BULLETIN 299 JANUARY, 1929

Connecticut Agricultural Experiment Station
New Haven, Connecticut

REPORT OF

THE TOBACCO SUBSTATION

AT WINDSOR

FOR

1928

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CONNECTICUT AGRICULTURAL EXPERIMENT STATION

OFFICERS AND STAFF

Press of The Wilson H. Lee Co., New Haven, Conn.

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Report of the Tobacco Substation

1928

P. J. Anderson and T. R. Swanback.

This, the seventh annual report of the Tobacco Substation is presented to the growers of Connecticut to inform them of the progress of experiments which are being conducted at this station.

On account of excessive rains, the season has not been a favorable one for the grower but in our experiments, definite progress has been registered in several of the lines of investigation and we feel that it has been a successful year from that standpoint.

The year has again been marked by increased requests from the growers for service in visiting farms, plantations and warehouses, soil testing, seed testing, personal conferences and public talks, correspondence and preparation of articles for the press. This service and contact work is extremely important, is welcomed and will be continued to the limit of our ability but the inroads which it is making on time of the station staff which can be devoted to more fundamental research emphasizes the early necessity of increasing the research staff. Mr. J. S. Owens, Extension Crop Specialist from the Agricultural College at Storrs gave a part of his time to this work and rendered valuable assistance, especially during the curing season, but the limited time which he is able to give falls far short of meeting the needs of the situation. Valuable work along this line is also being conducted by the Hartford County Farm Bureau through the efforts of the county agent, Mr. C. D. Lewis.

Especially significant has been the establishment of the tobacco advisory committee of twelve growers representing the three types of tobacco grown in the state. This committee functions both for the station and for the farm bureau and their advice and suggestions have been helpful in guiding the work of the station and in keeping it in constant touch with the growers. The members of this committee are:

Mr. Ralph G. Tryon, Glastonbury, Chairman
Mr. S. R. Spencer, Suffield
Mr. A. T. Pattison, Simsbury
Mr. W. H. Gowdy, Hazardville
Mr. J. E. Shepard, South Windsor
Mr. Louis L. Grant, Manchester
Mr. T. F. Holcomb, West Granby
Mr. J. E. Phelps, Suffield
Mr. R. D. Steane, Hartford
Mr. J. B. Stewart, Windsor
Mr. S. F. Brown, Windsor
Mr. R. E. Case, Granby

The annual field day was held at the station on July 30 in co-operation with the New England Tobacco Growers Association.

It was not only largely attended by our own growers but also by ninety growers from Pennsylvania who contributed much to the success of the meeting.

In co-operation with the Connecticut Leaf Dealers Association we also prepared an exhibit for the Connecticut State Fair during the first week of September.

For some of our lines of investigation this report presents a complete discussion with all pertinent data tabulated. However, the report would be too lengthy if all projects were presented in such detail and it has seemed advisable to merely summarize the points of progress on the others and reserve for future bulletins the more complete presentation.

Potash Fertilizer Experiments

The potash requirement of the tobacco crop is very high when compared with other agricultural plants. A good potash supply is not only essential to the growth of the tobacco plant but also the presence of an abundance of potash in the proper combination in the leaf is the most important factor in producing good combustion.

Potash has at least three functions in the tobacco. 1. It acts as a catalizer or condensing agent in the formation of carbohydrates and proteins; hence the plant would cease to grow if potash were not supplied. 2. It neutralizes acids which develop during the normal metabolism of the cell and removes them to older parts of the plant where they are precipitated and rendered harmless. Otherwise these acids would accumulate in the cells to such an extent as to poison them. The spots which appear on leaves starved for potash may be due to the accumulation of these acids. This may also account for the belief by some that potash makes leaves more resistant to disease. 3. Potash acts as a catalytic agent in combustion. In this role it is absolutely necessary for the type of slow combustion which we wish in tobacco. If it is absent, the leaf burns up like paper. In these important roles potassium does not function properly when combined with the mineral radicals such as chloride or sulfate, but must be present in an organic salt like malate, tartrate or citrate. From the results of several investigations it is now generally agreed that the fire holding capacity is governed largely by the abundance of organic salts of potash which are in the leaves. The potash problem then may be summed up in one question: How can we put into the plant the maximum amount of potash in these desirable organic combinations? Obviously its supply must come from the soil through the roots since there is no other way that the plant can obtain potash. There are two possible sources of potash for the roots, (1) the native potash which is normally in the soil and, (2) fertilizer potash which the grower adds to the soil. With respect to the first source we should inquire how much is present in our tobacco soils? In what combinations? How available to tobacco plant? How fast does it become available? Are there methods of making it more available? What is the effect of various cultural practices on its availability? With respect to the second source there arise the questions: To what extent can we

