those used commonly here for control of wildfire and would not involve much additional work.

A Bedrot Caused by the Fungus, *Pythium aphanidermatum*

The general term "bedrot" is used to describe a diseased condition in the beds when patches of the partly grown plants collapse and slough off in a rapid, soft, wetrot. Characteristically it comes when the plants are of considerable size, about ready for setting in the field, and are crowding each other, or in damp poorly ventilated beds, in heavy soil or during wet weather. This has also been called "damping off". The writer, however, has restricted the use of the term "damping off" to a disease of the younger seedlings which kills them just after the seed has germinated. Obviously this distinction is artificial, since it is quite possible for plants to die at any stage of growth, but it is convenient for purposes of discussion.

Bedrot may be caused by any one of several different parasitic organisms; and some of these organisms produce symptoms which differ, on close inspection, from those produced by others. There are thus several bedrots of tobacco, distinguishable both by the organisms that cause them and the different symptoms they exhibit. One of these, a bacterial bedrot, is described in a later section of this article.

By far the most prevalent type in this section is the one produced by the fungus, Rhizoctonia. Until recently, the writer has not found any other organism connected with the many cases examined. This bedrot may

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*Diseased leaves from one of the Connecticut beds were sent to Dr. Valleau of the Kentucky Agricultural Experiment Station, who inoculated healthy plants and produced there the symptoms which he regards as typical of blackfire in that state.

usually be distinguished by the cobweb of mycelial threads running from plant to plant around the advancing margin of a fresh disease patch.

This was the type first described by Selby* in Ohio who was the first to use the name "bedrot".

At about the same time, Clinton** in Connecticut described a similar disease under the name of "stem rot", which he referred doubtfully to the fungus Sclerotinia. Although Clinton reported it as the most common type in this State, we have not yet found it in the many beds we have examined during the last 14 years.

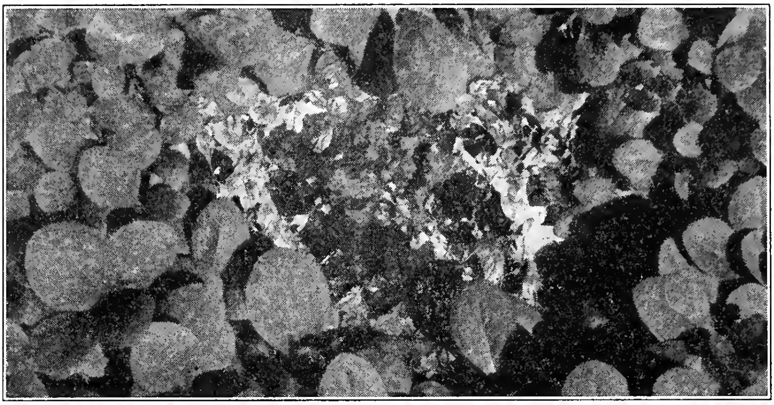

FIGURE 12. A bedrot spot due to the fungus, Pythium.

During May of 1938, a different type of bedrot was found on five or six farms in Suffield, Broadbrook and South Windsor. We are not certain whether this was its first appearance here or whether it had been overlooked and not distinguished from the usual type. Since it differs from the others found in Connecticut in some of its symptoms and is caused by a fungus not previously found connected with tobacco bedrot in this country, a more detailed description of the disease is given.

Symptoms. In all cases observed the plants were more than an inch high. The patches are definitely localized and from two to six inches in diameter in the crowded parts of the beds. This is a rapid wetrot, causing all the plants in the patch to fall to the ground in a water-soaked, dark green, slimy decay, leaving the spot quite bare. On drying out, the ground is covered with a brown crust of the bleached leaves. Unlike the Rhizoctonia disease, this is not characterized by the definite dark brown lesions on the stalk of the plant. The stalk becomes soft and watery and the bud rots out. The writer was unable to determine whether infection starts in the stalk or in the bud. A very characteristic symptom is the manner in which the light brown rot runs up the petiole into the lower part of the

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*Selby, A. D. Bedrot. Ohio St. Bul. 156: 97. 1904.

**Clinton, G. P. Stem rot. Conn. Agr. Exp. Sta. Rpt. 30: 326. 1906.

leaf discoloring it in a fan-shaped area corresponding to the base of the leaf (Figure 13).

Causal fungus. When the rotted tissues of the leaves and stalks are examined under the microscope, they are found to be permeated with a network of hyaline, non-septate branching threads (hyphae) of a parasitic fungus, a species of Pythium. The hyphae are no different from those of other species of Pythium such as *P. debaryanum*, described as a cause of damping off in Bulletin **359**, page 336-352. The mode of producing spores, however, is characteristic and readily distinguishes this from *P. debaryanum* and all the other species of Pythium. Two types of spores are produced within the rotted tissues of the plant: short-lived motile spores in sporangia, and long-lived resistant spores called oospores.

