Tobacco Station Bulletin 6 March, 1926

Connecticut Agricultural Experiment Station

New Haven, Connecticut

TOBACCO STATION OFFICES, SORTING SHOP, AND GREENHOUSE.

REPORT OF TOBACCO STATION AT WINDSOR

1925

The Bulletins of this Station are mailed free to citizens of Connecticut who apply for them, and to other applicants as far as the editions permit.

THE TUTTLE, MOREHOUSE & TAYLOR COMPANY

Report of Tobacco Station—1925

P. J. ANDERSON, ET AL.

INTRODUCTION

When the writer assumed charge of the work of the Tobacco Station, April 1, 1925, there were certain old lines of investigation which had been in progress for one, two or three years. Most of these were planned as long time experiments and in the main have been continued with but slight modification. Several new lines of work have been started and the old projects expanded. There are so many unsolved problems in the growing, curing, and fermenting of tobacco that it is obviously impossible with the present resources at our disposal to work on all of them. It is better to concentrate on a few than to do a little on all. Therefore a few of the problems, the solution of which seemed to offer most hope of permanent benefit to the grower and for which there was the most insistent demand were selected. It is realized however, that there are many other important ones and these will be undertaken as fast as time and resources will permit.

In the following pages, progress of the work up to date, on each line of investigation, is described in some detail. Few of these projects are complete and the present should be considered only a report of progress. It has seemed best to make these reports annually rather than to wait until the conclusion of each project because a part of the findings are immediately applicable and because a full discussion of the work while in progress invites suggestion and criticism which is helpful in further planning.

A list of the lines of investigation which are now being carried out at the Station is included here. This is followed by a detailed discussion of each one which has progressed far enough to warrant a report.

LIST OF TOBACCO STATION PROJECTS.

1. *Fertilizer Experiments.* A continuation of the old project but with some modifications and additions. Fully explained in the following pages except for the experiments on the effect of magnesium, chlorine and sulfur which are in coöperation with the United States Department of Agriculture.
2. *Strain tests of Havana seed and Broadleaf tobaccos.* Second year of these tests. Fully discussed in the following pages.
3. *Improvement of Shade Tobacco by breeding and selection.* In coöperation with Dr. D. F. Jones of the Plant Breeding Department. Partly an old project, partly new in 1925.
4. *The value of cover crops for tobacco.* New project begun in 1925. Since the cover crops were not planted until the fall of 1925, there are no results to report.

5. *Brown Rootrot.* In coöperation with Dr. G. P. Clinton of the Botany Dept. and Mr. H. F. Murwin of the U. S. Dept. of Agriculture. Results not reported here, but a general statement of the problem on page 66.
6. *Relation of soil reaction to black rootrot and optimum growth of tobacco.* In coöperation with Prof. M. F. Morgan of the Soils Department. Fully discussed in this report. Started in 1925.
7. *Investigation of cigarette types of tobacco for the Connecticut Valley.*
8. *Use of artificial light in the growing of Shade tobacco.* In its second year. Completed in 1925.
9. *Tests of chemically treated shade cloth.* Project in its third year.
10. *The role of humidity and temperature in curing.* This project was started in 1925 late in the season because of delays in installing the Carrier curing chambers. Not discussed in this report.
11. *The role of nitrogen and sulfur in the metabolism of the tobacco plant.*
12. *Topping and suckering experiments.* Effect on yield and quality.
13. *Relation of acid and alkaline fertilizers to Black Rootrot.* Project of the Botany Dept. under Dr. Clinton with field plots at the Tobacco Station. Not reported here.
14. *Control of wireworms.* In coöperation with the Dept. of Entomology and with the American Cyanamid Co. Emergency project begun in June, 1925. Preliminary report on page 74.
15. *Miscellaneous tobacco disease investigations.* This is a general project flexible enough to permit investigation of outbreaks of diseases which cannot always be predicted.

In addition to the above there are two lines of investigation of tobacco diseases undertaken by the botany department independent of the tobacco station, but of vital interest to the tobacco grower. These are the cause of the *mosaic disease* by Dr. Clinton and the life history of the *black rootrot fungus* by Dr. McCormick.

The function of the Tobacco Station is twofold. In the preceding paragraphs we have been considering only the first and primary function, viz., the research work, which attempts to find out something new and helpful to the grower, improve the quality or yield, or cut the cost of production. The second function is to carry the results of this investigation, augmented by all the information we can secure from other sources, directly to the grower. The first method of putting the information at the disposal of the farmer is through publication of results. Since the establishment of the Station, five bulletins have been published and the reports have been necessarily brief. This report is as complete as possible at the present time and covers all projects. Later bulletins dealing more fully with specific lines of investigation are also planned.

The fourth annual field day, attended by over four hundred growers, was helpful in bringing the growers and the Station into closer contact. Results of the investigations have been presented to gatherings of growers in a number of other public meetings. Many growers have visited the Station for personal consultations and many more have asked that members of the Station staff make visits to their farms. No request of this kind has been refused during the year. Such personal visits and consultations are, we believe, generally more helpful than public meetings, not only to the grower but to the station members who thus gain valuable first-hand knowledge of field conditions which is important if our work is to keep in vital touch with the grower. In this field work we have had the close coöperation of the Hartford County Farm Bureau and the Field Service Department of the Connecticut Valley Tobacco Association.

Considerable time has also been spent in more direct personal

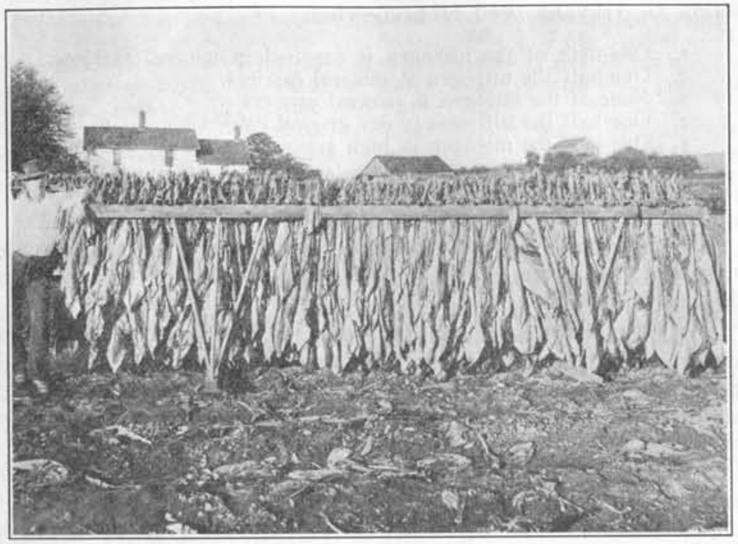

FIG. 1.—Long tobacco on the "hurdles." Fertilizer plots on station farm. 1925. This tobacco never touches the ground after spearing.

service such as testing and separation of seed, testing soil samples, diagnosis of diseases, and the like.

The work has been made possible not only by the appropriations of the State Legislature, but also by the generous support of the Connecticut Valley Tobacco Improvement Association and the Connecticut Valley Tobacco Association. Both of these organizations, because of their loyal support, deserve great credit. Growers and dealers, too numerous to mention by name here, have aided by their coöperation, support and kindly advice. The following farmers coöperated during 1925 by growing tobacco on their farm for the strain tests described later: J. B. Stewart of Windsor, Stanton Brown of Poquonock, Howard Ensign of Silver Lane, Ed. Handel of Glastonbury, Horace Vibert of South Windsor, Albert Oakes of Windsor, L. A. Bates of East Granby, and W. W. Sanderson of South Deerfield.

FERTILIZER EXPERIMENTS

P. J. Anderson and N. T. Nelson

The Old Nitrogen Series

This is a continuation of the series which has been in progress since 1922. For a detailed description and the results of the first three years the reader is referred to Bulletin 5 of the tobacco station. The objects of this series were to compare the yield and quality of Havana seed tobacco when:

1. One-fifth of the nitrogen is supplied in mineral carriers.
2. One-half the nitrogen in mineral carriers.
3. None of the nitrogen in mineral carriers.
4. One-half the nitrogen in dry ground fish.
5. One-half the nitrogen in high grade tankage.

The other carriers of nitrogen are cotton seed meal and castor pomace, which are considered standard.

Although the experiments were on the same plots as during the preceding three years, a few modifications were made for 1925 as follows:

1. The plots on which all the nitrogen was supplied in mineral carriers have been discontinued because the results of the preceding years showed that the tobacco grown with this fertilizer ration is so coarse and inferior in quality as to discourage further trials.

2. Nitrate of potash has been omitted in 1925 because the supply on the market seems to be limited and uncertain and it is questionable whether results obtained would be of practical benefit to tobacco growers.

3. Instead of combining nitrate of soda and sulfate of ammonia in one mixture as sources of mineral nitrogen, the two have been used independently on different plots. In this way the effects of each may be observed independently.

4. Acid phosphate has been omitted from the formula and the extra phosphoric acid supplied from precipitated bone which is considered a better source in tobacco fertilizers because it contains little if any sulfate. This also has the advantage of simplifying the formula.

5. In the preceding years, the acre applications of the three fertilizer plant nutrients have been: ammonia, 260 lbs.; phosphoric acid, 225 lbs.; and potash, 240 lbs. In 1925 this was reduced to 200-160-200 respectively. This was done first because the amounts previously applied were considered excessive on this land and it was feared that the effects of one nitrogen carrier would be masked by the excessive amount of another and secondly, because the adopted rates correspond in amount of plant nutrients to the standard 5-4-5 grade used at the rate of two tons per acre.

6. The potash was supplied equally from carbonate and high grade sulfate instead of all from the latter as previously. In this way the amount of sulfate in the mixtures was again reduced.

The composition of the fertilizer ration for each plot is shown in the following tables.

Nitrogen Series—Fertilizer Applications, 1925.

Plot N1. 1/5 ammonia in nitrate of soda.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.5	9.94	...	....	86.1	...
Total	2,846.9	$75.66	200	160.0	200.0	14.9

Plot N2. 1/2 ammonia in nitrate of soda.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	914.6	$22.87	75	26.5	13.7	6.4
Castor pomace	367.7	5.52	25	6.6	3.7	2.9
Nitrate of soda	531.4	18.06	100	....	....	...
Precipitated bone	329.6	9.89	...	126.9	....	...
Sulfate of potash	172.0	4.73	...	....	86.0	...
Carbonate of potash ..	132.3	9.92	...	....	86.0	...
Double sulfate	40.7	.71	...	....	10.6	4.6
Total	2,488.3	$71.70	200	160.0	200.0	14.9

Plot N3. 1/5 ammonia in sulfate of ammonia.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Sulfate of ammonia ...	160.0	6.00	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.5	9.94	...	....	86.1	...
Total	2,794.2	$74.43	200	160.0	200.0	14.9

Plot N4. 1/2 ammonia in sulfate of ammonia.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	914.6	$22.87	75	26.5	13.7	6.4
Castor pomace	367.7	5.52	25	6.6	3.7	2.9
Sulfate of ammonia ...	400.0	15.00	100	....	....	...
Precipitated bone	329.6	9.89	...	126.9	....	...
Sulfate of potash	172.0	4.73	...	....	86.0	...
Carbonate of potash ...	132.3	9.92	...	....	86.0	...
Double sulfate	40.7	.71	...	....	10.6	4.6
Total	2,356.9	$68.64	200	160.0	200.0	14.9

Plot N5. All ammonia in cottonseed meal and castor pomace.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,829.3	$45.73	150	53.0	27.4	13.0
Castor pomace	735.3	11.03	50	13.2	7.4	5.8
Precipitated bone	243.7	7.31	...	93.8	....	...
Sulfate of potash	165.2	4.54	...	....	82.6	...
Carbonate of potash ...	127.1	9.53	...	....	82.6	...
Total	3,100.6	$78.14	200	160.0	200.0	18.8

Plot N6. 1/2 ammonia in dry ground fish.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	731.7	$18.30	60	21.2	10.9	5.1
Castor pomace	294.1	4.41	20	5.3	2.9	2.3
Dry ground fish	957.8	35.92	100	72.7	....	...
Nitrate of soda	106.4	3.61	20	....	....	...
Precipitated bone	158.0	4.74	...	60.8	....	...
Sulfate of potash	169.0	4.65	...	....	84.5	...
Carbonate of potash ..	130.0	9.75	...	....	84.5	...
Double sulfate	66.4	1.16	...	....	17.2	7.5
Total	2,613.4	$82.54	200	160.0	200.0	14.9

Plot N7. 1/2 ammonia in tankage.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	731.7	$18.29	60	21.2	10.9	5.1
Castor pomace	294.1	4.41	20	5.3	2.9	2.3
Nitrate of soda	80.0	3.00	20	....	....	...
Tankage	769.2	21.15	100	53.3	....	...
Precipitated bone	208.3	6.25	...	80.2	....	...
Sulfate of potash	169.0	4.65	...	....	84.5	...
Carbonate of potash ...	130.0	9.75	...	....	84.5	...
Double sulfate	66.4	1.16	...	....	17.2	7.5
Total	2,448.7	$68.66	200	160.0	200.0	14.9

All treatments were in triplicate on the same 1/40 acre plots as in preceding years. Fertilizer was spread by hand in the early morning of May 22, when there was no wind to blow it, and harrowed in immediately. On May 27 the entire field was set with Havana seed plants of the Duncan Bros. strain. All plots were cultivated alike throughout the season, were topped July 20, and harvested August 10, 11, 12. Cutworms were a little worse on the first of the three series of plots and necessitated more restocking there. Otherwise the field was very uniform throughout the season. The N5 plots, however, appeared to be somewhat more backward than the others. Also, plots N3 did not grow quite as well as those adjacent.

All the tobacco in this and the following series was assorted and sampled in the Tobacco Station shop and graded on basis of selected samples by the grading department of the Connecticut Valley Tobacco Association. The price per pound for each plot was calculated by the accounting department of the Association from the sorting records and the grading. Since the loan value is estimated at one half the value of the tobacco, this figure was doubled for all grades except the dark stemming stock (11½ cents per pound) and brokes and fillers (9 cents). Twelve cents per pound was deducted for sorting, packing and overhead charges on the better grades and 3½ cents for the dark stemming, brokes, and fillers.

The sorting records of the 21 plots are presented below in Table I. The calculated yield per acre, pool record, and net return per acre are given in Table II.

TABLE I. PERCENTAGE OF GRADES IN THE NITROGEN SERIES, 1925.

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17" seconds	15" seconds	Brokes	Fillers
N1	12	9	32	7	19	4	0	11	6
N1*	14	11	29	9	17	3	0	12	5
N1**	8	9	34	6	25	1	0	13	4
N2	9	12	35	5	20	2	0	11	6
N2*	8	15	35	4	18	1	0	14	5
N2**	13	12	35	4	20	3	1	8	4
N3	10	12	36	5	20	2	0	10	5
N3*	12	17	32	5	17	2	0	11	4
N3**	8	11	38	6	19	2	0	11	5
N4	9	12	36	5	20	2	0	11	5
N4*	4	7	37	4	26	1	0	17	4
N4**	5	5	42	4	25	2	0	14	3
N5	7	11	34	6	21	1	0	14	6
N5*	6	8	36	5	20	1	0	19	5
N5**	5	9	36	5	24	1	0	15	5
N6	8	9	37	6	20	1	0	13	6
N6*	7	9	33	6	23	1	0	16	5
N6**	14	11	34	4	21	2	0	11	3
N7	14	14	28	6	20	1	0	12	5
N7*	6	9	38	6	22	2	0	11	6
N7**	11	14	30	5	19	1	0	15	5

* = first replication.
** = second replication.

Discussion of results. The value of any fertilizer ration is measured by the net return per acre after deducting price of the fertilizer, sorting, packing and overhead charges. (It is assumed that no other expenses vary with the fertilizer used although the labor item must be somewhat larger for stripping a higher yielding plot.) Therefore, the value of these seven treatments may be compared by reference to Table II.

When nitrate of soda is used as the mineral source of nitrogen it seems to make little difference whether it furnishes ⅕ of the nitrogen or ½ of it. The differences in acre yield, price per pound, percentage of grades and net return are too small to be of significance. All six plots were graded in Pool A. On the other

TABLE II. SHOWING ACRE YIELD, NET PRICE PER POUND AND NET RETURN PER ACRE, 1925.

Plot	Special form of NH_3(a): Carrier	Special form of NH_3(a): Lb. NH_3 per A.	Cost of fert. per acre	Yield per acre (Lbs.): Per plot	Yield per acre (Lbs.): Average	Net price per lb. (b): Per plot	Net price per lb. (b): Average	Net return per acre (c): Per plot	Net return per acre (c): Average	Pool rating
N1	Nitrate sode	40	$75.66	1814		.34245		$545.54		A
N1*	"	"	"	1787	1838	.36065	.34418	568.82	556.42	A
N1**	"	"	"	1914		.32945		554.91		A
N2	"	100	71.70	1729		.33595		509.16		A
N2*	"	"	"	1844	1808	.33385	.34853	543.92	558.99	A
N2**	"	"	"	1851		.37580		623.90		A
N3	Sulf. amm.	40	74.43	1681		.34580		506.86		A
N3*	"	"	"	1975	1811	.37875	.34748	673.60	557.09	A
N3**	"	"	"	1778		.31790		490.80		A
N4	"	100	68.64	1747		.33660		519.40		A
N4*	"	"	"	1945	1913	.26205	.29397	441.05	487.21	B
N4**	"	"	"	2047		.28325		501.17		A
N5	C. S. M. and C. P..	200	78.14	1709		.28520		409.27		B
N5*	"	"	"	1863	1819	.28200	.28840	447.23	446.60	A
N5**	"	"	"	1884		.29800		483.29		A
N6	D. gr. fish	100	82.54	1993		.30675		523.81		A
N6*	"	"	"	1826	1892	.31005	.33220	483.61	543.39	A
N6**	"	"	"	1857		.37980		622.75		A
N7	Tankage	100	68.66	1771		.38855		619.46		A
N7*	"	"	"	1879	1846	.30115	.34893	497.20	574.07	A
N7**	"	"	"	1888		.35710		605.54		A

(a) Cottonseed meal and castor pomace used to complete the formula up to the requirements of 200 lbs ammonia per acre.
(b) After deducting the cost of sorting, packing, sampling and overhead.
(c) After deducting the cost of the fertilizer.

hand, the final figures in the N1 and N2 plots do not show that any significant financial saving resulted in 1925 from the substitution of a larger amount of nitrate. The difference was somewhat larger in 1924. In comparing yields for the four years we find that it has been 60 lbs. less on the N2 plots than on the N1 plots. Neither the sorting records nor the notes which were taken during the sorting indicate that there was any difference in quality between the two. The same was true for the 1923 and 1924 crops, but in 1922 Dr. Chapman considered the N2 tobacco of not quite as good quality as N1.

FIG. 2.—General view of station farm showing greenhouse and two of the curing sheds.

Comparing sulfate of ammonia with nitrate of soda as a mineral source of nitrogen we note that the results are about equal when only ⅕ of the nitrogen is from mineral carriers (compare N1 and N3). Neither were any differences in quality observed. When, however, ½ of the ammonia was supplied from sulfate of ammonia the average yield was the highest of any of the plots but the net return was next to the lowest because a smaller percentage of leaves came in the higher grades. In two of these plots there was considerable white-vein which was largely responsible for the lower rating.

When *no* mineral nitrogen-carrier was used (cottonseed meal and castor pomace only—N5), the average yield was next to the lowest and the net return was the lowest of any of the plots. Two of these plots also had considerable white-vein and one had more than the usual amount of green tobacco. This latter defect accounts for the higher percentage of brokes in N5*. The common belief of tobacco growers that the best quality is secured by the exclusion of all mineral carriers of nitrogen is not supported by the results of this test. It should be remembered, however, that this is only one year's results and that during the preceding three years these plots had *all* their supply of nitrogen from mineral sources.

The plots on which one-half the ammonia was from dry ground fish (N6) produced the heaviest yield, save one, in the whole series. The quality on all of these plots was judged to be very good except for a tendency to light veins in the N6* plot. The net return after deducting cost of fertilizer was $10.83 per acre less than the basal ration plot N1. The results on the 1924 crop were almost identical, the corresponding difference being $10.87.

The plots treated with a ration containing high grade tankage to supply one-half the nitrogen (N7) gave a somewhat higher average yield than the N1 plots. The quality at time of sorting was rated as extra good. It was thin and had no white-vein. The net return after deducting cost of fertilizer was the highest of any of the plots of the nitrogen series, exceeding the N1 plots, by $15.56 per acre. These plots have yielded more tobacco than the N1 plots every year except the first year of the experiment. During the first year the N1 plots yielded over 100 lbs. per acre more than the N7 plots. The average for the four years is about 20 lbs. more for the tankage plots. The use of tankage has been avoided by many because it was thought to contain considerable chlorine. In the chemical analysis of this year's fertilizers made by the chemistry department of the Agricultural Station, it is interesting to note that tankage shows only .31% of chlorine which is about the same as that found in fish or nitrate of soda and less than one-fifth as much as occurs in high-grade sulphate of potash and in double manure salts. Tankage has also been objected to because it produces tobacco which burns with an unpleasant aroma. At the time of writing, the tobacco has not yet come out of the sweat room and therefore the burning qualities of the different plots have not been compared. No data on aroma was secured on the previous crops. This will be discussed in a later report.

Synthetic Urea as a Source of Nitrogen.

Synthetic urea contains a very high percentage of nitrogen (ammonia equivalent, 56%), is prepared from the free nitrogen of the air, contains no residues which could be harmful by accumulation in tobacco soils, and has several advantages if it could be used in tobacco fertilizer mixtures. It has been used with favorable results on tobacco in Germany. The supply, unlike that of cottonseed meal, is likely to become more plentiful and it should become less expensive with more general use. The present supply comes from Germany and is put on the market here, after paying the import duty, at about $200 per ton. The cost per unit of ammonia is thus about the same as nitrate of soda and considerably cheaper per unit than cottonseed meal or castor pomace at the prices quoted in the spring of 1925. It is chemically an organic compound but is said to be quickly available like nitrate of soda without being as subject to quick leaching as the latter. Since its effect on the yield and quality of our cigar types is not known, it seemed worth while to start a thorough test at the tobacco station to continue on the same plots for a number of years. This was begun in the season of 1925 and the plots had to be located on a different field from the other nitrogen series. The location proved less favorable, consequently the yields were smaller and more variable. The tobacco from these plots cannot be compared with that from the old nitrogen series but must be compared with check plots on the same field treated with the same ration as the older N1 plots but designated as N1***** and N1******. The plots were in duplicate and two formulas containing urea were used. In one formula urea was the only source of ammonia (N9 and N9*); while in the other formula it was used to supply one-half of the ammonia (N8 and N8*), the other half being in cottonseed meal and castor pomace in the same proportions as in the N1 plots.