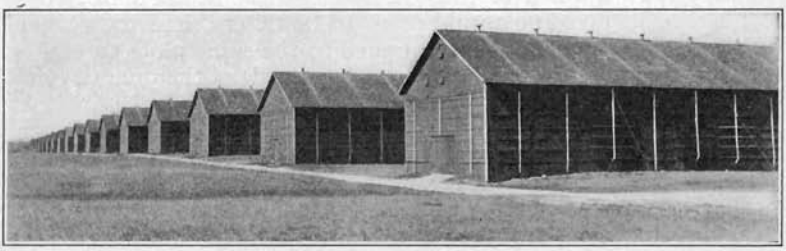

FIG. 13. Curing Sheds.

increase the potash content of the plant by increasing the soil supply? What is the optimum quantity of potash to add in fertilizers? In what carriers or combinations of carriers is it supplied to the greatest advantage? Will the plant absorb more potash from one carrier than from another? To what extent are the acid radicals with which potash is combined also absorbed and what is their effect on the tobacco? What are the effects of various potash compounds on the soil and are these effects beneficial or harmful to the crop? To what extent is potash leached? Does unused potash accumulate in the soil?

Some of these questions have been answered by the experiments of the last few years, some have been partially answered. We hope to answer others before the series of experiments is closed. The present report brings together the data which have been obtained to date and shows how far we have progressed toward answering the questions.

HOW MUCH FERTILIZER POTASH SHOULD BE APPLIED?.

It is a common practice in Connecticut to apply about 200 pounds of potash (K_2O) to an acre of tobacco although some have applied much more while others have grown good tobacco on less. There are no recorded local experiments on which to base a decision as to whether as good a crop may be produced by a smaller quantity or whether better quality would be produced by a still larger quantity. According to analyses which were made in Connecticut by Jenkins (Conn. Bul. 180:7. 1914) an 1,800 pound crop of tobacco removes from the soil about 133 pounds of potash in leaves and stalks. If the stalks are returned, the amount removed is only 85 pounds. These figures, however, give us little basis for deciding on the amount which is most advantageous since we know on the one hand that plants may take up quantities of elements which are in excess of their requirements and on the other hand that they may not be able to obtain as large a quantity as they need at a certain period even though that quantity has actually been applied to the soil and is there at the time. The safest way of deciding would seem to be actual field tests where different quantities have been applied to the same plots through a series of years and by making accurate records of the quantity and quality of the tobacco produced.

Such an experiment was begun in 1926 with six one-fortieth acre plots on Field V of the station farm. The soil here is coarse sandy loam of the Merrimac series with coarse sandy, open subsoil, subject to rapid leaching. The crop suffers here from lack of moisture during a dry year and from leaching of nitrogen in a wet year. Analyses by the Soils department show that this field contains about 35,000 lbs. of total potash per acre in the upper 8 inches of soil.

Two of the plots (K11, K11-1) received no potash in the fertilizer (except for the small quantity in the cottonseed meal and castor pomace of the formula). Two others (K12, K12-1) received 100

Composition of the three formulas was as follows:

PLOT K11. NO MINERAL POTASH

Carriers		Lbs. plant nutrient per acre		
Name	Lbs. per acre	NH_3	P_2O_5	K_2O
Cottonseed meal	1463.4	120	42.4	21.9
Castor pomace	588.2	40	10.6	5.9
Nitrate of soda	212.7	40		
Precipitated bone	277.9		107.0	
Total	2542.2	200	160.0	27.8

PLOT K12. ONE HUNDRED POUNDS POTASH

Carriers		Lbs. plant nutrient per acre		
Name	Lbs. per acre	NH_3	P_2O_5	K_2O
Cottonseed meal	1463.4	120	42.4	21.9
Castor pomace	588.2	40	10.6	5.9
Nitrate of soda	170.2	32		
Precipitated bone	277.9		107.0	
Sulfate of potash	48.0			24.0
Carbonate of potash	37.1			24.1
Nitrate of potash	53.5	8		24.1
Total	2638.3	200	160.0	100.0