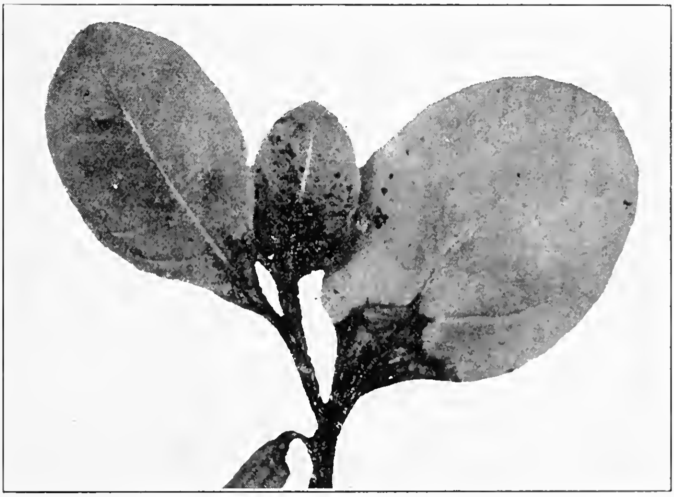

FIGURE 13. Pythium bedrot. Shows characteristic way in which the disease runs from stalk into the base of the leaf.

The most characteristic feature of this species is the peculiarly shaped sporangium from which the motile spores, zoospores, are developed. These sporangia are produced on the ends of the vegetative hyphae. The protoplasm from the hypha flows into the tip which swells up usually to two or three times the diameter and develops variously shaped, short stubby lateral branches. Meanwhile this body has been separated from the main hypha by a cross-wall. These occur in dense groups in the decayed leaf tissue and the whole mass presents a tangled, convoluted appearance in which the separate elements are difficult to distinguish. Some of the varied shapes which these sporangia may assume are indicated in Figure 14A. They are densely filled with protoplasm and are therefore very conspicuous when the rotted tissue is examined under the microscope. They are 10 to 20 microns in diameter and the lengths vary up to 10 times the width. Sometimes they are long and slender, not much thicker than the vegetative hyphae from which they arise. When these sporangia are mature, the protoplasmic contents pour out through a slender tube into a round vescicle which forms at its tip. The protoplasm in the vescicle then divides into numerous, (15 to 40) small motile spores, zoospores, which swim about in the moisture until they come to rest on another leaf where they germinate to start a new infection.

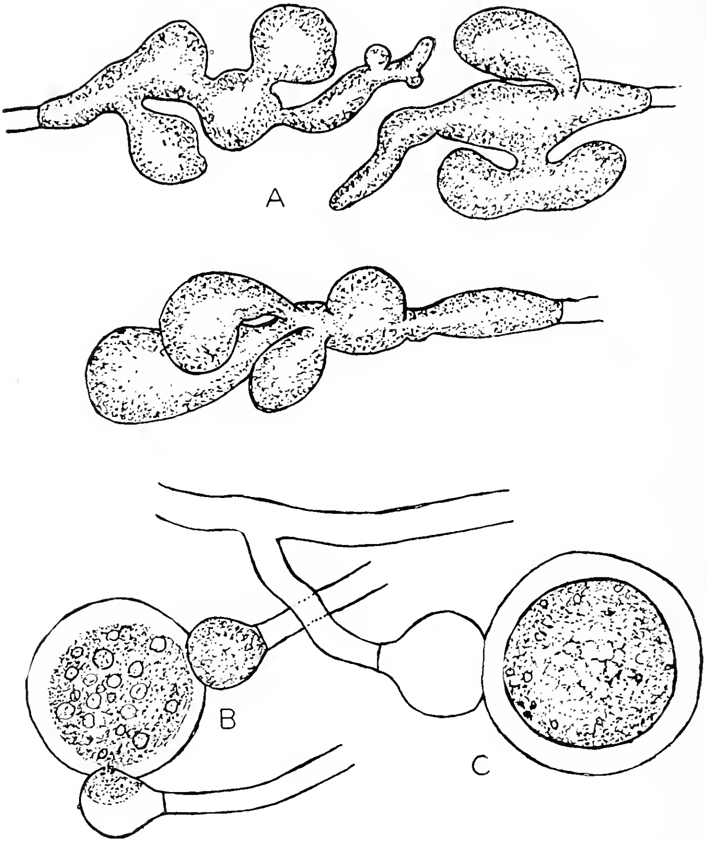

Figure 14. The fungus, Pythium aphanidermatum, which causes bedrot. A. The irregular lobulate sporangia. B. Oogonium in process of fertilization. C. Mature oospore with attached empty antheridium. Magnified 2000 diameters.

The second type of spores, oospores, are also developed on the ends of the hyphae inside the tissues. They are globose, regular in shape and have thick walls which make them resistant to unfavorable conditions of moisture and temperature (Figure 14 B, C). They retain their vitality for months, or until the following year, and thus serve to perpetuate the parasite from one year to the next. These oospores are 12 to 25 microns in diameter. They originate from terminal spherical bodies, known as oogonia, which are fertilized by smaller male organs, the antheridia, arising from other hyphae.

Taxonomy. This parasite is not confined to tobacco but has been found to cause diseases and rots of a considerable number of plants. Under the name of *Rheosporangium aphanidermatum* it was first described in 1915 as causing a damping-off of beets and blackroot of radish[*].

Four years later, the same fungus, under the name of *Pythium Butleri*, was described by Subramanium[1] as parasitic on tobacco in India. In 1923 Fitzpatrick[2] proposed the combination, *Pythium aphanidermatum* (or *Nematosporangium aphanidermatum*) for the same fungus. The next year a damping-off of tobacco in Africa was attributed to this parasite[3]. A stem rot or stem burn, of young tobacco plants caused by this fungus in the field was reported by several writers[4] in Sumatra.

We have not seen any previous report of this disease on tobacco in America.

