Bulletin 478 February, 1944

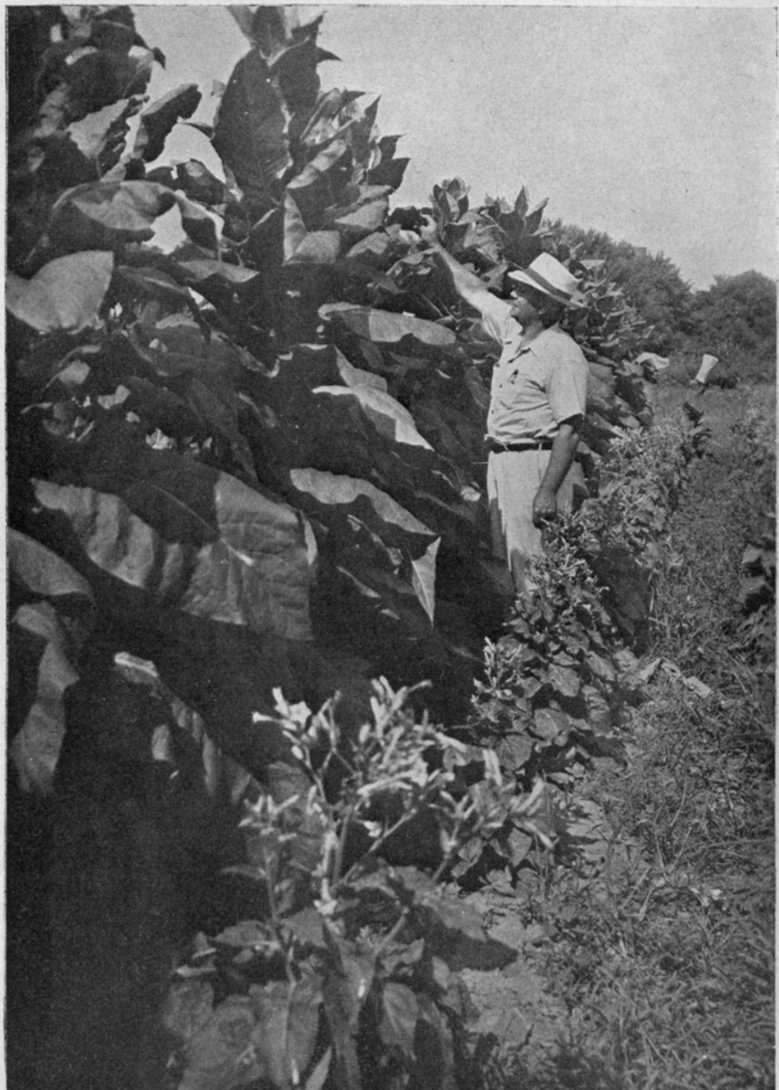
TOBACCO SUBSTATION AT WINDSOR

REPORT FOR 1943

P. J. Anderson
T. R. Swanback and S. B. LeCompte, Jr.

Connecticut
Agricultural Experiment Station
New Haven

CONTENTS



Tobacco breeding. Giant Broadleaf on left; Dwarf Shade on right.

Tobacco Substation at Windsor

REPORT FOR 1943

P. J. ANDERSON, T. R. SWANBACK AND S. B. LECOMPTE, JR.

THE Twenty-Second Annual Report of the Tobacco Substation at Windsor, is presented according to statute, to acquaint growers with the progress of experimental work on tobacco during the calendar year of 1943. In this, our second year of the war, tobacco growers have had to contend with many difficulties and restrictions.

Located in one of the most congested war implement centers of America, with the able young men in the armed services, with the older men and many women lured away by high wages of war industries, the grower could hardly find laborers enough to grow and harvest the tobacco crop. He paid high wages for inexperienced help, and the cost of all materials and tools he needed increased enormously. For example, Shade growers paid as high as $95 a ton for charcoal—four or five times the usual price. Then a ceiling price at which he could sell tobacco was set by the Office of Price Administration at Washington. This price was 40 cents a pound for Havana Seed and Broadleaf tobacco in the bundle, with a top price of 49 cents for sorted Broadleaf. Most of the tobacco was sold at, or near, the ceiling price. Most of the Broadleaf was sold in the field before it was harvested, for the first time since World War I days.

The increased cost of production and the scarcity of labor resulted in a reduction in acreage, as shown in Table 1, where the production of 1943 is compared with that of 1942 and also with that of the decade, 1932—41.

TABLE 1. ACREAGE AND PRODUCTION OF TOBACCO IN THE CONNECTICUT VALLEY FOR 1943 AND 1942, AND A TEN YEAR AVERAGE [1]

Type	Acreage			Production in pounds		
	Average 1932-41	1942	1943	Average 1932-41	1942	(Estimated) 1943
Broadleaf	7,690	6,800	6,300	11,937,000	10,344,000	10,028,000
Havana Seed	6,860	7,600	6,700	10,941,000	12,716,000	11,335,000
Shade	6,170	6,100	6,300	5,941,000	5,644,000	6,340,000
Total	20,720	20,500	19,300	28,819,000	28,704,000	27,703,000

[1] Data supplied by the New England Crop Reporting Service, December 24, 1943.

The war has cut off the supply of cigar wrappers grown in Sumatra and Java—formerly used to wrap a third or more of our cigars—and the supply that was stored in this country is now almost exhausted. This has resulted in an increased demand for domestic wrappers. All grades of Shade tobacco are in good demand at satisfactory prices. Another result of the wrapper shortage has been the revival of "priming" Havana Seed, a former practice which had become all but obsolete in the Connecticut Valley. How many acres were primed in 1943 has not been determined, but there were at least some hundreds. Also, some fields were planted to Roundtip tobacco to be primed for wrappers. This type had not been grown here for about 20 years. Finally, this effort to get more wrappers has developed some demand for the "light wrapper" grade of stalk-cut Havana Seed. In recent years this grade had been used entirely for binders.

A cold late spring delayed the starting of plant beds at least two weeks. The transplanting season was also delayed, but favorable weather in the early part of the summer pushed the plants ahead so fast that they were about up to the normal stage of development by the middle of the summer. Rainfall (see Table 2) was adequate, but with no serious leaching rains, up to the middle of July. From that date on, however, it became very dry and continued so throughout the summer. The fall was the driest in recent years. Some late crops of the open field tobacco and the late primings of Shade suffered from this drouth. The curing season was so dry that there was practically no pole rot in the sheds and very little charcoal was used in the curing of Havana Seed or Broadleaf. However, the dry curing season caused much of the tobacco to cure with white or prominent veins. A number of local hail storms caused damage to the open field tobacco, but except in a few small areas, the damage did not result in complete loss of the crop.

TABLE 2. DISTRIBUTION OF RAINFALL IN INCHES AT THE TOBACCO SUBSTATION, WINDSOR, 1943

		By 10-day periods	By months	Average for preceding 21 years
May	1–10	1.61	4.89	3.46
	11–20	1.77		
	21–31	1.51		
June	1–10	1.06	3.53	3.89
	11–20	1.49		
	21–30	.98		
July	1–10	.46	2.94	3.70
	11–20	.86		
	21–31	1.62		
August	1–10	.62	1.61	3.99
	11–20	.84		
	21–31	.15		

Work at the Station was curtailed somewhat by the war stringency and lack of help. Satisfactory progress was recorded, however, in most of the experiments. Very few new projects were started but all the old ones were continued as far as it was advisable to do so. Progress reports on some of them are given in the following pages.

One addition was made to our research staff. In our report for 1942, it was explained that the U. S. Department of Agriculture found it necessary to transfer Mr. Morrill, the entomologist who was assigned to investigate tobacco insects at Windsor, to another branch of the Department. This left us without an entomologist in 1942. In the spring of 1943 Dr. Douglas E. Greenwood, formerly of the New York Agricultural Experiment Station, was employed by the Entomological Department of the Station and assigned to the investigation of wire worms of both tobacco and potatoes. He is devoting all his time to this project.

The project on breeding of Shade tobacco has been actively continued in cooperation with the Shade Growers' Association. The field tests were located again on the plantation of the Imperial Agricultural Corporation in Windsor and the writers take this opportunity to express their appreciation for the splendid, efficient and generous cooperation of this company. The object of this project has been to develop a better type of Shade tobacco. After extensive breeding and selection trials in the first years and elimination of all but the most promising types, tests have now been narrowed down to two or three strains which appear to be quite superior to the ordinary Shade type. For testing on a somewhat larger scale, seed of the most promising type will be distributed in small amount to all Shade growers who wish to try it in 1944.