PLOT K9. TWO HUNDRED POUNDS POTASH

Carriers		Lbs. plant nutrient per acre		
Name	Lbs. per acre	NH_3	P_2O_5	K_2O
Cottonseed meal	1463.4	120.0	42.4	21.9
Castor pomace	588.2	40.0	10.6	5.9
Nitrate of soda	107.4	20.2		
Precipitated bone	277.9		107.0	
Sulfate of potash	114.8			57.4
Carbonate of potash	88.3			57.4
Nitrate of potash	132.3	19.8		57.4
Total....................	2772.3	200.0	160.0	200.0

lbs. of potash per acre. The other two (K9, K9-1) received the standard quantity, 200 lbs. per acre. Potash was supplied in equal amounts from sulfate, nitrate and carbonate because previous experiments had shown most favorable results from this triple combination of potash salts, and also in order to minimize the effect of possible accumulation of any one acid radical.

During the first year of the experiment no differences in growth were observed. The growth on all of these plots, however, was unsatisfactory on account of the dry weather and no conclusion was drawn from the records.

However, when the same plots were treated in the same way the second year (1927), the growth throughout the season appeared smaller on the no-potash plots but no differences between the others were apparent.

When sorted, the tobacco from the no-potash plots, was found to be short, yellow and of poor quality but as between the others the differences were not large. The sorting records are presented in Table 1.

TABLE I. QUANTITY OF POTASH SERIES. CROP OF 1927 ON FIELD V

Potash lbs. per A.	Plot No.	Acre Yield		Percentage of grades								Grade index*	
		Plot	Ave.	L	M	LS	SS	LD	DS	F	B	Plot	Ave.
0	K11	1150	1144	..	..	18	6	36	7	20	13	.281	.290
	K11–1	1137		..	..	18	11	41	4	16	10	.298	
100	K12	1247	1194	6	7	15	9	42	2	16	3	.368	.366
	K12-1	1141		6	5	14	8	42	5	16	4	.364	
200	K9	1152	1152	10	10	15	8	38	4	10	6	.411	.411

* *The Grade Index.* In comparing the quality of tobacco grown on different plots it is very difficult to keep in mind the percentage of six to eight commercial grades of tobacco from one plot and compare with a like number from another. To simplify these comparisons a grade index was devised. The grade index is a single number expressing the quality of *all*

These data show that there was a slight reduction in yield but a very decided reduction in grading during the second year where no potash was added.

The same treatment was repeated on the same plots in 1928 (3d year). During the summer it was quite apparent that the plots which received no potash were not making as good growth as the others. Distinct symptoms of acute potash hunger, however, were not seen.

In taking down the tobacco from the shed it was found that tobacco from the no-potash plots did not come "into case", i. e., become soft and pliable, during the "damps". Adjacent plots were in excellent condition for handling while this tobacco was hard and dry and never became really ready to take down. The same was true, but to a smaller degree, with tobacco from the plots where only 100 lbs. per acre of potash had been applied.

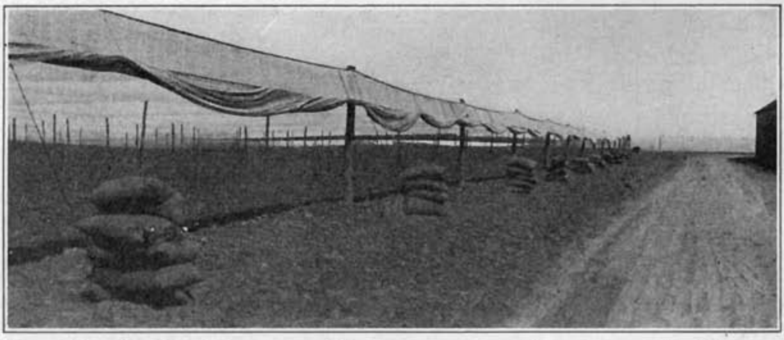

FIG. 14. Feeding the crop. Shade growers use two tons of fertilizer to the acre.