Blackleg, a Bacterial Bedrot

Although blackleg was first identified by the writer in the seedbed season of 1937, it is probably not new in Connecticut. In past depredations it may have been confused with other types of bedrot which it resembles closely in outward appearance. In 1937 it was so virulent and rapid in its destruction, causing complete loss of extensive beds in Glastonbury and in Rockville, that a detailed investigation was undertaken. It was found that, in addition to some differences in general symptoms, this type differed particularly from the other types of bedrot in the complete absence of any causal fungi. All the decayed parts of the plants were teeming with motile bacteria, however. The same trouble was found and first described by Johnson and Valleau[5] in seedbeds in Kentucky. All the symptoms of the disease and characters of the organism were so similar as observed here and described from Kentucky that there can be no doubt that the disease in Connecticut and in Kentucky is identical.

A brief description of blackleg, under the general title of *Bed Rot*, was published in our annual report for 1937 (Conn. Expt. Sta. Bul. **410**, p. 408). Since it was also found again in 1938 in a number of seedbeds here, and it is anticipated that it may recur annually, a more complete description by which it may be identified is given.

Symptoms. In all cases studied, blackleg first became evident when the plants were several inches tall and about ready for transplanting to the field. We have never seen it on younger plants. The first evidence of trouble which the grower notices is that patches of plants in his bed look

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[*] Edson, H. A. Rheosporangium aphanidermatus, a new genus and species of fungus parasitic on sugar beets and radishes. Jour. Agr. Res. 4: 279-291. 1915.

[1] Subramanium, L. S. A Pythium disease of Ginger, Tobacco and Papaya. Mem. Dept. Agr. India 10: 181. 1919.

[2] Fitzpatrick, H. M. Generic concepts in the Phthiaceae and Blastocladiaceae. Mycologia 15: 166. 1923.

[3] Bunting, R. H. Rpt. Agr. Dept. Gov. Gold Coast for 1923-24, p. 32. 1924.

[4] Van Hall, C. J. J. Ziekten en plagen der cultuurgewassen in Nederlandsch-Indie in 1924. Meded. Inst. Plantenziekten 67: 53. 1925.

Jochems, S. C. J. Parasitaire Stengelverbrandig bij Deli-Tabak. Meded. Deli Proefstat. te Medan-Sumatra ser. II 49: 35 pp. 1927.

Van der Goot, P. Ziekten en plagen der cultuurgewassen in Nederlandsch-Indie in 1927. Meded. Inst. voor Plantenziekten 74: 58, 83. 1928.

[5] Johnson, E. M. and W. D. Valleau. Blackleg of tobacco seedlings. Phytopath. 21: 973-978. 1931.

wilted and dark in color with the least drying on a warm day or when the sash are removed. Soon afterward the plants in these patches collapse in a wet rot and the decaying leaves and stalks sink to a flat black crust over the surface of the ground. Under moist conditions the affected patches spread rapidly in a centrifugal direction until they may be several feet in diameter and, in the worst cases, entire beds are destroyed.

A closer examination of the individual plants shows that the bases of the stalks are first attacked by a soft, slimy, dark, wet rot which advances up to the bases of the leaves. These droop and become dark green and water-soaked as they collapse. As they come into contact with other leaves, the rot spreads from leaf to leaf, runs down the leaf petiole to the stalk and thus spreads from plant to plant. Sprinkling the plants also spreads the germs over the soil so that leaves in contact with the soil serve as agents for conducting the disease to the stalk or to the next plant. The original infection may thus occur either through the leaf or through the stalk.

High moisture in the soil and particularly in the air surrounding the plants is the most potent predisposing factor. With the return of dry conditions, through proper ventilation and sunny weather, further spread is checked. The lesions on slightly affected plants dry up and such plants may recover completely.

Causal organism. Blackleg is caused by parasitic bacteria of the soft-rot group, organisms which cause a slimy decay of many kinds of vegetables: carrots, turnips, cabbage, etc. Johnson and Valleau have shown that this same organism is capable of producing a wet stalk decay of mature plants in the field. This disease is commonly known as Hollow Stalk which we have previously mentioned and described in our annual reports*, and which we have ascribed to the species, *Bacillus carotovorus* Jones. Cultural, physiological and pathogenicity studies by Johnson and Valleau, however, lead them to believe that the species more closely resembles *Bacillus aroideae* Townsend, a species which cannot be distinguished morphologically from *B. caratovorus*.

Since the soft-rot bacteria are known to live and overwinter in soil and are probably present in all of our soils, it is likely that the organisms pass from this source to the leaves or other parts of the seedlings in contact with the ground. Whether or not a wound is necessary for entrance of the germ has not been determined, but the rapidity with which it involves all the plants about a focus of infection would indicate that wounds are not necessary.

Control. No control experiments have been undertaken specifically for this type of bedrot. Since, like the other types, its prevalence depends on high moisture condition of the bed atmosphere and surface soil, the most obvious remedy lies in reducing the moisture in the beds as much as can be done without making conditions too dry for good growth of the plants. The beds should be well ventilated all the time and watered thoroughly but not too frequently, preferably during the morning so that the leaves will dry before night. Sometimes it is advisable to change the

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*See particularly Conn. Bul. 364: 779, and Bul. 410: 409.

location of beds to a drier site. Soil sterilization is advisable because it kills all bedrot organisms before the seed is sowed, but will not always prevent reinfection of the soil from outside sources. Keeping the beds thoroughly sprayed at all times with Bordeaux mixture, as for other diseases, is also a good preventive measure.

