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TOBACCO SUBSTATION AT WINDSOR

REPORT FOR 1932

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Connecticut
Agricultural Experiment Station
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TOBACCO SUBSTATION AT WINDSOR

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

This bulletin contains reports of progress on a number of the lines of investigation underway at the Tobacco Substation in Windsor. None of these are final reports, but some results have been obtained that are of sufficient interest to growers and others working along these same lines, to warrant publication at this time. No mention is made here of the majority of the projects, a complete list of which will be found on page 466. The scope of the fertilizer experiments has been considerably changed, so that most of the tests in 1932 were in the first year of long-time experiments and therefore warrant no report at this time. The potash tests for the most part were discontinued with the season of 1931. New series of tests dealing with nitrogen fertilizer materials and rates of application of nitrogen occupy the greater part of the experimental farm at Windsor.

In previous fertilizer experiments at Windsor, only the Havana Seed type of tobacco was used. In the new series of fertilizer experiments both Havana Seed and Broadleaf types are under test here. The Broadleaf fertilizer tests on the Frank Roberts farm, Silver Lane, were also continued under the direction of J. S. Owens, Extension Agronomist. Manure experiments on shade tobacco were continued in cooperation with Tudor Holcomb on his plantation in West Granby.

A new series of curing experiments on Shade tobacco was begun this year in cooperation with the Gershel-Kaffenburgh Tobacco Company on their plantation in East Hartford. The writers take this opportunity to express their appreciation of the excellent cooperation of these growers.

Since the appearance of our report for 1931, two other bulletins dealing with tobacco have been published by Connecticut investigators.

One is "A History of Tobacco Production in New England," by C. I. Hendrickson, Bulletin 174 of the Storrs Experiment Station, which should be read by every tobacco grower.

The other is "Chemical Investigations of the Tobacco Plant, III, Tobacco Seed," Bulletin 339 of the Agricultural Station, New

Haven. This bulletin is of special interest to the scientific investigator.

TOBACCO PROJECTS

1. Fertilizer experiments—comparison of carriers and rates of application of nitrogen, phosphorus, potassium and magnesium.
2. Field tests with farm manure.
4. Tobacco nutrition studies—the roles of magnesium and calcium and rates of nitrification of different fertilizers.
5. Improvement of Havana Seed tobacco with especial reference to root-rot resistance. (With U. S. Dept. Agr.)
7. Improvement of Cuban Shade strains.
8. Cover crops for tobacco fields.
9. Brown rootrot, nature and causes.
11. Soil reaction in relation to tobacco culture.
13. Preservative treatment of shade tent poles. (With Department of Forestry.)
17. Factors that influence curing.
19. Investigation of tobacco diseases.
20. Insects of tobacco. (With Department of Entomology.)
23. Metabolism as correlated with the stages of growth of tobacco.

HOW MUCH MAGNESIA SHOULD BE APPLIED TO TOBACCO LAND?

The importance of magnesia, not only for the proper growth of tobacco but more particularly for improvement of combustion of the cigar has been fully demonstrated at this Station.[1] It was found that the percentage of magnesia in the leaf could be readily increased by application of magnesia-containing materials to the soil, in the fertilizer mixture or alone. Although the organic fertilizer materials, such as cottonseed meal, linseed meal, or castor pomace, contain some magnesia, the quantity thus supplied is usually not sufficient to produce optimum improvement in burn.[2] Larger amounts may be applied in cottonhull ash or sulfate of potash-magnesia. The most economical material for this purpose is magnesian lime or limestone containing a high percentage of MgO.

When the proper amount of magnesia is present in the leaf, combustion is more complete, resulting in a whiter ash, closer burn (narrow coal band), and better taste and aroma. If, however, the magnesia is increased too much, the ash falls off the cigar in flakes, and in that respect the burn is not desirable. The optimum amount of magnesia in the leaf therefore is that percentage which is sufficient to give a light-colored, close burning ash, but is not enough to cause "flaking." It was tentatively concluded from experiments, chemical analyses, and burn tests, that this optimum percentage is obtained when the leaf contains about 2 per cent of MgO (calculated on moisture free basis).

[1] For a full discussion of experiments conducted and conclusions drawn, the reader is referred to our previous reports, particularly Bul. 326, pages 391-398, 1930.

[2] "Burn" refers to the composite effect of bases in the combustion of a cigar, thus differing from "fire holding capacity," which is primarily influenced by the potash content of the leaf.

From a practical standpoint it was next necessary to determine how much magnesia should be applied to an acre of land to insure a magnesia content of about 2 per cent in the leaf. Obviously the required amount will depend somewhat on the character of the soil, its native magnesia content, and the season. Despite these variable factors, it seemed desirable to determine by field tests as nearly as possible the optimum quantity to apply and how often it should be applied to an average tobacco soil such as we have on the Station farm. An experiment was therefore begun in 1930 on a field that was then in grass and had not grown tobacco during the preceding 9 years.

Plan of the Experiment

The plan was to apply different quantities of magnesia to adjacent plots of tobacco; then, by burn tests on the tobacco of each plot, to determine which had the optimum burn and to correlate this with the actual percentage of magnesia found in the leaf by chemical analyses. Magnesian lime with a MgO content of 30 per cent was used for this purpose (57 per cent CaO). It was also necessary to keep records of growth, yield, and sorting in order to see what effect each treatment had on these factors and to determine soil reaction at intervals, since there was danger that such applications might neutralize the soil to such an extent as to favor black rootrot.

There were 10 plots of one-twentieth acre size on which four treatments in duplicate were applied: 100, 200, 400, and 600 pounds of MgO to the acre. The other two plots received no lime and served as controls. The application of magnesian lime was broadcast 2 weeks before setting in 1930. No lime was applied in 1931 or 1932.

A general fertilizer was applied equally to all plots each year. This supplied 200 pounds of nitrogen, 169 pounds of phosphoric acid and 200 pounds of potash to the acre. The composition of the fertilizer (for an acre) was as follows:

Cottonseed meal	1500 lbs.
Castor pomace	500 "
Nitrate of potash	300 "
Sulfate of potash	70 "
Calurea	106 "
Precipitated bone	300 "

Effect on Yield and Grading

Observations during the growing season in these three years have not shown significant differences in growth where different quantities of lime were used. The tobacco from each plot was weighed and sorted separately and the grade index computed according to the scale used in all the work at this Station. The yields and grade indices for the three years are presented and averaged in Table 1. From this table it may be concluded that the application of magnesian lime improved somewhat both yield and grading, but between the different quantities of magnesia, the differences in yield and grading were too small to be significant.

TABLE 1. A SUMMARY OF THREE YEARS RESULTS ON YIELD AND GRADING OF MAGNESIAN LIME PLOTS

Quantity of MgO	Plot no.	Acre yield by years 1930	1931	1932	Average	Grade indices by years 1930	1931	1932	Average
None	L9	1216	1510	1784	1506	.280	.378	.346	.371
	L9-1	1472	1402	1650		.363	.414	.447	
100	L10	1376	1492	1784	1560	.457	.439	.369	.422
	L10-1	1474	1553	1678		.453	.409	.407	
200	L11	1320	1452	1800	1546	.324	.408	.366	.377
	L11-1	1474	1488	1742		.347	.404	.412	
400	L12	1333	1390	1613	1533	.326	.371	.383	.381
	L12-1	1440	1495	1924		.369	.425	.412	
600	L13	1407	1440	1770	1563	.266	.427	.471	.384
	L13-1	1441	1565	1754		.350	.429	.359	

Effect on Soil Reaction

Naturally, the application of such quantities of lime neutralizes, at least temporarily, the acidity of the soil. The reaction of this soil in the spring before application of lime in 1930, was 4.93. Results from tests at intervals during the three years are presented in Table 2.

To avoid the danger of black rootrot the soil reaction should be kept below 6.00 pH (preferably not higher than 5.6 pH). The highest two applications, 400 and 600 pounds MgO, kept the soil in the danger zone for three years. Therefore, these amounts certainly should not be used. The 200-pound application (680 pounds of the total lime per acre) kept it near the border line between danger and safety. The 100-pound application (340 pounds total lime per acre) has raised the reaction only slightly and never enough to bring it within the danger zone.

TABLE 2. REACTION OF SOIL ON LIMED PLOTS, 1930-1933 (pH)

Quantity of MgO applied to an acre	Reaction at different times of sampling				
	July 8, 1930	Aug. 15, 1930	April 16, 1931	May 10, 1932	Jan. 15, 1933
0	4.90	5.23	5.45	5.53	5.33
100	5.06	5.48	5.60	5.48	5.45
200	5.36	6.15	5.87	5.72	5.55
400	5.95	6.65	6.31	6.07	5.90
600	6.53	7.34	6.89	6.21	6.03

Seasonal fluctuation in soil reaction makes it difficult to follow the yearly trend of reaction in each plot, but by comparing each plot at any one time with the control, it is apparent that the plots with the higher applications are becoming relatively more acid each year and are approaching the reaction of the control. This is obviously due to greater loss by leaching from the high lime plots of calcium and magnesium.

Effect on Character of the Ash

In order to observe the effect of each increase in magnesia application on the burn, cigars were made from the fermented leaves (seconds) of the crops of 1930, 1931, and 1932. Wrapper, binder and filler were from the same plot. These were smoked and notes made on the color and coherence of ash.

On those made from the first crop (1930) after liming it was found that the ash was very light gray to white on all cigars from the limed plots, but usually too dark on the control plots. Each increase in amount of magnesia, however, made the ash more flaky. (Figure 129.) This flakiness made the ash quite unsatisfactory in the heaviest three applications. Where 100 pounds of magnesia were applied, however, both the ash color and its coherence were satisfactory. Of the different quantities tried, this then was the optimum for the first year.

The effect of magnesia on the second crop after application was shown when the cigars of the crop of 1931 were tested. (Figure 130.) Ash from the no-magnesia plots was now quite dark and "muddy," the taste and aroma were poor. Even where 100 pounds magnesia had been applied, the ash was not light enough in color to be satisfactory. On the 200-pound plots, the color, taste and aroma were satisfactory. With higher applications the ash became too flaky, but color, taste and aroma were excellent.

It appears then from this year's tests that 100 pounds of magnesia are not sufficient to carry its beneficial influence into the second year. Only the 200-pound application was now satisfactory. Below this, the ash was too dark; above this, it was too

Magnesia (MgO) Applied per Acre (lbs.)

0	100	200	400	600

Magnesia Found in the Leaf

1.32%	2.47%	3.13%	3.83%	4.59%

FIGURE 129. Partly smoked cigars from crop of 1930. Magnesian lime applied in spring.

Magnesia (MgO) Applied per Acre (lbs.)