The composition of the rations applied to plots N8 and N9 are as follows:

Plot N8. 1/2 ammonia in synthetic urea.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	914.6	$22.87	75	26.5	13.7	6.4
Castor pomace	367.7	5.52	25	6.6	3.7	2.9
Urea	178.4	17.84	100	....	....	...
Precipitated bone	329.6	9.89	...	126.9	....	...
Sulfate of potash	172.0	4.73	...	....	86.0	...
Carbonate of potash ...	132.3	9.92	...	....	86.0	...
Double sulfate	40.7	.71	...	....	10.6	4.6
Total	2,135.3	$71.48	200	160.0	200.0	14.9

Plot N9. All ammonia in synthetic urea.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Urea	357.0	$35.70	200	....	....	...
Precipitated bone	415.5	12.47	...	160.0	....	...
Sulfate of potash	165.8	4.60	...	....	82.9	...
Carbonate of potash ...	127.4	9.55	...	....	82.8	...
Double sulfate	131.8	2.31	...	....	34.3	14.9
Total	1,197.5	$64.63	200	160.0	200.0	14.9

The fertilizer was applied broadcast on May 23 and the entire field set with Havana seed plants on June 1. Dates of topping, harvesting, stripping and details of sorting and pooling are as above for the nitrogen series. No significant differences in growth or maturity were noted throughout the season. About the middle of the season it was discovered that a part of this field was affected with brown rootrot but the diseased area bore no obvious relation to the fertilizer treatment since it was present in both the check plots and the plots treated with the urea ration. The worst affected areas were eliminated at harvest and not included in calculating the results.

The sorting data on these six plots are presented below in Table III. The price per pound, acre yield, rating and net return per acre are given in Table IV.

TABLE III. PERCENTAGE OF GRADES IN SYNTHETIC UREA PLOTS, 1925.

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17" seconds	15" seconds	Brokes	Fillers
N8	3	6	21	16	20	4	1	19	10
N8*	0	3	35	19	17	6	1	10	9
N9	0	0	26	26	15	2	0	17	14
N9*	3	5	30	16	22	5	2	9	8
N10	12	9	33	5	23	3	1	11	3
N10*	15	6	34	5	21	3	0	12	4
N1***	15	14	33	9	12	5	0	7	5
N1****	12	8	33	9	18	5	1	8	6
N1*****	0	3	26	24	16	5	1	17	9
N1******	12	9	27	16	14	7	2	5	8

At the time of sorting, the quality of the tobacco from the N8 plots (½ ammonia from urea) was judged to be about the same as that from the check plots. The pool rating also indicates the same. The acre yield was approximately the same. The tobacco from the plots where all the ammonia was from urea (N9) was not of such good quality since a much larger percentage of the leaves had prominent and white veins. The pool rating was also lower on these plots.

On account of the small number of replications and the lack of uniformity on this field, it is too early to draw any final conclusions from these tests of one year. The indications up to the present are (1) that urea may be used to supply one-half the ammonia of the fertilizer ration without impairment of quality or yield and that (2) its use as the sole source of ammonia in the mixture reduces the quality of the tobacco as evidenced by white and prominent veins.

CONCENTRATED FERTILIZERS.

That the yield is not reduced but probably increased by the use of urea is indicated by a further test which was made in a small way on another field where the soil was more uniform and the

TABLE IV. SYNTHETIC UREA PLOTS, 1925. ACRE YIELD, POOL RATING, NET PRICE PER POUND, AND NET RETURN PER ACRE.

Plot	Lbs. NH_3 per acre as		Cost of fertilizer	Yield per acre		Pool rating	Net price per lb. (d)		Net return per acre (e)	
	Urea	C. S. meal		Per plot	Average		Per plot	Average	Per plot	Average
N1***** N1******	none "	200 (a) "	$75.66 "	1364 1561	1462	A B	.17840 .29605	.23722	$167.68 368.48	$277.08
N8 N8*	100 "	100 (b) "	71.48 "	1356 1597	1476	A B	24155 .18180	.21167	256.06 219.27	237.66
N9 N9*	200 "	none "	64.63 "	1347 1465	1406	C B	.13755 .23325	.18540	120.65 277.08	198.86
N1*** N1****	none "	200 (a) "	75.66 "	1646 1788	1717	A A	.37120 .33570	.35345	535.33 524.57	529.95
N10 N10*	160 (c) "	none "	60.29 "	1702 1766	1734	B A	.32870 .35990	.34430	499.16 575.29	537.22

(a) 40 lbs. NH_3 per acre as nitrate of soda, 160 lbs. NH_3 as cottonseed meal and castor pomace.
(b) No nitrate in this formula.
(c) 40 lbs. NH_3 as nitrate of potash.
(d) After deducting the cost of sorting, packing, sampling, and overhead.
(e) After deducting cost of fertilizer.

yield good. The original purpose of this experiment was to see what effect a highly concentrated fertilizer would have on the yield and quality of Havana seed tobacco. If our fertilizer mixtures could be reduced to smaller volume and still supply the same quantity of plant nutrients there would be a considerable saving in labor of transportation and application. The formula mixed for this trial was as follows:

Plots N10 and 10. Concentrated formula.*

Carrier Name	Lbs. per acre	Cost per acre	Lbs. plant nutrient—A NH_3	P_2O_5	K_2O
Urea 56%	286	$28.60	160	...	...
Treble superphosphate 40% ..	400	12.00 (a)	...	160	...
Nitrate of potash	267	10.01	40	...	116
Carbonate of potash	129	9.68	...	...	84
Total	1,082	$60.29	200	160	200

(a) Figured at same price as precipitated bone.

This formula furnishes the same amount of nutrients per acre as two tons of a 5-4-5 mixture but the amount of material to be

FIG. 3.—A good type of wagon for drawing tobacco to the sheds. Loaded from the ground. Station farm, 1925.

handled is reduced from 4000 to 1082 lbs. The grade is 18.5-14.8-18.5. In this way possible harmful residues are reduced to a minimum and the acre cost is very low. Duplicate plots (N10

and N10*) were treated with this formula while alternating check plots (N1*** and N1****) received the same basal ration as N1. During the growing season the tobacco on the N10 plots seemed a little more rank in growth and darker green than on the check plots. The harvested weights, however (Table IV), show only a very slight gain for the "concentrated" plots. The sorting records (Table III) show no significant differences in grades but during the sorting it was noted that the tobacco from the N10 plots had a strong tendency to white-veins. A great many leaves otherwise of medium wrapper quality were thrown into cheaper grades because of this defect. No other harmful effects from the use of the concentrated formula were observed at any time during the year. The plants started to grow just as quickly as on the check plots without any evidence of root injury. There was no yellow tobacco to indicate a leaching of the fertilizer or a lack of nitrogen. On the contrary, it has been suggested by the manufacturers of urea that the objectionable prominent veins may be due to an *excess* of nitrogen rather than the *form of the carrier*. They claim for this material that the nitrogen is used by the plant to a greater extent than is the case with such organic substances as cottonseed meal, the ration being about 4:3 in favor of urea. According to this interpretation we should use only about 150 lbs. of ammonia in a urea formula to be compared with our basal ration. The average price per pound calculated by the accounting department of the Association was nearly the same for the check and urea plots. The net return per acre was slightly higher for the urea plots but the difference is too small to be of significance.

The first year's results are surely encouraging enough to warrant further testing of synthetic urea.

SOILGRO.

It is claimed by the manufacturers of this product that, although Soilgro is not really a fertilizer, it serves the same purpose because it furnishes and stimulates the growth of certain efficient nitrogen fixing bacteria in the soil. At the tobacco station it was tested during 1925 in three ways:

1. In combination with ½ our basal ration formula.
2. Without any fertilizer.
3. With a full ration of phosphoric acid and potash as in the basal ration but without any source of ammonia, depending on the soilgro to furnish the ammonia.

Some was introduced into the water used at setting time, some was applied to the roots by soaking overnight, some was applied by drenching the soil after the plants started. All three of the methods in combination were tried on some of the plants.

All the plants started well and little difference was noticed during the first three weeks. After that, however, the rows which had received no nitrogen began to lag behind and after some heavy rains in midseason they began to turn yellow and top out short. Only the rows which received the half ration of regular fertilizer kept the normal dark green color. Apparently the addition of phosphoric acid and potash had little if any effect and the soilgro failed to supply the deficiency of nitrogen since these plants were as yellow and starved in appearance as those which received no fertilizer at all. The rows were harvested separately but no sorting records were taken because all of the tobacco except that from the rows treated with regular fertilizer was yellow and lifeless and fit only for brokes. It was sold for stemming without sorting. The tobacco on the regular fertilizer rows was of somewhat less than average quality, probably due to short rations, but was far superior to that which depended on Soilgro.

It was very obvious that this substance is worthless for tobacco. For further tests of Soilgro for other crops, see Journal of Agronomy 17 : 10. 1925.

Phosphoric Acid Series.

The object of this series which has been in progress since 1922 is to determine what *quantity* of phosphoric acid is best for the production of good Havana seed tobacco. (For a more detailed description of the experiment and the results of the first three years' trials, the reader is referred to Tobacco Bulletin No. 5 of this station.) In 1925 the location of plots and the general plan was the same as in the preceding years, but a few minor changes seemed advisable:

1. The check plots (P1) received the same fertilizer ration as the N1 plots in the nitrogen series.
2. Acid phosphate was omitted from the formulas completely, precipitated bone only being used.
3. Ammonia and potash were applied at the basal acre rate of 200 lbs. each to all the plots of this series but phosphoric acid at the rate of 53, 100, 160, and 240 lbs. It was not thought worth while to continue the trial of 306 lbs. per acre, the maximum amount of 1922-24, because the preceding years' trial had shown that the tobacco produced on this ration was inferior to the others.

The plots were on the same field as the nitrogen series and alternated with them. Treatment throughout the season was the same and needs no further description than that given in discussing the nitrogen series. No significant differences in growth or maturity were noticed in these plots during the growing season.

The plots were in triplicate. The fertilizer mixture for each of the four treatments was as follows:

Plot P1. Basal ration with 160 lbs. P_2O_5 per acre.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.5	9.94	...	....	86.1	...
Total	2,846.9	$75.66	200	160.0	200.0	14.9

Plot P2. Basal ration but no precipitated bone added. 53 lbs. P_2O_5 per acre.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.5	9.94	...	....	86.1	...
Total	2,569.0	$67.32	200	53.0	200.0	14.9

Plot P3. Basal ration but with phosphoric acid reduced to 100 lbs. per acre.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	122.1	3.66	...	47.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.5	9.94	...	....	86.1	...
Total	2,691.1	$70.98	200	100.0	200.0	14.9

Plot P4. Basal ration with 240 lbs. P_2O_5 per acre.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	485.7	14.57	...	187.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Carbonate of potash ...	132.0	9.94	...	....	86.1	...
Total	3,054.2	$81.89	200	240.0	200.0	14.9

The sorting records are presented in Table V and the acre yield, pool rating, price per pound and net returns in Table VI.

TABLE V. PERCENTAGE OF GRADES IN THE PHOSPHORIC ACID PLOTS, 1925

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17" seconds	15" seconds	Brokes	Fillers
P1	17	16	27	7	14	4	0	10	5
P1*	6	5	35	6	22	1	0	20	5
P1**	11	11	26	12	16	5	2	9	8
P2	14	17	29	5	18	2	0	10	5
P2*	7	10	34	8	21	2	0	13	5
P2**	10	13	24	13	17	5	1	10	7
P3	10	10	26	9	23	3	0	14	5
P3*	8	7	35	6	25	2	1	11	5
P3**	6	5	32	14	23	4	2	8	6
P4	11	12	30	9	19	2	0	11	6
P4*	8	7	35	6	23	2	0	12	7
P4**	10	14	26	11	22	1	0	9	7

Examination at the time of sorting showed the quality to be very good on nearly all the twelve plots. Some light vein was noted only in Plots P3*, P3** and P4. The tobacco with the highest percentage of phosphoric acid was compared carefully for objectionable red or double colors. It was the general opinion both in the sorting shop and at the grading department that the dark wrappers did show more of a cinnamon red than the other plots but there was no objectionable red or double color. Neither was the tobacco from the plots which received the least phosphorus objectionably green.

It seems rather significant that the tobacco from the low phosphorus plots (P2 plots) not only were rated the best at time of sorting, but also were pooled highest by the Association grading department. This not only gave as high a yield as any of the other treatments, but had the highest average price per pound and the lowest fertilizer cost. In addition, the net acre return was $51.03 higher than from any other plots.

In view of the good showing of these plots at the end of 4 years without any phosphoric acid other than that in the cottonseed meal and castor pomace, and in view of their record during the preceding three years when they were so near the top in yield, quality and net return that they were well within the range of experimental error, one could be pardoned for questioning the need of any additional phosphoric acid in the fertilizer on this soil. Analyses of this soil by Professor Morgan of the Soils Department of the Station indicate it to be well supplied with fairly available phosphorus. Certainly it would be safe on the station plots to cut down the application considerably below our basal rate of 160 lbs. per acre. There are probably many other tobacco soils which are annually oversupplied with phosphoric acid. A few growers of good tobacco have told the writers that they have omitted special carriers of phosphoric acid from their fertilizer for one or more years without injurious results. It is conceivable, however, that the continuous omission of phosphorus through a long series of years might deplete the soil to

TABLE VI. PHOSPHORIC ACID PLOTS, 1925. POOL RATING, ACRE YIELD, NET PRICE PER POUND, AND NET RETURN PER ACRE.

Plot	Lbs. P_2O_5 per acre	Cost of fertilizer	Yield per acre: Per plot	Yield per acre: Average	Pool rating	Net price per lb. (a): Per plot	Net price per lb. (a): Average	Net return per acre (b): Per plot	Net return per acre (b): Average
P2	53	$67.32	1879	1812	A	.40005	.34953	$684.37	$566.86
P2*	"	"	1885		A	.30080		516.65	
P2**	"	"	1673		A	.33875		499.57	
P3	100	70.98	1742	1785	A	.34395	.30865	528.18	472.32
P3*	"	"	1809		A	.32070		538.03	
P3**	"	"	1614		B	.26130		350.75	
P1	160	75.66	1804	1788	A	.40545	.32648	692.26	512.10
P1*	"	"	1753		A	.27235		401.77	
P1**	"	"	1717		B	.30165		442.27	
P4	240	81.89	1826	1814	A	.34745	.32777	552.55	515.83
P4*	"	"	1886		A	.30995		512.68	
P4**	"	"	1731		B	.32590		482.25	

(a) After deducting cost of sorting, packing, sampling and overhead.
(b) After deducting cost of fertilizer.

an extent which would be unfavorable for the best growth of tobacco. Furthermore it is not safe to conclude that all the Connecticut Valley tobacco soils would be as indifferent to phosphoric acid fertilizers as the soil of this field at the tobacco station.

The Old Potash Series.

The purpose of the old potash series was to compare sulfate of potash with double sulfate of potash and magnesia as sources of potash in the fertilizer ration. (See Tobacco Station Bulletin 5, p. 24 for a more detailed discussion.) The three plots have been in duplicate on the same field as the nitrogen plots for three years. Location of plots for 1925 and the general plan of the experiment was the same as in the previous years. The only modifications made were the reduction of quantity of fertilizer applied per acre to 200-160-200 of ammonia, phosphoric acid and potash respectively, as previously explained under the other series and the elimination of acid phosphate. The composition of the mixtures was as follows:

Plot K1. Basal ration with all mineral potash in sulfate of potash.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre			
			NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	344.4	9.47	...	....	172.2	...
Total	2,886.6	$70.45	200	160.0	200.0	14.9

Plot K2. Basal ration with all mineral potash in double sulfate of potash and magnesia.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre			
			NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Double sulfate	662.3	11.59	...	....	172.2	74.8
Total	3,204.5	$72.57	200	160.0	200.0	89.7

Plot K3. Basal ration with mineral potash, 1/2 in High Grade sulfate and 1/2 in double sulfate of potash and magnesia.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre			
			NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	7.23	40	....	....	...
Precipitated bone	277.9	8.34	...	107.0	....	...
Sulfate of potash	172.2	4.74	...	....	86.1	...
Double sulfate	331.2	5.80	...	....	86.1	37.4
Total	3,045.6	$71.52	200	160.0	200.0	52.3

All cultural operations were the same as described previously for the other fertilizer experiments.

The sorting records for the plots are presented in Table VII and the acre yields, pool ratings, average price per pound, and net acre returns are given in Table VIII.

Table VII. Potash Series, 1925. Percentage of Grades.

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17" seconds	15" seconds	Brokes	Fillers
K1	14	17	29	5	19	3	0	8	5
K1*	16	14	30	5	18	3	0	8	6
K2	15	16	33	4	17	3	0	8	4
K2*	15	17	23	6	19	2	0	12	6
K3	13	10	33	4	24	2	0	9	5
K3*	14	19	25	6	20	3	0	8	5
K4	2	2	24	19	18	6	1	18	10
K4*	13	7	24	16	14	5	1	13	7
K5	4	4	21	18	15	4	1	24	9
K5*	11	11	24	15	13	4	1	17	4
K6	3	2	45	7	24	4	1	11	3
K6*	2	4	44	12	20	5	1	8	4
K7	11	11	20	18	13	6	1	13	7
K7*	11	8	22	17	16	5	1	13	7
K8	5	9	27	16	19	5	1	15	3
K8*	10	10	25	11	15	4	1	17	7
K9	4	4	29	15	23	4	2	13	6
K9*	10	9	31	12	10	4	2	16	6
K10	3	3	18	18	18	3	0	26	11
K10*	7	6	30	11	24	2	0	15	5

No differences in growth were noticed on these plots (K1, 2 and 3) during the summer. The growth was rapid and uniform from the first. Nothing resembling magnesia hunger was observed on any of these plots at any time. At the time of sorting, the quality of the tobacco from all the plots was rated as excellent. The leaves were thin and there were no evidences of white-vein, premature yellowing, or dead tobacco on any of the plots. All were put in the A grade by the Association grading department. The percentage of light and medium wrappers was uniformly high as was also the calculated average price per pound. Differences among them are too small to be of significance. The highest yield and highest net return per acre were on the plots treated with high grade sulfate. The lowest yield and lowest net return per acre were on the plots treated with double manure salts. The plots treated with a mixture of the two yielded midway between the others. The average yields for the three years of the experiment are: High grade sulfate, 1824; double manure salts, 1764; combination of the two, 1806.

Although the differences between the three are rather small, they have been in favor of the high grade sulfate during two out of the three years of the experiment. The main reason advanced

TABLE VIII. POTASH SERIES, 1925. POOL RATING, YIELD PER ACRE, NET PRICE PER POUND, AND NET RETURN PER ACRE.

Plot	K_2O applied (a)		Cost of fertilizer	Yield per acre		Pool rating	Net price per lb.		Net return per acre	
	as	Lbs. per acre		Per plot	Average		Per plot	Average	Per plot	Average
K1	K_2SO_4	172.2	$70.45	2054	2057	A	.40665	.40447	$764.81	$761.75
K1*	"	"	"	2061		A	.40230		758.70	
K2	Doub. sulf.	"	72.57	1932	1912	A	.39530	.40285	691.14	697.52
K2*	"	"	"	1892		A	.41040		703.91	
K3	K_2SO_4 / Doub. sulf.	86.1 / 86.1	71.52	2029	1979	A	.37790	.39972	695.24	718.44
K3*	"	"	"	1929		A	.42155		741.65	
K4	K_2SO_4	172.2	70.46	1418	1486	B	.19010	.22635	199.10	268.23
K4*	"	"	"	1553		C	.26260		337.36	
K5	K_2CO_3	"	80.86	1425	1485	B	.19875	.24227	202.36	282.53
K5*	"	"	"	1545		B	.28580		360.70	
K7	KNO_3 / K_2CO_3	115.7 / 56.5	70.19	1434	1570	B	.28750	.28565	342.09	376.47
K7*	"	"	"	1695		B	.28380		410.85	
K8	K_2SO_4 / K_2CO_3	86.1 / 86.1	75.66	1458	1478	B	.25530	.25605	296.57	302.67
K8*	"	"	"	1497		C	.25680		308.77	
K9	K_2SO_4 / K_2CO_3 / KNO_3	57.4 / 57.4 / 57.4	72.14	1563	1544	C	.21915	.25172	270.39	315.76
K9*	"	"	"	1524		A	.28430		361.13	
K10	Marl	?		1324	1483	C	.16230	.20767		
K10*	"	"		1641		C	.25305			
K6	K Cl	172.2		1685	1742	B	.24315	.23567		
K6*	"	"		1799		B	.22820			

(a) Balance of potash (27.8 lbs. K_2O per acre) supplied in C. S. meal and castor pomace.
NOTE: K1, K2, and K3 are the old potash plots in field No. 1.
Treatments K4, K5, K7, K8, and K9 are in a different field and were begun in 1925.

for using double sulfate, however, is that it prevents the chlorotic condition of the plants commonly known as "sand-drown" or magnesia hunger. If, however, the grower uses considerable organic material such as cottonseed meal or castor pomace in his fertilizer mixture, as most growers do, he will have enough magnesia present and there would seem to be no need for using double manure salts. Our basal ration without any double manure salts contains about 15 pounds of magnesia to the acre and this seems to be sufficient to satisfy the needs of the plant for this material since magnesia hunger has not been observed on any plots which had that amount applied. The absence of magnesium starvation cannot be explained satisfactorily on the ground that this soil naturally contains a sufficient supply of available magnesia. We have two excellent demonstrations that the case is quite the contrary: (1) Within a distance of less than five rods from the old potash plots there is a series of plots on which "magnesia hunger" is being studied. Certain of these plots have not received any magnesia for four years. During the season of 1925 these plots were seriously affected with magnesia hunger. The same plots had magnesia hunger three years previously. (2) In the old nitrogen series there were certain plots (N3 and N5) which formerly received all their nitrogen in mineral carriers, and none of the fertilizer ingredients had more than a trace of magnesia. These plots were affected with magnesia hunger in 1922 (Bulletin 5, p. 8).

Summarizing the results of the old potash series we may say that up to the present no reason for substituting double manure salts for high grade sulfate has been found, either from the standpoint of preventing chlorosis or from the standpoint of improvement of quality or increase in yield. If, for any reason, a grower planned to reduce to a very low percentage the amount of cottonseed meal or other organic carrier of magnesium applied to the soil, it is conceivable that a mineral magnesia carrier would be advisable. But as long as the growers continue to apply manure, cottonseed meal, castor pomace, linseed meal, fish, wood ashes and tobacco stems in the quantities now used, there would seem to be some disadvantages and no real advantages in using the double sulfate of potash and magnesia.