Control of Damping-Off and Bedrot by Vapors of Benzol and Paradichlorobenzene

Both benzol and paradichlorobenzene have proved to be very effective in controlling downy mildew of tobacco. The possibility immediately suggests itself that the same treatment might be effective against other diseases. Some preliminary experiments in the greenhouse during the last two years lead us to believe that such is the case with at least two other diseases. In working with young tobacco seedlings in the winter under greenhouse conditions of moisture and light, many experiments are ruined because the young plants are killed off by the fungi causing damping-off and bedrot. In the Station greenhouse the damping-off when the plants are very young is almost always caused by the fungus, *Pythium debaryanum*, while the rotting off of the larger seedlings is most often due to Rhizoctonia, but sometimes two or more species of Pythium are involved also.

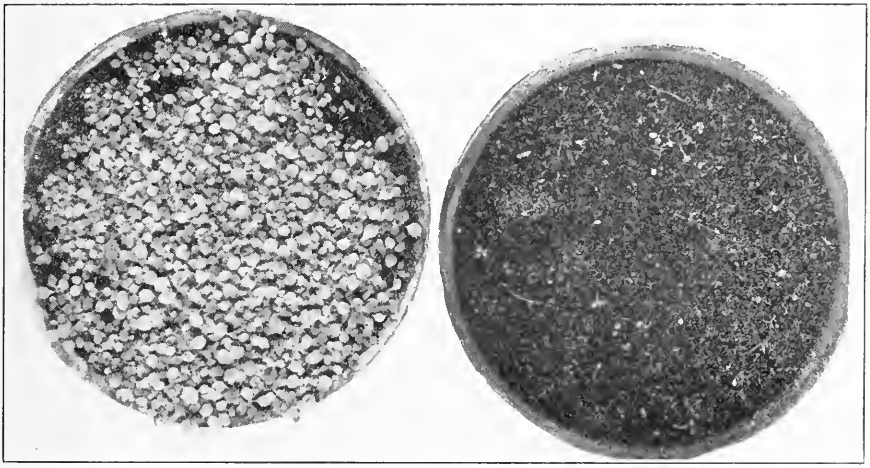

FIGURE 15. Control of damping-off and bedrot by fumes of paradichlorobenzene. Crock on right received no treatment and was a total loss.

During the winter of 1937-38 an experiment on control of downy mildew in which the treated flats of plants were subjected to fumes of benzol every second night was ruined because most of the plants in the untreated flats died from bedrot before the mildew was well established in them. No bedrot occurred, however, in the flats subjected to fumes of benzol.

These plants were kept in the flats until large enough to set in the field but not a single plant became diseased. In the meantime almost every plant in the untreated flats died.

A year later, when these diseases again became prevalent in the greenhouse, paradichlorobenzene was used in control tests. Four eight-inch crocks of plants were subjected to fumes of this chemical under glass sash similar to those used on tobacco beds, while four others seeded at the same time and kept under identical conditions except for absence of the chemicals served as checks. Damping-off had already started at an early stage in these crocks when the experiment began. Paradichlorobenzene at the rate of one-quarter ounce per square yard of bed was spread in a shallow watch glass in the treated chambers each night, or every second night, and removed during the day. The disease continued to spread in the checks until, at the end of about three weeks, hardly a live plant could be found in them. Microscopic examination showed both Pythium and Rhizoctonia in the dead plants. There was no further spread of the disease in the crocks subjected to paradichlorobenzene. Two of these crocks are shown in Figure 15 as they appeared three weeks after the experiment was started.

As yet this treatment has not been tried in the outdoor beds but the preliminary results suggest that this might be a simple method of controlling these diseases which often become serious in the beds and for which we have not previously had a very satisfactory method of control.

Leaf Blotch (or Scab)

Throughout the month of August this rather rare disease was observed on the mature bottom leaves of many fields of both Broadleaf and Havana Seed tobacco. For the most part, it was confined to the low-lying and poorly drained parts of the fields and the lower three or four mature leaves of the plant, frequently after the over-mature leaves had started to fade.

In this disease the blotches or spots are scattered irregularly over the upper surface of the leaves. They are roughly circular in outline, of indefinite margins, one-eighth to one-quarter of an inch in diameter, mostly separate but sometimes, when numerous on a leaf, coalescing to form irregular blotches. The color of the spots is olivaceous to olivaceous brown on the green leaves and a more distinct chestnut brown on the yellow background. As may be seen in Figure 16, the centers of the older spots are often lighter in color. Blotch differs from all the other typical leaf spots of tobacco in that the spot is visible only on the upper surface of the leaf. Only in very advanced stages does the underlying leaf tissue die so that spots may be seen from below. On account of this distinction, the names "blotch" or "scab" suggested by Wolf (4) seem more appropriate than "leaf spot". The appearance of the disease immediately recalls that of various scab diseases, such as the fruit tree scabs.

The actual damage caused by the disease is not great since only the smaller bottom leaves, mostly "sand leaves", are affected, and in curing the blotches become less distinct on a brown background. Moreover, it probably never occurs except during exceptionally wet years such as the

1938 season or in very wet parts of the field. It was first recorded in this State on field plants by Slagg (2) in 1922, another unusually wet season, and although the writer has searched for it many times since that date, it was not seen again until this year.