0	100	200	400	600

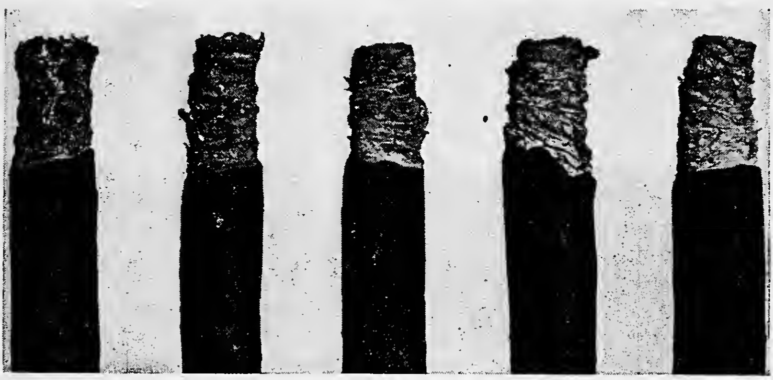
Magnesia Found in the Leaf

.86%	1.26%	1.55%	1.90	1.96%

FIGURE 130. Cigars from crop of 1931. Second year after liming.

flaky. However, since the 200-pound application was not satisfactory the first year, it appeared that in practice it would be best to apply a smaller dose (100 pounds or less) every year and not depend on a "carry-over" effect of larger applications. Figure 130 shows how the ash become lighter with increasing quantities of magnesia applied to the soil.

Cigars of the third year (1932) after application had a darker colored ash all through than corresponding plots of preceding years but it was not so flaky. (Figure 131.) Only the highest two applications gave satisfactory ash color and they were not as nearly white as in preceding years.



Magnesia (MgO) Applied per Acre (lbs.)				
0	100	200	400	600
Magnesia Found in the Leaf				
.87%	.92%	.92%	1.14%	1.53%

FIGURE 131. Cigars from crop of 1932. Third year after liming.

Effect on Chemical Composition of the Leaves

It was to be anticipated that each increase in quantity of magnesia applied to the soil would be reflected in an increased percentage of magnesia in the leaf. Previous experience also lead us to expect at the same time a decrease in the percentage of the other principal bases, calcium and potassium. In order to determine the extent of these changes and correlate them with the observed ash characters, analyses were made of the crops of 1930, 1931 and 1932.

The average percentage of the three bases in the three crops is presented in Table 3. The percentage of magnesia (1.32) in the control plot of 1930 was somewhat higher than anticipated, but may possibly be accounted for by the previous cropping and treatment of the field. With this percentage of magnesia, the ash was usually somewhat too dark. Each increase in applied magnesia resulted in a sharp increase in percentage in the leaf. The adverse effect of too much magnesia is seen in the extreme flakiness of the ash as shown in Figure 129. The next two years each showed a sharp reduction in the percentage of magnesia in the leaf. The differences between the control and the treated plots became less each year indicating a rapid leaching of magnesia from the soil. It is obvious that the optimum amount of magnesia can not be maintained in the soil by large applications at intervals of several years but in such a soil the grower must depend on smaller annual applications.

TABLE 3. EFFECT OF MAGNESIUM LIME ON THE PERCENTAGE OF CALCIUM, MAGNESIUM AND POTASSIUM IN THE LEAF. AIR-DRY BASIS ON UNFERMENTED LEAVES IN 1930 AND 1932, FERMENTED IN 1931

Pounds MgO applied per acre	Percentage found in leaves								
	K_2O			CaO			MgO		
	1930	1931	1932	1930	1931	1932	1930	1931	1932
None	4.83	6.32	6.45	6.75	5.36	5.26	1.32	.86	.867
100	3.98	5.29	5.73	6.22	6.01	5.22	2.47	1.26	.917
200	3.12	5.06	4.89	5.63	5.36	5.51	3.13	1.55	.917
400	3.09	5.18	5.67	5.26	5.07	4.55	3.83	1.90	1.136
600	2.40	4.69	4.94	4.95	4.72	4.85	4.59	1.96	1.534

Can we now correlate the percentage of magnesia in the leaf with the burn characteristics? The optimum burn for the first year was on cigars with a magnesia content of 2.47 per cent but even so the ash was too flaky thus indicating an optimum lower than this. On the other hand 1.32 per cent gave an ash which was not always light enough in color. In the 1931 crop a percentage of 1.55 gave satisfactory color and coherence while 1.96 was too flaky. In the 1932 crop, the only cigars with satisfactory ash characteristics were those with 1.53 per cent magnesia and even these were not as light as might be desired. The results are not altogether consistent, but are sufficient to indicate an optimum between 1.5 and 2.0 per cent of magnesia. It is not likely that any narrower range (more exact location of the optimum point) than this can be determined. In the first place, there is some variation between the percentage in leaves from the same plot. Secondly, the completeness of the combustion is probably influenced by the *ratio* of magnesia to potash quite as much or more than by the actual *percentage* of MgO in the leaf.

The depressing effect of magnesia on the other bases is well illustrated in these analyses.

Conclusions and Recommendations

These experiments indicate that the optimum percentage of magnesia in the leaf is about 1.5 to 2 per cent of the moisture-free weight of the cured leaf. When the percentage falls lower, the combustion is not so complete and a dark ash results. This is accompanied by a less desirable taste and aroma. On the other hand, when the percentage is raised to 2.5 per cent or higher, the ash is whiter but is undesirable because it flakes too much.

Of the rates of application tried in this experiment, the 100-pound application came the nearest to keeping the magnesia content of the leaf at the desired percentage during the first season. Since heavier rates of application all gave an undesirable flaky ash in the first year, it seems that the most advantageous practice would be to apply not more than 100 pounds, but to repeat it each year.

The practical grower will be guided by the character of the tobacco produced on a field. In many cases, where the ash is already satisfactory, no application of magnesia should be made. If it is too dark, he should apply only the minimum amount that will make the ash satisfactory. In no case should this be more than 100 pounds MgO to the acre. It is not unlikely that a smaller dose applied yearly will usually suffice, especially on heavier soils. The suitable dose may be determined by testing the burn each year on the cigar. The grower must always keep in mind the danger of liming his land so much as to encourage black rootrot. Small applications are not dangerous because the natural leaching of tobacco soils removes the excess. In using magnesian lime, he should purchase a material with the highest percentage of MgO obtainable, keeping in mind that the percentage of calcium oxide is higher in the low-magnesia limes and is almost as effective in raising the soil reaction as is the magnesium oxide. A pure magnesium oxide or carbonate might be better, but is not as readily obtained or as cheap as a dolomitic lime.

THE RELATION OF CALCIUM TO THE GROWTH OF TOBACCO

Calcium, the principal element in liming materials and a constituent of numerous materials used as fertilizer, is essential to the growth and development of tobacco and other higher green plants.

This element has several functions, or physiological rôles, in the plant. Exact knowledge of all these is not yet developed, or is a matter of controversy, but at least three functions are well established: (1) It neutralizes oxalic and other acids produced within the plant or taken from the soil in surplus quantity. By forming precipitates with the acids it prevents their accumulation, which might otherwise injure the cells. (2) In the form of calcium pectate it is an essential constituent of cell walls. (3) It serves as a vehicle in the translocation of nitrates and probably other anions.

Specific symptoms develop in the green tobacco plant deprived of a supply of calcium sufficient for normal growth. The roots turn brownish with the tips rotted off and the root hairs cease to develop. The entire plant is stunted in growth and in extreme cases the terminal buds curl and turn brownish. Tobacco plants grown without and with calcium, are shown in Figure 132.

Percentage of Calcium in the Leaf

A certain percentage of calcium in the leaf is required for normal growth of tobacco. Garner and co-workers (2) found in Maryland tobacco a minimum calcium requirement of 1.5 to 2.1 per cent CaO in the air-dry leaf. This is in fair agreement with

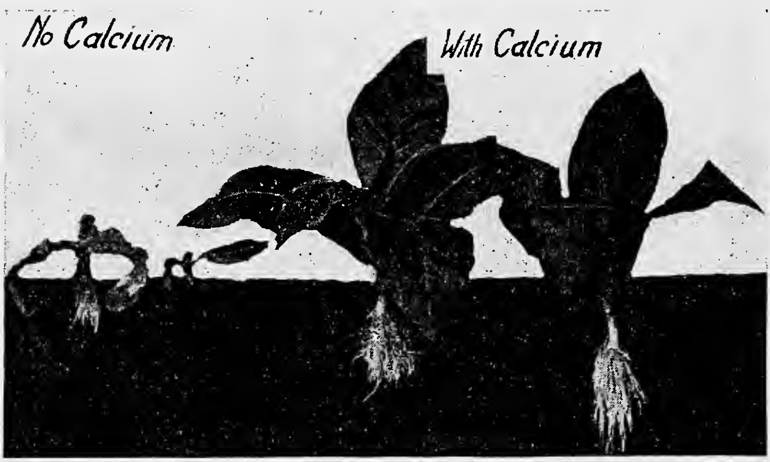


FIGURE 132. Tobacco plants grown without and with calcium.

results of greenhouse tests of Havana Seed tobacco at this Station, which did not show deficiency symptoms when the percentage of CaO was above two. A considerably higher percentage is needed, however, for optimum growth. Although there is no published information with regard to the optimum percentage, an indication is at hand from our own greenhouse tests that about 5 per cent CaO in the air-dry leaf corresponds to optimum growth. Numerous analyses of cured tobacco published in previous reports of this Station show a wide variation of CaO content (from about 5 to more than 8 per cent of the dry weight of the leaf). This variation may be governed primarily by the content of calcium (lime) in the soil. Experiments with gypsum at the Windsor station indicate that the CaO content of the leaf increases somewhat in proportion to the lime material added to the soil. Other experiments with pure calcium carbonate also show that the percentage increases with increased applications.

The Reciprocal Relation of Calcium and Other Bases

Many investigators (1)[1] have shown that the percentage of calcium in the tobacco leaf is decidedly affected by the percentage of potassium and magnesium; that is, the higher the calcium content the lower will be the content of potassium and magnesium. This was plain in a greenhouse test here in the case of a rather acid soil (4.38 pH) limed with pure calcium carbonate at a rate of 1 ton and 2 tons to the acre. Pots for quadruplicate treatments were filled with the limed and unlimed soils and were fertilized with ordinary tobacco fertilizer (200 pounds N, 200 pounds K_2O, 100 pounds P_2O_5 to the acre). One plant of Havana Seed was set in each pot and three crops were grown; for the second crop enough lime was added to bring the reaction up to the same level as for the first crop. The third crop received no additional lime. The tobacco was cured and later analyses were made for lime, magnesia and potash. The results are found in Table 4.

TABLE 4. PERCENTAGE OF CaO, MgO AND K_2O IN CURED LEAVES OF TOBACCO PLANTS GROWN WITH VARIOUS AMOUNTS OF $CaCO_3$

Crop	Amount of lime added to soil	Percentage found in leaf		
		CaO	MgO	K_2O
First	None	3.31	.57	5.05
"	1 ton	5.71	.33	4.61
"	2 tons	6.93	.25	4.18
Second	None	4.64	.71	5.56
"	1 ton equiv.	7.98	.48	4.28
"	2 " "	8.42	.38	3.93
Third	None	1.90	.53	7.49
"	Residual	2.78	.38	7.34
"	"	3.55	.32	7.13

Here it is seen that in every case where the percentage of calcium was increased, the magnesium and potassium were correspondingly lowered. On the other hand, where the calcium content was considerably lower, as in the third crop, the percentage of potassium came up to a higher level. In another section of this bulletin (page 472) where the effect of various quantities of magnesium are reported, it is shown that if the percentage of magnesium was increased in the leaf the calcium content (as well as that of potassium) was lowered somewhat in the same proportion.