THE NEW POTASH SERIES.

There are other carriers of potash besides high grade sulfate and double manure salts which may be used in fertilizer mixtures. The most important of these is carbonate. Nitrate may also be used but, as previously mentioned, the supply of this material is uncertain. There is pretty good evidence that aside from muriate, the worst form in which we can supply potash is sulfate (either in high grade or double sulfate), especially if we wish to improve the quality of our tobacco rather than to increase the yield. In the five years fertilizer experiment at Poquonock, 1892-96, it was found that the best quality of tobacco was produced on those plots which had the potash supplied in the form of carbonate, although the highest yields were produced where the sulfate was used. Later chemical work by Garner (U. S. D. A., B. P. I., Bulletin No. 105, 1907) indicates that the burn is greatly influenced by the ratio of sulfate and potash and that an excess of sulfate in the leaf should be avoided. The compounds in the leaf, which are of importance in producing good burn, are the potash salts of the organic acids, such as malate and

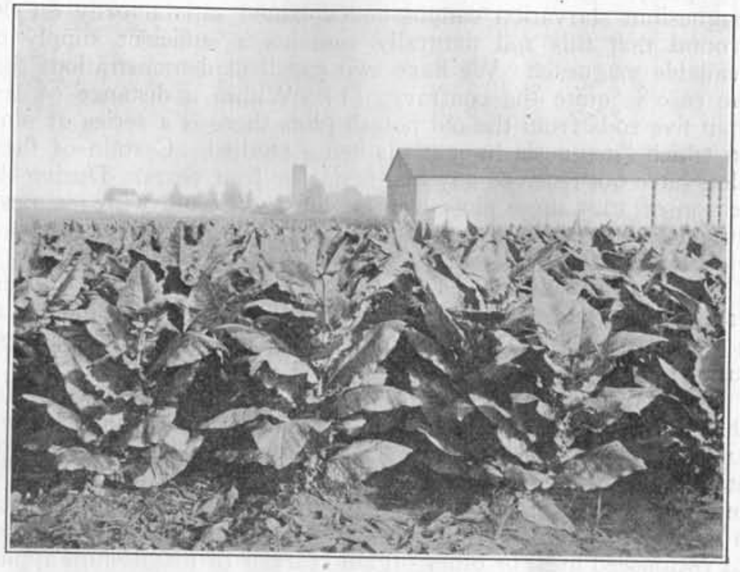

FIG. 4.—Duncan Brothers type of Havana Seed. Tobacco station farm, 1925.

citrate; but these salts are formed only from the potash which remains over after mineral radicals, such as the sulfates, have been neutralized. Hence, it is advisable to reduce, as much as possible, the sulfates supplied to the plant. The advantage of using carbonate of potash probably lies in the fact that it introduces potash without an unnecessary or harmful quantity of sulfates. In former years large quantities of carbonate were used on tobacco land mostly in such carriers as cotton hull ashes or wood ashes, but also to some extent as pure carbonate. Old tobacco growers state that the leaf grown in those days was superior in quality and burn to that which we raise now. It is rather difficult to prove that such was really the case and that

such superiority, if real, was due to the form in which the potash was supplied.

In view of the favorable influence of carbonate of potash on quality, why is it that nearly all fertilizer mixtures have their potash in the form of sulfate and why do most growers who mix their own fertilizers use sulfate? There are at least three contributing reasons (1) Cotton hull ashes, which was the standard source of carbonate of potash, went off the market. (2) Pure carbonate is an expensive form of potash. (3) Black rootrot was said to be favored through the use of carbonate.

The seriousness of the black rootrot menace first became apparent and attracted wide attention during the first decade of the century. Growers had been using large quantities of carbonate of potash and when it was found that an alkaline condition of the soil favored development of the disease, considerable blame was laid on the carbonate. Is it not more likely that the preceding era of heavy liming had more to do with bringing the tobacco field into this condition than the carbonate of potash? Canada ashes and cotton hull ashes also contain considerable lime in addition to carbonate of potash. Plant pathologists and other agricultural experts advised so strongly against carbonate that growers and fertilizer manufacturers have now almost ceased to use it. Meanwhile the tobacco soils have been dosed for many years with large quantities of sulfate.

One of the main objects of the potash series was to determine what effect a yearly application of the required potash in the form of pure carbonate would have on the reaction of the soil. During the last year we have determined pretty definitely the degree of acidity which is necessary in a soil in order to prevent rootrot. Most of the tobacco soils are so acid that there would seem to be little likelihood of reducing the acidity to a dangerous degree by the annual application of carbonate of potash to supply 200 lbs. of potash per acre. In order to test this, a new series of plots was laid out on a different part of the experiment station farm where tobacco has been grown for many years. This field is not so favorable for growing tobacco as the field where the old fertilizer plots are located. The soil is a lighter sand, more inclined to leaching ,and has never produced as much or as good tobacco. The plots are 1/40 acre in size and in duplicate. The fertilizer rations applied to each are as follows:

Plot K4. All mineral potash in H. G. sulfate.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	14.7	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	5.3	7.23	40	...	...	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Sulfate of potash ..	344.4	8.6	9.48	...	...	172.2	...
Total	2,886.6	72.1	$70.46	200	160.0	200.0	14.9

Plot K5. All mineral potash in carbonate.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	14.7	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	5.3	7.23	40	...	...	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Carbonate of potash.	265.0	6.6	19.88	...	...	172.2	...
Total	2,807.2	70.1	$80.86	200	160.0	200.0	14.9

Plot K7. 2/3 mineral potash in nitrate; 1/3 in carbonate.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	14.7	8.82	40	10.6	5.9	4.7
Nitrate of potash ...	266.6	6.7	9.92	40	...	115.7	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Carbonate of potash.	87.0	2.2	6.52	...	...	56.5	...
Total	2,683.1	67.1	$70.19	200	160.0	200.0	14.9

Plot K8. Mineral potash divided equally between sulfate and carbonate of potash.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120	42.4	21.9	10.2
Castor pomace	588.2	14.7	8.82	40	10.6	5.9	4.7
Nitrate of soda	212.7	5.3	7.23	40	...	...	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Sulfate of potash ..	172.2	4.3	4.74	...	...	86.1	...
Carbonate of potash.	132.5	3.3	9.94	...	...	86.1	...
Total	2,846.9	71.1	$75.66	200	160.0	200.0	14.9

Plot K9. Mineral potash divided equally between sulfate, nitrate, and carbonate.

Carrier Name	Lbs. per acre	Lbs. per 1/40 acre	Cost an acre	Lbs. plant nutrient per acre NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	1,463.4	36.6	$36.59	120.0	42.4	21.9	...
Castor pomace.	588.2	14.7	8.82	40.0	10.6	5.9	...
Nitrate of soda	107.4	2.7	3.65	20.2	...	...	...
Precipitated bone ..	277.9	6.9	8.34	...	107.0	...	...
Sulfate of potash ...	114.8	2.9	3.16	...	...	57.4	...
Carbonate of potash.	88.3	2.2	6.62	...	...	57.4	...
Nitrate of potash ...	132.3	3.3	4.96	19.8	...	57.4	...
Total	2,772.3	69.3	$72.14	200.0	160.0	200.0	...

It will be noted from the above that not only carbonate, sulfate and nitrate are being tested but various combinations of them.

No significant differences in growth were observed during 1925, the first year of the experiment. After the heavy rains in July there was considerable indication of leaching and the lower leaves showed considerable yellowing before harvest.

Growth was not entirely satisfactory; and besides, a spotting of the lower leaves resembling in all outward symptoms the southern bacterial disease, "angular leaf spot," caused considerable damage on one end of the field.

All sorting and pooling data are presented in Tables VII and VIII.

Comparison during the sorting placed the tobacco from the sulfate plots (K4) as the poorest of all. The leaves were inclined to be yellow, boardy, and lacking in life and elasticity. The plots having carbonate of potash alone (K5) were of better quality and the net return was higher although the yield was about the same. The highest yield and highest net return per acre were on the plots where ⅔ of the mineral potash was from nitrate and the other third from carbonate (K7 and K7*). (It was not possible to use nitrate as the only source of potash because the mineral nitrogen would thus have been raised above the requirements of the formula.) The average price was also highest on these and at the time of sorting the quality of both was rated as good. The plot, however, which rated highest was K9*. This tobacco was thin, elastic and showed no white-vein nor yellowing. Angular leaf spot was more serious on this than on any of the other plots in this field, and was responsible for the high percentage of brokes. Otherwise it would have made a much better showing. The duplicate plot K9, however, was not considered as good. Since this was the first year of the experiment and the growth on all the plots was not considered entirely satisfactory, it is best not to draw any conclusions.

The effect of the different carriers of potash on the reaction of the soil is of interest and importance. In May, before the fertilizers were applied, samples of the soil from each plot were taken and the reaction tested. Again in September after the crop was harvested, the soil was tested. Without presenting the results of these tests in detail it may be stated that the change in acidity on any of the plots was not perceptible within the limitations of the method. It will be necessary, however, to continue the determinations on the same plots through a series of years before generalizing on the effects of using different potash carriers on tobacco soils.

Soil tests on the fertilizer plots at the Rhode Island Station (R. I. Bul. 189) after 26 years of application of carbonate of potash and of soda are sometimes cited as proving that carbonate of potash has a strong tendency to make the soil alkaline. It should be noted, however, that in addition to the regular ration of carbonate of potash, these plots received a heavy application of carbonate of soda (620 lbs. per acre during the spring when the tests were made).

In view of the natural leaching of certain basic elements in average soils and the amount of potash which is removed by the tobacco crop every year, there would seem to be little danger of so reducing the acidity as to bring on rootrot by the annual application of two to three hundred pounds of potassium carbonate per acre. A long series of years of this treatment, however, might endanger some soils. Carbonate should be avoided on low, heavy soils where the seepage water from higher ground is apt to stand and from which there is little leaching. In many tests which were made during the past few seasons in tobacco fields it has been found that such low spots in the field are more alkaline than the lighter, higher soils and that rootrot is most serious in such places.

Greensand marl. This is a natural sand containing from 5 to 7% potash. It is claimed by the producers that it also furnishes sufficient phosphoric acid and that the addition of nitrogen is not necessary. Tests during 1923 and 1924 on plots where this was the only fertilizer used showed that it did not possess enough available plant nutrients to produce a normal development of tobacco. It was thought best in the tests of 1925 to supplement it by the addition of cottonseed meal. A mixture was therefore applied at the rate of 3200 lbs. of greensand marl and 800 lbs. of cottonseed meal per acre. The two plots (K10 and K10*) thus treated were in the same field and adjacent to plots N1*** and N1****. The results on the marl plots should be compared with these check plots and not with the other potash plots which were in a different field. The sorting records of the two marl plots and checks along with the yields and net return per acre are presented in Table IX.

Table IX. Greensand Marl and Check Plots.

Plot	Percentage of grades: M. W. and L. W.	Long darks	Dark stem	Long sec.	Short sec.	Fillers & brokes	Pool rating	Yield per acre	Average price per. lb.	Net return after deducting sorting charge
K10	6	18	18	18	3	37	C	1324	.25230	$237.07
K10*	13	30	11	24	2	20	C	1641	.34305	409.27
N1***	29	33	9	12	5	12	A	1646	.47335	610.99
N1****	20	33	9	18	6	14	A	1788	.43615	600.23

These data show that the check plots sorted out with more high grades, the quality was rated higher, the acre yield and average price were higher than the marl plots. The net return was nearly $300 less per acre on the marl plots. The addition of marl as a source of potash would make the mixture too bulky and the expense would be no less than that of using a higher grade potash carrier.

Fractional Application Series.

The two objects of this series were (1) to determine whether a given amount of fertilizer is more efficient when applied all at once or when only ⅓ of it is applied before setting, ⅓ as soon as the plants are well started and ⅓ two weeks later; (2) to compare a full ration applied at setting with a reduced amount applied fractionally. The plots were in duplicate on the same field as the nitrogen series with the exception of F4 and its duplicate which were on the same field as N1*** and N1**** and these must be compared with the latter plots.

Formulas for the mixtures are as follows:

Plot F1. Same as N2 but plant food reduced to 150-120-150 and applied in three applications.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre: NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	685.9	$17.15	56.25	19.9	10.3	4.8
Castor pomace	275.8	4.14	18.75	4.9	3.8	2.2
Nitrate of soda	398.5	13.54	75.00	...	...	...
Precipitated bone	247.2	7.42	....	95.2	...	...
Sulfate of potash	129.0	3.55	....	...	64.5	...
Carbonate of potash ..	99.2	7.44	....	...	64.5	...
Double sulfate	30.4	.53	....	...	7.9	3.5
Total	1,866.0	$53.77	150.0	120.0	150.0	10.5

Plot F2. Same as F1 but all applied broadcast before setting.

Plot F3. Same as N2 but plant food reduced to 125-100-125 and applied in one application.

Carrier Name	Lbs. per acre	Cost an acre	Lbs. plant nutrient per acre: NH_3	P_2O_5	K_2O	MgO
Cottonseed meal	571.6	$14.29	46.9	16.6	8.5	4.0
Castor pomace	229.8	3.45	15.6	4.1	2.3	1.8
Nitrate of soda	332.1	11.29	62.5	...	...	...
Precipitated bone	206.0	6.18	....	79.3	...	...
Sulfate of potash	107.5	2.96	....	...	53.8	...
Carbonate of potash ..	82.7	6.20	....	...	53.8	...
Double sulfate	25.4	.44	....	...	6.6	2.9
Total	1,555.1	$44.81	125.0	100.0	125.0	8.7

Plot F4. Same formula as F3 applied fractionally in three applications.

Sorting records for these plots are presented in Table X and the pool ratings, average price, acre yield, and net return per acre, are in Table XI.

Table X. Fractional Application Plots. Sorting Records, 1925.

Plot	Light wrappers	Medium wrappers	Long darks	Dark stemming	Long seconds	17" seconds	15" seconds	Brokes	Fillers
F1	4	5	28	13	17	2	0	23	8
F1*	3	11	29	9	21	2	0	17	8
F2	6	12	24	14	14	2	0	19	9
F2*	8	12	25	10	18	0	0	20	7
F3	4	8	30	12	14	3	0	23	6
F4	20	17	27	10	8	6	2	7	3
F4*	17	10	31	5	17	3	1	11	5

TABLE XI. FRACTIONAL APPLICATION SERIES, 1925. POOL RATING, YIELD, NET PRICE PER POUND AND NET RETURN PER ACRE.

Plot	Method of application	Lbs. plant nutrient per acre			Cost of fertilizer per acre	Yield per acre (lbs.)		Pool Rating	Net price per lb.		Net return per acre	
		NH_3	P_2O_5	K_2O		Per plot	Average		Per plot	Average	Per plot	Average
F1	Fractional (three)	150	120	150	$53.77	1607	1747	B	.21145	.24375	$284.18	$375.66
F1*	" "	"	"	"	"	1887		A	.27605		467.15	
F2	Broadcast (single)	"	"	"	"	1592	1645	A	.27480	.27702	383.71	402.19
F2*	" "	"	"	"	"	1699		B	.27925		420.67	
F3	" "	125	100	125	44.81	1667	1667	B	.21725	.21725	317.34	317.34
F4 (a)	Fractional (three)	"	"	"	"	1650	1746	B	.37530	.36135	574.44	584.77
F4* (a)	" "	"	"	"	"	1842		B	.34740		595.10	

(a) These two plots were on a different field and compared favorably with the check plots N1*** and N1****. (See Table IX.)

The duplicate plots F1 received exactly the same mixture and quantity as duplicate plots F2, the only difference being that the fertilizer on F1 was applied in three different portions while that on F2 was applied broadcast all at once at the time of fitting the ground. Comparing the average net return, however, we find that there has not been a gain but an actual loss of $17.09 per acre from the fractional application besides the extra expense of the labor for making the three applications. In 1924 there was an advantage for the fractional application of $4.01 per acre which would not pay for the extra work. In 1923 the advantage was with the single broadcast application.

Three years of testing on these same plots have failed to show that there is anything to be gained by dividing the fertilizer and making later applications. It was suggested, in writing up the results of the 1924 tests, that perhaps the results would be more favorable for fractional application during a season of more rainfall. But the rainfall in 1925 was above the average and still the results were less favorable for fractional application than in the preceding year. It does not necessarily follow, however, that the results would be the same on all tobacco fields. The soil where these plots are located is not of the light "leachy" type where one might expect the greatest benefit from fractional application. It is planned to repeat these tests during 1926 on such a soil.

The effect of *reducing the amount* of fertilizer is indicated by comparing plots F2 and F3. It will be noted that the saving in cost of fertilizer was more than counterbalanced by the reduction in net return. Effects of reducing the application for three years in succession may be seen by comparing Plot F2* with Plot K1 of the potash series. These two plots are immediately adjacent, being separated by only one row of tobacco. The differences in proportions of ingredients in the mixtures applied were very slight, but K1 received ammonia, phosphoric acid and potash at the basal rate of 200-160-200 while F2* received the same at the reduced rate of 150-120-150. The differences were in about the same proportion during the two preceding years. The net return of this year for the K1 plot was $764.85 as contrasted with a net return of $423.68 for the F2* plot.

The F4 plots were on a different field and were only started in 1925 after heavy applications in the dry year of 1924, hence the results are not comparable with the other plots of the fractional application series. The N1 plots on this field, however, averaged a net return of only $529.96 per acre, as compared with $584.77 from the fractional plots.

SOME GENERAL CONSIDERATIONS ON TOBACCO FERTILIZERS.

Four plant nutrients which must be furnished in the tobacco fertilizer are ammonia, phosphoric acid, potash, and magnesia. These four materials are not purchased in a "free" condition but each is a part of some common substance known as a "carrier." Any one of the four may be supplied in a variety of carriers; e. g., ammonia may be supplied in cottonseed meal, fish, nitrate of soda, or a dozen other carriers. Or, one carrier may furnish more than one element, e. g. cottonseed meal furnishes all four of them.

In deciding on the fertilizer to be used, the grower is confronted with two questions: (1) How much of these nutrients shall be applied to each acre? (2) What carriers can be used to the best advantage in the mixture? In the light of the experiments described in the preceding pages let us try to answer simply and briefly these two questions:

How Much Fertilizer Should Be Used?

It is unfortunate that many growers still think of their fertilizer applications only in terms of the number of pounds of total mixture which they spread on an acre. Such a practice is largely responsible for the inclusion of large quantities of useless "filler" in the mixture by fertilizer manufacturers. By doing this they can furnish a large bulk of mixture at a low price but the bulk applied to an acre does not necessarily bear any definite relation to the amount of nutrients furnished, their chemical form, or the nature of the carriers. The grower should think of his fertilizers in terms of the amount of nutrients supplied to each acre of tobacco without any regard to the weight of the mixture.

Ammonia. During the first three years of the experiments the quantity of ammonia in the standard mixture was about 260 pounds per acre. When this was reduced, the loss in yield and net return more than counterbalanced the saving in fertilizer cost. The same principle held in 1925 when we experimented with applications less than 200 lbs. It will be noticed in the tables presented in the preceding pages that the plots which produced the *most* tobacco also usually produced the *best* tobacco, i. e., there was a larger proportion of leaves in the higher grades and the average price was correspondingly high. The impression of many that a big growth of tobacco produces a heavy inferior leaf is not borne out by the actual sorting records on these experiments up to date. This was also the conclusion of Dr. Jenkins after the five-year Poquonock experiment of thirty years ago. In those experiments it may also be mentioned that it was found profitable to increase the nitrogen to 210 pounds (255 lbs. ammonia per acre). On the basis of experiments up to date and supplementary experience of many successful growers, we are led to believe that the proper amount of ammonia to be applied is in the neighborhood of 250 pounds per acre. It has been previously mentioned, however, that different fields may vary markedly as to fertilizer needs. Intelligent experience is the best guide for any grower and if years of experience have proved that he can raise the best tobacco on some of his fields with less than 250 lbs. while others need more, he will do well to avoid too radical a change. Those who think this amount too expensive should consider that there is money in outdoor tobacco only in the big yield. On the average it takes 1500 pounds of tobacco to pay the expenses of producing. The money the grower gets for those pounds in excess of that amount is his profit. He cannot afford to neglect any practice which will add to that excess. When pounds are all profit it does not take many to pay for a little extra fertilizer.

Phosphoric acid. The fact that we can grow the best tobacco where no mineral phosphorus carrier has been used for four years leads us to believe that many old tobacco fields are consistently oversupplied with that element. Although we are not ready to recommend that mineral carriers of phosphoric acid be omitted from all soils, we do believe that our basal ration of 160 lbs. per acre is too high and that growers could well afford to test their land by leaving off phosphorus carriers from parts of their fields for a few years to see whether there is any deterioration in quality or yield. A saving of $10.00 an acre might be made with a little intelligent experimentation.

Potash. Four years test in the Poquonock experiments showed no loss from reduction of the potash to 150 pounds. No other experiments to determine the actual amount of potash required for Connecticut Valley tobacco soils are on record. In the absence of carefully conducted long continued experiments of this kind our recommendations are largely guesses. At present we are using 200 pounds of potash per acre.

Magnesia. Fifteen pounds of magnesia per acre has prevented the appearance of any symptoms of magnesia shortage. The large amounts of double manure salts used by some growers and put in some prepared mixtures, are excessive and useless if not actually injurious.

What Carriers are Best.

Since any one of the four tobacco nutrients may be obtained in a variety of different carriers, the grower who mixes his own fertilizer is next confronted with the necessity of deciding which ones he should use. His choice will be influenced partly by the relative cost and the supply and ease of mixing, but more particularly should he be guided by what experience and experiment have shown to be the effect of a given material on the quality and yield of tobacco. Apparently the tobacco plant responds differently to different carriers of the same nutrient. For instance, we know that tobacco grown with nitrate of soda as the only source of nitrogen is different from tobacco grown on cottonseed meal although there is no known difference in the nitrogen which is derived from the two. Concerning the effect of some of the carriers there is considerable knowledge but very few and insufficient tests have been made with others. Under the circumstances we believe that the grower will do well to use only those which long use has shown to be satisfactory and to avoid new or little tried materials until their worth has been demonstrated by unbiased and competent experimenters.