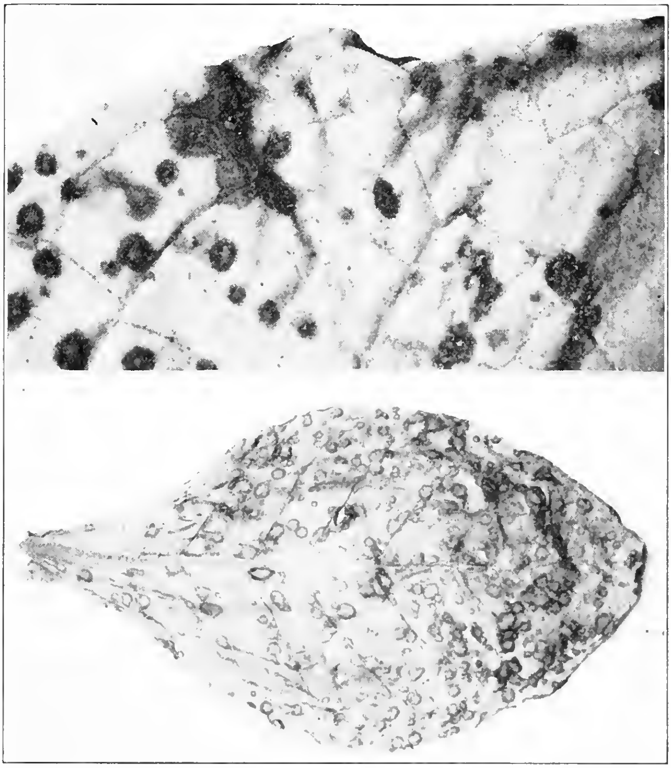

FIGURE 16. Leaf blotch or Fusarium spot. Natural size above and one-quarter natural size below.

Slagg (1) first reported it from Kentucky in 1918, as a disease of the seedbeds where it produced various symptoms "ranging from a type of damping-off, in very humid air, to a slight browning or girdling of the stems in less humid air". Tisdale (3) reported that this same trouble in seedbeds on new land, especially in partially shaded sections, had been common for many years in Florida. Infected areas of the beds were "conspicuous because of the yellowed and stunted condition of the plants. Under humid conditions the affected parts developed a soft rot, resulting in a ragged appearance of the leaves and the damping off of the petioles and stems". The seedbed stage of blotch has never been observed in Connecticut but should be watched for since this may sometime be more serious than the field disease.

Both the seedbed stage and the field symptoms are produced by the attack of the parasitic fungus which works first in the upper epidermis.

Later the fine threads, hyphae, penetrate and live on the deeper tissues of the leaf. On the surface of the blotch are produced many tiny simple spores which are distributed like seeds to other leaves to spread the disease. These spores, conidia, are hyaline, straight or slightly curved, frequently unequilateral, fusiform-cylindrical, tapering at one or both ends, uniseptate or sometimes nonseptate, measuring 13 by 2.8 microns (11-19 by 2.2-3.4 microns). The spores are borne singly on the tips of short-branched conidiophores which grow out to the leaf surface from the hyphae.

Diseased leaves were sent to Dr. C. D. Sherbakoff of the University of Tennessee, an expert on this genus of fungi. He identified the fungus as *Fusarium affine* Sherb. (=*Septomyxa affinis* (Sherb) Wr.) and stated that it was found abundantly in the seedbeds of Tennessee this year.

The fungus has been isolated, grown and described in pure culture and its pathogenicity demonstrated by inoculation of tobacco seedlings both by Slagg (1) and Tisdale (3).

It has now been reported from Connecticut, Massachusetts, Wisconsin, Florida, Tennessee and Kentucky and will probably be found under sufficiently moist conditions in all of the tobacco growing states.

No control methods have been investigated.

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1. Slagg, C. M. A new seedling disease of tobacco. Phytopath. 11: 49. 1921.
2. Slagg, C. M. New and unusual diseases and injuries of tobacco. Scien. Agr. 6: 193-198. 1926.
3. Tisdale, W. B. A disease of tobacco seedlings caused by *Septomyxa affinis* (Sherb.) Wr. Phytopath. 19: 90. 1929.
4. Wolf, F. A. Tobacco diseases and decays. Duke University Press p. 358. 1935.

REPORT ON THE INSECT INVESTIGATIONS FOR THE 1938 SEASON

A. W. Morrill, Jr., and D. S. Lacroix[1]

The coöperative investigations on the control of the insect pests of tobacco in the Connecticut River Valley which were begun in 1936 by the Connecticut Agricultural Experiment Station and the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture[2] were continued during the season of 1938.

In 1936 and 1937 two series of separate tests were conducted on tobacco for the control of the potato flea beetle, *Epitrix cucumeris* Harr., and the tobacco thrips, *Frankliniella fusca* (Hinds). In 1938 these tests were combined and dust mixtures and sprays were applied in an attempt to obtain a simultaneous control of both species of insects. Further preliminary experiments on the control of wireworms, chiefly *Limonius agonus* (Say), were carried out. In addition, a field survey of the abundance of tobacco insects was made in the Connecticut River Valley during July and August and some observations were recorded on the seasonal habits of the flea beetle, the wireworms and the tobacco worm, *Protoparce quinquemaculata* (Haw.).

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[1] Junior Entomologist, Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, U.S. Department of Agriculture; Assistant Entomologist, Department of Entomology, Conn. Agr. Exp. Sta., respectively.

[2] Morrill, A. W., Jr., and D. S. Lacroix. Experiments on Control of Tobacco Insects in 1936. Conn. Agr. Expt. Sta. Bul. 391: 84-98. 1937.