The phosphorus field tests are being continued now in the fourth year and are furnishing strong evidence that we will no longer be dependent on European supplies of this element.

In the following pages will be found a further report on the organic meal field tests, the results of which are giving an unexpected explanation of the differences in appearance of tobacco grown on different meals.

The articles on "plowing the fertilizer under" and on "timing the fertilizer application" present some data that may upset our long-standing ideas on these subjects. Further experiments on successful control of downy mildew are recorded. Fusarium Wilt, a disease of tobacco new to Connecticut is described. Finally the reader will find an article describing further evidence on the cause of "black" color in Shade tobacco.

THE RELATIVE EFFICIENCY OF NITROGEN IN OIL SEED MEALS

T. R. Swanback

"Cottonseed base" is the popular term used to describe most of the tobacco fertilizer mixtures sold or used in Connecticut. This term means that the bulk of the mixture is cottonseed meal, which also furnishes the greater part of the nitrogen. This has been the standard formula for over two generations, has given satisfactory results and undoubtedly has contributed much to the excellent reputation which Connecticut Valley wrappers and binders enjoy in the cigar trade.

From time to time vegetable residues from the manufacture of other kinds of oil have been tried as fertilizer substitutes for cottonseed oil residue. Castor pomace, residue of castor oil extraction, appeared as a competitor soon after cottonseed meal became popular. Linseed meal, from the linseed oil industry, has given satisfactory results but has not been used so extensively as a fertilizer because of its scarcity, high price, and its popularity as an animal feed. Most recent of all is soybean oil meal which is now produced domestically in enormous quantities.

These other meals were substituted on the assumption that a specified quantity of nitrogen in the fertilizer, regardless of which organic meal it is derived from, should produce the same quantity and quality of tobacco. This assumption, however, was not vindicated either by the experience of growers or by a ten-year field plot trial, at the Windsor Experiment Station. In other words, these meals when used to furnish the same amount of nitrogen, produce effects on the tobacco different from those of cottonseed meal. For example, most growers believe that castor pomace produces tobacco of a darker cast and heavier texture. This effect is particularly evident on the heavier types of soil but is not so noticeable on the sandy fields where nitrogen leaches more easily. The same effect, but less pronounced, has been reported for soybean meal.

Why these puzzling differences? The first hint of an explanation was furnished by a series of soil nitrate tests conducted here from 1932 to 1937 on plots where single sources of nitrogen were compared.[1] On each plot a single material furnished nitrogen at the rate of 200 pounds to the acre. Once a week during the growing season, the amount of nitrate in the soil of each plot was chemically measured in order to determine the rate at which each nitrogenous material broke down into a form which the tobacco plant could absorb. Averaging all weekly tests between June 1 and August 25 for the six years it was found that castor pomace maintained 39 per cent more nitrate in the soil than cottonseed meal during the growing season. A similar computation for soybean oil meal for three years, 1935—37, showed that this maintained 37 per cent more nitrate in the soil than did cottonseed meal. Since the greater part of the nitrogen that enters the tobacco plant is absorbed as nitrate, it is apparent from the soil tests that the tobacco on the castor pomace and soybean oil plots was fed at least a third more nitrogen than the tobacco on the cottonseed meal plots. Such luxury feeding of nitrogen could readily account for the darker color and heavier texture of the castor pomace and soybean plots. Thus, in other experiments here[2] it has been shown that an excess nitrogen ration, even though mostly from cottonseed meal, produces darker leaves of heavier texture. In other words, castor pomace and soybean oil meal are more efficient in making their nitrogen available to the tobacco crop. This extra efficiency has been disregarded in making up formulas and here was a possible explanation of the undesirable effects of these meals.

[1] Street, O. E. Nitrate nitrogen and soil acidity production by nitrogenous fertilizers. Conn. Agr. Expt. Sta. Bul. 386:552-578. 1936, and Bul. 410:360-364. 1938.

[2] Conn. Sta. Bul. 410:335-353. 1938.

To test the validity of this hypothesis, a series of plots was started four years ago to compare these three meals applied more nearly on an "efficiency" basis; that is, less nitrogen (as determined by the chemist) applied on the castor pomace and soybean meal plots than on the cottonseed plots. For reasons explained in a preliminary report[3] the quantities of castor pomace and soybean oil meal were not reduced as much as the computation from the experiment mentioned above indicated to be theoretically possible. Castor pomace was applied in sufficient amount to supply 160 pounds (chemically determined) of nitrogen, and soybean meal 170 pounds, while cottonseed meal supplied 200 pounds of nitrogen.

The other nutrient elements—phosphorus, potash, calcium and magnesium were supplied in equal amounts for all plots.

The experiments have been conducted now for four years in the same location with minor adjustments. The Havana Seed type of tobacco was used in all tests. Soybean oil meal nitrogen was used at the rate of 180 pounds per acre for the last two years, instead of the original 170 pounds. Furthermore, one more plot was added to each treatment in 1943 to allow quadruplicate plots of the three oil meals.

The results in terms of yield and grade of the 1943 crop in this experiment are found in Table 3. There is a remarkably close agreement for the three sources of nitrogen, since the differences in yield and grade are not statistically significant. The results obtained by 200 pounds of cottonseed meal nitrogen are no better than those of 160 pounds of nitrogen in castor pomace.[4] The use of 180 pounds of nitrogen in soybean oil meal resulted in considerably higher yield and grading than was obtained by cottonseed meal. Thus, 170 pounds might have been sufficient. The reason for the uncertainty about the quantity of nitrogen to be used in the form of soybean oil meal is that in years of excessive rainfall the lower rate does not seem to be quite sufficient, while in drier years the higher rate would be more than enough. It is safe, however, to conclude that the nitrogen in the soybean meal is at least 10 per cent more efficient than that in cottonseed meal. Castor pomace nitrogen is over 20 per cent more efficient.

More complete evidence in support of the conclusions stated above is presented in Table 4, containing a four-year summary of yield and grading. With the exception of a somewhat lower average yield produced by soybean oil meal, the results are quite uniform for the three oil meals. The small differences shown in the table are not statistically significant. Two years, 1940 and 1942, were relatively wet, while the other two were quite dry. In the wet years the yields were considerably lower than in the dry ones, especially for the soybean meal plots. This explains the slight decrease in average yield for the latter treatment.

---

[3] Conn. Agr. Exp. Sta. Bul. 444:238-244. 1941.

[4] Theoretically, 153 pounds might have been sufficient to match the results from cottonseed meal.

TABLE 3. YIELD AND GRADING RECORDS OF ORGANIC NITROGEN PLOTS, CROP OF 1943

Source and quantity of nitrogen	Plot No.	Yield Lbs. per A		Percentages of grades								Grade Index		Crop index	Relative crop value
		Plot	Ave.	L	M	LS	SS	LD	DS	F	B	Plot	Ave.		
Cottonseed meal—200 lbs. N per acre	N11A	2018		7	6	29	9	40	3	6	—	.431			
	N11B	1875		7	6	28	9	40	3	7	—	.434			
	N11C	1992	1964	5	2	27	10	46	2	8	—	.404	.435	854.3	100
	N11D	1969		9	3	37	5	40	1	5	—	.472			
Castor pomace—160 lbs. N per acre	N31A	2013		5	3	30	8	43	4	7	—	.416			
	N31B	1948		8	7	23	10	43	2	7	—	.430			
	N31C	1850	2054	6	4	28	9	44	2	7	—	.422	.437	897.6	105.1
	N31D	2403		10	6	35	5	36	4	4	—	.481			
Soybean oil meal—180 lbs. N per acre	N66A	2073		6	2	29	10	45	2	6	—	.421			
	N66B	2000		6	3	29	10	46	1	5	—	.427			
	N66C	1935	2070	13	7	21	10	40	2	7	—	.459	.444	919.1	107.6
	N66D	2273		10	6	31	6	40	2	5	—	.469			

TABLE 4. ORGANIC NITROGEN PLOTS, FOUR-YEAR SUMMARY ON YIELD AND GRADING

Source of nitrogen	Plot No.	Yields pounds per acre					Grade index					Relative crop value
		1940	1941	1942	1943	Ave.	1940	1941	1942	1943	Ave.	
Cottonseed meal	N11A	1610	1954	1770	2018		.388	.360	.413	.431		
	N11B	1620	1694	1698	1875		.369	.321	.404	.434		
	N11C	1729	1908	1825	1992	1820	.378	.378	.422	.404	.398	100.
	N11D	....	....	....	1969		.....	.....	.....	.472		
Castor pomace	N31A	1813	1906	1697	2013		.389	.372	.393	.416		
	N31B	1657	1675	1643	1948		.396	.351	.440	.430		
	N31C	1776	2094	1680	1850	1858	.354	.369	.420	.422	.403	103.4
	N31D	....	....	....	2403		.....	.....	.....	.481		
Soybean oil meal	N66A	1613	1938	1883	2073		.385	.370	.387	.421		
	N66B	1598	1672	1520	2000		.390	.356	.338	.427		
	N66C	1582	1798	1543	1935	1802	.395	.394	.388	.459	.398	99.0
	N66D	....	....	....	2273		.....	.....	.....	.469		

Soil nitrate determinations. Organic nitrogen carriers are preferred in our tobacco fertilization, because they furnish available nitrogen (nitrates) at desirable rates, concurrent with growth and development of the plant. In an attempt to follow the development of nitrates produced by the three meals, nitrates were determined on soil samples collected from the field plots of this experiment at weekly intervals the first two years and at ten-day intervals in the remaining two years. Nitrates were determined according to the phenol disulphonic acid method.