Other experiments here and at New Haven have indicated that sodium (the base in nitrate of soda) and ammonium (the base in sulfate of ammonia) to a certain extent, have a depressing effect on the absorption of calcium. This is in agreement with observations by other investigators (3, 4).

[1]Figures in parentheses refer to "Literature Cited," p. 478.

The Effect of Various Compounds of Calcium

In a greenhouse experiment at the Windsor station where the effect of different calcium compounds on tobacco was compared in both sand and water cultures, it was shown that the compounds varied considerably in availability.

Table 5 gives the percentages of CaO found in the leaves when equivalent quantities of CaO were supplied from various compounds. In examining these results, we find that calcium nitrate produced the highest percentage of CaO in the leaf and somewhat similar results were found with nitrate and sulfate (gypsum) in combination, while the latter alone produced a considerably lower percentage. Oxide and carbonate, were still less available than the sulfate. Mono- and tri-phosphate, contained in acid phosphate and bone materials, respectively, gave much less CaO in the leaf. Acetate, oxalate, tartrate and citrate, all of which may be present in organic materials, showed low availability of calcium.

Table 5. Percentage of CaO in Tobacco Plants Grown in Sand With Various Calcium Compounds

Form of compound	Percentage CaO
Nitrate	5.07
Nitrate — sulfate	4.96
Sulphate	3.55
Oxide	3.53
Acetate	3.30
Carbonate	3.19
Oxalate	2.68
Mono-phosphate	2.46
Tartrate	2.19
None	2.00
Tri-phosphate	1.92
Citrate	.56

Effect on Yield

It is commonly known that liming an acid soil will increase the yield of many different crops. The increase in growth usually has been attributed to the neutralizing effect of lime. This may be true in instances where the reaction is very low. Thus, Morgan and co-workers (5) report that very acid soils—below 4.8 pH—have produced increased growth of tobacco through addition of lime. That calcium (the active base in liming materials) as a nutrient is responsible for increase in growth has been shown in field experiments as well as in greenhouse tests at Windsor. Furthermore it has been indicated through other experiments that the activity of calcium is governed by the amount of magnesia present, and vice versa. In other words, there seems to be a lime-magnesia ratio at which the land will produce optimum growth. Garner (2) states that it takes at least four times as much lime as magnesia to produce the best growth of tobacco on Maryland soil. Similar results have been obtained in our own tests with greenhouse cultures. An indication that this ratio governs the growth somewhat is given in the article on magnesia in this bulletin (see page 468). It is shown here that the yield figures are kept at about the same level where varying quantities of magnesian lime were applied, while the ratio of calcium to magnesium was the same.

Recent studies here have pointed toward the possibility that an insufficient absorption of calcium by the tobacco plant may be the ultimate cause of brown rootrot on tobacco. This insufficient absorption may not always be brought about by a too low supply in the soil, but by an improper balance between calcium and other bases or a low supply of nitrates, which, as previously stated, would reduce the absorption of calcium. In some preliminary tests, a mixture of equal parts of nitrate of lime and land plaster applied at a rate of 300 pounds to the acre, restored the normal growth to tobacco.

Nitrogen is generally considered to be the first limiting growth factor for tobacco in Connecticut. Since nitrogen and calcium are interrelated in their action, as has been pointed out by Parker and Truog (6), both would thus be most important limiting factors in growth of plants. It is, therefore, of importance to consider the calcium need as well as the need of other nutrients in the fertilization of Connecticut tobacco soils. In general these soils have a low calcium content and furthermore a great deal leaches out of the soil annually. The extent of leaching is reported elsewhere in this bulletin (page 486).

It is difficult, however, to lime a tobacco soil to the extent of obtaining sufficient quantities of available calcium, without increasing the reaction to a critical point where black rootrot may occur. It is true that some lime is added where magnesian lime is applied to satisfy the need of magnesia (see page 467 of this bulletin) and in cases where a special phosphorus carrier (bone phosphates) is believed necessary. Some calcium is also added through the use of cottonhull ashes. If it is, however, necessary to exclude all these materials from the fertilizer formula, it is a good plan to include some neutral calcium salts such as nitrate of lime or gypsum (land plaster). The latter material may be applied at a rate of 300 to 500 pounds to the acre and the rate for nitrate of lime should be governed by the amount of nitrate desirable for any particular formula.

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FURTHER EXPERIMENTS WITH NITROPHOSKA[1]

Nitrophoska (No. 3) is a concentrated commercial mixture containing 16.3 per cent nitrogen, 16.3 per cent phosphoric acid, and 20 per cent potash. It is a purely chemical mixture without organic material. Because it contains the three important fertilizer elements in a very concentrated form, its use would mean considerable economy of time and labor if it were found to be suitable for tobacco. Long experience has lead to the commonly accepted belief in Connecticut that a good tobacco fertilizer must contain considerable organic material and in this respect Nitrophoska is lacking. However, in order to test the soundness of this common belief and at the same time to test the value of this new material, a field experiment was started in 1929. On adjacent plots, Nitrophoska alone was compared with a standard formula in which 80 per cent of the nitrogen was from organic material. As a compromise between the two, other plots were treated with a mixture in which one-half of the nitrogen was in Nitrophoska and one-half from the organic materials. Two plots received each treatment and the location and treatment of plots has remained the same during four years. (See the above mentioned previous reports for composition and quantity of fertilizer.)

No differences in growth could be observed in the field. The yield and sorting records for 1932 are presented in Table 6. The averages for three years of the treatment are given in Table 7.

From the results of this year as well as the average results of three years it appears that Nitrophoska under the conditions of the experiment, consistently produced tobacco of lower grading than the standard formula.

There is also a tendency, although less noticeable, toward lower yields through the use of this material.

[1] For previous reports on Nitrophoska see Conn. Sta. Buls. 326: 377-379 and 335: 252.

TABLE 6. YIELD AND SORTING RECORDS OF NITROPHOSKA PLOTS. CROP OF 1932

Proportion Nitrophoska	Plot no.	Acre yield		Percentage of grades								Grade index	
		Plot	Ave.	L	M	LS	SS	LD	DS	F	B	Plot	Ave.
None	N28	2070	2022	7	9	35	0	28	0	19	2	.439	.462
	N28-1	1974		11	8	33	1	28	0	17	2	.482	
Half Nitrophoska	N29	2016	1941	11	10	30	1	27	0	19	2	.455	.421
	N29-1	1866		4	5	32	1	31	1	26	0	.386	
All Nitrophoska	N30	1957	1898	9	11	29	1	27	0	20	3	.437	.409
	N30-1	1839		5	7	27	1	32	0	25	3	.381	

TABLE 7. NITROPHOSKA SERIES. SUMMARY OF THREE YEARS RESULTS

Proportion of Nitrophoska	Plot no.	Acre yield by years				Grade index			
		1930	1931	1932	Ave.	1930	1931	1932	Ave.
None	N28	1884	1793	2070	1886	.491	.493	.439	.475
	N28-1	1829	1764	1974		.464	.481	.482	
Half Nitrophoska	N29	1813	1813	2016	1870	.457	.451	.455	.447
	N29-1	1856	1856	1866		.453	.478	.386	
All Nitrophoska	N30	1915	1813	1957	1870	.435	.440	.437	.435
	N30-1	1875	1820	1839		.473	.446	.381	

BROADLEAF FERTILIZER EXPERIMENTS

J. S. OWENS[1]

During the last 10 years the fertilizer experiments conducted by the Tobacco Substation have been concerned with Havana Seed tobacco on soils west of the Connecticut River best adapted to that type. Are the conclusions drawn from these experiments equally applicable to Broadleaf tobacco grown on the fields east of the river on soils that are believed to be best adapted to Broadleaf? Since the type of soil, Merrimac, is the same on the Station farm as that in the larger part of the Broadleaf region, it has been assumed that the fertilizer response for the two sections would be similar. However, Broadleaf growers at times have been inclined to question this assumption and have made many requests that fertilizer tests similar to those at Windsor be conducted with Broadleaf and on typical Broadleaf soil.

It was in response to these requests that the experiments here briefly summarized, were begun. These experiments will be con-

[1] Extension Agronomist.

tinued and extended as far and as fast as funds at hand will allow. The present preliminary report deals with only two questions:

1. How much phosphorus, if any, should be used?
2. What sources of nitrogen are best and most economical?

A series of fertilizer treatments was planned in the spring of 1930, and located on the farm of Harry Farnham, East Windsor Hill. The crop was destroyed by hail. The growth had been erratic, apparently because of rootrot infestation and variations in soil.

The next season, a location of more uniform soil, better adapted to experiments was found on the farm of Frank Roberts, East Hartford. Plots were laid out and the treatments used in 1930 were continued.

The plots were one-twentieth acre in size and wide enough for three rows; only the center was saved for measurements. Each treatment was applied to one plot in each of three series. Records of each treatment were therefore obtained each season from three plots.

Sources of Nitrogen

Three sources of nitrogen, cottonseed meal, castor pomace, and urea, were compared on plots where each in turn furnished a large proportion of the nitrogen. The formula with cottonseed meal as the chief source of nitrogen was as follows:

Materials per acre	Nutrients per acre N	P_2O_5	K_2O	MgO
Cottonseed meal, 2425 lbs.	160	72	48	24
Nitrate of potash, 295 lbs.	40		130	
Sulfate of potash, 45 lbs.			22	
Precipitated bone, 72 lbs.		28		
Magnesian limestone, 70 lbs.				14
Total 2907 lbs.	200	100	200	38

In a second series, castor pomace replaced the cottonseed meal in supplying 160 pounds of nitrogen, and, in the third, cottonseed meal and urea each supplied 100 pounds. The yields and grade indices are given in Table 8.

TABLE 8. NITROGEN SERIES. SUMMARY OF TWO YEARS RESULTS

Nitrogen Source	Acre yields 1931	1932	Ave.	Grade index 1931	1932	Ave.
Cottonseed meal 4/5..........	1519	1871	1695	.495	.447	.471
Castor pomace 4/5............	1632	1948	1790	.444	.469	.457
Urea 1/2....................	1599	1859	1729	.434	.469	.452

Thus the highest average yield for the two years was on the castor pomace plots, while the cottonseed meal tobacco had a slightly better grading. However, these tests have not been continued long enough to warrant final conclusions.

Quantity of Phosphorus

Four quantities of phosphoric acid were used, the lowest being only that contained in the 1,740 pounds of cottonseed meal (50 pounds P_2O_5 per acre). Precipitated bone was added to the other plots to make the total amounts of phosphoric acid. The basic formula used was as follows:

Materials per acre	Nutrients per acre N	P_2O_5	K_2O	MgO
Cottonseed meal, 1740 lbs.	114	50	35	17
Urea, 100 lbs.	46			
Nitrate of potash, 295 lbs.	40		130	
Sulfate of potash, 72 lbs.			35	
Magnesian limestone, 100 lbs.				20
Total 2307 lbs.	200	50	200	37

The yields and grading are given in Table 9.

The variations, if any, that can be attributed to the phosphorus treatments are slight. The yield on one of the plots with the smallest phosphorus application treatment was so low that the average for the treatment was appreciably changed. However, the lower grade index of the highest phosphorus treatment in 1932 was due mainly to shed damage to the tobacco from one plot.