Ammonia. It is generally believed that a part of the ammonia should be derived from mineral sources but the larger part from organic sources. The mineral carriers are more active and are included usually as a starter. Also nitrogen from this source is less expensive. The recent station experiments indicate that mineral carriers may be used to furnish up to one-half the ammonia of the formula without injury to quality or yield. Some successful growers however, use no mineral carriers at all. Of the organic carriers, cottonseed meal is the most extensively used and regarded as standard. The grower can make no mistake in using this as his principal ammoniate. Castor pomace is used almost as extensively and it is questionable whether there is any difference in the effects of the two on quality of the tobacco. There is a general belief that it should be used more extensively on the lighter soils. Linseed meal seems to be about as good as either of the above, but experiments indicate that the yield is not quite as good. Dry ground fish is used in smaller quantities by most growers either in the original mixture or as a side dressing. There is an impression in some quarters that it is not best for the burn and aroma if too much is used. The same may be said of tankage. Of the mineral carriers of ammonia, nitrate of soda is standard. Sulfate of ammonia, which is sometimes used, is subject to the objection of adding too much sulfate to the soil. It could probably be used to advantage, however, where the soil has been made too nearly neutral and it is desired to make it more acid. Nitrate of potash should be an excellent source of mineral nitrogen if the supply was dependable. Ammonium phosphate ("Ammophos") should also be a good carrier since it carries two essential plant elements and the residue is small. It should be tried more extensively in an experimental way, however, before making sweeping recommendations. The same may also be said concerning synthetic urea and a whole list of other "air-nitrogen" materials.

Phosphoric acid. Precipitated bone is the standard. Acid

phosphate contains too much sulfate but the high grade treble superphosphate should be nearly free from this objection. Fish is a commonly used source of phosphoric acid. Ammophos as previously mentioned should be tested more extensively. In view of the previously mentioned low response of our tobacco soils to lack of this element, it is possible that raw rock phosphate, the cheapest of all sources of phosphorus, would furnish all that is necessary.

Potash. Carriers of potash have been fully discussed on a previous page. High grade sulfate is most extensively used but we believe that on the more acid soils carbonate in the pure form or in ashes could be substituted to advantage. Another very excellent source of potash is tobacco stems. In this source the grower not only gets potash but also phosphoric acid and nitrogen. Besides the four elements under discussion, it is possible that tobacco stems also furnish other things which are advantageous for the growth of tobacco but of which we have no specific knowledge. It is pretty safe to assume that whatever is needed by the tobacco plant will be found in "stems,"

In conclusion we believe that it is a good principle not to depend always on one carrier for each nutrient but to mix several carriers. On the same principle it is well to vary the formula from year to year.

STRAIN TESTS OF OUTDOOR TOBACCO.

P. J. Anderson and N. T. Nelson

It is a fact well known among tobacco growers and dealers that neither the Broadleaf nor the Havana tobacco grown in New England are all of the same strain. The differences in the Broadleaf are more pronounced and the different kinds have received distinctive names, such as the John Williams Broadleaf, Hockanum Broadleaf, etc. The distinctive features of some of these types are readily apparent even to the inexperienced, as for example, the long, pointed leaf shape of the Bantle Broadleaf. Some of the other types, however, are distinguished by characteristics which are apparent only to the eye of experts long accustomed to judging Broadleaf Tobacco. Even though the differences may not be apparent in the field, they may be quite plain on the sorting bench. A third way in which these differences are manifested is in the adaptability of certain strains to certain localities, for example, the John Williams strain in the South Windsor section. Nearly any experienced Broadleaf grower will tell you that *his* farm is better adapted to one particular type than to another.

The origin of these distinctive strains is not as clear as might be desired. In fact we know very little about the origin of Connecticut Broadleaf. Were these differences already there when the seed was originally brought to New England or have they developed since then? It is doubtful whether Connecticut Broadleaf had a common source. Undoubtedly different types were introduced at different times and the source is not recorded. For example, we are told that the John Williams Broadleaf was so called because a grower of that name living in Manchester obtained some seed from Washington, D. C. grew it and distributed seed to neighbors who liked the type he grew better than their own. Whether it was originally a Maryland Broadleaf, Pennsylvania, Ohio, or something else can only be guessed. Other strains have been introduced in the same unrecorded way and are still being introduced, but nothing is put on record lest

FIG. 5.—Strain test plots on station farm. Broadleaf to left, Havana seed to right and Cuban Shade strains ahead.

the buyers should think it was not really Connecticut Broadleaf and would not pay so much.

It is entirely possible that differences have developed and become fixed in types of tobacco subsequent to their introduction here. Whether one believes that the differences in strains which he observes are due to small mutations or to segregation after fortuitous crossing is not of so much importance as the fact that these differences do exist and that they are inherited. Many growers have kept their own particular seed for twenty, thirty, or even forty years, always selecting the best plants for seed and as a result have won a reputation in their own neighborhood for

growing a superior type. In some cases this reputation is probably not due to the seed but to the type of land on which the crop is grown; or, the cultural practices may be so judicious that it is difficult to distinguish the results of such differences in handling from those which are inherent in the strain. Progressive growers are constantly trying to improve their type of tobacco by selection of their seed plants or by getting better seed from some other source.

If such differences do exist it is reasonable to believe that some strains are better than others and will yield a larger profit to the grower when grown under similar conditions. The differences in which the grower and dealer are most interested are those which appear in the sorted tobacco. They should be measured by the sorting record and the expert's judgment of quality.

In order to see whether there are such differences it is necessary that the strains to be compared be grown on the same land side by side and with the same cultural treatment throughout and then sorted and judged together.

Such strain tests were started by the Tobacco Station in 1924 with the object of (1) determining definitely whether there are strain differences in the Broadleaf and Havana seed which will remain constant, (2) measuring such differences, if present, in terms of sorting and pooling, (3) picking the best strains for seed distribution, and (4) selecting strains for possible further improvement through individual plant selection. The seed lots for the original trials were selected by Mr. Hickey of the Connecticut Valley Tobacco Association. The lots were selected on the basis of the crop records of the growers rather than on any known differences. It seemed best to make the tests not only on the station farm but also on other farms to see whether the differences observed in one place would be the same elsewhere. Also it seemed essential in the case of the Broadleaf to grow each of the well recognized types in the section in which it was most extensively grown.

The tests have continued through only two years; results have been delayed through the unusually dry weather of the first year and in some cases by unfortunate selection of the fields for the tests. Nevertheless a preliminary report is offered at this time which should be considered only as a report of progress and not final.

HAVANA SEED STRAIN TESTS.

*Tests of 1924.**

Some preliminary tests on a few strains of Havana seed were made at the Tobacco Station in 1922 and 1923. Although no

* Report by N. T. Nelson.

deailed records of yield and quality were kept, it was the opinion that the observed variability in type and quality of Connecticut tobaccos was more attributable to environmental differences than to the seed. In 1924 a larger number of seed lots was tested and sorting and pooling records taken. The tests were made both on the Tobacco Station farm and on the farm of Mr. Howard Henshaw in Suffield. The extremely dry summer in Windsor, however, resulted in a crop of such poor quality that records were taken only on the tobacco grown by Mr. Henshaw. Seed was furnished by the following growers:

W. K. Rice	Bloomfield
N. E. Kendall and Sons	Granby
Howard Henshaw	Suffield
L. C. Mills	Westminster
E. B. Graves	Canton
Lyman Crafts	Whateley
Larkin Proulx	Hatfield
Stanton Brown	Poquonock
M. Duda and Sons	Easthampton
L. J. Pelissier	Hadley
J. W. Alsop	Avon
Duncan Brothers	New Milford
George A. Peckham	Suffield
T. L. Warner	Sunderland
Howard Sikes	Suffield
F. A. Johnson	Southwick
J. E. Phelps	Suffield

The yield, sorting and pooling data are presented below in Table XII.

TABLE XII. HAVANA SEED STRAIN TESTS AT SUFFIELD, 1924. COMPARATIVE YIELDS, QUALITY AND RETURN PER ACRE.

Grower	Yield per acre	Price per pound	Total return per acre	Relative rating Yield	Relative rating Quality
Rice	1344	$0.2164	$280.71	69	51
Kendall	1764	0.3424	603.99	91	81
Henshaw	1596	0.4199	670.16	82	100
Mills	1596	0.3834	611.91	82	91
Graves	1428	0.3332	475.81	74	80
Crafts	1806	0.3904	704.06	93	93
Proulx	1596	0.3639	580.78	82	86
Brown	1932	0.4007	774.15	100	96
Duda	1596	0.3543	565.46	82	84
Pelissier	1764	0.3931	693.43	91	93
Alsop	1596	0.3218	513.59	82	70
Duncan	1764	0.3470	612.11	91	81
Peckham	1512	0.3420	517.10	78	81
Warner	1680	0.3054	513.07	87	73
Sikes	1596	0.2594	414.00	82	62
Johnson	1764	0.3708	654.09	91	88
Phelps	1386	0.2177	300.73	71	52

The price per pound is based on sorting percentages, pooling, and corresponding 1923 prices without deducting for sorting, packing and storage. The return per acre is the product of the yield and the price per pound. The yields ranged between 1344 and 1932 pounds per acre. Relative ratings were calculated by calling the best 100 and figuring the others on percentage of the best. Rating them in order of total return per acre, the relative rank of the first six is: Brown, Crafts, Pelissier, Henshaw, Johnson, and Duncan. The results of 1924, although preliminary, indicate good possibilities for improvement and selection on the average Havana now grown in the Valley.

Tests of 1925.

In 1925 the tests were conducted on a rather light sandy soil at the station farm. This field proved to be a rather unfortunate selection since there was apparently considerable leaching of the fertilizer just after the heavy rains of mid-season and the lower leaves turned yellow before harvesting. As a result the strains sorted out poorly. Nevertheless, this test has the advantage of showing what the different strains will do under adverse conditions. The tobacco was sorted and pooled as described under the fertilizer tests. The pool rating, acre yield, price per pound and return per acre are presented in Table XIII.

TABLE XIII. HAVANA STRAINS AT TOBACCO STATION—1925. POOL RATING, ACRE YIELD, PRICE PER POUND, AND NET RETURN.

Strain	Rating	Acre yield	Average price	Total Value	Sorting and Overhead	Net Value
Shean	C	1385	$0.2609	$361.35	$106.16	$255.19
Crafts	D	1410	0.2735	385.42	111.67	273.75
Proulx	C	1276	0.2298	293.22	90.21	203.01
Brown	D	1367	0.2317	316.67	100.13	216.54
Pelissier	C	1147	0.2022	231.87	72.33	159.54
Viets	D	1250	0.2273	284.13	87.31	196.82
Warner	D	1244	0.2312	287.55	76.69	210.86
Duncan	C	1311	0.3021	396.05	81.90	314.15
Johnson	C	1194	0.2371	283.04	72.06	210.98
Alsop	D	1209	0.1763	213.15	62.75	150.40
Graves	D	1214	0.2112	256.40	74.05	182.35
Henshaw	C	1240	0.2121	262.94	72.42	190.52
Peckham	D	1396	0.2803	391.23	96.04	295.19
Kendall	C	1218	0.2716	330.81	80.63	250.18

Using total return per acre as basis of rating, as for the 1924 series, the first six are: Duncan, Peckham, Crafts, Shean, Kendall, Brown. Three of the first six were the same for both years, viz., Brown, Crafts, and Duncan.

Final conclusions as to the relative value of the strains, however, must wait until after more comprehensive tests of longer duration.

Broadleaf Strain Tests.

*Tests of 1924.**

Very little work was done on Broadleaf during 1922 and 1923. In 1924 the Broadleaf project was expanded through the coöperation of the Connecticut Valley Tobacco Association and the Hartford County Farm Bureau. Several lots of seeds representing each of the leading types of Connecticut Broadleaf were secured and tested in their respective districts. The results of these tests are given in Table XIV. The only fair comparisons are between the different strains of one type. The different types cannot be compared for they were grown on different farms.

Table XIV. Comparative Yields, Quality and Return Per Acre on Broadleaf Lots in Farmer's Coöperative Trials—1924.

Type	Strain	Yield per acre Lb.	Price per pound $	Return per acre $	Relative rating Yield %	Relative rating Quality %
John Williams Broadleaf at H. Vibert's So. Windsor	Cannon	1834	.3995	732.68	91	73
	Hambach	1799	.4378	789.60	90	79
	Cavanaugh ..	1785	.3863	789.55	89	70
	Foran Bros...	1890	.5062	956.72	94	92
	Vibert	1750	.4420	773.50	87	81
	Killam	1659	.3933	652.48	83	72
	Riordan	1715	.4011	687.89	86	73
	Bancroft	1554	.5488	737.84	78	100
	Miskill	2009	.4748	953.87	100	86
	Grant	1895	.4183	792.68	96	76
Frank Roberts Broadleaf at F. H. Ensign's Silver Lane	Roberts	1960	.2493	488.63	100	74
	Hills	1925	.2782	535.54	98	83
	Oliver	1645	.1338	220.10	74	39
	Heller	1610	.2785	448.39	72	83
	McIlvane	1610	.2097	337.62	72	62
	Ensign	1855	.2185	405.32	95	65
	Vogel	1680	.1292	212.06	76	38
	Forbes	1890	.3367	636.36	96	100
	Evans	1680	.2065	346.92	76	61
Hockanum Broadleaf at J. M. Herr Hockanum	Geiselman ...	1715	.0871	149.38	99	34
	Cooley	1722	.2516	433.26	100	99
	Hamilton	1575	.1685	265.39	92	66
	Dusch	1440	.1325	194.78	84	52
	Brewer	1484	.2309	342.66	86	91
	Hollister	1624	.2232	352.48	94	87
	Dunham	1610	.2543	409.42	93	100
	Horton	1659	.2349	389.70	96	92
	Herr	1715	.2432	417.09	99	96
Barber Broadleaf at Burnham Liebler's So. Glastonbury	Demar	1952	.1483	289.63	100	93
	H. Smith	1922	.1073	206.23	98	67
	Liebler	1798	.1372	245.69	92	86
	Bachl	1488	.1032	153.56	75	65
	G. Smith	1643	.1434	235.61	84	89
	Hoffman	1829	.1598	292.27	93	100

* Report by N. T. Nelson.

An examination of Table XIV shows the wide variation within each type, some strains returning twice the value per acre of others. How much of this was due to inherent strain differences, how much to soil variation or to other sources of error cannot be stated. The tests of 1924 indicated the need for a continuation of this work as reported below.

John Williams Broadleaf Tests of 1925.

The John Williams strain trials were conducted on the farms of Mr. Horace Vibert of South Windsor, Mr. E. Handel of Glastonbury and at the Tobacco Station. This type did not do well as Handel's although other types alongside it on the same field of apparently quite uniform soil did very well. Mr. Handel, in former years, had tried the John Williams tobacco on his farm but had discarded it for the Hockanum type because the John Williams was unsatisfactory there. The growth was only fair at the Station Farm but was quite satisfactory in South Windsor where this type is generally recognized as being at its best. For this reason more weight should be attached to these tests in that locality than at the other two. All tests were on single rows of 100 plants each.

The percentage of grades is presented in Table XV and the rating, acre yield, average price per pound, and net return in Table XVI.

TABLE XV. JOHN WILLIAMS STRAINS OF BROADLEAF. PERCENTAGE OF GRADES, 1925.

(T = Tobacco Station, V = Vibert, H = Handel)

Strain	L. W.			M. W.			Long Sec.			Sh. Sec.			Long Dks.			Dk. Stem.			No. 2 Sec.			Brk. and Flr.		
	T	V	H	T	V	H	T	V	H	T	V	H	T	V	H	T	V	H	T	V	H	T	V	H
Cannon	6	1		4	3		15	32		1	8		20	22		27	13		10	10		17	11	
Hambach	4	0	5	2	5	3	17	24	22	1	8	3	19	25	25	24	8	15	7	19	12	26	11	15
Cavanaugh	2			1			13			0			19			28			17			20		
Vibert	2	2	0	3	3	0	19	18	20	2	4	3	23	25	27	20	22	18	15	15	6	16	11	26
Riordan	5	5	10	3	7	10	18	26	24	1	8	3	20	21	25	18	11	11	14	11	5	21	11	12
Bancroft	4	4	0	2	8	0	15	27	20	0	3	2	20	22	17	22	11	16	14	16	17	23	9	28
Miskill	6	0	2	6	4	1	18	18	25	1	5	1	21	24	24	21	21	14	12	17	18	15	11	15
Grant	3			4			19			1			16			22			13			22		

TABLE XVI. JOHN WILLIAMS BROADLEAF STRAIN TESTS, 1925 POOL RATING, ACRE YIELD, AVERAGE PRICE, AND NET RETURNS.

Vibert Farm, South Windsor.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Cannon	B	2164	$0.37145	$803.82	$182.64	$621.18
Hambach	B	2010	0.3604	724.40	176.28	548.12
Vibert	C	1991	0.2866	570.62	156.40	414.22
Riordan	C	1984	0.35335	701.05	170.03	531.02
Bancroft	B	2063	0.38975	804.05	179.58	624.47
Miskill	C	2317	0.28405	658.14	183.51	474.63
Handel Farm, Glastonbury.						
Hambach	B	1126	$0.34225	$385.37	$ 90.66	$294.70
Vibert	A	1008	0.3041	306.53	70.94	235.59
Riordan	B	1230	0.40515	498.33	105.61	392.72
Bancroft	C	1025	0.2543	260.66	73.19	187.47
Miskill	B	1156	0.332	383.79	93.81	289.98
Tobacco Station Farm.						
Cannon	B	1338	$0.30075	$402.40	$ 95.04	$306.36
Hambach	A	1352	0.314	424.53	91.26	333.27
Cavanaugh ...	C	1156	0.2397	277.09	79.53	197.56
Vibert	B	1053	0.3073	323.59	80.66	242.93
Riordan	C	1270	0.2857	362.84	94.81	268.03
Bancroft	A	1140	0.35(?)	399.00	80.66	318.34
Miskill	A	1327	0.38165	506.45	101.64	404.81
Grant	C	1206	0.2752	331.89	86.11	245.78

The Foran strain which made a good record in 1924 was not planted on account of lack of seed. The Cavanaugh strain was found to be the same seed as the Vibert strain and hence was not tested at Vibert's or Handel's. The seed of the Grant and Cannon strains did not come well in the seed beds and hence there was a shortage of plants, which accounts for the fact that they were not set at all three farms. In point of yield alone, the Miskill strain has made much the best showing. It was highest in the 1924 test, highest at Vibert's in 1925, second at Handel's and within 25 lbs. of the highest at the station farm. It was within $3.00 per acre of the highest in net return in 1924, highest in net return at the station farm in 1925. The net return at Vibert's, however, was much less than some of the others because of the high percentage of dark grades. In point of quality the Bancroft strain has made an excellent showing being rated as best in 1924, best at Vibert's, second at the Station Farm, but poorest at Handel's.

Frank Roberts Broadleaf Strains in 1925.

These tests were on the farms of Mr. Howard Ensign at Silver Lane, at the Station Farm, and at Handel's. Growth was best at Ensign's where the tests of 1924 were also conducted.

TABLE XVII. PERCENTAGE OF GRADES IN THE FRANK ROBERTS BROADLEAF STRAIN TESTS OF 1925.
(T = Tobacco Station, E = Ensign, H = Handel)

Strain	L. W.			M. W.			Lg. Sec.			Short Sec.			Long Dk.			Dk. Stem.			No. 2 Sec.			Brk. and Flr.		
	T	E	H	T	E	H	T	E	H	T	E	H	T	E	H	T	E	H	T	E	H	T	E	H
Roberts	2	4	9	1	6	16	14	25	23	1	1	2	16	30	26	25	12	7	13	7	8	28	15	9
Hills	0	1	5	0	4	8	9	23	21	0	2	3	11	28	29	37	17	10	15	7	11	28	16	12
Heller	0	3	6	0	3	8	8	19	22	0	1	2	12	28	31	29	25	9	14	8	14	37	15	9
McIlvane	0	4	5	0	5	11	10	24	29	0	1	1	10	26	27	31	20	9	14	5	10	35	15	8
Ensign	3	6	4	1	10	8	10	26	20	1	2	1	16	32	28	31	8	15	15	4	14	23	12	10
Vogel	0	1	7	0	2	11	12	25	29	0	1	2	19	25	29	28	22	9	18	9	6	23	15	7
Forbes	0	6	2	0	4	4	9	22	22	0	1	2	12	28	24	34	19	16	11	6	10	34	14	20
Evans	0	2	4	0	2	9	10	27	23	1	2	3	13	30	27	33	17	12	17	8	10	26	12	12

The Station tobacco of this strain sorted out very poorly and the results cannot be considered as indicative as the others, particularly at Ensign's.

The final data on these tests are presented in Tables XVII and XVIII.

TABLE XVIII. FRANK ROBERTS BROADLEAF STRAIN TESTS, 1925. POOL RATING, ACRE YIELD, AVERAGE PRICE PER POUND AND NET RETURN.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Handel Farm.						
Roberts	B	1381	$0.42835	$591.55	$122.74	$468.81
Hills	C	1230	0.3401	418.32	105.41	312.91
Heller	C	1331	0.34515	459.39	117.53	341.86
McIlvane	C	1390	0.37365	519.37	123.64	395.73
Ensign	C	1181	0.32385	382.47	103.34	279.13
Vogel	C	1348	0.38335	516.76	120.78	395.96
Forbes	C	1196	0.2906	347.56	91.61	255.95
Evans	D	1268	0.3084	391.05	107.02	284.03
Ensign Farm.						
Roberts	B	1626	$0.3545	$576.42	$134.06	$442.36
Hills	B	1494	0.32815	490.26	117.35	372.91
Heller	B	1747	0.28945	505.67	129.28	376.39
McIlvane	B	1560	0.3341	521.20	107.38	413.82
Ensign	B	1698	0.3928	666.97	147.73	519.24
Vogel	B	1647	0.3150	518.80	125.09	393.71
Forbes	B	1682	0.33885	569.95	132.12	437.83
Evans.........	B	1693	0.33735	571.13	137.39	433.74
Tobacco Station Farm.						
Roberts	D	1219	$0.21615	$263.49	$80.91	$182.58
Hills	C	1110	0.18975	210.62	64.10	146.52
Heller	D	1190	0.17185	204.50	67.95	136.55
McIlvane	D	1103	0.17755	195.84	63.08	132.76
Ensign	C	1230	0.22645	278.53	79.83	198.70
Vogel	D	1231	0.2053	252.72	82.42	170.30
Forbes	D	1143	0.1721	196.71	63.78	132.93
Evans	D	1095	0.18975	207.78	67.61	140.17

Hockanum Broadleaf Strain Tests of 1925.

The best test of the strains of the Hockanum type was at the Handel farm in Glastonbury where the Hockanum is said to grow at its best and where, on the Handel farm, it was very plainly better than the other types. Growth at the Station Farm was not as good as for the John Williams type. Sorting and pooling data are presented in Tables XIX and XX.

TABLE XIX. HOCKANUM BROADLEAF TESTS, 1925. PERCENTAGE OF GRADES.
(T = Tobacco Station. H = Handel Farm.)