The graphs in Figure 1 indicate the nitrate levels produced by the three oil meals during four growing seasons. With minor exceptions, castor pomace and soybean oil meal developed nitrates at a higher rate than cottonseed meal, although the first two supplied less nitrogen in the original applications.

An important feature is that in each instance the three sources of nitrogen terminated their nitrate-producing activities almost simultaneously at the end of the season. Thus there would be a minimum of available nitrogen in the soil at the time the crop should mature. This removes the objection to the use of castor pomace and soybean oil meal that these materials furnish an excess of nitrogen at the end of the growing seasons. Any resulting delay in the maturity of tobacco may be avoided when the oil meals in question are used as suggested above.

TABLE 5. FOUR-YEAR SUMMARY OF NITRATE LEVELS IN SOILS OF ORGANIC NITROGEN PLOTS

Source of nitrogen	Average nitrate nitrogen levels, ppm, in the season of				
	1940	1941	1942	1943	Ave.
Cottonseed meal..........	55.3	20.3	27.8	57.1	40.1
Castor pomace...........	45.0	22.6	35.1	88.5	47.8
Soybean oil meal..........	43.2	22.9	28.0	67.6	40.4

As a final criterion of the activity or behavior of the three sources of nitrogen applied at the suggested rates of nitrogen per acre, the four-year seasonal average of nitrate levels may be taken, as given in Table 5. This shows that cottonseed meal and soybean oil meal both developed similar levels, about 80 pounds of nitrate nitrogen per acre, while castor pomace reached a somewhat higher level, 90 pounds per acre.

Reasons for the differences. The reason for the different behaviors of the three oil meals may be found in their composition. Recently Rubins and Bear[5], working with carbon-nitrogen ratios in organic

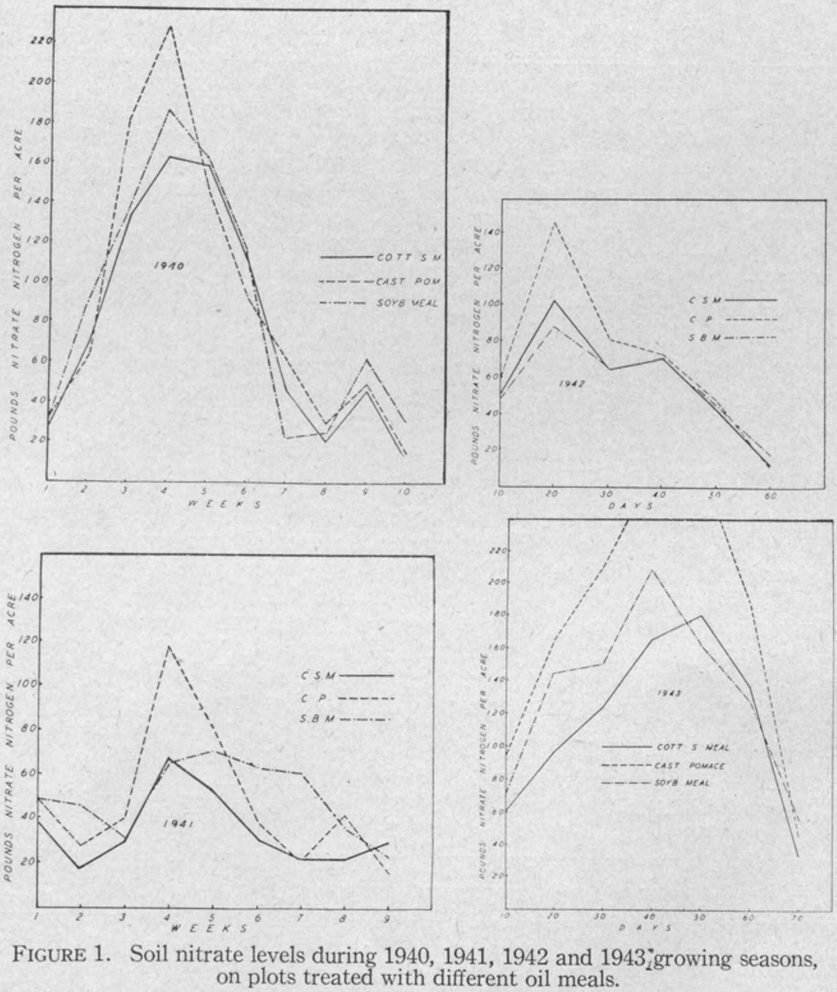


FIGURE 1. Soil nitrate levels during 1940, 1941, 1942 and 1943 growing seasons, on plots treated with different oil meals.

[5] Rubins, Edward J. and Firman E. Bear. Carbon-nitrogen ratio in organic fertilizer materials in relation to the availability of their nitrogen. Soil Science 54 (6):411-423, 1942.

fertilizer materials, found the ratio-values for cottonseed meal, soybean oil meal and castor pomace to be 5.4, 5.9 and 9.4, respectively. They also found that 54 per cent of the nitrogen in cottonseed meal, 65 per cent of that in soybean oil meal and 67 per cent of the nitrogen in castor pomace were recovered in nitrification tests. The "gap" between cottonseed meal and castor pomace corresponds rather well with the results of the present experiments, i. e., 160 pounds of castor pomace nitrogen matched the performance of 200 pounds of nitrogen in cottonseed meal. While the nitrogen in soybean oil meal is practically as available as that in castor pomace, its efficiency does not measure up to the results from the latter material. The fact remains that the performance of castor pomace is quite unique.

The investigators, quoted above, further report that castor pomace contains over 32 per cent lignin, while the cottonseed and soybean products contain only 5.4 and 1.6 per cent, respectively. The high percentage of lignin accounts for the high carbon:nitrogen ratio, mentioned above. However, they found that lignin had *no adverse* effect on nitrification. On the other hand, it is possible that the high percentage of lignin indirectly may have a *favorable* influence on the usability of the nitrogen in castor pomace, on the assumption that lignin would not be a suitable substratum for denitrifying bacteria.

Summary

1. The chemically determined percentages of nitrogen in cottonseed meal (6.5 per cent), castor pomace (5.5 per cent) and soybean oil meal (7.2 per cent) do not reflect correctly the relative crop producing value of these meals.

2. Field soil tests showed that when each of the three meals was used to furnish equal amounts of nitrogen, there was actually more than a third more nitrate in the soil during the growing season where castor pomace or soybean oil meal was used in comparison with cottonseed meal.

3. Crop producing capacities of the three meals (measured by yield and grading) also showed large differences in the same direction but not exactly proportional to the nitrate production.

4. On field plots, an attempt was made to establish the relative efficiency of the three meals by reducing the quantity of nitrogen supplied by castor pomace or soybean oil meal.

5. Compared with 200 pounds of nitrogen in cottonseed meal, equal crop results (measured by yield and grading) were produced by 160 pounds in castor pomace, and by 170 to 180 pounds in soybean oil meal. Thus, castor pomace is rated as at least 20 per cent more efficient than cottonseed meal. Soybean oil meal is 10 to 15 per cent more efficient.

6. Undesirable effects of castor pomace and soybean oil meal, sometimes observed by growers are thus readily explained as due to a too generous supply of nitrate in the soil. This also explains the difference in behavior of these meals on light and heavy soils.