Table 9. Phosphorus Series. Summary of Two Years Results

Pounds P_2O_5 per acre	Acre yields			Grade index		
	1931	1932	Ave.	1931	1932	Ave.
50	1593	1876	1735	.440	.458	.449
100	1589	1936	1763	.454	.452	.453
200	1661	1902	1782	.456	.451	.454
300	1631	1923	1777	.442	.441	.442

The growth of the 1932 crop was large and uniform throughout the plots. In 1931, drought affected a portion of one side of the field sufficiently to conceal small differences that might be due to the fertilizers.

The variations in both the nitrogen and phosphorus treatments seem to have made but small differences in either yield or quality of the tobacco, as shown by the sorting records. If any conclusion can be drawn at this time it is that all of the treatments grew good crops of Broadleaf. It will be necessary to continue the experiment for several more seasons to be certain what effects are important.

CONSERVATION OF PLANT NUTRIENTS BY COVER CROPS

M. F. Morgan[1] and O. E. Street

In a five-year field experiment at Windsor[2] on cover crops it was found that the sowing of cover crops each year increased the yield and improved the grading of tobacco. Of the several ways in which such improvement might be effected through cover crops, it seems likely that the most important is through the conservation of plant nutrients. In order to find out just how much of each nutrient material is actually saved by cover crops, the experiments here described were begun in 1931.

When tobacco is grown continuously, without intervening cover crops, the soil surface lies bare for nine and a half months of the year. Severe leaching usually occurs during fall and spring months, and during mild winter periods. Since not more than two-thirds of the nitrogen applied in fertilizer of the usual tobacco formula, is accounted for in the crop removed, there is a residue of fertilizer nitrogen, in addition to the more slowly available nitrogen reserve of the soil at the time of tobacco harvest. Much of this is transformed to nitrates during the comparatively warm period from August 15 to November 1. When no cover crop is seeded after the tobacco is removed, all of the valuable product of this nitrification process is leached from the soil before the following season. The nitrates take with them other valuable nutrients, calcium, magnesium, and potassium, in their downward escape from the soil.

If a cover crop is seeded after tobacco, much of the nitrogen becoming available as nitrates during the fall period is taken up by the crop. The more luxuriant the fall growth, the more efficiently are nitrates withdrawn from danger of leaching. Also, the growing cover crop removes much moisture, hence a smaller portion of the rainfall washes down through the soil.

If, as in the case of oats, the cover crop dies at the onset of winter, the dead residue of stems and leaves lies upon the soil surface until plowed under in the spring. During this period most of the potassium and a good part of phosphorus in the above ground residue may be leached into the soil, as has been shown in studies of changes in the chemical composition of dead leaves exposed to the weather during the fall and early winter period. However, these elements are not readily leached from the soil. The nitrogen, calcium and other mineral elements in the dead crop residue are not liberated to any appreciable extent until decomposition begins in the spring, particularly after the crop is plowed under.

If the cover crop is winter-hardy, the nutrients taken up by the crop are retained in the living parts until plowed under.

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[1] Agronomist in charge of Soils Department.
[2] Final report in Conn. Agr. Expt. Sta. Bul. 335: 227-231. 1932.

These statements could be made as a result of logical deductions from established principles, but a quantitative measure of the value of cover crops in conserving nutrients against leaching losses is now supplied by a series of lysimeter trials established at Windsor in the spring of 1931. Data are now available for the year 1931-32 and the period from May 26 to November 25, 1932.

Drainage water from the following treatments has been collected and analyzed.

Tank Nos.	Fertilizer	Crop
211-212	No nitrogen	Fallow
213-214	" "	Tobacco, no cover crop
215-216	Nitrogen as calurea	Fallow
217-218	" " "	Tobacco, no cover orop
219-220	" " "	Tobacco, oats cover crop
221-222	Windsor N-1 tobacco formula (1/5 of nitrogen as nitrate of soda, 4/5 of nitrogen as organics)	Tobacco, no cover crop
223-224	" " " "	Tobacco, oats cover crop
225-226	" " " "	Tobacco, rye cover crop
227-228	" " " "	Tobacco, timothy cover crop

Nitrogen is applied at the rate of 200 pounds per acre per year, phosphoric acid at the rate of 100 pounds, potash at the rate of 200 pounds, and magnesia at the rate of 50 pounds are applied to each tank.

The tanks are 30 inches deep and contain 8 inches of surface soil and 20 inches of subsoil.

Quantity of Water Leached

The growth of cover crops has exerted a significant effect upon the quantity of water leached during the fall and early winter period. This is shown in Table 10.

The greater effect of the cover crops sown in 1932 is probably due to the more luxuriant growth that resulted from more favorable moisture conditions. The 1931 season was unusually dry during late summer and fall.

On the basis of these results, it is evident that oats withdraw water from the soil to a greater extent than either rye or timothy during its short period of active growth.

Temporary Withdrawal of Nitrogen by the Cover Crop

In an effort to reveal the amount of nitrogen taken up by the cover crop, the green oats plants, including all of the fine roots which could be separated from the soil, were collected from four typical areas in the fields at Windsor, each 4 by 4 feet in size.

Plants and heavy roots of the oats cover crop weighed (oven dry) 1204 pounds per acre on October 21, 1931, and contained 29.31 pounds of nitrogen.

Fine fibrous roots weighed 796 pounds per acre, and contained 18.4 pounds of nitrogen.

The nitrogen thus accounted for in the living oats plants on that date amounted to 47.71 pounds per acre. The crop grew slowly until the middle of November before being killed by cold weather. It must be kept in mind that the cover crop of 1931 was lighter than usual, due to dry weather conditions.

TABLE 10. EFFECT OF COVER CROP UPON QUANTITY OF WATER LEACHED DURING FALL AND EARLY WINTER PERIOD (IN ACRE INCHES).

Treatment	Period Sept. 1, '31-Feb. 1, '32		Period Sept. 1, '32-Jan. 1, '33	
	Total leaching	Decrease for cover crop	Total leaching	Decrease for cover crop
Fallow, no nitrogen	5.686	....	8.015	....
Tobacco, no nitrogen, no cover crop	4.560	....	7.900	....
Fallow, nitrogen as calurea	5.803	....	7.845	....
Tobacco, nitrogen as calurea:				
No cover crop	3.994	....	7.445	....
Oats cover crop	2.512	1.482	4.618	2.827
Tobacco, Windsor N-1 formula:				
No cover crop	4.282	....	7.795	....
Oats cover crop	2.675	1.607	4.623	3.172
Rye cover crop	3.007	1.275	6.212	1.583
Timothy	3.840	0.442	6.861	0.943

The amount of nitrogen taken up by the oats cover crop in 1931 was also determined by comparing the nitrate nitrogen content of the soil on October 21. There had been no leaching of nitrates from the surface soil since the sowing of the cover crop.

The average of four samples under the oats crop showed approximately 16 pounds of nitrate nitrogen per acre in the surface soil. Four samples from an adjacent plot without cover crop gave 81 pounds on the same basis. The oats crop had caused a decrease of 65 pounds of nitrate nitrogen per acre in the surface soil. The amount recovered in the oats was somewhat lower than this last figure, due to the failure to separate a part of the fine fibrous roots from the soil.

Effect of Cover Crop on the Leaching of Nutrients

The results of drainage water analyses for important nutrient elements are shown in Tables 11, 12, 13 and 14.

The data for the six-months period May 26, 1932, to November 25, 1932, does not give a complete picture for the year. However, because of very heavy autumn precipitation, the leaching of practically all of the nitrates present in the soil during that period, was assured. Concentration of the leachates collected on January 3, 1933, did not exceed 10 parts per million of nitrate nitrogen on any of the cropped tanks, and had fallen to less than one part per million under oats and rye cover crops.

The value of the oats cover crop in conservation of nutrients is demonstrated by averaging the data for the two types of fertilization for two seasons, as shown in Table 15.

Rye conserved the nutrients to about the same degree, while timothy was significantly less effective in preventing losses through leaching. There were no consistent differences in the amounts of other elements leached from the soil as a result of cover cropping.

Although while it is difficult to evaluate fairly the monetary value of residual plant nutrients, it is worth bearing in mind that the above figures represent the equivalent of at least $7.00 worth of nitrate of soda, 75 cents worth of sulfate of potash, and 50 cents worth of dolomitic lime, at 1933 fertilizer prices. One must also take into consideration that a retention of this amount of nitrogen is associated with a conservation of 1000 pounds per acre of organic matter, or as much as would be supplied in 2 tons of manure.

Table 11. Leaching of Nitrogen as Affected by Cover Crops (Pounds per Acre)

Treatment	May 26,'31-May25,'32		May 26,'32-Nov. 25,'32	
	Leached	Retained by cover crop	Leached	Retained by cover crop
Fallow, no nitrogen	157.69	....	72.75	....
Tobacco,no nitrogen, no cover crop	64.51	....	33.53	....
Fallow, nitrogen as calurea	316.14	....	218.01	....
Tobacco, nitrogen as calurea:				
No cover crop	71.69	....	68.61	....
Oats cover crop	24.90	46.79	2.67	65.94
Tobacco, Windsor N-1 formula:				
No cover crop	81.14	....	55.88	....
Oats cover crop	21.69	59.45	4.94	50.74
Rye cover crop	18.89	62.25	1.38	54.50
Timothy cover crop	28.19	52.95	27.61	28.27

TABLE 12. LEACHING OF CALCIUM AS AFFECTED BY COVER CROPS (POUNDS PER ACRE)

Treatment	May 26,'31-May 25,'32		May 26,'32-Nov. 25,'32	
	Leached	Retained by cover crop	Leached	Retained by cover crop
Fallow, no nitrogen	186.44	....	87.41	....
Tobacco, no nitrogen, no cover crop	106.41	....	49.45	....
Fallow, nitrogen as calurea	351.57	....	206.98	....
Tobacco, nitrogen as calurea:				
No cover crop	120.61	....	76.89	....
Oats cover crop	72.55	48.06	19.62	57.27
Tobacco, Windsor N-1 formula:				
No cover crop	101.41	....	47.36	....
Oats cover crop	62.16	39.25	15.60	31.76
Rye cover crop	64.95	36.46	16.10	31.26
Timothy cover crop	74.62	26.79	27.75	19.61

TABLE 13. LEACHING OF POTASSIUM AS AFFECTED BY COVER CROPS (POUNDS PER ACRE)

Treatment	May 26,'31-May 25,'32		May 26,'32-Nov. 25,'32	
	Leached	Retained by cover crop	Leached	Retained by cover crop
Fallow, no nitrogen	132.53	....	84.60	....
Tobacco, no nitrogen, no cover crop	89.85	....	49.66	....
Fallow, nitrogen as calurea	198.84	....	126.97	....
Tobacco, nitrogen as calurea:				
No cover crop	72.10	....	54.39	....
Oats cover crop	61.55	10.55	23.52	30.87
Tobacco, Windsor N-1 formula:				
No cover crop	88.53	....	56.46	....
Oats cover crop	67.16	21.31	24.94	31.52
Rye cover crop	66.00	22.53	28.80	27.66
Timothy cover crop	72.77	15.77	43.88	12.58

TABLE 14. LEACHING OF MAGNESIUM AS AFFECTED BY COVER CROPS (POUNDS PER ACRE)

Treatment	May 26,'31-May 25,'32		May 26,32-Nov. 25,'32	
	Leached	Retained by cover crop	Leached	Retained by cover crop
Fallow, no nitrogen	29.00	....	14.29	....
Tobacco, no nitrogen, no cover crop	22.57	....	6.83	....
Fallow, nitrogen as calurea	61.40	....	41.15	....
Tobacco, Nitrogen as calurea:				
No cover crop	23.67	....	12.45	....
Oats cover crop	10.70	12.97	4.21	8.24
Tobacco, Windsor N-1 formula:				
No cover crop	15.12	....	8.76	....
Oats cover crop	10.71	4.41	1.99	6.77
Rye cover crop	11.73	3.39	1.91	6.85
Timothy cover crop	18.85	....	2.74	6.02

TABLE 15. AVERAGE CONSERVATION OF NUTRIENTS BY THE OATS COVER CROP

Nutrient	Pounds per acre	Equivalent Oxides
Nitrogen	55.73	.....
Calcium	44.08	61.68
Potassium	23.56	28.38
Magnesium	8.09	13.41

Lysimeter Results at Other Stations

In lysimeter studies made at other stations, no strictly comparable tests have been recorded, but the following data from the Cornell lysimeters strengthen the conclusions drawn from our own findings.