Experiments for the Control of the Potato Flea Beetle and the Tobacco Thrips on Shade Tobacco

In an attempt to determine a single control measure which can be applied against both the flea beetle and the thrips, the following insecticide materials were applied:

1. A cubé dust mixture containing 1 percent of rotenone; sterilized tobacco dust used as the diluent.
2. A cubé dust mixture containing 1.5 percent of rotenone; sterilized tobacco dust used as the diluent.
3. A cubé dust mixture containing 1 percent of rotenone; sterilized tobacco dust used as the diluent, with a commercially-prepared, water-soluble sulfonate of petroleum hydrocarbons as a wetting agent, used dry 1 part to 100 parts of dust.
4. A spray suspension consisting of 2 pounds of cubé root powder, containing 4 percent of rotenone, in 400 gallons of water, with the same wetting agent mentioned for material No. 3, 1 part to 800 parts, by weight, of insecticidal mixture.
5. Same as material No. 4, with a commercially-prepared sodium salt of an alkylated naphthalenesulfonate, as a wetting agent, 1 part to 800 parts, by weight of insecticidal mixture.
6. Untreated check.

Each of the plots was one-fortieth acre in size. They were arranged at random in a Latin square in such a manner that there were six replications for each of the insecticidal materials and for the untreated check plots.

Applications of each insecticide were made between May 31 and July 26 at semiweekly intervals except when prevented by rain. The rates of application of the dusts were from 5 to 8 pounds per acre at the beginning of the season and from 8 to 12 pounds per acre at the end of the season. The sprays were applied at rates ranging from 30 to 80 gallons per acre as the size of the plants increased.

Owing probably to the variability of the weather during the season and the long periods of rain, the summer generation of the flea beetles did not emerge in its expected numbers. The frequent rains also removed the dust mixtures and sprays so rapidly that their effect on the thrips was no doubt lessened. During the period of applications, counts were made on 10 plants in each plot. The counts included all living potato flea beetles and thrips and also the number of leaves showing damage by them. At harvest time all leaves from these 10 plants were harvested, cured and examined carefully for insect injury. Four pickings of three leaves each were taken beginning at the bottom of the stalk, in accordance with the usual commercial practice. Using the customary designations, these four pickings were labelled 1, 1½, 2, and 2A, respectively, and are thus shown in Table 12. In this table is shown the percentage of damage in the treated and in the untreated plots as determined by the examination of the leaves from the 10 sample plants. The average percent of all leaves damaged by each insect is shown in the final column of the table under the heading "total leaves".

The differences between treatments, as given in Table 12, are not significant for flea beetle control or for thrips control, but the differences between the treated plots and the check plot, No. 6, are significant in the case of flea beetle control. In thrips control, Plot 4 is the only one significantly different from the check. Differences of more than 5 are considered significant in flea beetle control and of more than 23 in thrips control. When the control of both species of insects is considered, Plot 4, a spray, was best. Of the other plots, No. 3, a dust containing a wetting agent, appeared somewhat superior.

FIGURE 17. Graph showing the average results of applying insecticides for control of the potato flea beetle in comparison with no treatment, as determined by the examination of samples of cured tobacco leaves, from the No. 4 treated plots and untreated plots, Windsor, Conn., 1938.

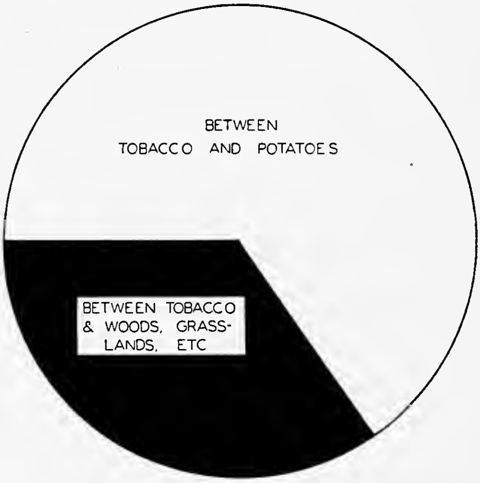

FIGURE 18. Migration of potato flea beetles between tobacco and potatoes (shown in white) and between tobacco and woods, grasslands, and field borders (shown in black), as indicated by catches on adhesive screens, Windsor, Conn., 1938.

The data included in Table12 do not give a complete picture of the results, for damage to leaves from the check plot usually is severe enough to cause such leaves to lose nearly all value, whereas damage to leaves from treated plots in 1938 was so slight as to occasion at most a drop in quality of only one grade. It is frequently observed that whereas two or three beetles on a plant may choose separate leaves, larger numbers, when present, will tend to congregate on the same leaves. The ratio of leaves damaged, therefore, does not increase in direct proportion to an increase in the beetle population.

Table 12. Percentage of Leaves Damaged by Flea Beetles and Thrips in Control Experiments as Determined by Examinations of the Cured Leaves, Windsor, Conn., 1938*

Material No.	Picking 1		Picking 1½		Picking 2		Picking 2A		Av. of all Pkgs.	
	Percent Injured		Percent Injured		Percent Injured		Percent Injured		Percent Inj.	
	Beetle	Thrips	Beetle	Thrips	Beetle	Thrips	Beetle	Thrips	Beetles	Thrips
1	5.9	32.2	3.4	22.1	.54	15.6	0	19.2	2.5	29.8
2	8.8	37.3	3.1	26.4	1.7	12.4	0	16.5	3.1	23.1
3	1.4	26.8	2.1	37.4	2.8	9.1	2.7	17.2	2.3	22.6
4	3.5	19.8	8.5	28.3	1.6	8.4	.98	15.5	3.6	18.0
5	2.7	31.2	2.2	31.7	1.7	8.5	3.4	56.8	2.5	32.0
6	2.9	63.8	11.6	54.1	8.4	26.9	12.3	29.5	8.9	43.2

*An average of 429.5 tobacco leaves was examined for each insecticide treatment.