Strain	L. W.		M. W.		Long Sec.		Short Sec.		Long Darks		Dark Stem.		No. 2 Sec.		Brk. and Flr.	
	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H
Cooley	0	22	0	28	8	17	0	2	18	22	23	0	18	4	33	5
Hamilton ...	0	10	0	16	9	22	0	2	13	24	38	12	18	7	22	7
Dunham	0	21	0	30	7	16	0	1	12	20	23	2	14	4	44	6
Horton	0	12	0	23	6	20	0	1	8	27	32	6	14	6	40	5
Herr	0	20	0	19	6	26	0	1	8	19	25	4	14	3	47	8
Geiselman ...	0	14	0	18	5	22	0	1	12	26	32	4	19	10	32	5
Hollister	4	9	0	14	15	27	1	2	12	24	24	10	13	7	31	7
Dusch	4	10	0	10	12	31	0	1	16	26	28	7	19	7	21	8

TABLE XX. HOCKANUM BROADLEAF STRAIN TESTS, 1925. POOL RATING, ACRE YIELD, PRICE PER POUND, AND NET RETURN.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Handel Farm.						
Cooley	A	1612	$0.6315	$1,017.98	$155.96	$862.02
Hamilton	B	1590	0.4255	676.55	139.36	537.19
Dunham	B	1485	0.58 ?	861.30	140.78	720.52
Horton	B	1832	0.4631	848.40	170.10	678.30
Herr	B	1544	0.5077	883.89	142.36	741.53
Geiselman	B	1711	0.4697	803.66	161.09	642.57
Hollister	B	1323	0.4332	573.12	117.68	455.44
Dusch	B	1354	0.43965	595.29	122.17	473.12
Tobacco Station Farm.						
Cooley	D	1242	$0.18615	$231.20	$78.99	$152.21
Hamilton	C	1191	0.1995	237.60	72.65	164.95
Dunham	D	1203	0.16625	200.00	67.91	132.09
Horton	D	1275	0.1584	201.96	67.83	134.13
Herr	C	1349	0.16605	224.00	71.77	152.23
Geiselman	C	1162	0.1801	209.28	67.86	141.42
Hollister	D	1156	0.2201	254.44	74.27	180.17
Dusch	C	1290	0.2421	312.31	87.91	224.40

Among the strains of this type are two which stand out as preëminently the best, viz., the Cooley and the Dunham strain. After the completion of the 1925 tests it was learned that these two strains have a common origin in the same lot of seed within recent years.

Bantle Broadleaf Strain Tests of 1925.

These tests were also conducted at the Tobacco Station and at the Handel Farm in Glastonbury. Sorting and pooling data are presented in Tables XXI and XXII.

TABLE XXI. PERCENTAGE OF GRADES IN BANTLE BROADLEAF, 1925.
(T = Tobacco Station. H = Handel)

Strain	L. W.		M. W.		Long Sec.		Short Sec.		Long Dark		Dark Stem.		No. 2 Sec.		Brk. and Flr.	
	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H
Bidwell	1	7	0	8	8	28	0	2	25	26	21	11	21	8	24	10
Lorenze	2	7	1	9	14	29	1	2	27	31	19	10	21	7	15	5
Bantley	3	15	3	19	17	22	1	2	27	29	19	4	13	3	17	6
Fox	0	14	1	19	14	24	1	1	24	21	22	10	20	4	18	7
Benton	3	13	2	17	19	24	0	1	19	24	24	8	13	6	20	7
Bantle	4	7	1	13	16	29	0	1	23	24	22	9	16	9	18	8
Hickey	2	23	0	18	15	17	1	1	21	24	25	8	15	2	19	7
Estrom	1	10	0	11	12	29	0	1	18	28	24	7	19	8	26	6

TABLE XXII. BANTLE BROADLEAF STRAIN TESTS, 1925. POOL RATING, ACRE YIELD, PRICE PER POUND, AND NET RETURN.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Handel Farm.						
Bidwell	B	1244	$0.39985	$497.41	$107.42	$389.99
Lorenze	B	1260	0.4163	524.54	113.72	410.82
Bantley	C	1454	0.4292	624.06	135.95	488.11
Fox	C	1415	0.4204	594.87	126.51	468.36
Benton	B	1412	0.4551	642.60	127.43	515.17
Bantle	B	1352	0.42535	575.07	120.26	454.81
Hickey	C	1263	0.4386	553.95	113.99	439.96
Estrom	B	1490	0.44065	656.57	136.41	520.16
Tobacco Station Farm.						
Bidwell	D	1140	$0.20635	$235.24	$ 81.66	$153.58
Lorenze	C	1152	0.26595	306.37	89.74	216.63
Bantley	B	1395	0.30265	422.20	106.86	315.34
Fox	C	1163	0.2476	287.96	86.06	201.90
Benton	C	1157	0.2686	310.77	82.61	228.16
Bantle	C	1183	0.2685	317.64	87.54	230.10
Hickey	C	1318	0.25445	335.36	94.10	241.26
Estrom	D	1209	0.2096	253.41	81.61	171.80

Barber Broadleaf Strain Tests of 1925.

These tests were conducted at the same places as the Bantle and Hockanum. Results are presented in Tables XXIII and XXIV.

TABLE XXIII. BARBER BROADLEAF STRAINS, 1925. PERCENTAGE OF GRADES. (T = Tobacco Station. H = Handel.)

Strain	L. W.		M. W.		Long Sec.		Short Sec.		Long Darks		Dark Stem.		No. 2 Sec.		Brk and Flr.	
	T	H	T	H	T	H	T	H	T	H	T	H	T	H	T	H
Liebler	3	8	1	15	15	21	0	1	21	32	20	6	14	9	26	8
Bachl	0	8	0	16	8	29	0	2	13	24	27	8	14	4	38	9
G. Smith	2	18	0	18	11	21	0	2	18	19	29	11	19	5	21	6
Hoffman	0	13	0	19	7	24	0	2	17	27	25	6	14	5	37	4

TABLE XXIV. BARBER BROADLEAF STRAIN TESTS, 1925. POOL RATING, ACRE YIELD, PRICE PER POUND, AND NET RETURN.

Strain	Rating	Acre Yield	Av. Price per lb.	Tot. Value per Acre	Sorting and Overhead	Net Return
Handel Farm.						
Liebler	C	1444	$0.3787	$546.84	$131.27	$415.57
Bachl	B	1590	0.4385	697.22	141.43	555.79
G. Smith	A	1882	0.55805	1,050.25	167.40	882.85
Hoffman	B	1652	0.4712	778.42	154.46	623.96
Tobacco Station Farm.						
Liebler	D	1296	$0.2312	$299.64	$90.85	$208.79
Bachl	C	1254	0.18375	230.42	72.52	157.90
G. Smith	D	1319	0.21185	279.43	89.03	190.40
Hoffman	D	1300	0.17425	226.53	77.61	148.92

IMPROVEMENT OF SHADE TOBACCO BY HYBRIDIZATION AND SELECTION.

D. F. Jones, P. J. Anderson and N. T. Nelson.

The testing of Cuban strains and hybrids which has been in progress under the direction of D. F. Jones in charge of Plant Breeding since the establishment of the Tobacco Station, has been continued during the season of 1925. Sixty-three strains were grown under cloth, including selections by Beinhart and Chapman, selections from a strain grown by Clark Bros. of Windsor, selections from imported Partidos and Vuelta Abajo seed, Big Cuban, resistant Cuban and various hybrids originated by Jones. As a check with which to compare these, every fourth row in the tent was set with plants from seed of a good local strain furnished by Mr. J. B. Stewart of Windsor. This is the strain which Mr. Stewart originally selected from imported Cuban seed and which he developed while in the employ of the United States Department of Agriculture and has carefully guarded by constant selection during the last twenty years. Each row was harvested separately. After bulk sweating in the usual way, all strains were sorted by an experienced sorter and complete records made on percentage of all grades and general notes on quality, burn, etc. Sample hands from the best three grades (L, LL, LV) were kept out and have been submitted to experienced judges of shade tobacco for their opinion. Since neither the sorting records and notes nor the opinion of the experts indicates that any of these strains is superior to the Stewart strain, there seems to be no object in publishing here the rather lengthy sorting records of these tests. These records are tabulated and filed at the Tobacco Station where they may be consulted by any growers or others who may be interested in them.

When the Cuban variety of tobacco now commonly grown in the Connecticut Valley was first grown under shade cloth here, it was found that it lacked the uniformity which the manufacturer desires and which is necessary to make the raising of this most expensive type profitable. There were too many plants which either yielded no leaves of the high grades or so few that there was no profit. The variety was made uniform or standardized by several years of selection and breeding from plants with a high record for production of better grades. Yet there are few shade growers who are satisfied that the strain they are growing is either as uniform or as good as they would like. Any shade grower can point out in his fields several types of plants. How many of these are genetic differences which will breed true? If they do breed true, which type will produce the highest percentage of good grades? Are some of these types inferior and responsible for a high percentage of the low grades which we would like to keep out of the sorting shop? These questions can be answered only by keeping separate records of the leaves from individual plants through the sorting, saving the seed of each one and keeping year after year the sorting records of the progeny. This involves a considerable amount of tedious work which very few growers care to undertake, especially since it comes in the very busiest season when they have little time to think of anything except getting the crop harvested.

Believing that there is a possibility for the improvement of the Cuban variety through this method of selection the writers began by keeping individual records on 1000 plants of the Stewart strain in 1925. Each priming of each plant was labelled permanently so that when the cured and fermented leaves came to the sorting bench it was possible to tell the plant from which every leaf came. After taking the sorting and sizing record of every leaf of the thousand plants, all the leaves from each plant were assembled and the product of each one of the 1000 appraised as a whole. The most promising of these individual plant selections will be grown and compared on the basis of their progeny performance record. Additional selections will be made within certain lines to test their uniformity and fixity of type.

The points for which we are selecting and which we hope to attain by this method are:

1. Larger number of L's per plant
2. Thinner leaves
3. Better shape
4. Better burn
5. Less prominent vein
6. Those other characteristics of the leaf which we group under the undefinable term "quality" but which are hard to separate and enumerate but are very evident to every experienced tobacco man.

Wide variations were found in the product of different plants. Contrasted with some plants which did not bear a single L were others with 10 L's. Some had thin leaves almost up to the top of the plant, others were thick throughout. The plants with thin leaves at the bottom suddenly becoming thick at about the 12th leaf predominated. Whether the exceptions are due to inherent differences in the seed or to place effect is the question on which the possibility of improvement by this method hinges. Not only were the best plants selected for further progeny test, but also some of the poorest plants. It was also found that quality in the cured product was correlated with certain observable differences in the field.

COVER CROPS FOR TOBACCO

P. J. Anderson.

It was stated in the introduction that there are no results as yet on the cover crop project since this was not started until the fall of 1925. However the cover crop problem is one which is the subject of considerable discussion at present, not only in the tobacco sections of New England but also in other parts of the country, and a brief statement of what the problem is and its present status seems worth while.

When the present generation of tobacco growers were boys, the planting of a winter crop on the fields was unknown. The fields were left bare from the time the crop was harvested until the next crop was set in June. With the beginning of the present century, however, there was a widespread movement, fostered largely by agricultural experts, for seeding the land each fall to some crop to keep the ground covered through the winter and spring. Within a few years this practice became quite general until it is safe to estimate that now more than half the tobacco land is seeded every fall. Probably ninety per cent of the crop is timothy, five per cent rye and the rest more unusual crops such as winter vetch, barley, oats, etc. The leguminous crops, other than vetch, have been used very little, probably because experience has shown that they do not winter well or they do not thrive on the acid tobacco land.*

A puzzling feature about this wholesale adoption of the cover crop practice is the entire absence of any published experimental data to show that the succeeding crop of tobacco derives any benefit from it. At least three reasons have been assigned for the use of these crops on tobacco land:

* The fact that some of them are known to be hosts of the black rootrot fungus has also had its influence against them.

(1) On light lands it prevents the land from blowing. This is probably correct to a large extent but it gives no reason for the use of a cover crop on some thousands of acres of land which rarely, if ever, blows.

(2) It holds nitrogen which would otherwise leach away and furnishes it to the next crop of tobacco. It unquestionably does take up nitrogen but whether this nitrogen is used to advantage by the succeeding tobacco crop is open to question.

(3) The reason most frequently given for the cover crop is that it adds a large amount of humus to the soil. It is doubtful whether many growers would take the trouble to put in cover crops except on some light "sand blows" if it were not for this last supposed benefit. This third reason is based on the assumption that the addition of organic matter is always *per se* a direct benefit to soil.

One also frequently hears it said by farmers that a cover crop adds nitrogen or other fertilizer elements to the soil. It is probably superfluous to point out that the cover crop returns to the soil only such fertilizer elements as it took from the soil in the first place and adds nothing to them, unless it be a leguminous crop such as vetch in which case it may add some nitrogen. The main element which it *adds* to the soil is *carbon* (derived from the air), concerning which we shall speak below.

Five years ago the writer had occasion, in connection with some black rootrot experiments in Massachusetts, to compare the effect of timothy cover crop and no cover crop on alternating one-quarter acre strips of land. This experiment was not planned to test the value of timothy as a cover crop but rather the effect of the timothy cover crop on black rootrot. It was assumed at the outset that the timothy would increase the yield or improve the quality of the tobacco—or both. When, however, the harvesting records of the plots were computed and compared it was a surprise to find that the most outstanding result of the whole experiment was the fact that the timothy had *reduced* the yield of tobacco. The experiment was continued for the two following years on the same plots and each year the depressed yield was observable in the field and measurable on the sorting bench. In a later, more comprehensive experiment on a different field at the Massachusetts Agricultural Experiment Station, J. P. Jones found that ten plots without timothy cover crops yielded an average of 165 pounds per acre more than ten adjacent plots with cover crops and that the quality was in about the same ratio.*

* Jones, J. P. Havana seed Tobacco as Influenced by Timothy Cover Crop. Mass. Agric. Expt. Sta. Circ. 73. 1925.

Such, in summary, is the experimental data on which our present estimation of the value of the timothy cover crop is based. In the absence of any conflicting data of scientific experimental calibre, the conclusion seems warranted that timothy not only does not benefit tobacco but is on the contrary detrimental, at least under the conditions of these trials.

In what way could the cover crop produce an injurious effect on the tobacco crop? The cover crop idea has been adopted with entire disregard of two fairly well known agricultural facts:

1. Certain crops do have an injurious effect on the succeeding crops.
2. Organic matter added to the soil is not always beneficial, but may be absolutely harmful.

Space is lacking to review the literature on these points but a brief statement on each may be worth while:

Influence of one crop on another. Almost a hundred years ago, DeCandolle began to experiment and theorize on the toxic influence of one crop on another showing that it was then recognized. Various other investigators, too numerous to mention here, have worked and theorized on the same peculiarity. Very conveniently, within the last year, there has been published a very comprehensive review of the literature of this subject and the theories as to the cause,* and the reader is referred to this publication, for further information. The principal theories advanced have been (1) the soil toxin theory, (2) the fertilizer exhaustion theory, (3) the plant pathogen theory. Although these experimenters do not decide which of these theories is responsible, their experimental work does show "that the tobacco plant is particularly sensitive to the effects of preceding crops and attempts to apply intensive methods, as turning under soil improvement crop freely . . . . are likely to fail. The growth of the tobacco plant may be seriously retarded as a result of the effects of preceding crops of tobacco itself or of various other plants." Although their results were not always consistent, they were not able to find that any of the cover or rotation crops could be depended on to improve the tobacco and that usually they were positively injurious. They found that the harmful factor was the roots of the preceding crops rather than the tops. This is rather significant to the farmers of the Connecticut Valley in view of the fact that the use of timothy as a cover crop has been urged because of the organic matter furnished by its unusually large root development.

But our tobacco farmers do not need such far away exper-

* Garner, W. W., W. M. Lunn, and D. E. Brown. Effects of crops on the yields of succeeding crops in the rotation, with special reference to tobacco. Jour. Agric. Res. 30: 1095-1132. 1925.

imental evidence to prove the sensitiveness of tobacco to a preceding crop. It is pretty general knowledge among growers that tobacco does not do well on a grass sod of the previous year. Neither the yield nor the quality is good under these conditions and most of the growers admit that they do not expect good tobacco the first year.* Yet by some obscure mental hocus pocus these same growers believe that the same grass crop when used as a cover crop will have a different effect from what it would if used as a rotation crop. If there is such a difference, its effect would probably aggravate rather than alleviate the ill effect of a grass crop.

Vegetable organic matter not always beneficial. It is a more recently established fact that the addition of plant materials with a high carbohydrate content such as straw, green manure, sawdust, etc., to the soil may materially depress the growth of following crops. It is therefore not at all safe for the grower to assume that he is improving his land by turning green manure crops into it. The experimental evidence on this problem has recently been reviewed by Collison and Conn† and new light shed on it by their experiments with straw. They find that plant residues incorporated in the soil have a harmful influence in two ways; (1) by giving rise to a toxic substance which acts deleteriously on the roots of the plants, and (2) by stimulating (by means of their carbonaceous energy-forming material) the growth in the soil of a class of organisms which require more nitrogen than the decomposing straw or plant residue can furnish and thus they deplete the soil of nitrates. If these principles hold true for the timothy cover crop on tobacco soils, then we may expect that the timothy not only does not furnish nitrogen to the tobacco plants, but that it produces effects which actually rob the plant of the nitrogen which is put into the soil in the fertilizer. They, and others, have found that the deleterious effect would be partially, at least, overcome by supplying sufficient nitrate in readily available form to supply both the plants and the denitrifying organisms. Thus the grower who uses a cover crop should add more nitrogen in his fertilizer than the one who uses no cover crop. If however, these plant residues have had a long time to rot, the effect gradually disappears; thus the growers previously memtioned, who find that they get better results by plowing under a grass sod in the fall and adding heavy applications of manure, are escaping the injurious effects of a cover crop plowed under immediately before setting the crop. In some experiments at

* Heavy applications of manure and fall plowing of grass sod have been found by some to overcome this, at least partially. The reason is explained below.

†Collison, R. C. and Conn, H. J. The effects of straw on plant growth. N. Y. (Geneva) Agric. Expt. Sta. Res. Bul. 114. 1925.

the Tobacco Station in 1925 it was noted on plots where some of the cover crop was plowed under on April 1 and the rest six weeks later that there was a remarkable difference in favor of the early plowed when no fertilizer was added. But on plots which were heavily fertilized the difference was not so noticeable. If the grower is going to use cover crops he will do well to plow them under early and give them abundant opportunity to rot before the tobacco is set.

In the Massachusetts experiments previously mentioned the writer found, on examining the roots of the tobacco, that those on the timothy plots were more seriously affected with brown rootrot. This is also confirmed by considerable observational field evidence showing that the timothy, whether in rotation or as a cover crop, "predisposes" the following tobacco crop to brown rootrot. Since however, we know nothing about the cause of brown rootrot it is hardly an illuminating explanation of the effect of timothy on tobacco, to say that is produces brown rootrot. Brown rootrot may be merely the expression on tobacco roots of the toxic effect of a preceding crop comparable to the effects of plant residues described by Collison and Conn on other plants.

This brief review shows how far we are from a solution of the cover crop problem. It was in an attempt to learn more about it that the cover crops plots were started at the Station in 1925.

BLACK ROOTROT AND SOIL REACTION.

P. J. Anderson and M. F. Morgan.

In 1908 Briggs* first called attention to the fact that the application of lime, wood ashes, alkaline fertilizers, or other substances which tend to make the soil alkaline, favor the development of black rootrot and that this disease, which had become very serious in the Connecticut Valley at that time, could be kept in check by avoiding such substances. He apparently did not measure the actual degree of acidity in the soils under experiment. Johnson and Hartman† in Wisconsin, and Chapman‡ in Massachusetts confirmed the general conclusion of Briggs that rootrot is favored by the application of substances which reduce the acidity of the soil. The former by plot experiments and the latter by field survey attempted to measure in terms of lime requirement the degree of acidity which is necessary to prevent damage

*Briggs, L. J. The field treatment of tobacco rootrot. U. S. Dept. Agr. Bureau Plant Industry, Cir. 7, 1908.

†Johnson, J. J. and Hartman, R. E. Influence of soil environment on the rootrot of tobacco. Jour. Agr. Res. 17:41-86, 1919.

‡Chapman, G. H. Tobacco investigations. Mass. Agr. Exp. Sta. Bul. 195. 1920.

from rootrot. Johnson and Hartman found the disease practically absent in soil with a lime requirement of 9.38 tons, considerable infection at 7.19 tons and heavy infection at 4.6 and all more alkaline soils. Chapman found heavy infection usually present in soils with a lime requirement of 3000 to 8000 pounds, but very little in soils either more acid than the 8000 pound requirement or less acid than the 3000 pound requirement. The latter finding is not in agreement with the Wisconsin results.

It has been mentioned previously in this report that most growers, constantly warned against the danger of using lime, wood ashes or carbonate of potash, have ceased altogether to use them. On the other hand there is good evidence both from experience of growers and scientific experiment that a moderate amount of all three of these substances is beneficial for tobacco. Many have decided that they have gone too far in the omission of alkaline substances and are returning to the practice of liming or using wood ashes. In some cases this has been attended with favorable results. In other cases the results have been disastrous in bringing on rootrot and rendering the land unfit for tobacco. More puzzling to the grower is the fact that the same application of lime on two fields may benefit one and ruin the other.

In the face of the fact that some soils apparently need these substances and others do not, how shall the grower know what practice to follow? Is there not some simple soil tests by which we may quickly determine what treatment a field should receive? It was in an attempt to answer this question, to find such a test, that the writers began the investigation now to be discussed. This investigation has been in progress only one year and is far from complete, but it seems advisable to make yearly reports of progress because we believe that the results already secured will be of benefit to the growers and because it is hoped that they will be in better position to coöperate with us in this work if they understand from the annual reports the purpose and progress of the investigation.

It is obvious from the work previously mentioned that lime, wood ashes and carbonate of potash do not directly affect the organism causing rootrot by furnishing elements of food or through a direct stimulating effect, but they merely reduce the acidity of the soil which would otherwise be detrimental to its growth or ability to attack the tobacco roots. In other words, damage from infection can occur only when the roots of the plant are in a soil the acidity of which has been reduced beyond a certain critical point. Just where is that critical point? To answer this question was the first and most important task of the investigation. First of all, the answer should be sought through a wide soil survey. It is planned to take and test for degree of acidity, soil samples from at least 1000 tobacco fields scattered throughout the Connecticut and the Housatonic Valleys, making

a record in each case of the presence or absence of rootrot on each field and the severity of infection if present. With this information before us we should be able to determine what correlation exists between rootrot and soil reaction. Incidentally it is also hoped that we may learn whether there is an optimum reaction for the growth of tobacco and where that optimum lies.