TABLE 16. NUTRIENTS LEACHED FROM CORNELL LYSIMETERS (NOS. 1 to 12, PERIOD OF 1910-1919)

Treatment	Annual drainage loss per acre (pounds)			
	Nitrogen	Calcium	Magnesium	Potassium
Fallow	69.0	398	63	72
Permanent sod	2.5	260	50	62
Rotation without legumes	6.7	246	43	61

At the New York State Agricultural Experiment Station, Geneva, an early series of lysimeters (1884-1886) showed an annual drainage loss of 195 pounds of nitrogen per acre from fallow soil, while permanent sod permitted the leaching of only 0.67 pounds per acre per year.

In more recent experiments at Geneva, in a comparison between a rotation of alfalfa-barley-wheat and two years of alfalfa followed by two years of fallow, the soil under the grain crops leached 123 pounds less nitrogen per acre as an annual average of the six years. In this case, however, the crops were harvested.

TOBACCO INSECTS IN 1932

Donald S. Lacroix

Prevalence of Various Species

The eastern field wireworm, *Pheletes ectypus* Say, caused quite as much damage to newly transplanted tobacco as in 1930, and the effects of the activities of this insect were apparent until July. This is unusual, as wireworm injury normally occurs only over a period of two to three weeks, from late May until about the middle of June. Adults of this insect were flying in small numbers during the last two days in May and the first week in June. Many fields that suffered last year had a light infestation this year, or none at all.

The potato flea beetle, *Epitrix cucumeris* Harr., was much less in evidence during the 1932 season than in 1931. As usual, the insect was present in practically all fields visited, but injury caused by it was generally light.

The tobacco flea beetle, *Epitrix parvula* Fabr., was found in small numbers on shade grown tobacco at the Station in Windsor. This is the first record of the occurrence of this species in Connecticut.

Tobacco horn worms, *Phlegethontius quinquemaculata* Haw., and *P. sexta* Johan., appeared in their usual numbers. Broadleaf tobacco in the eastern part of the tobacco-growing district was injured most.

The tobacco thrips, *Frankliniella fusca* Hinds, occurred throughout the Connecticut tobacco areas on Broadleaf, Havana Seed and shade tobacco, causing considerable injury to lower leaves (Figure 133). This was in direct contrast to last year's condition, when only a few fields bore evidence of the insect.

The stalk borer, *Papaipema nitela* Guen., was reported from only two plantations.

The tarnished plant bug, *Lygus pratensis* Linn., appeared in its usual numbers and caused considerable damage. More about this insect will be found on page 493.

The Mexican bean beetle, *Epilachna corrupta* Muls., was taken on tobacco leaves during late July and early August. To see whether the insect actually would feed on tobacco, several larvae were placed on a plant. They promptly migrated without feeding.

The tobacco budworm, *Heliothis virescens* Fabr., appeared on both shade grown and sun grown tobacco this season in Avon, East Hartford, Poquonock, and Windsor, but in such small numbers that injury was not extensive. More concerning the life history

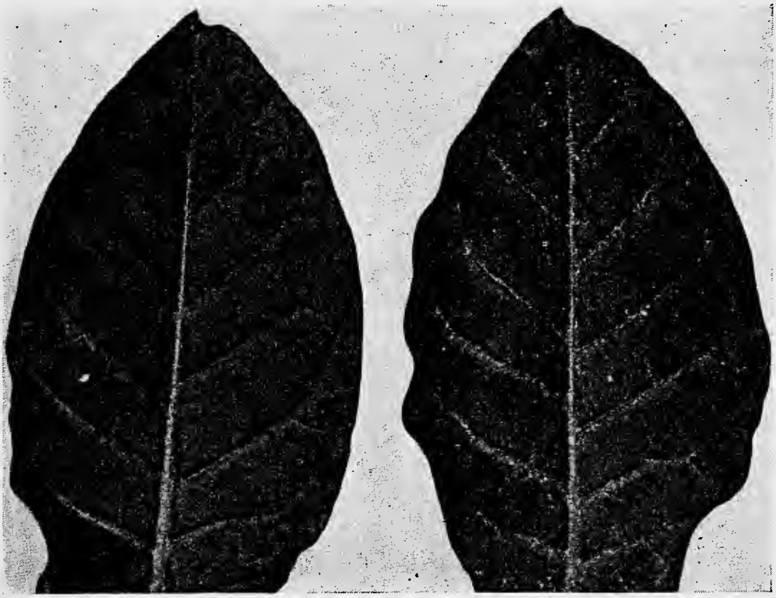

FIGURE 133. Thrips injury (right) to leaf of Havana Seed tobacco as compared with normal leaf (left).

and habits of this southern species appears on page 491 of this publication.

Grasshoppers of various species were about as numerous as in 1930 and 1931 on sun grown tobacco. Chief among these was the red legged grasshopper, *Melanoplus femur-rubrum* De G.

Potato Flea Beetle[1]

Studies of the habits and activities of the potato flea beetle on tobacco were continued this season. Eggs were deposited in rearing jars at different times from late June through early August, and

[1] *Epitrix cucumeris* Harr.

hatched in five to eight days. Due to the fact that difficulty was experienced in getting mature larvae from eggs laid in rearing, no reliable figures as to length of larval life can be given. Larvae taken from potato fields pupated in rearing jars and emerged in seven days. No larvae or pupae were found in potato fields after July 29. The first adults of the season were taken in the seed beds in the middle of May. No larvae or pupae were found this season in tobacco soils, either in seed beds or out in the field, although there was an abundance of larvae and pupae in potato soil about 400 yards from the tobacco. Repeated siftings were made throughout the summer in order to obtain larvae or pupae. Although this may seem to indicate that the adults migrate from the outside onto the

Table 17. Flea Beetle Population on Station Tobacco, 1932.

Date	Number of flea beetles on 25 plants				
	Sun grown		Shade grown		Total
	Section 1	Section 2	Section 3	Section 5	
June 18	52	48	6	2	108
" 25	12	40	9	0	61
" 28	16	66	5	2	89
" 30	25	74	6	1	106
July 2	18	74	0	0	92
" 6	13	26	4	1	44
" 8	19	32	6	7	64
" 12	26	39	11	8	84
" 14	19	42	8	9	78
" 16	32	33	7	11	83
" 20	39	31	6	3	79
" 23	28	33	..	..	61
" 27	13	21	..	..	34

tobacco, it must be borne in mind that the infestation on Station tobacco during 1932 was unusually light.

The population of adult beetles on the Station tobacco is presented in Table 17. A comparison of this table with those included in the reports for 1930 and 1931 will show a marked decrease in beetle abundance for the past season.

Control. After trying barium fluosilicate for three seasons against the flea beetle, it is concluded that this material, used as a dust, is a very satisfactory way to combat this pest. The use of it during 1930 and 1931 showed conclusively that it was of value in holding the flea beetle in check, but an undesirable residue was left. To obviate this, it was necessary to reduce the amount and use it undiluted. Applying barium fluosilicate at a rate of 4 to 5 pounds to the acre resulted in good control, and four dustings at weekly intervals left no visible residue. Three different plots were treated two on sun grown tobacco and one on shade grown. One of the sun grown plots was treated three times, once every two weeks, and showed as good results as did the other two.

Several growers in Connecticut used this material during the season of 1932 with satisfactory results. One used it at a rate of 3 pounds to the acre, diluting with tobacco dust to make it more bulky, and got very good control with a single application.

In seasons of light infestation, relatively few applications of dust are necessary. In seasons of heavy infestations, four or five weekly applications during the month of July should be sufficient to hold the beetles in check. It is essential that the dusting be done during the part of the day that is most calm, either early in the morning or in the evening. Due to the fact that the tobacco leaf possesses glandular hairs, which secrete a gummy substance, the dust will stick to the foliage very well, and therefore it is not necessary to dust while dew is on the leaves.

NUMBER OF FLEA BEETLES PER 25 PLANTS ON TREATED AND UNTREATED PLOTS

	Treated			Not Treated	
	July 8	July 21		July 8	July 21
Plot 1, Sun grown	4	2	Check	19	31
" 2, Shade grown	0	1	Check	7	3
" 3, Sun grown	1	3	Check	32	39

An examination of the plants on July 26 indicated no injury from beetles or dust on the treated areas, but some beetle injury on the untreated areas.

Tobacco Budworm[1]

This insect, which causes injury of great importance to tobacco grown in the south, appeared in several fields in Connecticut this summer. Although quite widely distributed here, it did comparatively little damage. The first infestation that came to our attention was in Avon early in July.

Type of injury. The worms, when immature, feed on the buds (growing tip) and suckers, eating holes in the leaves as they unfold. As the leaves grow larger, the holes also become larger, and a malformed leaf results. The more mature worms feed on larger leaves.

Life history and appearance. On July 5, 1932, the larvae in the field were in all stages from newly hatched individuals to half-grown worms. The smallest ones were about one-eighth inch in length and rusty brown in color. The half-grown ones were about three-fourths inch long, pale green, with several black tubercles on

[1] *Heliothis virescens* Fabr.

each segment, from each of which sprouted a single hair. Usually only one larva could be found on each plant, rarely two.