None of the materials recorded in Table 12 gave thoroughly satisfactory thrips control, although, as previously stated, the conditions for experimentation were far from perfect. In Figure 17 is shown graphically the percentage of damage in the plot treated with material No. 4 and in the untreated plots as determined by the examination of cured leaves from the 10 sample plants in each plot. It will be seen that considerable control was nevertheless effected. Since thrips habitually remain in the crevice in the midrib of the leaves, where damage is removed in the stemming process, only damage of commercial importance on the leaf area was recorded. In the case of flea beetles, damage is inflicted without regard for its location on the leaf and therefore any feeding by flea beetles indicates potential commercial damage. The degree of flea beetle damage in all but the check, however, was slight and rather difficult to discern on the tobacco leaves examined in these tests.

Experiments for the Control of the Potato Flea Beetle on Sun-grown Tobacco

A cubé dust mixture containing 1 percent of rotenone was used with various diluents as follows: (1) Sterilized tobacco dust, (2) ground pyrethrum flowers after the extraction of pyrethrins, (3) a mixture of these two and (4) a material composed of finely-ground walnut shells. Each of these diluents was satisfactory, although the dust mixtures containing the three latter materials seemed to give a better degree of control of the potato flea beetle on tobacco than the dust mixture containing only tobacco dust as a diluent. This experiment, however, was disrupted by the "drowning" of the plants in one portion of the field, as illustrated elsewhere in this bulletin. This caused the size of the treated plots and condition of the plants to vary considerably.

Studies of Flea Beetle Migration

As in previous years, adhesive screens were used to determine the movements of flea beetles between tobacco fields and potato fields. On similar screens the migration between tobacco fields and woods, grasslands and field edges was studied. The observations made in 1936 and 1937 regarding the relationship between potatoes and tobacco were again substantiated, as may be seen in Figure 18.

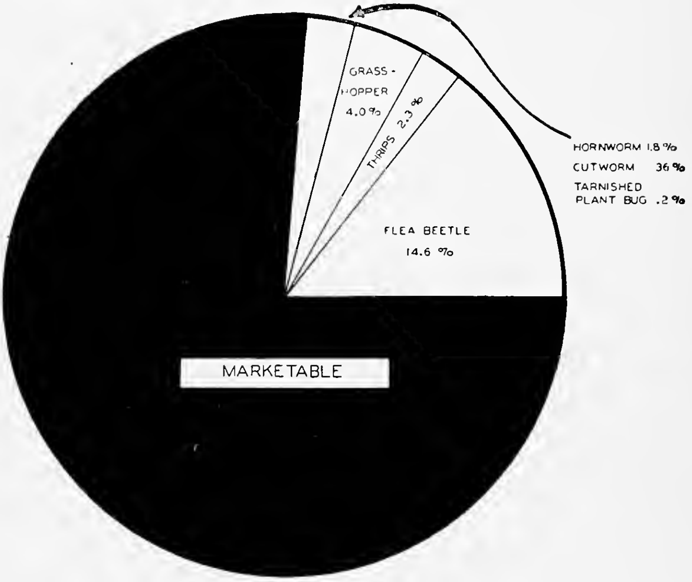

FIGURE 19. Graph showing the estimated average damage by some of the principal insect pests of sun-grown tobacco, as determined by a series of field examinations made immediately before harvest in the Connecticut River Valley, 1938.

Wireworms

The studies on wireworms in 1938 were limited to the testing of a finely ground naphthalene and dichloroethyl ether. These two materials have been experimented with rather successfully in California and Washington by federal workers. They were tested at the Windsor laboratory last season against the wireworm, *Limonius agonus* (Say), and showed some promise. The results obtained were in no way conclusive and it is apparent from these tests that further experimentation is essential before the exact value of these materials is definitely shown.

Insect Losses Sustained in Sun-grown Tobacco

During July and August a survey was made of sun-grown tobacco in a selected group of fields in the Connecticut River Valley in Connecticut and Massachusetts. Fifty-three fields were examined for insect damage. Five plants were chosen at random in the center and five in each quarter of the fields, and an estimate of the insect damage to every leaf on each of these plants was recorded. A separate score was kept for the damage caused by flea beetles, thrips, grasshoppers, hornworms, climbing cutworms, and tarnished plant bugs.

Following the same method adopted in 1937, an estimate was made of the total losses sustained from each insect based on the ratio of leaves damaged to those undamaged. The average of these estimates is presented in graphical form in Figure 19.

Extreme damage by the potato flea beetle to tobacco planted near potato fields was again observed. Plants on the edge of tobacco fields adjoining potatoes were occasionally nearly completely skeletonized (Figure 20) and were always more severely riddled than those farther in the interior or on the other edges of the field.

FIGURE 20. Leaf of sun-grown tobacco showing extreme damage by potato flea beetles migrating from an adjoining potato field not treated with insecticides. Broadbrook, Conn., 1938.

Notes on Abundance of Insects

The wireworm, *Limonius agonus* (Say), caused its usual amount of damage to both sun-grown and shade-grown tobaccos.

The potato flea beetle, *Epitrix cucumeris* Harr., appeared in large numbers at setting time and through early June, but the second brood of adults was delayed until late in the third week of July, when there was a sudden increase in population. This infestation lasted less than three weeks and the peak of flea beetle emergence was very small. Growers generally applied insecticidal dust mixtures along the edges of their fields, as illustrated in Figure 21, to prevent the inward migration of these flea beetles.