Since there are several methods of measuring and expressing soil reaction, we were confronted at the outset with the problem of deciding which one to use. The lime requirement method as used by Johnson and Chapman is subject to the objection that it measures amount of acidity and not intensity of acidity. It is reasonable to believe that the activity of the parasite varies with the intensity of acidity. The so-called "hydrogen ion" method was therefore selected. The concentration of hydrogen ions (active acidity) may be determined either electrometrically or colorometrically. The first is the most accurate but too laborious and time-consuming for the testing of such a large number of soils. Also it is questionable whether such extreme accuracy is essential in this work. The colorometric method was therefore selected and all samples during the season of 1925 were tested with the double wedge comparator of Stirlen and Wallace. This method is rapid and was considered sufficiently accurate for the field survey. All tests were made on fresh soils immediately when brought in. (It was found that if these soils were kept for several days and dried out before testing they gave a more acid reaction.) Tests were therefore made while the soil was fresh, after which it was dried and stored for different tests.

Hydrogen ion Method of Measuring Soil Acidity.

The following non-technical explanation is offered for the benefit of those unacquainted with the hydrogen ion concentration method.

A soil that is exactly neutral (neither acid nor alkaline) is represented by the figure 7; alkaline soils by figures above 7, and acid soils by figures below 7. The further away from 7, the more acid or alkaline it is; thus 5 is more acid than 6, 4 more acid than 5, etc.

Although the figures of the hydrogen ion scale are from 1 to 14, only a small part of this scale is used in measuring soils. Up to the present we have not found a tobacco soil more acid than slightly below 4 or more alkaline than 7.3. Figure 6 may help to visualize the important points on the scale.

The method of preparing the solution for testing was as follows: Test tubes were filled with distilled water up to a mark indicating 10 cubic centimeters. The soil after thorough mixing was then added to the water until it rose to the mark on the tube indicating 12½ cubic centimeters (4 parts of water to 1 of soil). After shaking thoroughly, the suspension was either centrifuged until fairly clear or permitted to stand until the supernatant liquid was clear. In many samples the water does not become clear, but

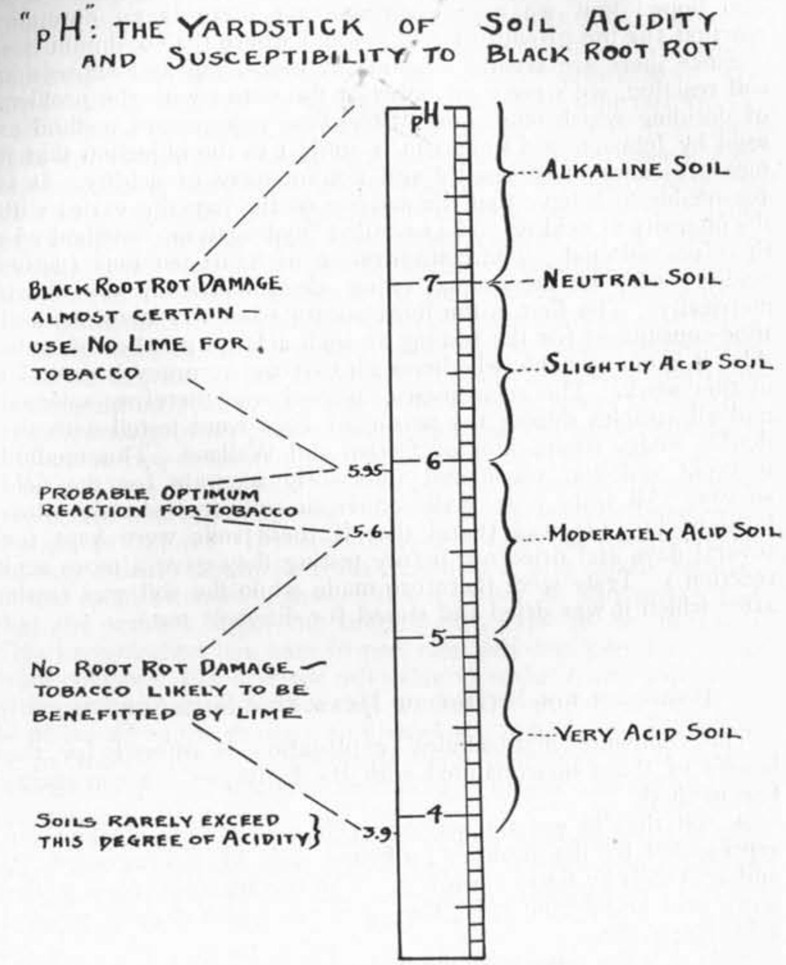

FIG. 6.—Black Rootrot in relation to Soil Reaction.

retains a murkiness which will not settle out for several days. This was particularly true of the less acid samples. The turbidity however, is compensated for by placing a tube of water without indicator in the comparator back of the double prism. Trials showed that the reaction was the same whether the solution was centrifuged at once, or permitted to settle until the next day. Two solutions were prepared from each sample—or more if the first two did not check closely. The indicators which were

found most suitable for this work were *brom thymol blue* at all ranges above 6.2, *brom cresol purple* from 6.2 down to 5.4, and *methyl red* below this. *Chlor phenol red* was used to some extent in the same range as *brom cresol purple*, but was not so satisfactory, especially in the upper half of the range. *Brom cresol green* gave results which were so clearly incorrect (possibly due to salt errors) that it was found to be worthless for this work and methyl red was substituted.*

STUDIES IN 1925.

Samples were taken and records of field history made as the writers had opportunity during the summer and fall of 1925. Conclusions can be drawn only from tests of old tobacco fields. New fields (1-4 years in tobacco) may have a high reaction and still not be seriously affected with rootrot. The same may also be said of old fields which were formerly very acid in reaction but have been limed heavily within the last year or two. Soil tests under such conditions might lead one to expect severe infection when really the crop is not appreciably injured. It is for this reason that one must know the past history of the field as regards lime and fertilizer treatment and use considerable judgment in selecting fields for data. Even when soil conditions are made favorable for rootrot, it seems to require from 1 to 3 years before serious infection is noticed. The first year after heavy liming is usually marked by increased growth and the injurious effects of an overdose become apparent only afterward. The black rootrot fungus (*Thielavia basicola*) is present to some extent in all tobacco fields. We have not yet seen a field where the roots were found entirely free from its lesions if enough plants were dug and the roots carefully washed and examined. The reason that more fields do not suffer severely from rootrot is that the soil conditions are not right for abundant propagation and infection. As soon as those conditions are made right (by liming, principally) propagation increases and becomes apparent in reduced yield after 1-3 years as mentioned above. In collecting the data, fields cannot be listed as "infected" and "not infected" because all are affected. They must be classified according to the degree of injury which is apparent on the parts above ground. This injury is measured by lack of growth and consequent reduced yield. For purposes of classification the degree of injury was designated as none, slight, moderate, heavy, and very heavy. In fields of the first class, no injury had been noticed by the grower. In fields of the last class the injury was so severe that the tobacco was not worth harvesting. If the field was uniform, only one composite sample was taken. If, however, there were some parts

* The method used is thus described in detail for the benefit of any who wish to compare results or to undertake similar work. Results can be compared only when the same method of procedure is used.

of the field which showed evidences of rootrot while other parts appeared normal, two or more samples were taken from the same field. A few samples were also taken from seed beds which were affected with rootrot. Data on uninfected beds are of little significance because most beds are sterilized and rootrot will not be found in them even when the soil reaction is apparently favorable for it. The 234 samples which were tested during 1925 were distributed among 17 towns of the Connecticut and Housatonic Valleys as follows: Amherst 26, Northampton 2, Hadley 7, Sunderland 15, Granville 7, Southwick 2, Suffield 4, Granby 11, Windsor 81, Bloomfield 20, Simsbury 6, Hazardville 15, Ellington 14, East Windsor 2, South Windsor 6, Manchester 1, New Milford and neighboring towns in Housatonic Valley 15.

A complete presentation of the data on these samples is too lengthy to include here. The data as regards rootrot and reaction are summarized in Table XXV.

Table XXV. Soil Reaction and Black Rootrot Injury. Summary of 234 Tests in 1925.

Reaction, pH	Number of Soils tested	Degree of damage from rootrot: None	Slight	Moderate	Heavy	Very heavy
Below 5.5	8	8	..	..	..	..
5.5 –5.6	11	11	..	..	..	..
5.6 –5.7	25	25	..	..	..	..
5.7 –5.8	56	56	..	..	..	..
5.8 –5.9	49	49	..	..	..	..
5.9 –5.95	23	23	..	..	..	..
5.95–6.0	5	1	4	..	..	..
6.0 –6.1	8	1	6	..	1	..
6.1 –6.2	7	1	2	4	..	..
6.2 –6.3	10	..	1	4	5	..
6.3 –6.4	7	..	..	1	6	..
6.4 –6.5	8	..	..	..	4	4
6.5 –6.6	3	..	..	..	2	1
6.6 –6.7	2	..	..	1	..	1
6.7 –6.8	2	..	..	1	..	1
6.8 –6.9	2	..	..	..	..	2
6.9 –7.0	3	1	..	..	..	2
7.0 –7.3	5	..	..	..	..	..
Total	234	176	13	11	18	16

An inspection of this table shows that:

1. The 68 samples taken from infested fields or beds all had a reaction of 5.95 or above.
2. The most severe infection was from 6.4 upward, i. e. those soils which are nearly neutral or slightly alkaline.
3. Of the 176 samples from fields which showed no injury, all but four were below 5.95. Lack of infection on these four may have been due to the fact that the reaction had been brought up to that point only within the last few years.

It is perhaps too early to draw definite conclusions because more extensive survey may reveal some fields which are not in agreement with those tested and because a different kind of season may shift the critical point upward or downward (since Johnson and Hartman show that soil temperature also plays an important role.) Results up to date indicate that the critical point between rootrot and safety is in the neighborhood of 5.95. We have yet to find a field suffering seriously from rootrot at a more acid reaction than this. Apparently the problem for the grower is to keep his soil below this point. How shall he do this? Fortunately, most soils in the tobacco sections are naturally more acid than this. In the Connecticut Valley the only cases of a more alkaline reaction we have observed were due either to heavy applications of lime or ashes or to location on heavy, low places in the field *into* which the alkaline elements leach from the other parts and *from* which the leaching seems to be very slow, thus resulting in an accumulation of alkaline substances. From the typical sandy tobacco soils the alkaline elements leach rather quickly, so that if applications of lime or wood ashes are avoided for a few years the soil naturally reverts to an acid condition. In the heavier soils where leaching is slower the case is not so simple. There is no fertilizer or other fairly inexpensive substance which can be applied to the soil to make it quickly acid comparable to lime for making soil alkaline. Large applications of sulfate of ammonia and sulfate of potash, however, will gradually produce an acid condition. The use of these salts in place of nitrate of soda or carbonate of potash is recommended in soils which are too nearly neutral, but rapid results should not be expected. It is perhaps best to avoid heavy, naturally neutral or nearly neutral soils for tobacco and on the lighter soils when the reaction is too high to avoid the application of alkaline substances.

However, it must be remembered that there is also a danger of getting the soil too acid. As previously mentioned, there is good evidence that lime, wood ashes and carbonate of potash are beneficial in tobacco culture. In fact it seems that the more nearly neutral a soil can be kept without incurring rootrot, the better the tobacco which is grown on it. In other words, the grower should attempt to keep it up as near 5.95 pH as possible without actually getting it above that point. Among the fields tested during 1925, there were many which had the reputation of producing the best tobacco in their respective neighborhoods and were selected for tests on that account. The larger part of these showed a reaction between 5.6 and 5.9 pH, the maximum number centering around 5.85. An occasional good field could be found as acid as 5.1 but on most of those below 5.5 the owners did not consider the growth satisfactory. Such fields would probably be benefited by applications of lime or wood ashes.

Soil conditions in the Housatonic Valley are somewhat different and need a few words of explanation. This part of the state is characterized by outcroppings of limestone and the soil is frequently called a limestone soil. One would naturally expect to find such a soil neutral or slightly alkaline, in which case it would not be possible to grow tobacco profitably on account of rootrot. Yet we know that good tobacco is grown in the Housatonic Valley. In order to see what the rootrot situation was there, the writers made a partial survey of the region about New Milford and tested the soil from 15 tobacco fields. The best tobacco fields were on the sandy terraces along the river and its larger tributaries, and the soil was no more alkaline than corresponding fields in the Connecticut Valley. Rootrot was causing no damage here. Other fields were located where there were outcroppings of limestone either in the fields or in such a position that there was direct wash from them into the fields. Such fields were suffering severely from rootrot and the reaction of the soil was found to be well above 6.0 pH. That more such fields were not found was probably due to past experience of the farmers which had taught them that tobacco could not be grown at a profit on these fields.

Many growers are interested in this problem and are anxious to know if lime may be safely used or if on the other hand an effort should be made to get their fields into a more acid condition. Soil samples may be brought or sent to the tobacco station for testing and while the number of pounds of lime to use can not be stated exactly, the test is sufficiently accurate to serve as a safe guide.

TOBACCO DISEASES OBSERVED IN 1925.

P. J. Anderson and G. P. Clinton.

The following paragraphs record only the observations the writers have made on the diseases prevalent in 1925. A more comprehensive bulletin treating of all the diseases will be published at a somewhat later date.

Brown Rootrot.

This is probably the least known of all the diseases of tobacco and yet there is no more important disease problem which confronts the Connecticut Valley tobacco grower. Scattered all over the valley are fields which once grew the best tobacco but which are now being rested or turned to other crops because tobacco will no longer grow there. The fields have become "tobacco sick" or

"run out." Many other good fields have patches of various sizes where the owner doesn't expect to make the crop pay. Some of these are cases of black rootrot, some are unexplainable, but the majority are brown rootrot cases.

The symptoms of brown rootrot as seen above ground in the field are the same as black rootrot, viz., slow growth, yellow narrow pinched leaves which wilt on hot days, premature topping

FIG. 7.—Brown rootrot "patch" in an otherwise good field of Havana seed. 1925.

out resulting in undersized plants and dead yellow tobacco when sorted. When the roots of such plants are washed and examined, many of the smaller ones, especially at the very base of the stem, are found to be dead and brown. There are no black segments of roots or enlarged rough black lesions such as one finds in the case of black rootrot. The stunted growth above ground is apparently caused by the destruction of so many of the roots with consequent starvation of the plant. Later in the season when the new roots are developed from the stalk, the dead lower roots are not so much in evidence.

The greatest gap in our knowledge of this disease is our ignorance as to the case of it. If we sufficiently understood the cause, it would probably not be so difficult to find some method of preventing it. In contrast to black rootrot, no one organism has been found associated with it. Yet there is some evidence that it is caused by an organism, although the responsible one has not been isolated. The fact that it can be prevented by sterilizing the soil with steam or formaldehyde lends support to this view since such treatment would be expected to kill the causal organism. Yet it is quite possible that such sterilization may have other effects on the soil. The fact that the disease can be prevented by spreading the soil out in a thin layer and aerating it for two weeks would be very unusual for a disease caused by the attack of an organism, since we are not acquainted with any pathogenic organisms which can be destroyed by such a mild measure. We know that certain preceding crops or cover crops have considerable influence on its prevalence. The writer has shown, in experiments in Massachusetts for instance, that timothy used as a cover crop favors brown rootrot. Hence there are those who see in brown rootrot only a crop effect. This might operate, but it could be only one of the operating factors at best since we have many fields where rootrot affects only small patches but the whole field has been cropped alike for many years. Up to the present, no practical remedy has been found. Cover crops should be avoided. Also nothing will be gained by "resting" the land to timothy for a few years, as has been tried by some. It will do better in continuous tobacco. The reaction of the soil seems to have no influence as we have observed during the soil tests of 1925. Growers have also learned from experience that application of additional fertilizer does not help it.

In view of the seriousness of the situation and the little progress that had been made in finding a way to combat it, a combined attack on the problem was planned in the spring of 1925 by representatives of the United States Department of Agriculture, the Botany Department of the Agricultural Experiment Station and the Tobacco Station. Field plots for this investigation were located on a badly affected lot in Poquonock. It was planned that these plots should be continued for at least three years. This is being supplemented by laboratory and greenhouse tests. The experiments have not progressed to a point which warrants a report at this time.

Other Diseases in 1925.

Wildfire. The first case of wildfire in the seedbeds seen by the writer was on May 1. No other case was found for two weeks and even as late as May 30 only ten cases had been reported in the Connecticut Valley, although hundreds of beds had been examined. In comparison with previous years, seed bed infection was thus rather light. More developed during the first two weeks of June. A few cases were found in the Housatonic Valley during the second week of June. First cases in the field were found at about this same time. From this time on, more and more cases were found in the field until their number was surprisingly large in consideration of the light seed bed infection. It was a season of pretty heavy rainfall in most tobacco sections and it was feared that many of the crops would be ruined. Happily such was not the case. Not only were there no crops ruined—as the writer has frequently seen in recent years—but the amount of wildfire in the harvested crop has been almost negligible as far as we have been able to judge from visiting a considerable number of sorting shops and from many reports.

The unexpected behavior of wildfire during 1925 will be interpreted by some as an indication that this disease is losing its virulence. Such may be the case, but it would be dangerous on such an assumption to neglect any precaution against it in 1926. This year may witness a virulent epidemic.

Some growers tried field spraying with Bordeaux mixture where the infection was serious and believed that they gained a measurable degree of control, but the data are not so convincing in view of the fact that it was not very serious even in the unsprayed fields when the tobacco was cut.

At this point it is well to repeat that every effort should be made to keep it out of the beds since this is the most vital point of attack. It has now been pretty well demonstrated that the wildfire germs do not winter in the soil, but that the principal source of spring infection is the tobacco shed where they winter in infected leaves or on the dry floors. From here it is carried to the beds on tools, feet of workmen, sash, boards, or may be blown. Every precaution should be taken to prevent such transfer of the germs. If the beds are very close to the sheds the grower should be careful to hang any wildfire tobacco he may have in the other sheds or move the beds so that they will be further away from the sheds. The most important measure in control of wildfire is the spraying or dusting of the beds. Some prefer the dust and some the liquid spray. Either will control the disease if it is regularly and thoroughly applied. After having had experience with both, and watching their operation in the hands of practical growers for four years, we are inclined to recommend spraying with home-made Bordeaux mixture as easiest, safest and cheapest. We know of few growers who, after trying both, have not come to the same conclusion. If the stock solutions are made up beforehand, it is not very much work to spray twice a week and keep the plants healthy all the time. There is no stunting of the plants, no dust-burn; other diseases are also controlled as well as flea beetles. Any growers who have not had experience with Bordeaux mixture and contemplate using it should send to the Tobacco Station for full directions for preparing it. A member of the staff will be glad to visit as many growers as desire in order to demonstrate methods of preparation and application.

Extreme care should also be taken not to set plants from a bed which has wildfire. A diseased plant has only about ⅓ as many chances of living when set, as a healthy plant has—not to mention the later effects of spreading the infection in the field.

Dust burn and Fertilizer burn. Dead spots on the leaves of plants in the beds resulting from the application of copper lime dust or of strong fertilizers such as nitrate of soda or fish were unusually common during the spring of 1925. The fertilizer burns may be prevented by care in washing the fertilizer off the leaves with water after application. The conditions which cause dust to burn in some cases and not in others are not so well understood. In some cases, at least, it is caused by putting the glass back on immediately after dusting wet plants and keeping the copper in solution for a long time.

Paris green burn. This injury was prevalent in many fields when the poison bait against cutworms was applied directly on the plants. It produces round dead spots of various sizes in the leaves. Frequently the grower confused it with the lesions of wildfire but the characteristic yellow halo of the latter spot was absent.

Angular leaf spot (Blackfire). This bacterial disease, which is considered more destructive than wildfire in the South, has not proved of serious import in New England. Anderson first reported it in Massachusetts in 1922 but it caused no serious damage at that time. It was also observed during the same year in Connecticut by Clinton but has been reported only once since until 1925 when several rather serious cases were observed. It produces numerous dead spots, commonly somewhat angular, on the leaves. Although there is some yellowing about the margins of the spots, it does not develop the broad definite halo of the wildfire spots. One of the worst cases seen was in the Station Broadleaf field. Many of the lower leaves were worthless when sorted. The effect on the cured leaf is just the same as that of wildfire. It is to be hoped that this disease is not destined to increase and become as destructive as it is in the Virginia and Kentucky districts. There is some basis for believing that the disease will not be serious here since attempts to inoculate plants have failed.

Hollow Stalk. This disease, also caused by bacteria, was found in a few fields but the damage in the aggregate has not been large. It appears first after topping and reduces the pith of the stalk to a wet black rotten mass which later shrivels and dries, leaving the stalk hollow. The lower leaves also become affected,

the midribs become black and they sometimes rot off at the stalk and drop away. The cases observed have not been sufficiently widespread to warrant special control measures.

Bed Rot. (Damping off) This disease is present every year and may affect the plants in any stage of growth in the beds. The worst cases observed during the past year were after the plants were well grown and almost ready to pull. Large patches in the beds were rotted completely off. These bad cases were invariably in beds which had been sowed too thick. When the plants get large the leaves are so tight together that there is no circulation of air, resulting in a constant state of high humidity around the bases of the stalks at the surface of the ground. Such conditions are ideal for the development and rapid spread and infection of the fungi which cause bed rot. No experiments have been undertaken on this disease during the year, but it has been found that beds which are kept thoroughly sprayed from the first are rarely affected with bed rot. The disease was checked in some bad cases by thoroughly ventilating and drying out the beds. Steam sterilization is advised and does much to prevent it from starting, but some of the bad cases of the year were in sterilized beds. We have never found bed rot in beds which were properly sterilized, ventilated, sprayed, planted not too thick and not overwatered. After the plants have developed to the stage when the stem is hardening there is little danger from bed rot.

Oversterilizing beds. Several cases came to our attention during the year where injury was apparently caused by too intensive or too long steaming. In one case a grower sterilized for about two hours at 120 lbs. pressure. He was unable to make tobacco plants grow at all on this soil. Another grower with an acre of beds sterilized some in the fall and the others in the spring. All were on the same kind of soil and all treated alike in every other way and seeded at the same time. The fall-sterilized beds were entirely satisfactory. In the spring-sterilized beds the seeds were said to have sprouted all right but they became thinner every day and probably 80% of them died before they were half grown. No evidence of disease could be found on those which died. Although the evidence all indicated that the damage was due to steaming, an experiment was begun during the last week of May by way of confirmation. One of the beds where the loss had been the heaviest was worked up again. One part of it was then steamed again, one was treated with formaldehyde and the third part was untreated. From another part of the bed the soil was removed and new soil put in. All were then reseeded with the same lot of seed as had been used before. The seed sprouted normally on all, but the plants became thinner day by day on the steamed part until soon there were hardly any left. The stand remained very thick on all the others. Since there was a good stand in the part which was not sterilized, it was apparent that the injurious influence of the early spring steaming had now passed away. The grower had waited at least ten days after sterilizing the first time before sowing, but apparently the injurious influence was of longer duration in this case.