On the sorting bench, the tobacco from the no-potash plots was found to be yellow, short, thick, "boardy", entirely lacking in elasticity and of such inferior quality generally that it was not fit to sort. Tobacco from the 100 lbs.-potash plots was somewhat

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the tobacco grown on a particular plot. It is based on the percentage of carefully assorted commercial gradès and the relative price value of the different grades. Although market prices vary from year to year, it was found, after consultation with experienced dealers, that the ratios of prices between the different grades are fairly constant. These adopted price relationships for the different grades are as follows:

(L)	Light wrappers......	1.00	(LD)	Long darks (19″ up).	.30
(M)	Medium wrappers...	.60	(DS)	Dark stemming (17″)	.20
(LS)	Long sec. (19″ up)...	.60	(F)	Fillers..............	.10
(SS)	Short seconds (15″ and 17″)..............	.30	(Br)	Brokes.............	.10

The grade index of any plot is obtained by multiplying the percentage of each grade by the price in the above schedule and adding the products.

longer but showed much of the same characters as above but to a less degree. Tobacco from the "200 lbs.-potash" plots was rated as satisfactory.

The sorting records for the 1928 crop are presented in Table 2.

TABLE 2. QUANTITY OF POTASH. SERIES OF 1926. ACRE YIELD AND GRADING OF CROP OF 1928

Quantity of potash	Plot No.	Acre Yield		Percentage of grades								Grade Index	
		Plot	Ave.	L	M	LS	SS	LD	DS	F	B	Plot	Ave.
0	K11	1107	1135	..	..	..	21	..	67	27	..	.194	.214
	K11-1	1163		..	..	..	21	38	15	21	5	.233	
100	K12	1107	1092	3	7	9	25	24	16	16	..	.321	.322
	K12-1	1076		3	5	13	15	31	15	18	..	.324	
200	K9	1178	1199	13	9	12	18	31	8	9	..	.428	.463
	K9-1	1221		22	16	5	17	30	1	9	..	.498	

It appears from these data that the reduction in quality is much more serious than the decrease in yield when potash is omitted from the fertilizer. When 100 lbs. of potash was supplied the quality was somewhat improved but was still much inferior to the tobacco receiving the regular ration. Tobacco from the 200 lbs.-plots was of good quality exhibiting none of the dry, thick, non-elastic, yellow characters of the other plots.

In the Field V experiments just described all treatments were in duplicate. After the first year it was decided to increase the number of replications and enlarge the experiment also by adding 300 lbs.-potash plots. These additional plots were on Field I, a soil of a somewhat different type, being a fine sandy Merrimac loam with a more compact subsoil and less subject to leaching. This field usually grows better tobacco than Field V. The complete lay-out of plots was now as follows:

K11	No potash	6 plots
K12	100 lbs. potash	5 "
K9	200 " "	6 "
K13	300 " "	5 "

During the first year of the new series no differences in growth were observable in the field but the sorting records as presented in Table 3 show that there was a slight reduction both in yield and grading when potash was omitted from the fertilizer.

During the second season (1928) when all treatments were repeated on the same plots on Field I, the effect of the entire omission of potash was apparent in the field. The plants appeared smaller and less "leafy", i. e., they did not seem to fill out the rows as well. The sorting records for this crop, however, do not indicate a reduction in yield. Probably the thickness of the leaves com-

FIG. 15. Transplanter at work under the tent.

TABLE 3. QUANTITY OF POTASH. FIELD I SERIES. SORTING RECORDS ON CROP OF 1927

Potash lbs. per A	Plot No.	Acre Yield		Percentage of grades								Grade index	
		Plot	Ave.	L	M	LS	SS	LD	DS	F	B	Plot	Ave.
	K11-2	1230		8	9	17	6	40	3	11	6	.397	
	K11-3	1213		7	5	25	6	36	4	11	6	.401	
0	K11-4	1160	1184	2	4	14	6	39	6	16	13	.304	.369
	K11-5	1152		3	5	19	6	42	2	13	10	.345	
	K11-6	1163		8	7	20	7	38	2	13	5	.399	
	K12-2	1287		7	8	18	4	38	4	13	8	.381	
100	K12-3	1384	1274	9	11	18	9	35	4	10	4	.418	.386
	K12-4	1152		4	7	19	7	38	2	14	9	.358	
	K9-5	1321		4	8	22	4	40	3	14	5	.377	
200	K9-6	1312	1286	6	6	21	5	37	3	13	9	.364	.374
	K9-7	1258		6	4	18	7	37	6	14	8	.358	
	K9-8	1254		8	6	19	6	43	2	11	5	.397	
	K13	1230		7	4	24	7	36	2	10	10	.391	
	K13-2	1316		9	10	19	5	36	4	12	5	.412	
300	K13-3	1325	1264	11	8	19	7	36	3	13	3	.423	.397
	K13-4	1205		8	7	23	6	34	3	12	7	.405	
	K13-5	1246		2	4	25	10	33	5	12	9	.354	