The seed corn maggot, *Hylemya cilicrura* Rond, was recorded on a few fields early in June.

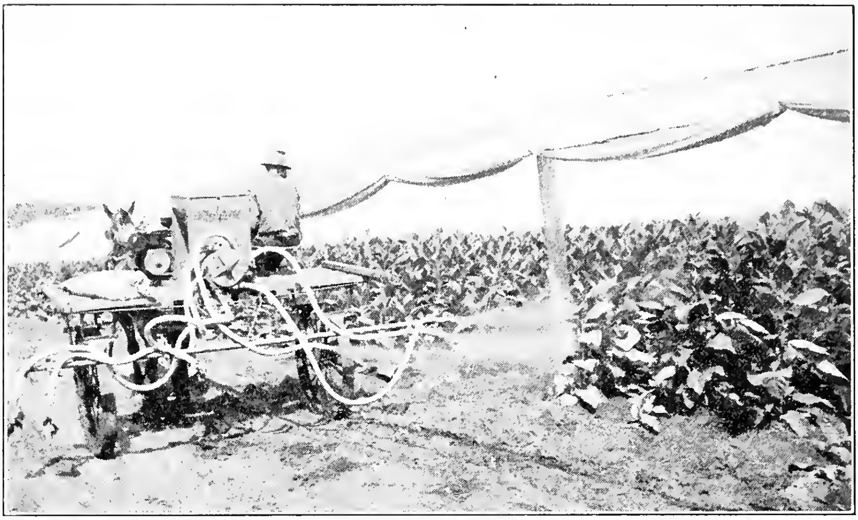

FIGURE 21. Applying insecticidal dust mixtures to tobacco with power equipment around the edges of a shade tent for the control of late-emerging potato flea beetles migrating in from outside. Windsor, Conn., 1938.

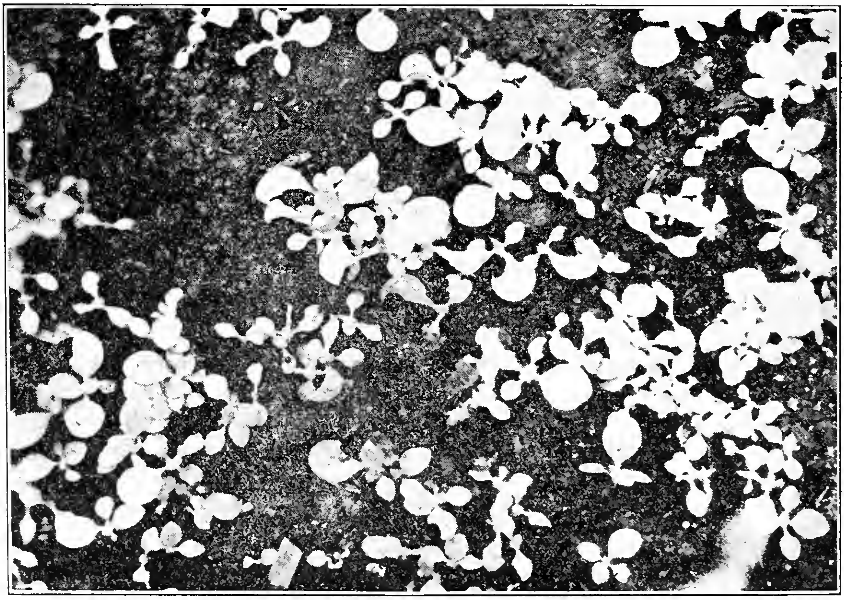

FIGURE 22. Young plants in seedbed, showing damage by cutworms. Three-fourths natural size. Simsbury, Conn., 1938.

Grasshoppers were not abundant, but were taken in a majority of fields. A few infestations of the lesser migratory locust, *Melanoplus mexicanus mexicanus* Saussure, were found in shade tents which had been in sod in 1937.

The tobacco thrips, *Frankliniella fusca* (Hinds), appeared in large numbers late in May and persisted through early August. Injury of commercial importance appeared on the lower leaves of tobacco.

The tobacco budworm, *Heliothis virescens* (F.), was not found this season.

The tarnished plant bug, *Lygus pratensis* (L.), appeared on some fields of sun-grown tobacco, particularly in the highlands west of the Connecticut River Valley.

Hornworms of both species were found in most fields of sun-grown tobacco and a few in shade tents. *Protoparce sexta* (Johan.), the tomato worm or "southern" hornworm, appeared generally throughout the Connecticut Valley early in July and was more abundant than the "northern" tobacco hornworm, *P. quinquemaculata* (Haw.). Parasitism of these insects by the larvae of the branconid, *Apanteles congregatus* (Say), was not so heavy as in 1936 and 1937.

The garden springtail, *Bourletiella hortensis* (Fitch), was unusually abundant in seedbeds in May, and caused considerable damage in some instances. It was also observed feeding on plants in the field in June.

Occasional specimens of the spined stink bug, *Euschistus variolarius* Beauv., were seen on sun-grown tobacco, and a few cases of wilt caused by this insect were observed.

Cutworms, especially *Euxoa messoria* (Harr.) and *Agrotis c-nigrum* (L.), were reported on many fields, particularly where no poisoned-bran bait was used before setting. Several plant beds similarly unprotected suffered severe damage. Figure 22 shows a section of one such bed.