Practical Application

In making the fertilizer mixture, castor pomace and soybean oil meal should not be calculated on the chemical basis but on the "efficiency basis" if one wishes to avoid the ill effect sometimes observed from their use. Thus if the guaranteed analysis of the castor pomace is 5.5 per cent, it should be calculated at 20 per cent greater, or 6.6 per cent. Since this brings it up to about the average analysis of cottonseed meal, one may substitute castor pomace, pound for pound, for cottonseed meal. Similarly, if the soybean oil meal analyzes 7.2 per cent it should be calculated at about 8 per cent or slightly higher (increase of 10 to 15 per cent). Thus 1600 pounds of soybean oil meal could be substituted for a ton of cottonseed meal.

TIMING THE FERTILIZER APPLICATION

It has long been the practice of tobacco growers here to distribute the complete fertilizer on the field a week to two weeks before transplanting the seedlings. Later additional applications, especially of nitrogenous compounds during wet seasons may be made during the early growth of the plants. The origin or basis of this custom of applying all, or the bulk of, the fertilizer so far in advance of setting has not been recorded in the literature of tobacco culture, so far as the writers are aware. Among the reasons that might be advanced for the practice are:

(1) It allows time for the organic materials in the mixture to decay and nitrify to a point where there will be a sufficient supply of available nitrate in the soil for the transplants as soon as they are set. In the early stages of growth, however, the young seedlings require very little nitrogen.

(2) It allows time for soluble salts to become better diffused through the soil, and thus less concentrated in spots where direct contact might injure plants (set directly in contact).

(3) It allows time for chemical and physical reactions which occur between the soil complex and the incorporated fertilizer components, such as base exchanges.

The principal objection to such early applications of fertilizer is that heavy rains, which may occur at that time, may leach out not only the soluble nitrates in the original mixture but also any that have been formed by nitrification of the original non-soluble compounds. To a less extent, potash and calcium may be leached out.

Another objection is that often the farmer who has been delayed by unfavorable weather in plowing and fitting his land, does not have time to let the fertilizer "work" for ten days before his plants become too large for proper transplanting. Often in these circumstances he spreads his fertilizer at the same time he sets the plants.

Renewed interest in methods of fertilizer application and results of a great deal of investigation in recent years have shaken our faith in many accepted fertilizer practices. This has lead us to a re-examination of the reasons and the experimental bases of some customary practices. Among others is the practice of applying fertilizer a week or two previous to setting.

In connection with a series of tests on fertilizer placement during the last four years, we have accumulated considerable data which should help to answer the question of the most favorable time for applying the fertilizer. For purposes of this discussion we shall consider only the 24 plots where the fertilizer was broadcast, leaving out of consideration 24 others where the fertilizer was applied in bands.

In a two-acre field there were 12 plots of one-twenty-fourth acre area on which the fertilizer was broadcast one week ahead of setting in 1941 and 1943, and 10 days ahead of setting in 1940 and 1942. Distributed on the same field were 12 similar plots to which the fertilizer was applied on the same day as setting. All plots were randomized.

A standard 8-4-8 fertilizer mixture was used on all plots. At the beginning of the experiment it was planned to keep the composition of this mixture exactly the same throughout the years of the test. Scarcity of some materials, due to the war situation, made substitutions necessary. However it is unlikely that these had any effect on the results. Composition of the fertilizer was as follows:

	Pounds of ingredients per ton			
	1940	1941	1942	1943
Cottonseed meal	500	400	400	400
Soybean oil meal	800	700	700	700
Urea	130	210	220	220
Nitrate of potash	150	...	...	...
Sulfate of potash	150	150	150	150
Bone meal	220	130	...	...
Precipitated bone	...	...	80	80
Triple superphosphate	...	100	70	70
Cottonhull ashes	...	160	160	160
Magnesian limestone	...	150	220	220
Landplaster	50	...	...	...

The standard rate of application of this 8-4-8 mixture was 2,500 pounds to the acre. This rate was used on one-third of the plots; on another third the amount was reduced to seven-eighths of the standard; on the other third it was reduced to three-quarters of the standard.

Treatment of all plots was identical throughout the season with respect to dates of setting, culture, topping, harvesting and curing. Accurate records of the yield and grading were made on the cured tobacco from the middle rows of the plots. The yield and grading of these 24 plots for four years is shown in Table 6.

The data in this table show that at least as good results were obtained by applying the fertilizer on the day the tobacco was transplanted, as a week or 10 days ahead of transplanting. The average yield increased from 1,872 to 1,907 pounds to the acre, or about 2 per cent.

TABLE 6. COMPARISON OF LATE AND EARLY APPLICATION OF FERTILIZER, YIELD AND GRADING FOR FOUR YEARS

Time of fertilizer application	Pounds of fertilizer per acre	Yield in pounds per acre					Grade index					Crop index	Relative crop value
		1940	1941	1942	1943	Ave.	1940	1941	1942	1943	Ave.		
Early	1,875	1,748	2,041	1,828	1,971	1,848	.319	.456	.370	.426	.367	678.2	95.6
		1,697	1,983	1,664	1,954		.334	.378	.287	.400			
		1,526	1,983	1,551	2,068		.290	.389	.320	.396			
		1,861	2,250	1,519	1,923		.423	.431	.274	.385			
	2,188	1,781	2,250	1,708	2,045	1,891	.366	.428	.347	.390	.378	714.8	100.8
		1,681	1,895	1,818	1,988		.363	.385	.375	.404			
		1,500	2,267	1,755	2,135		.343	.425	.401	.405			
		1,771	2,130	1,478	2,052		.359	.395	.295	.368			
	2,500	1,505	1,998	1,765	1,946	1,876	.322	.369	.356	.415	.378	709.1	100
		1,749	2,250	1,624	2,148		.332	.434	.358	.416			
		1,754	1,906	1,661	1,922		.386	.355	.370	.386			
		1,669	2,361	1,683	2,077		.347	.448	.368	.385			
	Average of all early applications					**1,872**					**.374**	700.1	98.7
Late	1,875	1,742	2,169	1,661	1,866	1,882	.309	.413	.366	.391	.382	718.9	101.4
		1,733	2,108	1,638	2,096		.374	.380	.353	.410			
		1,805	2,218	1,743	1,957		.422	.429	.374	.418			
		1,765	2,182	1,512	1,924		.309	.429	.304	.425			
	2,188	1,913	2,155	1,940	1,905	1,887	.408	.458	.384	.430	.385	726.5	102.4
		1,560	1,890	1,624	1,866		.312	.380	.302	.397			
		1,625	2,154	1,872	2,181		.350	.399	.383	.412			
		1,505	2,346	1,645	2,002		.300	.432	.383	.428			
	2,500	1,762	2,085	1,811	1,848	1,953	.391	.480	.373	.442	.410	800.7	112.9
		1,882	2,284	1,933	2,041		.418	.426	.433	.419			
		1,734	2,216	1,683	2,233		.390	.424	.367	.417			
		1,791	2,265	1,700	1,975		.370	.420	.375	.424			
	Average of all late applications					**1,907**					**.392**	747.5	105.4

The grade index increased from .374 to .392, or about 5 per cent. These differences are not statistically significant.

These results are contrary to the accepted belief that it is better to apply fertilizer prior to transplanting. Though only one fertilizer combination was used, this was a common tobacco formula, and there is no reason for believing that the results would have been reversed through the use of some other mixture.

The weather records show that in 1940 and 1942 there were heavy rains between the time the fertilizer was applied and the plants were set, and leaching occurred. During the other two years, on the other hand, rainfall was less than one-half inch in this period, and no leaching occurred. An analysis of yields for the four years shows that differences in plants receiving early and late applications were no larger in wet planting seasons than in dry seasons. Therefore, the leaching of fertilizer elements between the time of fertilizer application and the setting of plants could hardly have influenced the results.

Other explanations, such as the better co-incidence of the time curve of availability of the fertilizer elements with the time curve of the needs of growing plants for such elements, might be advanced. But as yet we have not obtained sufficient evidence to support these.

Regardless of the final explanation, the practical implication from this experiment is that fertilizer need not be applied to the soil a week or two in advance of setting the plants. As good or better results may be expected by applying it at the time of transplanting.

PLOWING UNDER THE FERTILIZER

For tobacco, the customary method of incorporating fertilizer in the soil is to broadcast it on the surface after the land has been plowed and levelled, and then work it into the surface with a disc harrow. Several objections to this method might be: (1) It encourages the feeding roots to develop near the surface. Shallow rooted plants have less resistance to drouth and wind storms. (2) During a dry season, too much of the fertilizer would stay in the surface dust mulch or loose dry soil, stirred by repeated cultivation. Consequently the roots could not penetrate it to absorb the plant food. (3) When the young seedlings are planted near the surface, as is customary, the salt concentration from the fertilizer may be so high as to injure the roots. This results in a poor start, or even death of seedlings, and a consequent uneven stand of plants.