These larvae were placed in rearing jars and reached maturity about the middle of July. At the mature stage the larvae were approximately 1½ inches long, green, with stripes running lengthwise along the sides, and with sparse hairs (Figures 134 and 136). On July 17, 18, and 19 the mature larvae left the foliage and went below the soil surface, where they rested for four days. At the end of this "rest period" pupation took place (July 23, 24, and 25). The pupa, Figure 135, is at first greenish, and spindle-shaped, but it

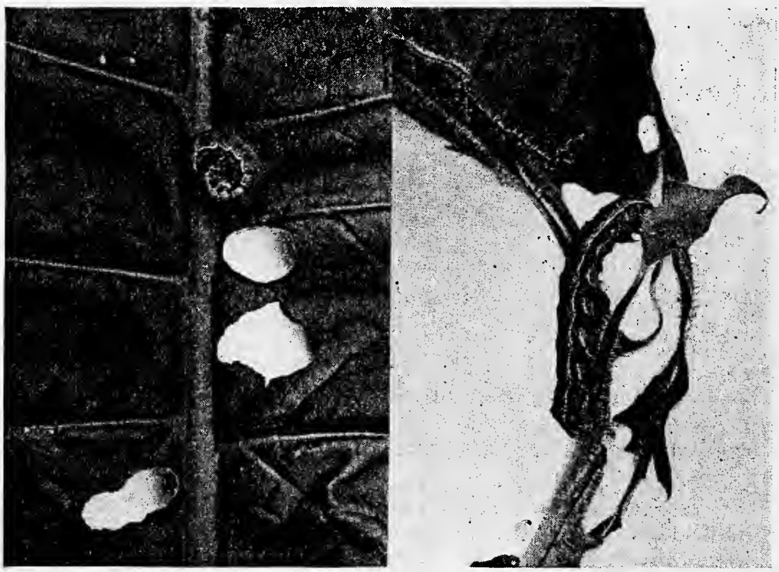

FIGURE 134. Tobacco budworm larvae and their injury to tobacco foliage.

turns gradually to a mahogany brown. About 10 days are spent in the pupal stage. From this emerges a small moth with light green wings. Each front wing is crossed by four paler oblique bands (Figure 135).

On August 25, half to two-thirds of the grown larvae were found boring into seed pods of some shade tobacco that was not grown under cloth (Figure 136). Several of these pupated during the first week in September and adults emerged from late in September through the middle of October.

This insect has been previously reported in Connecticut (Report of Connecticut State Entomologist for 1909-10, pp. 367-368) as feeding on tobacco September 15, with moth emergence October 15-21. It seems possible then, for two generations to occur here.

Control. In the south, the budworm is held in check by applying one pinch of a mixture of 1 pound of lead arsenate to 75 pounds of corn meal on the bud of each plant. This is usually done by hand. Unless the insect becomes more abundant than it did in 1932, hand picking is the most satisfactory method of control here.

Red Arrow spray at a dilution of 1 to 500 was tried as a control measure for budworms, but failed to kill them at this strength. Horn worms and climbing cutworms treated with the same material and at the same time, died shortly

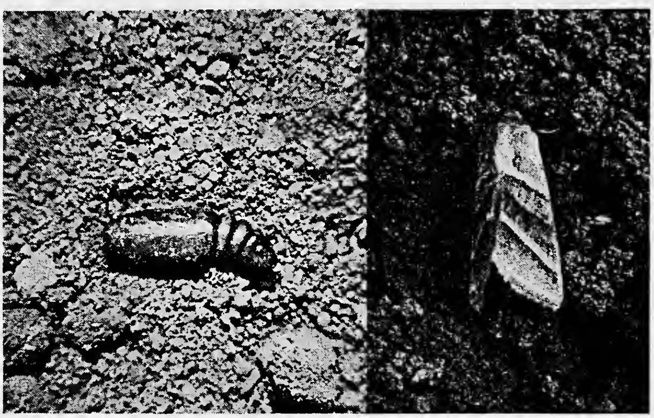

FIGURE 135. Pupa (left) and adult moth (right) of tobacco budworm (twice natural size).

In one field of Havana Seed tobacco, signs of early feeding were found, but no signs of later damage were visible. A careful examination showed that parasites had been at work and had killed the budworm larvae. The parasite cocoons were found fastened to the leaf with parts of the dead worm still hanging to the cocoons. The adults that emerged from the cocoons have been identified as *Sagaritis provancheri* Dalla Torre (*dubitatus* Cresson) of the family Ichneumonidae.

Tarnished Plant Bug[1]

Type of injury. The tarnished plant bug pierces the growing tip of the tobacco plants and sucks juices from the bud tissue. As a result of this feeding, the unfolding leaves become twisted and curly in appearance. Malformed plants were found on many plantations growing Havana Seed.

Appearance and habits. The adults are about one-fourth

[1] *Lygus pratensis* Linn.

of an inch long, flat, and oval in outline with a small head. They vary in color, usually being brown with spots of black and reddish-brown. They spend the winter under trash, stones, bark of trees, and similar concealed places and appear early in the spring, particularly on weeds, flowers, and grass. Flying is rapid when disturbed.

Observations made in Windsor during the past two seasons indicate that they appear on tobacco only to feed, as no eggs or young bugs could be found. Several times during the season of

FIGURE 136. Tobacco budworm boring into seed pod (twice natural size).

1932 adults were caged on single plants. They all died in time, without depositing any eggs, but seemed to feed freely.

Control measures. It is almost impossible to reach the adults with a contact spray, since they are very active and fly away rapidly as soon as one approaches within four or five feet of them. A stomach poison is of no value in controlling this type of insect. Keeping down weeds and cleaning up all trash near the fields may be of some help in reducing their numbers.

Distribution of Wireworm[1] Larvae in Tobacco Soil

Very little information is available concerning the habits and activities of wireworms in tobacco soil. To obtain some of this very necessary information, careful observations were made on the

[1] At least two species were present, *Pheletes ectypus* Say and *Limonius plebejus* Say.

distribution of larvae in the soil of an infested field in East Granby throughout the season of 1932.

At intervals during the summer and fall, soil areas 2 feet square and 2 feet deep were excavated at two different parts of the field. Each area was located so that one-half of the soil was removed from the tobacco row directly beneath the roots, the balance between the rows and away from the roots. Soil to the depth of 3 inches was removed and examined and its larval content noted. Successive soil horizons were treated in a similar manner. Table 18 indicates the results of these periodic soil examinations.

An analysis of these data indicates that throughout the growing season, the largest number of larvae were in the tobacco rows, and also that during the summer months the greatest percentage of larvae, as far as depth is concerned, was from 6 to 9 inches below the soil surface.

During these observations it was found that wireworms feed all summer on the roots and bases of stalks, but the plants were growing so fast that this injury was not always apparent above ground. Heretofore it has been assumed that feeding ceased in June, and that the larvae went down to escape heat. An examination of the data presented in Table 18 will disclose that the greater percentage of larvae are at a depth of from 6 to 9 inches during the heat of summer, but in the cooler months of October and November, the population seems to move upward, and at this time of year the greatest number of larvae occur in the 3 to 6 inch layer. Just why this condition exists is not readily explained, as no indications of feeding could be found on cover crops that had been sowed immediately after the tobacco was harvested.

As soon as the crop was removed, the stalks were cut and harrowed in. Two days later, many larvae could be found in pieces of stalks on or near the surface in spite of the fact that the greatest percentage of larvae was still at the 6 to 9 inch level below the surface.

Pupae of *Limonius plebejus* Say (Figure 137) were first taken late in July at the 6 to 9 inch level. Adults (Figure 137) of this species were not found in the field, but emerged late in August from pupae removed to the insectary.

The fact that about two-thirds of the larval population was found to be concentrated in the tobacco rows immediately below the plants suggested the possibility of obtaining some means of control by applying insecticides in the row. Several tests were conducted, based on this suggestion, but the results were unsatisfactory.

Another series of experiments was conducted to see if there was preference on the part of wireworm larvae for any particular cover crop. Plots of wheat, oats, barley, rye, and timothy (the usual cover crops planted in the fall on tobacco soil) were sown on an infested field, but the fall feeding of the worms was negligible so that no accurate figures were obtained.

TABLE 18. DISTRIBUTION OF WIREWORM LARVAE IN SOIL OF TOBACCO PLANTATION, EAST GRANBY. SEASON OF 1932.

Date	Depth	Number larvae in soil: In row		Between rows		Total	Per cent
June 29	0″– 3″	5		2		7	19
	3″– 6″	3		7		10	28
	6″– 9″	8		4		12	33
	9″–12″	6		1		7	19
	12″–24″	0		0		0	0
		22	61%	14	39%	36	
July 8	0″– 3″	2		2		4	11
	3″– 6″	3		3		6	20
	6″– 9″	10		4		14	46
	9″–12″	6		0		6	20
	12″–24″	0		0		0	0
		21	70%	9	30%	30	
July 18	0″– 3″	2		1		3	6
	3″– 6″	12		6		18	36
	6″– 9″	17		11		28	56
	9″–12″	1		0		1	2
	12″–24″	0		0		0	0
		32	64%	18	36%	50	
July 28	0″– 3″	3		0		3	11
	3″– 6″	3		3		6	22
	6″– 9″	5		6 (1 Pupa)		11	40
	9″–12″	6		1		7	26
	12″–24″	0		0		0	0
		17	63%	10	37%	27	
Aug. 9	0″– 3″	0		0		0	0
	3″– 6″	2		2		4	12
	6″– 9″	8(3 Pupae)		5		13	42
	9″–12″	11		2		13	42
	12″–24″	1		0		1	3
		22	71%	9	29%	31	
Aug. 18	0″– 3″	0		0		0	0
	3″– 6″	3		1		4	14
	6″– 9″	10 (4 Pupae)		3 (1 Pupa)		13	46
	9″–12″	7		4 (1 Pupa)		11	39
	12″–24″	0		0		0	0
		20	71%	8	29%	28	
Sept. 10	0″– 3″	0		1		1	4
	3″– 6″	0		0		0	0
	6″– 9″	7		4		11	50
	9″–12″	8		2		10	45
	12″–24″	0		0		0	0
		15	68%	7	31%	22	

Table 18. Distribution of Wireworm Larvae in Soil of Tobacco Plantation, East Granby. Season of 1932.—*Continued.*

Date	Depth	Number larvae in soil In row		Between rows		Totals	Per cent
Oct. 1	0"– 3"	0		0		0	0
	3"– 6"	6		3		9	52
	6"– 9"	3		4		7	41
	9"–12"	1		0		1	5
	12"–24"	0		0		0	0
		10	58%	7	41%	17	
Nov. 5	0"– 3"	0		0		0	0
	3"– 6"	7		5		12	54
	6"– 9"	5		3		8	38
	9"–12"	0		1		1	4
	12"–24"	0		0		0	0
		12	54%	9	42%	21	

Insecticide Tests Against Wireworms

Naphthalene. This material, in the powdered form and mixed with Kayso and water, remained in suspension well and gave some promise in wireworm control last season. It was given another trial at a dilution of 16 teaspoonfuls to 1 gallon of water along with 4 teaspoonfuls of Kayso. This mixture repelled the worms, but burned the plants.

Paradichlorobenzene. This insecticide has been used successfully in controlling the peach tree borer, clothes moths, and other insects. Several different tests were conducted with it in 1932 against wireworms, and thus far it has proved more satisfactory than any of the other materials tried. The material was placed in the holes dug to receive transplants, water poured in, and the plants set. At the rate of 1 teaspoonful to a plant, severe burning resulted. A half teaspoonful caused much less plant injury, and kept the wireworms away. When the material was placed on top of the soil (1 teaspoonful to a plant) even less injury was noted unless it came in direct contact with the stalk, and some control of wireworms was noted.

Broadcast over the soil at a rate of 10 pounds to the acre and harrowed in, this insecticide had little or no effect on the insect and did not hurt the plants.