TABLE 4. QUANTITY OF POTASH. FIELD I SERIES. ACRE YIELD AND GRADING OF CROP OF 1928

Quantity of potash	Plot No.	Acre Yield		Percentage of Grades							Grade index	
		Plot	Ave.	L	M	LS	SS	LD	DS	F	Plot	Ave.
0	K11-2	1259	1206	4	4	22	12	32	11	15	.365	.357
	K11-3	1114		2	8	29	10	33	6	12	.395	
	K11-4	1152		7	3	11	24	29	12	14	.351	
	K11-5	1185		4	7	9	25	32	7	16	.337	
	K11-6	1312		5	5	19	16	32	7	16	.368	
	K11-7	1216		1	3	17	22	32	11	14	.328	
100	K12-2	1202	1197	7	6	30	11	34	2	10	.435	.419
	K12-3	1306		18	8	17	11	33	3	10	.478	
	K12-4	1083		7	7	7	28	20	17	14	.346	
200	K9-5	1403	1238	15	13	17	11	31	3	10	.472	.458
	K9-6	1229		8	9	29	9	32	5	8	.449	
	K9-7	1063		9	6	17	14	21	18	15	.394	
	K9-8	1257		25	10	13	11	26	4	11	.518	
300	K13	1106	1207	13	10	22	11	26	7	11	.464	.446
	K13-1	1200		24	12	9	12	22	9	12	.498	
	K13-2	1355		5	5	27	15	36	2	10	.409	
	K13-3	1234		12	10	19	13	34	2	10	.449	
	K13-4	1138		11	6	19	16	19	18	11	.412	

pensated for their smaller size. There was, however, a decided reduction in quality when no potash was applied, the cured leaves being short, yellow, heavy and non-elastic. This is reflected in the lower grade index (Table 4). Tobacco from the 100 lbs.-potash plots was not quite as good as that from the 200 lbs.-plots. There were no significant differences between the 200 lbs. and the 300 lbs.-plots.

In general, the results from the Field I series confirm those from Field V series.

Wilting due to lack of potash. During hot days, tobacco leaves wilt and flag. During the summer of 1928 it was commonly observed on the above experiments and also in other tests on shade tobacco that the no-potash plots wilt first, and at all times the wilting is more pronounced on these plots.

Effect of quantity of fertilizer potash on burn. Strip burn tests were made on the crops of 1926 and 1927 as recorded on p. 171 These showed only a slight reduction in fire holding capacity the first year after potash is omitted, but serious reduction during the second year. One hundred pounds of potash per acre seems to have been enough to keep up the fire holding capacity, during two years.

Effect on the chemical composition of the leaves. Samples from the crop of 1926 (first year of test) were analyzed by Dr. E. M. Bailey of the chemistry department to see what effect the omission or reduction of fertilizer potash would have on the quantity of potash absorbed. The results presented in Table 5 show a consistent reduction in potash even for the first year and furnish reason to believe that the potash content of the leaves may be very materially affected by the quantity applied to the soil.

TABLE 5. QUANTITY OF POTASH IN LEAVES FROM PLOTS WITH REDUCED FERTILIZER POTASH. CROP OF 1926

Grades	Percent of potash in leaves when each acre received		
	No. Fert. potash	100 lbs. Fert. potash	200 lbs. Fert. potash
Darks	6.96	7.20	7.97
Seconds	7.03	7.33	8.32
Both	**7.00**	**7.27**	**8.15**

Conclusions. Despite the fact that this soil contains naturally very large quantities of potash it is obvious from these experiments that the availability of the native supply is so low that regular yearly applications in the fertilizer are necessary. When all potash is omitted from the fertilizer, the quality is slightly reduced the first year, seriously reduced the second year and the product is so inferior the third year that it is not worth sorting. The reduction in weight has not been so serious as in quality. One hundred pounds of potash per acre is not enough to keep up the quality for more than one year. As between 200 and 300 pounds, no differences have appeared in two years. Until further data are at hand it would seem best to use 200 pounds per acre although the possibility is not precluded that the minimum application may be somewhat lower or higher.

WHAT CARRIERS OF POTASH ARE BEST?