It is possible that these objections might be overcome by distributing the fertilizer on the ground before the land is plowed. In this way it would be incorporated deeper in the soil, away from immediate contact with the transplants and below the dust mulch, and should encourage deeper rooting.

In a preliminary test, a comparison of the two methods was made on a field of Merrimac coarse sandy loam. This soil is inclined to be too dry for optimum results in a dry year, and to allow leaching of fertilizer in a wet year. An 8–4–8 fertilizer was used at the rate of 2,500 pounds to the acre, on all plots. The composition of this fertilizer was:

400	pounds	Cottonseed meal
700	"	Soybean oil meal
220	"	Urea
80	"	Precipitated bone
70	"	Triple superphosphate
160	"	Cottonhull ashes (40% K_2O)
150	"	Sulfate of potash
220	"	Magnesian limestone
2,000	pounds	

On some of the plots the fertilizer was broadcast and worked into the top soil with a disc harrow in the customary way after plowing and fitting the land. On an equal number of plots the fertilizer was broadcast on the ground before plowing. In this way it was incorporated more deeply in the soil and was probably disturbed little if any by the harrow or cultivator. The whole field was set uniformly with Havana Seed tobacco on June 8. There were no leaching rains, but rainfall was sufficient for good growth up to the middle of July. The rest of the season was excessively dry.

During the early part of the season, there was quite a noticeable difference in "stand" between the plots. Many transplants died early on the disc-in plots and it was necessary to restock several times, with consequent uneveness in size of plants. On the plow-under plots, in contrast, the plants were uniform in size and appearance, and much less restocking was required. Apparently the concentration of fertilizer in the upper soil of the disc-in plots was sufficiently injurious to the roots of the seedlings to keep many of them from establishing themselves in such a season. In the plow-under plots, on the other hand, the transplants did well because the roots did not come in contact at once with the fertilizer.

A uniform number of plants from each plot was harvested, cured and sorted in the usual way for comparative data. The yield and grade indexes are shown in Table 7.

The most obvious difference between the two treatments, as reflected in this table, is the difference in yield of 112 pounds to the acre in favor of the plow-under plots. Since our method of sampling makes no allowance for "skips" or under-developed "set-overs", it is probable that this difference was even greater between the two treatments. On the other hand, the grade index was higher on the disc-in plots, due to a somewhat greater percentage of the higher grades of leaves. An adequate explanation for this difference is not apparent.

TABLE 7. METHODS OF INCORPORATING THE FERTILIZER. YIELD AND GRADE INDEX FOR CROP OF 1943

Fertilizer	Plot No.	Acre Yield		Grade Index		Crop Index
		Plot	Ave.	Plot	Ave.	
Plowed under	A1	2,325		.404		
	A2	2,363		.382		
	A3	2,325		.370		
	B1	2,175	**2,206**	.405	**.400**	882
	B2	2,100		.417		
	B3	1,950		.420		
Disced in surface	A1	2,100		.438		
	A2	2,213		.433		
	A3	2,025		.383		
	B1	2,100	**2,094**	.401	**.417**	871
	B2	2,100		.439		
	B3	2,025		.407		

Obviously, a one-year test does not give conclusive evidence. Different weather conditions might produce different results. We can only state that under the prevailing conditions of 1943 on this field, the "plow-under" method of incorporating the fertilizer gave a decided increase in yield—with some reduction in grade—and that it had the distinct advantage of producing a more uniform stand of plants. The differences are striking enough to warrant a more thorough trial of this method of applying fertilizer.

DISEASES OF TOBACCO IN 1943

P. J. ANDERSON

As in most dry seasons, diseases of tobacco were not particularly destructive in 1943. Many ordinarily common diseases were not found at all or were found in such small amount that they caused no concern. This was true of bed rots and damping-off, black and brown rootrot, blackfire, sore shin, hollow stalk and ring spot. The Sclerotinia and Botrytis diseases so prevalent in 1942 did not occur at all in 1943. None of the various forms of pole rot caused any concern, due apparently, to the extremely dry weather during the curing season.

The following notes on diseases are based on personal observations of crops and information submitted by growers. Investigations were continued on mildew, damping-off and mosaic. One new disease was found and investigated, as reported in the following pages.

Wildfire. This bacterial disease has practically disappeared from our beds and fields in recent years. On July 13, 1943, however, we visited a Broadleaf farm in Glastonbury on which all the fields had plants badly spotted with wildfire. The plants were about a foot high. The grower reported later that the disease did not spread much in the dry weather that followed but that he suffered considerable loss in grading of the infected leaves. The source of the infection was an infected seed bed from which the plants were taken to all the fields. Wildfire was not observed on any other fields in the State this year.

Frenching in seed beds. This disease, of unknown cause, distinguished by numerous narrow strap-shaped leaves[1] is rather uncommon in Connecticut. When found at all it is usually in the field. However, one grower reported this year that a large proportion of the plants in his seed beds were affected. The specimens he submitted had all the typical symptoms of frenching. When these plants were set in the field they quickly recovered and all new leaves that developed were normal. From this, it is apparent that the trouble was due to some abnormal condition of the soil in his seed bed.

Calico or mosaic. This virus disease seemed to be more prevalent than usual. One very badly affected farm in Suffield was visited on July 6. Plants in the field were about a foot high. More than 50 per cent of them had mosaic. Examination of the seed beds showed numerous mosaic plants and indicated plainly that this was the source of the field infection. Another farm, in East Windsor, had some fields where more than half of the plants were infected and the loss was very heavy. The trouble apparently originated from unsterilized ground tobacco stems used in the fertilizer mixture. Most farms, however, showed less than 2 per cent of infected plants.

Experiments on the breeding of mosaic-resistant Broadleaf have been continued and have reached the stage where we are ready to test the strains commercially on a small scale with the growers.

Control of Mildew and Damping-off with Fermate

Our experiments for the season of 1942[2] showed ferric dimethyl dithiocarbamate (Fermate) to be the most promising spray material that we have yet found for controlling mildew in the seed beds. Before drawing final conclusions about the effectiveness of any spray remedy, however, it is first necessary to test it through several seasons because different weather conditions may influence the degree of control. Therefore the tests of 1942 were repeated and extended in 1943.

Spray tests in 1943 were made (1) in the greenhouse during the winter and early spring, (2) in the seed beds on the Experiment Station farm and (3) in the seed beds of, and in cooperation with, commercial growers.

Greenhouse tests in mildew control. Tobacco seed was sowed in 10-inch porous crocks. Six to eight crocks were used in each experiment. As soon as the seedlings had developed about four leaves, half of the crocks were sprayed with Fermate at the rate of two pounds of Fermate powder stirred into 100 gallons of water. This treatment was repeated twice a week until the plants were large enough to transplant to the field. No lime or "wetting" or "sticking" material was added. The other half of the crocks were not sprayed but otherwise were submitted to the same conditions as the sprayed crocks.

---

[1] Conn. Agr. Expt. Sta. Bul. 335:256.

[2] Conn. Agr. Expt. Sta. Bul. 469:107.

After the second application of spray, all crocks were inoculated by atomizing them with a water suspension of fresh mildew spores. The crocks were kept in a moist chamber for several days to offer favorable conditions for infection. This type of inoculation was repeated weekly until the conclusion of each series. The whole experiment was repeated three times in the greenhouse with essentially the same results.

In every experiment, mildew appeared first on the unsprayed plants six to eight days after inoculation. It continued to spread in these crocks until practically all of the plants were infected. Most of the plants died in the early stages but a few recovered later. When the experiments were terminated at the end of six weeks and the plants counted, the average number of living plants for each unsprayed crock was only nine.

Most of the sprayed crocks remained entirely free from mildew. In one sprayed crock of one experiment, a half-dozen leaves showed mildew but the plants recovered. The average number of healthy plants per sprayed crock was 322 at the close of the experiments. The Fermate-sprayed plants were greener and larger than unsprayed plants at all times. No spray injury was observed.

The experiments of 1943 confirm the results of the previous year and show that under greenhouse conditions Fermate gives perfect control of mildew.

Damping-off. In these experiments, as in previous tests, it has been observed that many of the plants in the unsprayed crocks were attacked by damping-off fungi, and sometimes it was not possible to determine how many of the plants died from damping-off and how many from mildew attack. Both diseases affected the same plants and usually killed them. Plants treated with Fermate, however, never were affected by damping-off. Although no experiments were undertaken to test Fermate for damping-off alone, the results clearly show that Fermate may also be used to control damping-off.