Another series of tests was conducted to determine the tolerance of the plant, in which 1 part of paradichlorobenzene was mixed with 10 parts of sand, and sown in a shallow furrow in the soil. The plants were set in this furrow One row was treated at the rate of ¾ of a pound of this mixture to 36 plants, a second row of 1¼ pounds to 36 plants, and a third row treated with 3 ounces of paradichlorobenzene to 36 plants (drilled in before planting) and two rows were left untreated as checks No ill effect was observed on any of the treatments.

Other tests were conducted in which the material (about ½ teaspoonful to a plant) was placed directly in the soil with the transplant in a field heavily infested with wireworms. About 10 days later an investigation showed that there were few or no wireworms within one foot of plants so treated, and in a few instances dead larvae were found near the roots. Injury to the plants was

FIGURE 137. Pupae (left) and adult beetles (right) of wireworms, *Limonius plebejus* Say, twice natural size.

slight and only occasional. The characteristic odor of the insecticide was strongly evident in the soil 12 days after its application.

Barium fluosilicate. This material mixed with water at a rate of 15 teaspoonfuls to the gallon and poured into the soil before setting had no effect on either the plants or the wireworms.

Control of Thrips

The tobacco thrips mentioned on page 488 was controlled satisfactorily with Pyrethrol and water (1-200). Nicotine sulfate and water (3 ounces to 5 gallons) with 3 ounces of liquid soap gave about 30 per cent kill, and when used with Penetrol (1-200) gave from 50 to 75 per cent kill. An examination of the leaves showed that thrips kept away from the Pyrethrol and nicotine-penetrol plots for two days, whereas they were observed in small numbers on the nicotine sulfate-soap plot 12 hours after the application. Three sprayings with Pyrethrol (at the rate stated) five days apart should reduce injury from thrips to a minimum.

COMPARATIVE STUDIES OF FUELS FOR CURING IN 1932

Natural lump charcoal (made by burning wood with only a scanty supply of air) is commonly used to promote optimum conditions in the shed for curing. In recent years, however, processed charcoal, a by-product of certain manufacturing industries, has come into the market. Although these processed materials cost more per ton than lump charcoal, the dealers claim for them certain advantages which compensate for the increased cost.

In order to determine to what extent these claims are warranted and to get actual data on their heating value, comparative tests of lump charcoal and two of these processed materials, Ford Briquets and Eastman Charkets, were conducted in shed compartments at the Tobacco Substation in 1932. These compartments are 16 feet square and the height of the shed. Each compartment was filled equally with shade tobacco, four fires placed in each chamber, and the firing commenced as soon as the tobacco was hung. Accurate records were kept of the weight of fuel used and at the end of the firing period the unburned fuel in the pits was screened and the net consumption computed. The tests were made at three periods in the curing season, with the fuels rotated among the three compartments, in order to overcome any differences in heat loss due to position of the compartments, area of the outside wall, or tightness of the walls.

Using a sling psychrometer, records of temperature and humidity in each chamber and outside of the shed were taken at hourly intervals during the entire periods of the test. Observations on the uniformity of combustion, ease of starting the fires, labor of maintaining the fires, smoke production, fire hazard through sparks, and proper manipulation of the fires were made from time to time.

In the first two trials laths from each chamber were tagged as random samples. After the tobacco had been sweated these samples were sorted and the grade index computed.

Fuel consumption and temperature records for the three trials and a summary of the complete records are given in Table 19. The average temperatures maintained were not as high as would be obtained under ordinary shed conditions because the relative wall space per fire is much greater in small compartments. However, it was felt that the precautions taken to insure uniformity of conditions made the tests comparable. The last trial was refiring on tobacco of the same picking as the second trial and lasted for only 24 hours. In averaging results, due weight was given to this fact.

In each trial the least efficient chamber was No. 1, which was characterized by either lower temperature or greater fuel consump-

TABLE 19. FUEL AND TEMPERATURE RECORDS.

Trial	Chamber	Fuel	Fuel consumed. lbs.	Average chamber. temp. °F.	Average outside temp. °F.	Gain °F.	Length of run.
1	1	Lump charcoal	263	84.4	72.4	12.0	48 hours
	2	Ford Briquets	219	84.5		12.1	
	3	Eastman Charkets	214	87.4		15.0	
2	2	Lump charcoal	233	90.3	71.2	19.1	48 hours
	3	Ford Briquets	243.5	90.6		19.4	
	1	Eastman Charkets	234.5	87.4		16.2	
3	3	Lump charcoal	107.5	86.6	68.3	18.3	24 hours
	1	Ford Briquets	94	81.6		13.3	
	2	Eastman Charkets	103.5	83.7		15.4	

Summary

Fuel	Fuel consumed, lbs.	Weighted averages—120 hours		
		Chamber temp. °F.	Outside temp. °F.	Gain °F.
Lump charcoal	603.5	87.00	71.10	15.90
Ford Briquets	556.5	86.36		15.26
Eastman Charkets	552.	86.66		15.56

tion, or both. Other compartments were about equally economical of fuel and heat. The summary discloses that lump charcoal had the highest consumption, but also maintained the highest average temperature under the conditions of this experiment. Eastman Charkets had the lowest consumption and the second highest gain in temperature, while Ford Briquets, although practically as efficient in fuel consumption as Charkets, was the lowest in average temperature maintained.

In the ease of management of the fires, both of the processed charcoals were much superior to lump charcoal. Starting the fires was not difficult with any of the fuels. The Charkets smoked the least, when the kerosene was applied, because of the less absorptive nature of the product. The temperature increased most rapidly with lump charcoal, but also dropped most quickly and consequently required much more attention. During the night it was necessary to tend the lump charcoal fires at least every hour and the other fuels every two hours. During the day, the processed fuels need replenishing every six hours as compared with two hours for charcoal. Because of the much higher volume weight of the processed fuels, the bulk of fuel applied had to be very carefully watched or the fires would go too high. The best method, especially during the day, was to apply a counted number of the Charkets or Briquets.

It was also necessary, with the processed fuels, to use care that unburned fuel did not remain at the bottom of the pits. This was obviated by using a homemade wire fork and overturning the fires entirely at intervals.

Fire hazard was much reduced by use of the processed fuels and this is one of the greatest advantages of these fuels. Because of the uniform and compact nature of these briquets, there are no sudden minor explosions with consequent scattering of sparks.

The percentage of grades and grade indexes for the tobacco from the first trial are presented in Table 20. The grading of the tobacco from the latter tests is not given, since the tobacco was fourth picking and all treatments showed poor grades with no significant differences.

No significant difference in the grade indexes of the tobacco cured with the two processed fuels was found, but the lump charcoal was distinctly inferior in this respect. The most plausible explanation of this difference is the lack of uniformity of temperature with lump charcoal. The large volume of charcoal that must be applied tended to smother the fires, and a temperature fluctuation of 5 to 10 degress often occurred, especially under unfavorable weather conditions. These fluctuations of temperature were accompanied by much wider fluctuations of relative humidity and consequent changes in the rate of water loss and chemical activity, with the result that the tobacco lacked uniformity of color and yellow shades predominated.

TABLE 20. SORTING RECORD OF SHADE TOBACCO (TRIAL 1)

Type of fuel	Percentage of grades						Grade index[1]
	L	LL	LC	LC_2	XL	Br	
Lump charcoal	7	22	47	10	7	7	2.89
Ford briquets	15	29	33	9	11	3	3.16
Eastman charkets	13	35	26	14	9	3	3.15

[1]See Bul. 334, p. 178, for explanation of grade index. The comparative values for the different grades of shade tobacco were as follows:

L	5.00	LC_2	1.50
LL	4.00	XL	1.00
LC	3.00	Br	.50

SHADE CURING EXPERIMENTS IN 1932

The experiments conducted in small curing chambers during the three previous years having indicated rather definitely that a temperature of 90° F. with a relative humidity of 70 to 80 per cent maintained constantly would produce good colors on first and second pickings, it was decided to study the effect of comparable conditions in the shed. Through the courtesy of the Gershel-Kaffenburgh Tobacco Company, hygrothermograph records of the curing periods in four sheds were obtained and the effect of the treatments correlated with the quality of the tobacco.

Preliminary Runs

The preliminary run on first picking was started on July 13 and records obtained until July 27. The first firing period was 48 hours, at an average temperature of 91° F., and average relative humidities of 50 to 60 per cent, 35 to 45 per cent, and 30 per cent for successive 16-hour periods. The leaves were definitely in the yellow green, wilting was thorough, and some tips near the fires were becoming husky by the end of this period. The second firing period, of 14 hours duration, following a moist spell, was characterized by a rapid drop in shed humidity to 30 per cent, which indicated that very little of the original water content of the leaves was present, and that the only effect was the removal of the absorbed water. Further control in this shed consisted only of operation of the side ventilators.

The preliminary run on 1½ picking was started July 20, and records obtained for nine days. The initial firing period covered 84 hours at an average temperature of 90.2° F. At no time did the relative humidity drop below 40 per cent. Somewhat lower temperature in the final phase of the firing and high outdoor humidity tended to keep the shed humidity at a higher level. A second firing of 12 hours' duration and a third of 6 hours were employed to overcome the effect of moist weather.

Humidified Versus Non-humidified Sheds

The results of the preliminary runs indicated that the first firing period for the 1932 crop needed to be considerably longer than was ordinarily required. As this firing is primarily designed to remove the great volume of water in the fresh tobacco, any factor that would hinder the removal of the water would make necessary firing either at higher temperatures or for longer periods at the usual temperatures. Such a factor was present in the thicker and heavier leaves caused by the dry weather at the time these leaves were developing. Temperatures much in excess of 90° F. are not advisable, as the leaves on the lower tiers are apt to be scorched and there is danger of the production of green colors, "haying down," hence the necessity of prolonging the firing period.

In this experiment, the effect of artificial humidification was studied in comparison with the lack of such equipment. From studies conducted in controlled chambers it seemed reasonable to expect benefits from humidification, as ordinary diurnal fluctuations give only a few hours per day during which the shed humidity is sufficiently high to permit absorption of water by the tobacco. Periods of high humidity and alternations of humidity in curing are desirable for several reasons: (1) The movement of solutes from the midrib to the leaf tissue is facilitated and fewer "fat stems" occur. (2) Areas of leaf tissue that cure at a slower rate do not become isolated and remain greenish in color. (3) The colors on the leaf are more uniform, as a better opportunity is provided for diffusion of the water soluble pigments. (4) The chemical changes incident to curing are encouraged, and the leaves are more thoroughly exhausted of excess carbohydrate and nitrogenous compounds. (5) Unless other factors intervene, thinner and more elastic leaves will be found.

The experimental equipment used in the humidified shed was furnished by the American Moistening Company of Providence, R. I., and was designed to deliver 6 pounds of water per nozzle per hour, with eight nozzles to a bent, four just above the level of the fourth tier and four above the plate line.

The check shed was filled with 1½ picking tobacco on July 25 and 26, and firing started at 6 P. M. of the latter date. The temperature was gradually increased during the first 16 hours, averaging 86° F. for this period, and was maintained slightly above 90° for 60 hours, followed by 20 hours at 87°. The weighted average for the entire period was 9c°. The relative humidity rose sharply when the fires were lighted, and remained above 60 per cent for about 30 hours, dropped gradually to 40 per cent after 70 hours, and dropped sharply to nearly 30 per cent at the end of the firing period.