Mosaic. "Brindle" was present in about the usual amount in all parts of the tobacco sections. Some unusually virulent cases occurred about Middletown in the extreme south end of the tobacco country. In some of these fields fully 95% of the plants were diseased. The effect on the plants was also unusual. The leaves were not merely mottled with areas of darker and alternating lighter green as in the ordinary case. The younger leaves especially were distorted and wrinkled and the dark green areas stood out like huge blisters from the surface. The leaves looked like peach leaves affected with the parasitic leaf curl. The growers stated that they had not noticed the disease in the beds. One attributed its virulence to a heavy application of nitrate of soda made shortly before the disease became so prominent. Just why it should be so exceptionally virulent in the fields in that particular neighborhood this year is difficult to explain.

Frenching. This disease, characterized by narrow but heavy strap-like chlorotic leaves, was formerly confused with mosaic and the leaves do frequently have a mosaic character. The number of leaves is also usually increased, especially in the upper part of the plant. Very little of this disease was noticed during the summer in the Connecticut Valley, but a few fields in the Housatonic were found to be rather seriously affected.

Lightning Injury. On account of the frequent electric storms during the early growing season, in the field a number of cases of lightning injury occurred. Some of these which were observed by the writer were three or four rods in diameter. Usually all the plants in the center were quite dead and around this a zone of stunted and deformed plants, the degree of injury gradually diminishing with the increasing distance from the center. When the dead plants were examined a slender cavity was found in each corresponding to the pith. When the marginal plants were allowed to grow they made a one-sided deformed growth.

Injury from tarvia fumes. One grower was very much puzzled at a peculiar injury to his plants along the side of a macadam road. When first examined the leaves had a glistening, varnished appearance. After a few days, parts of the leaves died, the dead places being either marginal strips or irregular areas between the veins. A thorough investigation of the case showed that it had been induced by fumes blowing on to the plants from tarvia which was being spread in a hot condition on the road with a tarvia "sprinkler." Although there were tobacco fields on both sides

of the road, no injury occurred on the side from which the wind was blowing when the "sprinkler" came along.

Curly dwarf. This rare and peculiar disease was again found in fields around Windsor Locks where it had been found in previous years by Mr. Slagg. The plants are very much stunted in growth, the leaves are distorted and wrinkled, and set very close together. The whole aspect of the plant reminds one more of a cabbage or cauliflower. The plants are worthless. Fortunately the disease is confined to a very small locality and a very small percentage of the plants in a field are affected. The cause is entirely unknown.

Yellowing from fertilizer leaching. Shortly before harvesting, it became apparent to anyone who travelled the tobacco section very extensively that something was wrong in a great many of the fields. The growth was not all that it promised to be early in the season. More particularly it was noticeable that the leaves on the lower part of the plant were "yellowing." There was also more than the usual amount of spotting, particularly in the broadleaf. After the tobacco was cured this same condition resulted in a high percentage of dead, yellow and double color tobacco which was very largely responsible for the disappointing quality of the 1925 crop. Most of the tobacco sections had very heavy rains during the middle of the growing season and, without having absolute proof for our conviction, we are inclined to believe that these rains were responsible for the later yellowing by causing loss of the nitrogen through leaching. If these rains had been followed immediately by rather heavy applications of quickly available ammoniates such as fish and nitrate of soda, it is probable that a great deal of this injury could have been prevented. When, however, the grower waited until the symptoms of nitrogen shortage were visible, it was so near harvest that he feared to stimulate growth by application of extra fertilizer at that time.

Physiological Spotting of Broadleaf. Soon after the heavy rains of midseason, large brown dead spots began to develop in the broadleaf to an extent which caused alarm to many of the growers. Since no organisms were found associated with these spots, it seems likely that they were of physiological origin. The most characteristic kind of spot was the "star and crescent" spot, characterized by a small round dead area encircled incompletely by a slender curved dead line. The whole "star and crescent" varies in size, from a quarter of an inch to two inches across. Various other irregular shaped spots occur among them. These spots are quite different and distinct from the little round white spot characteristic of the John Williams type of broadleaf. The writer has noticed in previous years that these spots frequently come soon after heavy rains but the connection between the two is not plain. No method of preventing these spots is known.

TOBACCO INSECTS OBSERVED IN CONNECTICUT IN 1925.

W. E. Britton and P. J. Anderson.

The following pages include our observations of insect injuries to the tobacco crop during the season of 1925. Some of the chief features were the unusually severe outbreak of wireworms, which caused great injury, the prevalence of cutworms, flea-beetles, seed-corn maggots, and a new form of injury caused by the larvae of a crane fly. Most of the field observations of the past season were made by the junior author, but these have been supplemented by records, identifications and illustrations from the Department of Entomology of the Station in New Haven, and this paper is the joint effort of both authors.

Wireworms.

The first reports of wireworm trouble came to the Tobacco Sub-station on May 25. During the next two weeks, numerous reports were received and the junior author visited a number of infested fields, some of which were near the Tobacco Sub-station so there was abundant opportunity to keep in daily touch with the situation. On June 2, the epidemic was at its height, but the extremely hot weather of that week caused the wireworms to go deeper into the ground, so by June 15 it was hard to find one except by digging down deep under the rows. No reports after that date came to our attention. The most severe cases observed were on plantations of shade-grown tobacco, though many cases were also reported in outdoor tobacco fields.

One grower of shade tobacco had 84 acres under cloth, and 40 acres of newly-set plants were ruined. All of it was reset once, much of it twice, and some of it three times. At the second resetting, the wireworms appeared to be just as thick as at the time of the first resetting. On some of his fields, 95 per cent of the plants were dead when the junior author first saw them. The stalks were completely riddled with tunnels, as shown in Figure 8. Usually one or more wireworms still remained in the stalk, and from three to six others could be found in the soil close around each plant, but in some cases the numbers ran up to 18 and even 24 wireworms per plant. Apparently, all had been attracted to the plants and were gathered immediately around them, and only rarely could one be found in the soil between the rows.

The writers visited this field on June 2, in company with Dr. Philip Garman, Assistant Entomologist of the Station, and some of the wireworms were collected and taken to the laboratory in New Haven. Many adult click beetles were observed resting

upon the cloth, both inside and outside the tent. They were not known to be connected with the wireworms but it was suspected that they might be the adult stage, and some of these also were collected.

The writers together visited the field again on June 5, when it was found that most of the wireworms had disappeared by going deeper into the soil. Some wireworms could be found by digging for them, but very few were seen around the plants or near the surface. Adults on the cloth were also less numerous than on

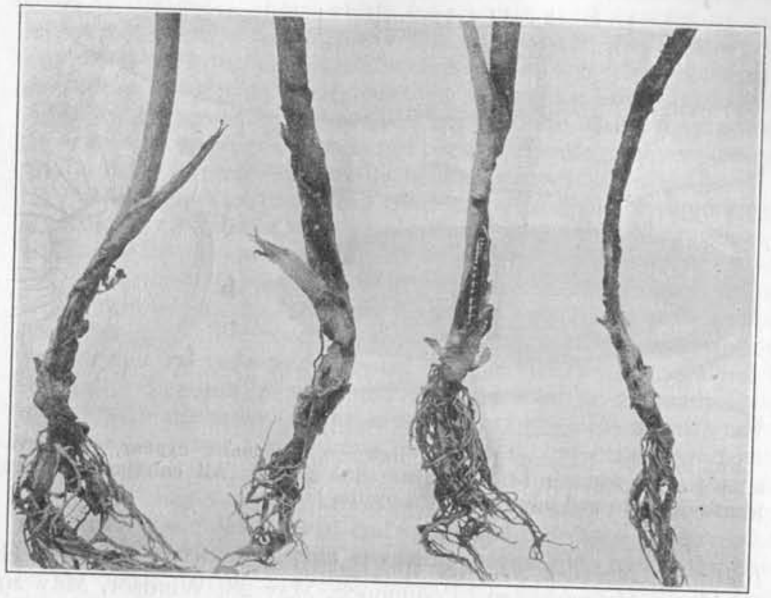

Fig. 8.—Injury to young plants by wireworms, natural size.

June 2. When one of the fields was plowed late in the fall, wireworms were observed near the bottoms of the furrows.

Identity of the Species: Mr. B. H. Walden, Assistant Entomologist of the Station, examined the wireworms and identified the species as *Limonius agonus* Say, by comparison with some named material in the collection and this identification was afterward confirmed, and the adult beetles pronounced the same species, by Mr. J. A. Hyslop of the Bureau of Entomology, at Washington, D. C. The general appearance of both wireworms and adult beetles is shown in Figure 9. Mr. Hyslop visited East Windsor Hill in 1917 and found this species, which he calls the eastern field wireworm, causing considerable damage to newly-set tobacco, though the attack was much less severe than this 1925 outbreak.

We also have material from Hockanum, July 1, 1920. Little is known about the life history of the eastern field species or the length of the wireworm stage. With other kinds according to species, this stage may require from two to six years.

Though perhaps *Limonius agonus* is the most common wireworm attacking tobacco in Connecticut, we have other material in the Station collection identified by Mr. Hyslop and bearing the

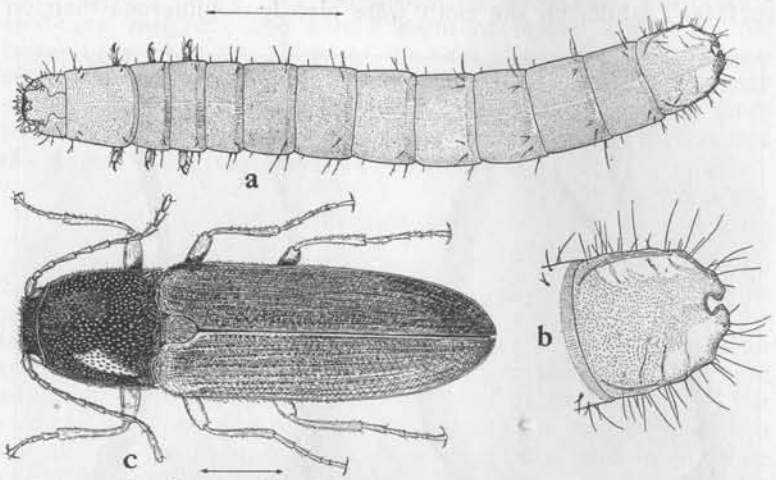

FIG. 9.—The Eastern Field Wireworm, *Limonius agonus,* a. larva; b. posterior segment of larva; c. adult beetle. All enlarged. Natural length of larva and adult indicated by the lines.

following records: *Asaphes* sp., Portland, June 12, 1906, B. H. Walden; *Melanotus* sp., Poquonock, May 28, Windsor, May 29, 1921, E. H. Jenkins.

All wireworms are the grubs or larvae of click beetles, which form the family Elateridae, of which there are nearly 100 different species occurring in Connecticut.

CONTROL OF WIREWORMS.

Probably no group of insects has so baffled the tobaccco grower as has the wireworms. For most of the tobacco insect pests and diseases some partial or complete remedy has been found, but before the wireworms the farmer has been helpless. No remedy was known. When the wireworms came, he had his choice of abandoning the field, or part of the field, for that year, or restocking every few days until the worms were driven down by hot weather. Since frequent restocking results in objectionable differences in maturity at harvest and considerable financial loss, many

prefer to harrow the whole field and reset with the setter. In cases of bad infestation, however, it is frequently necessary to repeat this operation several times before an even "stand" is secured. Wireworm infestation is not equally severe every year. Some years they cause little or no damage; the next year may see an epidemic. Growers have noticed, however, that there is a tendency for them to appear in cycles. If they are injurious on a certain field or part of a field, it is probable that they may occur in the same place the following one or two years. Only rarely is a field equally infested throughout. More often the damage occurs in spots which may cover several acres or may be no more than a rod across. When the wireworms are numerous in the soil, the plants die within a few days after setting; in fact they frequently never recover from the initial wilt after setting. If, however, wireworms are few, the plants may not die at once but remain stunted and sickly. Some recover entirely and make a normal but usually belated growth.

Various remedies have been tried in the past, but without signal success. Fall plowing is frequently recommended but growers who have made careful tests of this method report that it has given no relief. One prominent grower, who considers the wireworm problem as the most serious with which the tobacco farmer has to contend, informed the writers that one of the most serious infestations he ever had was on a lot which he had plowed in the fall. The use of camphor dissolved in wood alcohol and mixed with the water in the setter barrel has also had its advocates, and a few claim to have had success, but others who have spent hundreds of dollars for camphor and alcohol state that the total result has been the repelling of wireworms for a few days with subsequent return and destrûction of the crop. Many other substances such as turpentine, various soaps, etc., have been used in the setter barrel and still have their advocates but none of them stand the test when the infestation is serious. Others have tried soaking potatoes or corn in mercuric chloride, formaldehyde, Paris green and other poisons. Wireworms are attracted by these baits which are soon riddled with their tunnels, but they are apparently not killed. Failure may be due either to the extreme resistance of wireworms to such poisons or to the fact that the poisons do not penetrate the baits. At any rate, this method has not been generally successful. Growers sometimes think that the methods they employ are successful because the worms disappear very soon after some remedy has been tried. It is very easy to be misled, however, because of the peculiar habits the wireworms have of disappearing as suddenly as they came. When the soil warms up sufficiently they dig deeper into it and leave the plants on which they have been feeding. If this migration into the deeper soil happens to coincide with the time the grower applied some remedy, he is prone to believe that the remedy has been successful, although it may have had no effect whatever. This habit of the wireworms also probably explains why during some years there is no wireworm injury, since the soil warms up earlier some seasons than others.

EXPERIMENTS AT THE TOBACCO SUB-STATION.

Carbon disulfide; On June 2, Dr. Garman and the writers made a carbon disulfide soap emulsion in the setter barrel and applied it to rows which were being reset. Two rates of application were used; first, one part of carbon disulfide to 360 parts of water, and, on other rows, one part to 720 of water. Three days later it was found that the stronger mixture had killed all the plants, and the weaker mixture had failed to kill the wireworms.

Calcium cyanide: Another remedy suggested by the entomologists was calcium cyanide compound, or "Cyanogas," a poison which had been used in other parts of the country against wireworms in beans and other vegetables. The method used by the bean growers in California is to sow a bait crop of split beans, or other inexpensive seeds, in the field before it is time to plant the main crop. The wireworms from all sides congregate in these seeds and plants. The Cyanogas is then drilled into the soil along the row of infested plants and the fumes kill the wireworms. At our request the American Cyanamid Company of New York, manufacturers of Cyanogas, sent one of their experts to Windsor to investigate the situation and to aid in testing the toxicity of Cyanogas against the tobacco wireworm and in working out a practicable method of using it. Unfortunately at the time Mr. Rice, their expert, arrived, on June 11, the epidemic was subsiding and extensive field experiments were out of the question. Some experiments on a small scale, however, were made to test the toxicity of Cyanogas on the wireworms and the effect it had on the plants. Such experiments seemed essential as preliminary to field experiments, which it is hoped will be tried in the season of 1926. Some of these may be briefly described.

Toxicity to wireworms: When a wireworm is placed in direct contact with Cyanogas, it dies within a minute or two, but in the soil it is seldom that many come into direct contact with the poison. In order to see how the fumes would pass through the soil, 24 wireworms were distributed in the soil of a box one foot square. A small teaspoonful of the cyanide was then buried at the center of the box about three inches below the surface. Eighteen hours later the soil was sifted and 21 of the worms were dead, while three of them were barely able to move.

With the idea that the enclosing walls of the box might have some effect, the next test was carried out in the open field. Eighty

wireworms were distributed in the soil of a row of plants, eight feet long. A thin line of cyanide was then drilled in the row two inches deep. Two days later the row was dug up but only 60 of the wireworms could be found. All but three were lifeless and these three were very sluggish. This soil was not screened and it is not always easy to find them in the open field without screening. Undoubtedly more of them could have been accounted for by more careful search, but some may have been far enough away to escape the fumes and have crawled away.

In a third test, Mr. Rice distributed 140 wireworms in a narrow box ten feet long and a foot deep and wide, and then set a row of plants in the center. After a few days, when the wireworms were working well in the plants, a thin line of cyanide at a rate calculated to equal 100 pounds per acre, was drilled two or three inches deep along the row. Then after a few days the soil was sifted, but only 60 of the wireworms could be found, all of which were dead. The box was thought to be tight enough to prevent escape of any wireworms, but the soil and water had warped it so that there were cracks large enough for them to escape, which they probably did before the application of cyanide was made. Not a live wireworm was found in the box.

Effect of Cyanogas on tobacco plants: When the cyanide is placed directly in contact or even very near a tobacco plant, it wilts and dies within a few hours. It is therefore not possible to use it directly on plants which one wishes to save, but of course when the plant is affected with wireworms, one does not wish to save it. The important question is: how soon after applying the cyanide to a soil will it be safe to set the plants? In order to test this, a row of cyanide was drilled in at the rate of 100 pounds per acre. After four days a part of the row was set with plants, directly over cyanide. An additional part was set each following day until the row was all set at the end of ten days. All were watched carefully for any signs of wilting, stunting, or other injury, but all grew alike into strong healthy plants. Apparently four days was ample time in this test for the toxic effects tc pass out. It should be mentioned, however, that in this test there was a *heavy rain* during those four days which may have had some effect in dispelling the toxic substances. Experts of the American Cyanamid Company recommend seven days before setting.

Another important question to be answered is: will the cyanide have any effect on the quality of the cured leaf? In order tc test this, four rows of Havana seed tobacco were set where cyanide at the above mentioned rate had been applied six days before. Four alternating rows were set at the same time, but where no cyanide had been drilled. Throughout the season the tobacco was watched for any differences in growth but none were apparent. The rows were kept separate at time of harvesting and sorted separately. No difference in quality could be seen at time of sorting. Neither were there any differences when burn tests were made.

From these preliminary tests we may conclude that:

1. Calcium cyanide is highly toxic to the wireworms not only when in contact but is able to kill them through several inches of soil.

2. Most of the wireworms during the danger season congregate in or very close to the plants, leaving the more distant soil almost uninfested.

3. Although Cyanogas kills tobacco plants when first put near them in the soil, its toxic effects disappear within a few days and it is safe to set plants there at least within a week or possibly sooner.

4. Cyanogas seems to have no injurious effect on the quality of the cured leaf.

Suggested Method of Application: Pending more extensive field trials we are not yet ready to give unqualified recommendation to the cyanide method, but it is by far the most promising method which has been tried. We make the following suggestions for those who are troubled with wireworms and are willing to try something, even though success has not been fully demonstrated, rather than to do nothing and see their fields ruined. The average grower will not do anything until he finds his plants already infested. When this stage is reached it is hopeless to try to save any of the plants in the infested area. It is best then to drill the Cyanogas into the row as deeply as can be conveniently done with the least disturbance of the soil. For this purpose the writer has found a Planet Junior hand seed drill very convenient. Other drills of similar construction and on which the outflow can be regulated may be used. For more extensive work a larger drill operated by horses such as a corn drill or a fertilizer attachment on a tobacco setter could be used. Cyanogas is a fine powder which does not lump and flows freely from the drill. All the plants which remain in the row will be killed along with the wireworms. A week later the plants may be set in the same row. This method has the disadvantage of delaying the final setting of the plants. Another method is to bait and kill the wireworms before the field is set in the first place. This may be done by drilling corn or other seeds in the field ten days before ready to set and then killing the wireworms which gather in the row by the method mentioned above. If the grower is uncertain as to whether his soil is infested with wireworms, he may find out by planting a few rows of corn across the suspected places and see whether or not wireworms attack it. It is not necessary to wait until the corn comes up, since it will be attacked within a few days if the wireworms are there. If it has an abundance of tobacco plants, the grower may find it best to set these as the bait crop. It has also been suggested that the bait rows be

located somewhat to the side or between where the final rows will be set. In this way the cyanide may be applied and the final setting made immediately afterward without a week of delay. Yet another method may be used on fields where infestation is not severe enough to warrant replacement of the entire stand. If there is only an occasional plant affected, the grower may make a hole beside each affected plant with a dibble or a stick, insert a half teaspoonful of Cyanogas and close with dirt. After a few days the field may be restocked with safety.

The Tobacco Sub-station will be glad to coöperate with any growers who wish to try these methods and to learn of results obtained by the use of Cyanogas.

Cutworms.

Cutworms cause more or less injury each year in tobacco fields and were unusually troublesome in 1925. They are the larvae or

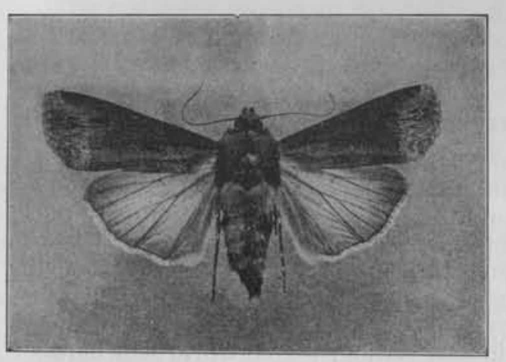

Fig. 10.—Moth of the black cutworm. Natural size.

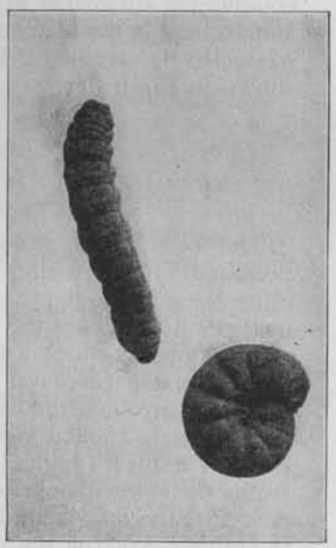

Fig. 11.—The variegated cutworm. Natural size.

caterpillars of certain species of Noctuid moths, a dozen or more different species having been recorded as causing injury. Though the different kinds have varying habits and life histories, with most of them there is one annual generation, the eggs are laid on grass, weeds or other plants in late summer, and the larvae hatching from them feed upon the smaller weeds, grass and other vegetation of the field, becoming about half-grown on the approach of cold weather, going into the ground, or under rubbish to gain protection during the winter. When warm weather arrives in spring and vegetation begins to grow, they emerge from their winter quarters and resume feeding. When the land is plowed, the weed growth is turned under and the cutworms have difficulty in finding food and accumulate great appetites. Consequently they are all ready and waiting for a full meal, and proceed to take it as soon as the plants have been set. Their attacks necessitate a great deal of resetting followed by a lack of uniform maturity at harvest time.