Spray tests in seed beds. It is not safe to draw conclusions from greenhouse tests alone. Conditions of temperature, water, humidity, etc., are more easily controlled in the greenhouse than in seed beds. Variables might affect the results of any spray program. Hence, although results with Fermate were quite satisfactory in the greenhouse, it was necessary to compare them with spray tests in seed beds.

A 6-foot bed, 75 feet long, was divided into 15-foot sections by board partitions. Beginning on May 13, when the plants were mostly in the four-leaf stage, alternate sections were sprayed twice a week with Fermate at the rates used in the previous greenhouse tests. The twice-a-week schedule was continued regularly, regardless of weather, until June 11. The only lapse was on June 7 when it was necessary, on account of continuous rain, to postpone the application one day. Since no mildew had appeared naturally in our beds when the experiment was started, all the sections, sprayed and checks, were inoculated on May 18 by sprinkling them with a water suspension of fresh spores from a sprinkling can. They were inoculated a second time on June 1.

Mildew first appeared in the unsprayed sections eight days after the first inoculation. For the most part, the weather was clear and warm, conditions under which mildew would not spread rapidly. It spread slowly throughout the unsprayed sections, however, until most of the plants were infected. A low percentage of them died. No mildew at all was found on any of the sprayed plots until the plants were ready to set in the field (June 12), on which date a few infected leaves were found but no dead plants. On June 14 sample areas of 4 square feet each were pulled up, inspected and counted. All plants from each sample area were examined for mildew symptoms. The average percentage of plants showing infection in the unsprayed areas was 98. In the Fermate areas, only a small fraction of one per cent of the plants showed mildew.

All the other beds (300 feet) at the Experiment Station farm were also sprayed with Fermate. They were not inoculated with mildew spores, and no mildew occurred on any plants in these beds.

Thus, the results in the seed beds confirmed in every way the greenhouse results and show that mildew may be controlled by spraying regularly twice a week, beginning before the disease makes its appearance in the beds.

Experience of commercial growers. On the recommendation of the Experiment Station, a large number of growers sprayed their beds with Fermate in 1943. No attempt was made by the Station staff to supervise or even keep in close touch with these operations by growers except in a very limited number of cases. Conclusions drawn from grower spraying operations are of limited value because few if any of them left unsprayed beds or parts of beds as checks.

Most of the growers reported satisfactory results. Letters came from several of the large corporations that grow hundreds of acres of tobacco reporting excellent results with Fermate. We had opportunity to watch carefully throughout the spring the spraying operations of two of these companies that are growing over a thousand acres of tobacco and had the seed beds widely distributed in a half-dozen towns. No mildew was found at any time on any of their beds.

Some growers reported that Fermate controlled the disease perfectly in the early stages, but that mildew started in the beds after the plants were full grown and ready to set in the field. On only a few farms did growers report failure. It is natural to expect that there would be some failures since most growers are unfamiliar with this new remedy. Some delayed applications until too late, or failed to apply the spray at regular intervals, or made the applications too weak. It is true that 1943 was not a very bad mildew year. Nevertheless, we had occasion to visit many infected beds, and in most cases such beds had been either left unsprayed or incorrectly or insufficiently sprayed.

The weight of evidence from two years of controlled experiments at the Station and from grower experience seems sufficiently favorable to warrant the general use of Fermate for control of mildew.

Experiments with Salicylates for Control of Mildew

In cooperation with Dr. E. E. Clayton, Pathologist of the Division of Tobacco Investigations, U. S. Department of Agriculture, spraying experiments were conducted with bismuth subsalicylate and benzel salicylate. Dr. Clayton and his associates had found that these salicylates had promising fungicidal value for control of mildew and wished to have them tested in other regions. Both of these chemicals were therefore tested, in the Station greenhouse and seed beds at the same time as the Fermate experiments described above. Additional crocks of seedlings and additional seed bed sections were treated at the same twice-a-week intervals as previously described.

Bismuth subsalicylate, three-quarters of a pound, was mixed with one-half pound of Vatsol (a "wetting" agent) and stirred in 50 gallons of water.

For the benzel mixture, a concentrated emulsion was made up by using one-quarter of a pint of benzel salicylate, one-tenth of a gallon of an emulsifier (B1956) and nine-tenths of a gallon of cottonseed oil. This standard concentrate was diluted with water at the rate of 1 to 100 when applied to the plants.

Bismuth subsalicylate gave complete control of mildew in the greenhouse. However, it caused some injury to the plants. The leaves faded somewhat and sustained burned tips. Many of the plants died either from the chemical injury or from a damping-off which was not controlled. When the plants were finally pulled and examined there were less than one-half as many living plants as in the Fermate crocks. Most of the plants had brown lesions at the base of the stalk.

In the seed bed tests, however, injury from the bismuth salts did not appear. Control of mildew was good but it could be found on a few plants when they were large enough to set in the field. When sample areas were pulled finally for examination on June 14, about 3 per cent of the plants had mildew but none of them died. After the last spray on June 11, the bed was left unmolested for two weeks to see whether the mildew would spread from the adjacent check plots into the sprayed sections or whether some of the spray materials might give a residual protection. The weather was very warm and unfavorable to development of mildew but there was some spread over the previously treated sections.

The fact that there developed slightly more mildew on the bismuth sections than on the others showed that bismuth did not have a longer protective aftereffect than did Fermate or the benzel salt. None of the salts appear to make the plants resistant to attack longer than a few days. Hence the necessity of frequent applications.

Benzel salicylate also gave excellent protection against mildew. But in the greenhouse it caused considerable plant injury. The plants became pale and were retarded in growth. Many of them died. When the plants were finally pulled for examination, the roots were brown and there were brown lesions at the base of the stem. Less than half as many plants were alive as on the Fermate crocks. In the seed beds the injury was less pronounced but the plants were plainly paler and more retarded. Control of mildew, however, was almost as complete as in the Fermate sections.

So far as we can decide from tests to date, neither of the salicylates seems to offer any advantages over Fermate. They give no more complete control, are not as simple to prepare and are more expensive. They do give good control of mildew, however, and they should be subjected to further investigation to see whether the methods of application or preparation can be changed or improved sufficiently to make them more desirable than Fermate.

Paradichlorobenzene for Mildew

The value of paradichlorobenzene (PDB) for fumigating the beds to control mildew has been thoroughly established by experiments here and elsewhere, as well as by the experience of growers. Such experiments have been described fully in our previous reports and bulletins. Continuation of PDB experiments on a large scale seems unnecessary. It may be worth recording, however, that in the seed bed experiments described above, one 15-foot section was treated with PDB as a check on results with Fermate and the salicylates. The PDB crystals were distributed every second night on two 3 by 5½-foot cloth frames over the plants. This gave complete control as long as the treatment was continued. All these sections had been inoculated with mildew spores. When the fumigation practice was omitted after the plants were large enough to set, mildew appeared in about 10 days, possibly spreading from the adjacent unsprayed sections.

Since mildew can be controlled either by fumigation with PDB or by spraying with Fermate (or salicylates), the question arises, "which should the grower use?" This will depend on the grower's preference and on the condition of the beds. Many growers have beds of such loose construction, or leaky sash, that they cannot hope to fumigate successfully because the PDB gas escapes too rapidly. For such growers, the Fermate spray is best—in fact the only remedy. Many growers who have tried both methods think the Fermate spray is less trouble than the fumigation method. They also consider it less expensive. Others, however, find the fumigation method less trouble.

Many large growers are prepared to play safe and use both methods if necessary. They spray with Fermate when the seedlings are small and then use PDB if mildew appears in the later stages. Very few of them, however, had to resort to fumigation in 1943. Under unfavorable weather conditions, however, it might be necessary. Since Fermate is a preventive spray, and PDB a curative practice, the two naturally complement each other. The grower who is prepared to use either or both, as conditions require, has a well-rounded program and should have no fear of losing his plants.

FUSARIUM WILT, A NEW STALK DISEASE IN CONNECTICUT

During the harvesting period, Fusarium wilt was found on a few plants on the Experiment Station farm. This is the first record of its appearance in this State though it may have been present for some time. It is not a common disease, but has been found in most of the southern tobacco states, in Canada, South Africa and Russia. Only in a few counties of North Carolina and in Maryland[1] has it reached destructive proportions. Elsewhere it is not considered a major disease. We do not anticipate that it will become destructive here.