Subsequent firing periods of 17 hours and 32 hours, both at average temperatures of 89°, were employed to remove excess moisture during rainy periods. The remaining record indicates only the ordinary diurnal fluctuations prevailing at this season.

The record obtained from this shed shows most of the features of air conditions found in an average shed. The 30 hour high-humidity period during firing corresponds with the time during which the most rapid loss of free water occurred. Both the temperature and relative humidity were higher in the shed than outside, while the absolute humidity (grains of water per cubic foot of air) was 25 per cent higher.

The period during which the leaves in this shed regained moisture was rather brief, roughly from midnight to sunrise, and averaged 7 hours. The maximum humidity of the day usually occurred immediately after sunrise, when the heat of the sun evaporated the condensed moisture on the leaves. The minimum day humidity averaged 44 per cent for the latter period of curing with nine days below 40 per cent. Thus it may be seen that the opportunity for optimum curing was rather limited, as only two periods of more than 12 hours with average humidities above 80 per cent occurred in 18 days.

On July 26, filling of the humidified shed was commenced, but was interrupted by heavy rains on the 27th and 28th, and was not completed until the 29th. Firing was started at 6 P. M. of the last date and continued at an average temperature of 88.4° F. for 106 hours. The slightly lower temperature maintained in this shed made it necessary to continue the firing for 10 hours longer than in the check shed.

As soon as the first firing was stopped, the moistening apparatus was turned on and a humidity of above 80 per cent maintained for 20 hours. Firing was then resumed for about an equal length of time at an average temperature of 87.5°. A period of humidification of 5 hours followed, and the afternoon of the following day another period of 4 hours. The humidity rose to more than 90 per cent during the night and in the afternoon of the next day the fires were lighted and allowed to taper off gradually for a total firing of 16 hours at an average temperature of 87°. Subsequent to this firing, the tobacco was moistened for short periods at seven different times, as indicated by the chart, and fired for about 2 hours after a night of high humidity.

As may be seen from the charts (Figure 138), it is possible to compare conditions in the two sheds at any one time, as the corresponding time periods are placed directly in line vertically. In general, the most conspicuous difference caused by humidification was a lengthening of the night period of high humidity. It was not possible with the equipment at hand in this shed to maintain consistently a high humidity above a few bottom tiers when the outdoor humidity was low during the day. This is illustrated by the humidity graphs for the last two moistening periods, during neither of which it was possible to hold the moisture at a high level.

As compared with the check shed, in which the average period with a humidity of 75 per cent or greater, was 7 hours per day, the humidified shed for the same period of time had 10 hours per day with humidity sufficient for tobacco to regain water. The minimum day humidity averaged 46 per cent for the final 16 days, with only 2 days below 40 per cent. Thus it may be seen that the tobacco in the humidified shed had considerably more opportunity to cure under favorable conditions.

Considerable difference in the appearance of the tobacco during curing was noted. In the check shed, the colors were not as uniform, some leaves being distinctly of the reddish brown type, others olive brown. Fleshy midribs, "fat stems," persisted for some time after their disappearance in the humidified shed. The distribution of color on the individual leaves was not as satisfactory, a considerable spottiness prevailing on most of the leaves. Some staining of the leaf tissue from the midribs and secondary ribs was noted. These areas remained in a moister condition throughout the curing period, and the result was the development of a bright red color, which contrasted sharply with the color of the adjacent tissue. The most common colors in the darker areas of the leaves were medium to reddish brown, in the lighter areas yellowish to light reddish brown.

In the humidified shed the colors were quite uniform in the whole lot of tobacco, all the leaves tending toward a medium olive brown to light olive brown. The distribution of color on the leaves was uniform, and staining from the midribs was practically absent. The leaves were thinner and more elastic, as might be expected with the increased proportion of favorable curing time and the greater opportunity for the chemical activities of curing.

The length of time necessary for complete cure was considerably reduced in the humidified shed. Notwithstanding the fact that the curing period was started three days later in this shed, the tobacco was cured from a week to 10 days before the check shed and was taken down nearly 2 weeks before that in the check shed.

After the tobacco had been sweated, notes were taken on colors, and sorting records obtained on samples from the humidified and check sheds. The most common color of the tobacco from the preliminary run on first picking was a light olive brown. Above the sixth tier in this shed the colors were not so bright and more leaves were mottled, indicating inferior curing conditions in the top of the shed. The tobacco from the preliminary run on 1½ picking was most commonly an olive brown to medium brown. From the check shed the predominant color was a medium brown, as was also the case in the humidified shed, but in the former the colors were slightly darker, and more leaves showed a "muddy" overcast. Above the plate line in both sheds, the colors were distinctly yellower.

It was observed by Mr. Kaffenburgh that after sweating, the tobacco cured in the humidified shed seemed to be further advanced and could be used on cigars with less ageing or "after-curing."

In order to obtain an impartial opinion of the tobacco, the samples were sorted in a commercial warehouse, the sorters not being informed of the treatments. The results are shown in Table 21.

It is apparent from the grade indexes that the difference between the tobacco from the two sheds was negligible. Any differences which might have operated in favor of the humidified tobacco were almost entirely masked by the characteristics imparted to the tobacco by the climatic conditions during the growing season. These common characteristics were thickness of leaf, prominence of veins, darkness of colors, and lack of elasticity.

TABLE 21. SORTING RECORD OF SHED-CURED SHADE TOBACCO, 1932

Treatment	Percentage of grades							
	LL	LL_2	LC	LV	LV_2	SLV	YL	AL
Humidified	3.2	2.0	3.5	1.6	7.9	10.0	11.8	4.3
Check	2.0	3.2	3.2	1.4	11.6	7.0	10.6	5.3

Treatment	Percentage of grades							Grade index
	LB	SV	SV_2	LW	XL	K	Br.	
Humidified	6.3	6.0	14.7	5.7	14.0	7.1	1.9	1.392
Check	3.0	8.8	12.9	8.7	12.0	7.9	2.4	1.360

Summary

1. An initial firing period varying from 48 to 106 hours at 90° F. was necessary with the 1932 crop.

2. Firing should be terminated when the leaves begin to show a tendency to become brittle, "huskiness," which condition corresponds with a relative humidity in the shed of 30 per cent in dry weather or about 45 per cent in moist weather.

3. The greater part of the original water content of the leaves is removed during the first 16-30 hours of firing.

4. The use of fires subsequent to the first firing period is necessary to prevent damage from pole sweat in damp periods, and may also be of benefit in hastening the rate of chemical activity in the late yellow or early brown stage.

5. The use of humidifying equipment in the shed permitted more rapid cure of the tobacco by supplying moisture for chemical activity. More uniform distribution of colors was found on the cured tobacco from the humidified shed, but the difference was not apparent after sweating. Fleshy midribs were not as common in the curing tobacco, but no difference in prominence of veins of the sweated tobacco was noted.

6. Tobacco did not absorb moisture from the air when the relative humidity was below 75 per cent.

7. Tobacco hung in the peaks of sheds was inferior to that placed in the body of the shed, and there is some question whether it is profitable to fill the peak of a shed. It was not possible, even in the humidified shed, to maintain a proper balance between temperature and relative humidity in the peak.

8. Due to the unfavorable climatic conditions under which the crop was grown, no definite information concerning the value of humidification was obtained.

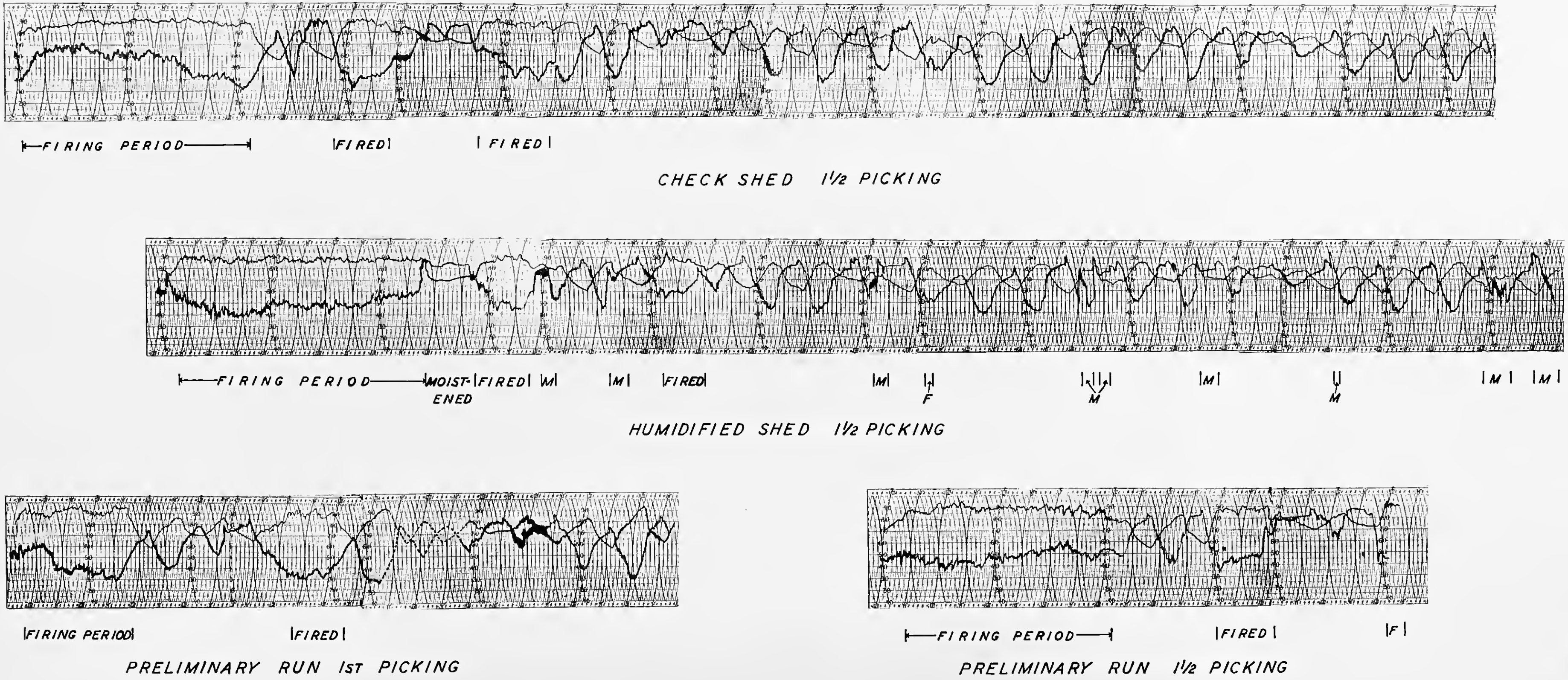

FIGURE 138. HYGROTHERMOGRAPH CHARTS SHOWING TEMPERATURE AND HUMIDITY RELATIONS IN SHED CURING. UPPER LINE DURING FIRING PERIODS SHOWS TEMPERATURE, LOWER LINE HUMIDITY.