Cutworms do their feeding at night and hide during the day, usually curled up just beneath the surface of the soil, where they may be found by hunting for them around the base of injured plants. The adult moths are mostly grayish or brownish to black in color and also fly and lay their eggs at night and rest during the day in protected places on barns, fences, trees, etc. One of the commonest cutworms in tobacco fields and vegetable gardens in Connecticut is the black cutworm, *Agrotis ypsilon* Rott., the adult of which is shown in Figure 10. The variegated cutworm is shown in Figure 11.

CONTROL OF CUTWORMS.

The best growers now control cutworms by the use of a poisoned bait consisting of a mixture of Paris green with some diluent such as brand, hominy feed, or middlings. There are two methods of applying the mixture: (1) on the row at the time of setting, and (2) broadcasted before setting. Those who applied it broadcast beforehand seem to have been more successful this year in controlling the cutworms. This is to be expected because if the bait is applied at time of setting, the cutworm will hardly leave its natural food, a tender plant, and seek the dry bait. Consequently many plants will be eaten and must be replaced. If, however, the bait is applied beforehand to the bare ground there is nothing else for the cutworm to eat, and it will naturally be attracted to the bait, and should be killed before the crop is set. In order to test the two methods side by side, alternating plots were treated by each method and the number of plants destroyed by cutworms was recorded. Unfortunately, this field proved to be one of the few in the Connecticut Valley which was not seriously infested with cutworms even where no bait was used. The final results were all in favor of the application before setting, but since the infestation was very slight on the untreated plots, the results were not very convincing. The mixture used in these tests was made as follows:

Bran (1 bag)	100 lbs.
Paris green	5 lbs.
Oranges or lemons	½ doz.
Cheap molasses	4 qts.
Water ....about	15 gals.

The amount of water to be used must be determined by the condition of the mixture. Enough must be added to make the bran stick together in small lumps so that it can be broadcasted by hand, but not enough to "puddle" it. The bran and Paris green were first mixed dry by shoveling over, as one mixes fertilizer on a platform. The oranges were cut into very small pieces and mixed with the water and molasses. After thoroughly stirring, the sweetened water was sprinkled over the bran in order, while shoveling, to mix thoroughly. The mixture was broadcasted on the field just before night, several days before the tobacco was set. The oranges and molasses are said to attract the worms to the poisoned bran.

FLEA-BEETLES.

The cucumber or potato flea-beetle, *Epitrix cucumeris* Harris, often causes injury to newly-set tobacco plants, and even afterwards the large leaves are frequently eaten. Flea-beetles usually attack the under surface of the leaves, where they eat away portions of the tissue, giving a spotted appearance. The injured spots become dry and drop away, leaving holes through the leaves as shown in Figure 12. Sometimes the beetles feed upon the upper surface with similar results.

In most tobacco growing regions, particularly southward, such injury is caused by the tobacco flea-beetle, *Epitrix parvula* Fabr., but in all the collections made from tobacco plants in Connecticut only *E. cucumeris* was obtained and so far as we know, *E. parvula* has not been recorded from Connecticut.

The cucumber or potato flea-beetle is about one-sixteenth of an inch in length, black in color, with rear legs enlarged and fitted for jumping. It also has wings and can fly. It is shown in Figure 13.

The junior author in 1925 made an interesting observation on the ability of the beetles to distinguish between the different kinds of tobacco. In the shade tent at the Tobacco Sub-station, there were under experiment a large number of selections and hybrids of Cuban tobacco. During the summer it was noticed that the beetles gathered on one particular row, a hybrid near the center of the field. After the tobacco was cured and this hybrid came to the sorting bench, it was found to be so riddled with small holes that it was not worth sorting. This was the only row on the whole field which was severely injured, and rows on either side of it showed hardly a trace of flea-beetle injury. Apparently there was some factor in the make up of this hybrid strain which was attractive to them, or perhaps it lacked some principle which in the other strains was repellent to them. We have not seen any references in tobacco literature to this selective taste of flea-beetles

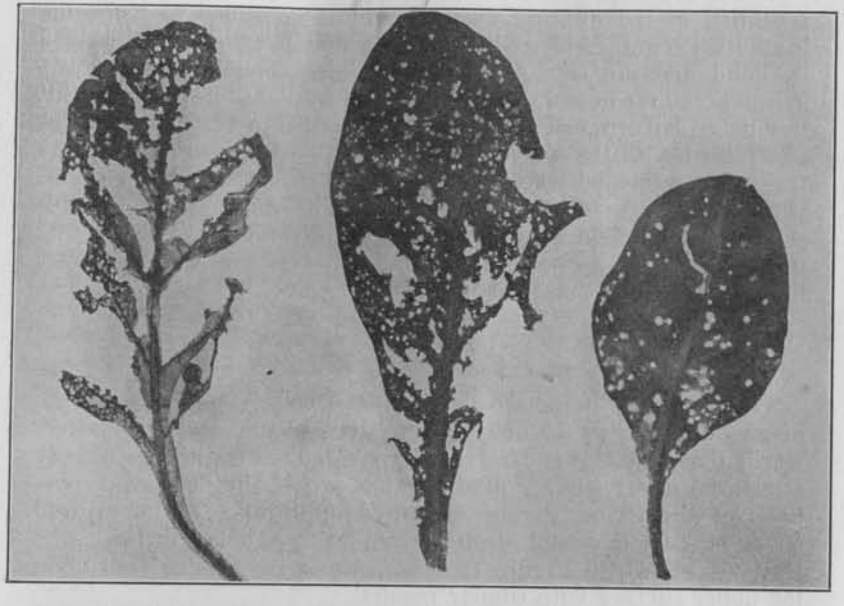

FIG. 12.—Lower tobacco leaves injured by flea-beetles.

for different kinds of tobacco. One grower of long experience states, however, that he has previously noticed this peculiarity. The worst cases of flea-beetle injury on the grown leaves which we have seen this year were on the edges of fields immediately adjacent to potato fields. After the potato tops died the beetles swarmed upon the tobacco and ruined the outside rows.

There is some question about the best method of controlling flea-beetles. In potato fields, they are kept in check by heavily spraying both upper and under sides of the leaves with Bordeaux mixture and lead arsenate. In the Station experiments many years ago, it was found that tobacco plants as well as tomato and cabbage plants could be dipped, root and leaf, before setting, into a mixture of lead arsenate, one pound in 10 gallons of water. This caused no injury to the plant and flea-beetles did not injure the leaves which were dipped. In the senior author's garden in 1925, one day when using a nicotine spray, it was noticed that

some tomato plants were being injured by flea-beetles. The plants were sprayed with nicotine (Black Leaf 40, 2 teaspoonfuls in a gallon of water with an inch cube of laundry soap dissolved

FIG. 13.—The cucumber flea beetle *Epitrix cucumeris*. (After Chittenden, Bureau of Entomology, U. S. Department of Agriculture.)

and added) and there was no further trouble. It is probable that all of the treatments mentioned act chiefly to repel the beetles instead of killing them.

THRIPS.

Thrips have never been considered among the serious insect pests of tobacco in Connecticut, but are said to cause severe injury in tobacco sections of the south. However, a number of cases were seen in Connecticut during the year, and there is an impression among the growers that they are becoming more prevalent each year in certain sections of the valley. Most, but not all, of the cases which came to our attention were in shade fields. It has also been observed in Florida that shade tobacco is more seriously affected than the sun-grown crop. This may be due to the fact that heavy rains do not beat them off under the shade cloth, as may be the case outside. It is said that they are worse during dry seasons and are partially kept in check by heavy rains. At the Tobacco Sub-station, the most serious infestation was on Havana seed, adjacent to the tent tobacco. The symptoms appear on the lowest leaves, and then slowly on the successively higher leaves. In this case, none were observed as high as the middle of the plants, and damage was confined to the first few leaves. In the field the veins of the affected leaves have a silvery appearance which makes them stand out from the remaining green tissue of the leaf. The insects work along the main veins on the upper leaf surface. Close examination shows the silver lines peppered over with tiny black specks. The insects themselves are not so often seen as are their effects. They are slender, brown, very small (about one twenty-fifth of an inch long) and when disturbed jump and disappear like fleas. Badly affected leaves turn yellow and may die prematurely. In the cured leaf, the veins are still more conspicuous, and the average sorter calls it "white vein" without recognizing the difference between this and the ordinary "white vein" which usually occurs on leaves higher up, and which is of a physiological origin. Close examination, however, will show the distinctive tiny black specks and a rather irregular outline to the veins.

As we have made no collections of thrips from tobacco plants, we cannot identify the species attacking tobacco in Connecticut, but hope to obtain such information next season. *Thrips tabaci* Linde. is said to injure tobacco in Europe, but though it is a common pest of onions in Connecticut, so far as we can learn is not a tobacco pest in the United States.

Up to the present, thrips have not seemed to be of sufficient importance to warrant special control efforts. Attention is called to them at this time in order that growers will be on their guard and may know them if they should become serious. We have no reason to believe that they will become more prevalent.

The Garden Springtail.

Tobacco plants, as well as the young seedlings of many vegetable plants, are often attacked and injured in the seed beds by the garden springtail, *Sminthurus hortensis* Fitch. The individuals are extremely abundant near the surface of the soil when

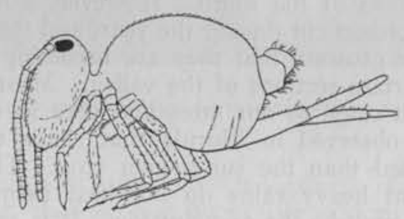

Fig. 14.—The garden springtail. Outline profile. This insect is purple with pale yellow irregular spots. Enlarged about 40 times.

the plants are coming up and eat very small holes in the leaves and enlarge the wounds made by flea-beetles and other insects. In fact, large areas of young seedlings are destroyed by the springtails, each year before their presence is noticed by the owner. They are scarcely more than a millimeter in length and it takes twenty of them end to end to reach an inch. They are dark purple, spotted with yellow, and jump like fleas so that it is almost impossible to catch them. Each has a globular shaped body with a rather large head and narrow neck. From beneath the body extends a forked tail-like appendage by means of which

the insect is able to throw itself. See Figure 14. Seed beds in Silver Lane, East Hartford, were infested in 1925. There were four beds each about 100 feet long and covered with cloth, and containing broadleaf plants from one-fourth to one-half inch high when attacked. All the beds were invaded and some had hardly any plants left. The junior author visited this plantation and also saw another less severe case in Simsbury. This insect caused much injury to vegetable seedlings in Pine Orchard in 1922 and 1923. The garden springtail can doubtless be controlled by dusting or spraying the seed beds with nicotine.

The Seed Corn Maggot.

Tobacco plants are occasionally injured by small white maggots which enter the stems just below the surface of the ground. Sometimes only a pin hole is visible, but often a larger injury is apparent. On cutting into the stem, one or more white mag-

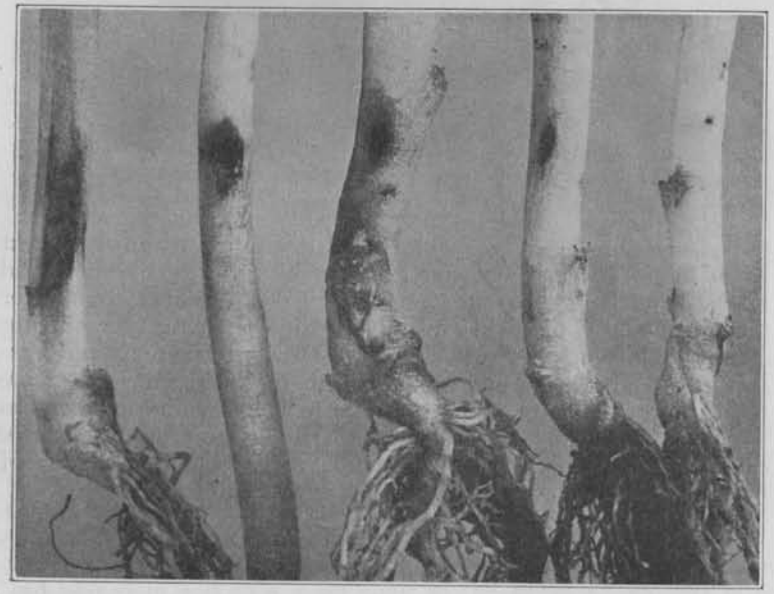

Fig. 15.—Stems of newly-set tobacco plants, showing injury by seed corn maggot. Twice enlarged.

gots may be found and sometimes the entire stem has been hollowed out by their feeding. Injured plants are shown in Figure 15. The insect responsible is a small two-winged fly, *Hylemyia cilicrura* Rond., shown in Figure 16, with its brown cocoons or puparia in Figure 17. Serious injury to tobacco caused by this insect occurred in Windsor in 1921, particularly on a portion of the field where clover had been plowed under in the spring, and some 40 acres under cloth had to be harrowed and reset. This insect is liable to be abundant following heavy applications of stable manure.

During the first week in June, 1925, Mr. C. A. Huntington, a shade grower of Windsor, brought to the Tobacco Sub-station a handful of young plants, the stalks of which were riddled with

Fig. 16.—Adult of seed corn maggot. Four times enlarged.

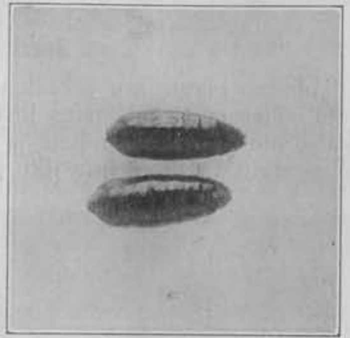

Fig. 17.—Pupae of seed corn maggot. Four times enlarged.

tunnels, somewhat resembling those made by wireworms, but when the stalks were cut open, small white maggots were found in the tunnels. These maggots attacked the plants soon after they were set in the field and killed many of them, necessitating considerable work in restocking. A week later they had disappeared completely, but in a visit to the field on June 5 we found a few puparia and were able to identify the invaders as seed corn maggots. No other report of damage from this source came to the Tobacco Sub-station this year. Apparently it is of unusual occurrence and does not cause widespread injury.

Tobacco Plants Injured by Crane Fly Maggots.

The authors visited the shade field of Mr. Huntington of Windsor on June 5, and while hunting for seed corn maggots, found many "leather jackets" or crane fly larvae near the surface with an occasional pupa case protruding from the soil. Many plants were also observed with notches eaten in the stems, causing them to break off, that did not seem to be the characteristic injury of the seed corn maggot. The crane fly maggots

were often found near the plants, but were also present half way between the rows; in fact they were distributed quite uniformly over a portion of the field. On account of their abundance in that particular section of the field where the injured plants were found, we began to wonder if there might not be some connection. Mr. Huntington believed these maggots to be the cause of the trouble, and stated that so many plants were killed that it was

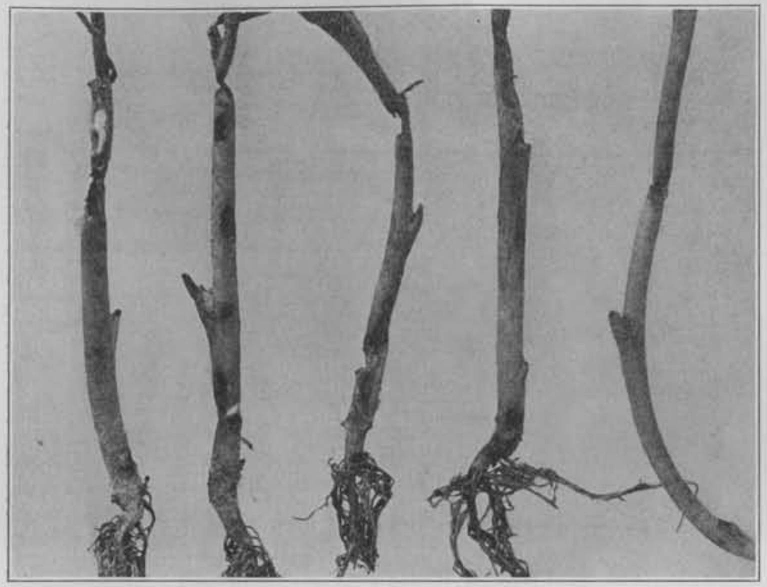

Fig. 18.—Injury to plants by crane fly larvae. Natural size.

necessary to harrow and reset certain parts of the field. Here the soil contained considerable undecomposed organic matter which may have served to attract these insects. A few adult crane flies were also collected from the cloth on the tent and from a tobacco barn close by. Before leaving the field, we collected about 30 of the larvae, which were taken to New Haven and placed in soil in a cage sunk in the ground. In this cage were set some uninjured tobacco plants. Three days later two of the plants had holes eaten in the sides of the stems like those observed in the tobacco field, and shown in Figure 18. On September 9, adult flies emerged and have been identified as *Nephrotoma ferruginea* Fabr., by Professor Charles P. Alexander of the Massachusetts Agricultural College, Amherst, Mass. These crane flies proved to be identical with those collected from the cloth of the tent and from the tobacco barn, and belong to the family Tipulidae. The maggots are tough and leathery in texture, gray in color, about an inch in length with four curious protuberances at the head. There is probably a generation each

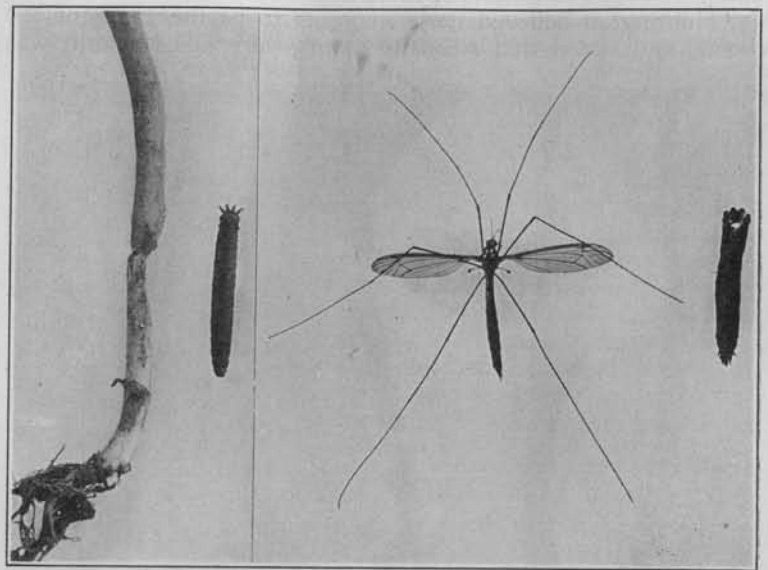

FIG. 19.—Adult crane fly, larva and pupa skin. Natural size.

year, and Figure 19 shows the maggot, pupa case, adult and injured plant.

According to the Insect Pest Survey Bulletin for July, similar injury to tobacco by crane fly maggots was observed in Hadley, Mass., by Dr. H. T. Fernald late in June of the past season. So far as we are aware, these are the first records of damage to tobacco by crane fly maggots, at least in this country. No control measures can be recommended at this time.

TOBACCO WORMS OR HORN WORMS.

Horn worms are the larvae or caterpillars of sphinx moths, also called hawk moths or hummingbird moths, which are found feeding on tobacco and tomato leaves during July, August and September. They are called horn worms on account of the single horn, which is only a fleshy protuberance on the back near the

tail. When fully grown, they may be nearly as large as one's finger, between three and four inches in length, and have the appearance shown in Figure 20. They then enter the ground and transform into curious "jug-handle" pupae shown in Figure

FIG. 20.—Tobacco worms. Natural size.

21. There are two species in Connecticut, the northern tobacco or tomato worm, *Phlegethontius quinquemaculata* Haworth, and the southern tobacco or tomato worm, *Phlegethontius sexta* Johansen. The pupa of the northern species has the longer "jug-handle," and both are shown in Figure 21. The northern species is the more common in the tobacco fields north of Hartford, though the southern species is more common in the vicinity of New Haven. Horn worms are highly parasitized by small four-winged wasp-like insects and it is not unusual to find them covered with white cocoons as shown in Figure 22. In such cases the horn worm dies without transforming, but never before the crop of parasites has been brought through to maturity. It is uncertain whether more than one generation occurs in Connecticut, but if so, the second is not distinct from the first, and larvae of all sizes are often found in the field at the same time late in the

season. The adult moths have large heavy bodies with long narrow wings which expand between four and five inches as shown in Figure 23. They fly just at dusk, lay eggs singly on the tobacco plants and sip nectar from deep throated flowers by means

FIG. 21.—Pupae of both species showing difference in length of tongue cases. Northern species at the right.

FIG. 22.—Young tobacco worm bearing cocoons of parasite.

of the long tongue which is coiled up like a watch spring under the head.

Hand picking is the common remedy in Connecticut, but in southern tobacco fields spraying and dusting with lead arsenate is commonly practiced.

GRASSHOPPERS.

Grasshoppers caused some damage to tobacco in 1925 by eating large holes in the leaves. They were especially prevalent along the margins of the fields which were adjacent to grass or other vegetation, upon which they feed. They were not of sufficient importance to warrant special control measures.

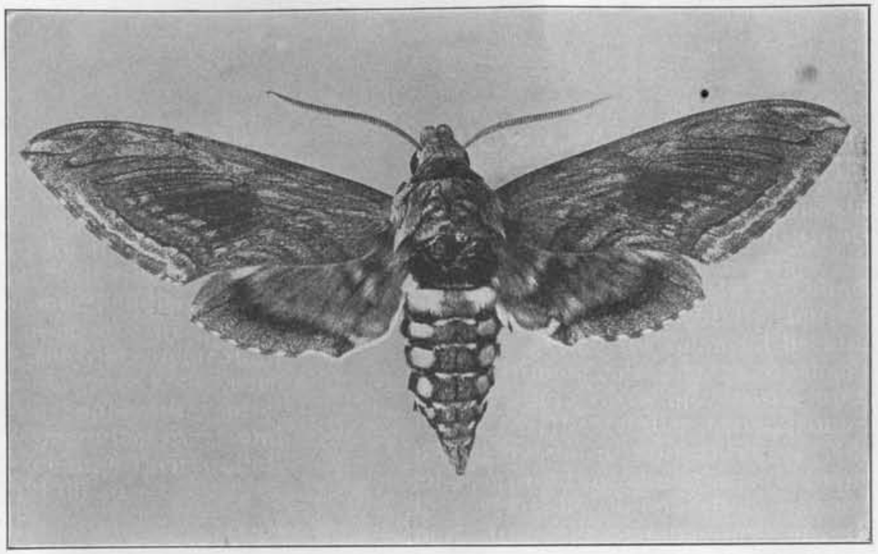

FIG. 23.—Moth of Northern tobacco worm *Phlegethontius quinquemaculata* Haw.