The general appearance of a Fusarium wilt plant is so similar to that of a plant affected with the common "sore shin" disease that one might see it many times in the field without recognizing it as a new disease. The Fusarium wilt plant, however, lacks the distinct, sunken canker at the base of the stalk that is always present in sore shin. The following description is presented to enable growers to recognize the disease and in the hope that if it is found elsewhere, it will be reported to us so that we may determine the extent of its distribution in this State.

Symptoms. The first sign of Fusarium wilt is the gradual fading of the leaves on one side of the plant, followed by slow but complete yellowing and drooping. Characteristically, this is confined to one side of the plant, the affected leaves being vertically disposed. The leaves on the opposite side appear perfectly normal. In some few plants, however, the leaves wilt on all sides. The drooping wilted leaves then begin to die. Irregular brown patches appear and increase in size and number until the whole leaf is dead and brown. The color changes in an affected leaf remind one of the changes that occur in the curing of a leaf in the shed. The affected stalk curves or bends over toward the stricken side, probably due to arrested growth of that side while the normal side is still elongating. As a result, the top leaves, as they wilt, bend over the bud and hang down over the affected side. This appearance (See Figure 2) has suggested the name "crook-neck", commonly used for this wilt by growers in South Africa. The entire plant may finally die or the non-affected side may remain green until harvest. However, there is probably little salvage in any of the infected plants.

The outside of the stalk remains a normal green and appears no different from the other stalks until a late stage of wilt. Then a black dead streak may run the length of the stalk on the affected side. When the green cortex, or bark, is peeled off, the underlying woody part of the stalk is found to be dark brown or black—not white, as in a normal stalk. This dark discoloration is confined to the affected side and extends to the top of the plant. It also runs out into the midribs of the leaves, and if the midribs are split open the dark streak can be traced well out through the central vascular bundle. The dark color goes through the woody cylinder of the stalk and causes some

---

[1] It was reported (Plant Disease Reporter 27:541) in some fields of Maryland to have affected 60 to 80 per cent of the plants.

slight darkening of the pith inside it. This dark color of the woody cylinder under the bark is the best diagnostic symptom of the disease and definitely identifies Fusarium wilt.

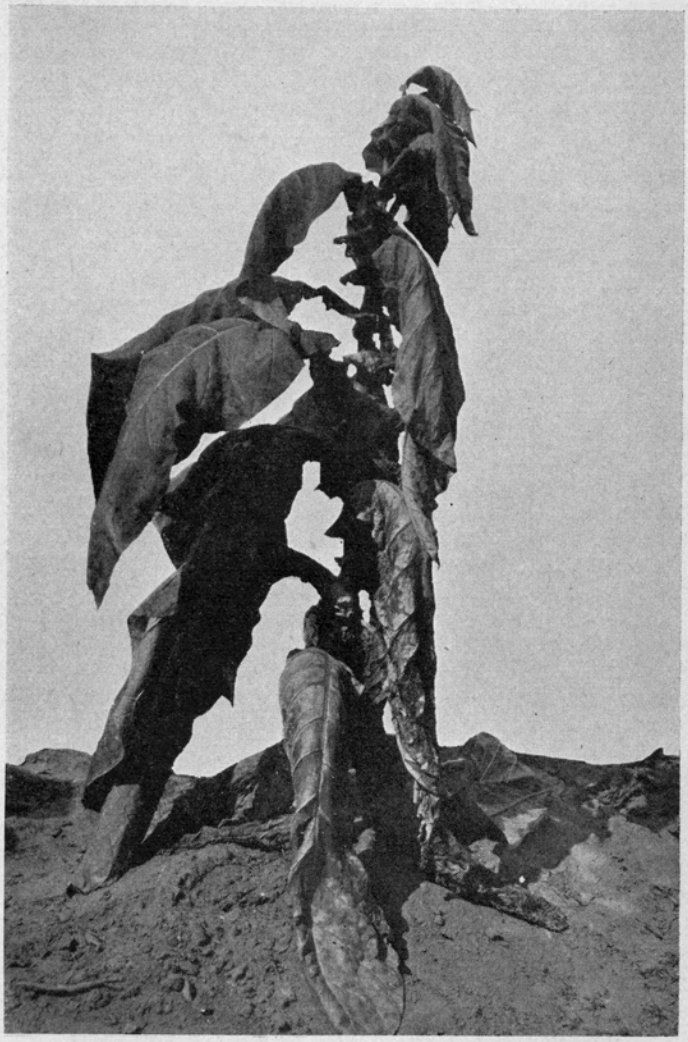


FIGURE 2. Fusarium wilt on Broadleaf. Only one side of the plant is affected at this stage.

The infected parts of the plant do not rot or undergo any watery disintegration. This is distinctly a wilt or drying-up disease in all its manifestations. Neither do the leaves rot—they merely cure on the stalk.

Examination of the roots of infected plants shows that sometimes they appear quite normal and healthy, while on other plants some of the roots are dead and the larger ones show a blue-black discoloration when split open.

The causal agent. When a thin section of the woody part of the stalk is examined under a microscope, the water tubes and all the other cells of this tissue are found to be infected and permeated with numerous threads, or mycelium, of a fungus. Johnson[1], who first investigated Fusarium wilt, and to whom we owe most of our knowledge of the disease, called this fungus *Fusarium oxysporum*, variety *nicotianae*. *Fusarium oxysporum* causes similar wilt diseases on potatoes and various other plants, but since the fungus on tobacco showed some constant morphological differences from the causal organism on other plants, it was considered a distinct variety. He believed that the death of the plant, or parts of it, is due to the action of a toxin produced by the fungus rather than to a clogging of the water vessels (thrombosis) which would deprive the affected leaves of their water supply. The fungus lives in the soil and apparently invades the stalk or roots through wounds beneath the surface of the soil.

In order to identify more certainly the disease and to study the causal fungus, the writer made numerous isolations from the plants found in Windsor. Small bits of affected tissues from roots, leaf, midribs and stalks at various heights were transferred under sterile conditions to potato dextrose agar slants. All gave pure cultures of a typical Fusarium, white cottony growth that covered the surfaces of the slants in five days. The agar took on a faint pink color.

At the end of three days, hyaline spores of two kinds were found in great abundance. The smaller spores (microconidia) were quite variable in shape and size. (Average size 8.8 x 3.2 microns). These little spores are usually oblong and straight but often oval or ovate and inaequilateral or slightly curved, usually unicellular but rarely uniseptate. The other, larger spores (conidia) are fusiform, sickle-shaped and pointed at both ends, but one being slightly blunter than the other. (See Figure 3). Most of them are three-septate but many are five-septate and occasionally four-septate. Some, possibly young stages, are non-septate. In some of the spores, individual cells are swollen almost globose and constricted at the septa. The average

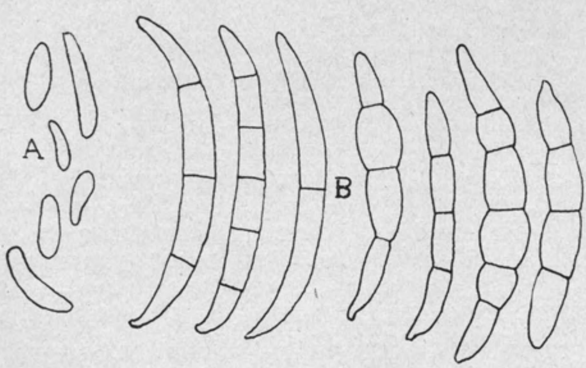


FIGURE 3. Spores of the Fusarium wilt fungus, magnified 1,400 times natural size. A, microconidia; B, conidia.

[1] Johnson, James. Fusarium wilt of tobacco. Jour. Agr. Res. 20:515-535, 1931.

size of these spores is 30 x 5 microns. This length is slightly less (but probably not significantly so) than the measurements recorded by Johnson. In all other respects, the characteristics of this fungus were so similar to the descriptions of other writers that there can be no doubt that the organism is the same.

It has been shown recently by Smith and Shaw[1] that the Fusarium which causes wilt of tobacco is the same as the fungus that causes stem rot of sweet potatoes. On the Windsor plots where this tobacco wilt was found in 1943, sweet potatoes had been grown within the last three years - one plot the previous year. All the crops of sweet potatoes grown here in previous years suffered somewhat from stem rot. This suggested that the prevalence of the disease now may be connected with the sweet potato crop. In order to get further evidence on this, sweet potato runners in the field in 1943 were inoculated with cultures of the Fusarium which had been isolated from tobacco. All inoculations caused typical blackening of the vascular bundles of the vines. Isolations made from these runners two feet or more from the point of inoculation produced pure cultures of Fusarium identical with the tobacco pathogen.

Sweet potatoes are not grown extensively in the Connecticut Valley and therefore this does not suggest a serious menace. If, however, they should be at any time grown more commonly here it might be well to avoid rotating them with tobacco.

Inoculation experiments by Johnson indicate that different varieties of tobacco vary in their susceptibility to Fusarium wilt. He listed all of our Connecticut varieties as highly resistant. The first diseased plants found here were in the Havana Seed variety but the greatest number were on a row of a Giant Broadleaf mutant which the writer discovered last season and described in our Annual Report for 1942. Some were also found on the ordinary Broadleaf but the fact that most of them were on the Giant Broadleaf row indicates that we are dealing here with varietal susceptibility.

It has been observed by other investigators that the disease is favored by high temperatures. The fact that it was first observed here in 1943 which was an extremely hot season is possibly a further indication of the influence of heat.

No method of controlling the disease is known except through breeding and selecting resistant strains. Unless Wilt becomes more prevalent, no control efforts seem warranted here.

STUDIES ON BLACK TOBACCO

III. Statistical Analysis of a Field Crop

STUART B. LECOMPTE, JR.

Certain data of Field A, 1941 reported previously (7) have been re-examined, statistically.[2] The limitations of this experiment are kept in mind. Different environmental conditions in another year may not yield the same results, so that the material should be viewed in the light of other work on black tobacco. The term "significant" in the following discussion refers in every case to statistical significance, which may discriminate smaller differences than are of practical significance.

---

[1] Smith, T. E. and K. J. Shaw. Pathogenicity studies with Fusaria isolated from tobacco, sweet potato and cotton. Phytopathology 33:469-483. 1943.

[2] Grateful appreciation is extended to Dr. C. I. Bliss, Biometrician, for much help and guidance in the computations.

The percentages of sorted weight of black tobacco grades (KV2+KVB) and of merely dark grades (V+V2+KV) have been considered in their relationship to soil tests of phosphorus, aluminum and calcium for each of the four pickings of 1941 by analysis of co-variance (4).

As has been noted elsewhere[1] criteria for separating black and dark grades were not constant at all pickings and all plots. However, the usual commercial sorting methods were employed as the simplest means of evaluating Shade tobacco leaf.

Apart from fertilizer treatments, the proportion of black tobacco (KV2+KVB) increased very significantly with the aluminum in the soil in the first and second pickings. This effect was not apparent in the third and fourth pickings. Also exclusive of the fertilizer treatment, calcium and phosphorus exerted an effect approaching significance upon the first picking, the former increasing black tobacco and the latter reducing black tobacco.

The effect of fertilizer upon percentage of black leaf (KV2+KVB) was divided into two parts: (a) the effect of phosphorus and (b) that of all other fertilizers. Adjustments for the constituents phosphorus, aluminum and calcium in the soil exclusive of treatment were made where necessary by the analysis of co-variance. From this, phosphorus applied as fertilizer reduced black tobacco significantly in the first and fourth pickings, but not in the second and third pickings. At the same time other fertilizer constituents showed no significant effect on black tobacco in any picking.

The percentage of dark grades (V+V2+KV) in the second and third pickings increased significantly with the aluminum in the soil, exclusive of fertilizer treatments; calcium and phosphorus had no significance, exclusive of treatments.

In the study of the effect of fertilizer on the percentage of dark tobacco, calcium increased the amount of dark grades significantly in the fourth picking but no constituent appeared to have any effect in the first picking. When adjusted by co-variance for the aluminum in the soil, phosphorus reduced the amount of dark leaf in the third picking significantly. No such significance was shown for the second picking.

The evidence that the amounts of grades V, V2 and KV in the second and third pickings varied with soil aluminum and were reduced in the third picking as fertilizer phosphorus was greater suggests that the leaves graded V, V2 and KV in this study are "better quality" black tobacco—less extreme manifestations of the true black or blue-black type (KVB). This idea has been noted elsewhere[2] and is supported by analysis of cured leaf for iron and manganese.

---

[1] Conn. Agr. Expt. Sta. Bul. 469:152.

[2] Conn. Agr. Expt. Sta. Bul. 469:153.

Some of the data on analysis of fresh tissue[1] have been examined statistically. The constituents potasium, calcium, magnesium, manganese, phosphorus, nitrogen as ammonia and nitrate in the midrib of the fifteenth leaf showed no significant relationship to phosphorus, calcium or aluminum in the soil tests. Phosphorus in the fertilizer showed a significant effect in reducing the amount of aluminum in the midrib tissue of the fifteenth leaf. However, the data on fresh tissue content of aluminum obtained by rapid analysis are not wholly satisfactory in these midrib tests, because the values for single plots have only one significant figure and only about a two-fold range.

Discussion

It is emphasized again (6, 7) that no single factor should be regarded as the only cause of black tobacco. The statement which was made in the statistical section of this article to the effect that black tobacco increased very significantly with soil aluminum in the first and second pickings does not mean that soil aluminum was the unique cause of a greater yield of black-curing leaf. It means merely that of the three soil constituents measured, namely, aluminum, calcium and phosphorus, the aluminum varied directly with the percentage of black tobacco. Other soil factors which remained unmeasured might have shown even more intimate relationship.

For the analysis of variance, aluminum soil tests were chosen from the data which formed the averages of Table 4, Bulletin **469**, because the spot plate estimates seemed more reliable than those for iron or manganese. It is not unreasonable to expect that soil iron and soil manganese might have revealed in statistical analysis a variation similar to that shown by aluminum. Phosphorus and calcium were selected for the statistical treatment because they were the main ingredients of the experimental fertilizer, viz., 48 per cent superphosphate and hydrated lime.

The effect of phosphorus in significantly reducing the amount of black or dark tobacco appears at first thought to be mainly that of a soil amendment, not raising the phosphorus content of the leaf, on a dry weight basis. Anderson, Morgan and Nelson (1) have discussed the functions of phosphorus as a fertilizer. Phosphorus content of leaf tissue from Field A, 1941, of comparable age or picking was about the same, irrespective of leaf grade or soil phosphorus/aluminum ratio, on both good plots with little black tobacco and on poor plots with much black tobacco.[2] All the leaf samples tested show a normal phosphorus content (0.40 to 0.71 per cent phosphorus pentoxide, dry weight basis), comparable with earlier analyses of Connecticut tobacco (5, 1, 2, 3). In this sense, then, it is illogical to speak of any leaves of this experiment as being phosphorus-deficient. The untreated soil of Field A undoubtedly had but low amounts of phosphorus readily soluble in 0.5 N acetic acid; this is shown in Table 4, Bulletin **469**.

---

[1] Bul. 469:146, Table 13.
[2] Unpublished data of Dr. E. M. Bailey.

The untreated soil of Field A, but not the unit weight of leaves grown upon it, may be termed phosphorus-deficient. However, total phosphorus per average entire plant was probably below normal on untreated plots because of the limited plant development on such plots. In this sense, such whole plants were phosphorus-deficient. Although the benefit of phosphorus to tobacco quality may lie largely in chemical action with iron, manganese, aluminum or other metals among the soil particles, there are probably within the plant unknown vital effects of phosphorus upon leaf quality.

LITERATURE CITED

1. ANDERSON, P. J., M. F. MORGAN and N. T. NELSON. The phosphorus requirements of old tobacco soils. Conn. Agr. Expt. Sta., Tobacco Substation, Bul. **7**, 1927.

2. ANDERSON, P. J., T. R. SWANBACK and O. E. STREET. Further experiments with phosphatic materials in the fertilizer. Conn. Agr. Expt. Sta. Bul. **367**:108-113, 1935.

3. ANDERSON, P. J., T. R. SWANBACK and O. E. STREET. Malnutrition symptoms due to deficiencies or excesses of plant food elements. Conn. Agr. Expt. Sta. Bul. **410**:393-406, 1938.

4. FISHER, R. A. Statistical methods for research workers. Sixth Ed., Oliver and Boyd, London, 1936.

5. JENKINS, E. H. The effects of fertilizers on the composition of wrapper leaf tobacco. Conn. Agr. Expt. Sta. Report for 1896, 322-333.

6. LECOMPTE, S. B., JR. Studies on black tobacco. Conn. Agr. Expt. Sta. Bul. **444**: 270-278, 1941.

7. LECOMPTE, S. B., JR. Studies on black tobacco II. Field crop response to phosphate and lime fertilization. Conn. Agr. Expt. Sta. Bul. **469**:130-155, 1943.