There are a number of forms (carriers) in which potash may be added to the fertilizer mixture. Although the element, potassium, is the same from all sources, nevertheless it is a mistake to believe that equal results can be secured irrespective of the form in which it is supplied. New England tobacco growers learned, for instance, many years ago that potash could not be supplied in the form of muriate because it ruined the burn. Such differences and resultant preferences are due to the acid radicals and other undesirable companions of potassium which may either affect the soil adversely or produce unfavorable effects when they enter the plant and change the composition of the leaves. Thus sulfate of potash and double sulfate of potash-magnesia are objectionable because too much sulfur in the plant reduces the fire holding capacity. Carbonate may cut down the yield. Nitrate may introduce too much nitrogen in the nitrate form. Cottonhull and wood ashes may have an unfavorable effect on soil because of caustic lime, etc. When one tries to make selection among them by theorizing on their possible effects he is confronted with so many conflicting possibilities that he is forced to the final conclusion that the only way of coming to a decision is through actual field tests. It is for this reason that a large number of the experimental plots on the station farm are now devoted to a comparison of different forms of potash. These experiments are being conducted under the most carefully controlled conditions we are able to maintain and every record possible is being made on them. Such experiments must ultimately answer the question proposed, at least as far as this type of soil is concerned.

In Table 6 all the sources of potash which have been used commonly in this section are listed with their essential analyses. Most of these are now included in the tests at the station or elsewhere.

TABLE 6. AVERAGE ANALYSES OF POTASH CARRIERS WHICH MAY BE USED FOR TOBACCO

Name of Carrier	Percentage of plant food						
	Potash (K_2O)	Nitrogen (N)	Phos. Acid (P_2O_5)	Lime (CaO)	Magnesia (MgO)	Sulf. Acid (SO_3)	Chlorine (Cl)
Sulfate of Potash	50	....	....	0.2	1.3	43.6	1.6
Nitrate of Potash[1]	44	12.5	....	....	....	....	0.6
Nitrate of Potash-Soda	12.0	14.5	....	....	....	....	0.7
Carbonate of Potash	64	....	....	....	....	....	0.5
Sulf. Potash-Magnesia	28	....	....	....	11.3	46.7	2.0
Wood Ashes[2]	6.6	....	2.1	36.6	5.7	1.2	0.5
Cottonhull ashes[2]	25	....	9.8	5.2	11.2	2.4	0.2
Tobacco Stems[2]	6.4	2.1	0.6	3.8	0.5	0.5	0.5
Cow manure[3]	0.5	0.4	0.3	0.2	0.1	0.1	0.1
Horse manure[3]	0.6	0.4	0.7	0.5	0.2	0.1	0.1

Since the purpose and progress of these experiments have been discussed in previous reports, they will not be repeated here but the present discussion will be confined to results of the last year or two and comparisons with those of the preceding years.

[1] German synthetic or Calcutta.
[2] Composition variable.
[3] Containing 60-70% water.

COMPARISON OF HIGH GRADE SULFATE WITH SULFATE OF POTASH-MAGNESIA

The possible benefit to be derived from the substitution of sulfate of potash-magnesia (double manure salts) for the more common sulfate of potash, lies in its content of magnesia which is essential for the growth of tobacco and without which the plant suffers from the malnutrition trouble commonly called sand-drown.

TABLE 7. COMPARISON OF HIGH GRADE SULFATE OF POTASH WITH DOUBLE MANURE SALTS. YIELD AND GRADES FOR CROP OF 1928

Source of potash	Plot No.	Acre Yield		Percentage of Grades							Grade index	
		Plot	Ave.	L	M	LS	SS	LD	DS	F	Plot	Ave.
High Grade Sulphate	K1 K1-1	1309 1280	1295	24 24	14 10	13 14	13 12	24 27	4 2	8 11	.529 .516	.522
Double Man. Salts	K2 K2-1	1313 1318	1315	22 16	13 9	14 21	13 13	28 29	2 3	8 9	.517 .481	.499
Half from Each	K3 K3-1	1341 1378	1354	19 17	8 10	19 17	11 13	28 27	4 4	01 12	.488 .472	.480

Just as in the preceding five years (See Tob. Sta. Buls. 5, p. 24; 6, p. 22; 8, p. 36), two of the plots (K1, K1-1) had all of their potash in the form of high grade sulfate, two more (K2, K2-1) all from double manure salts, and the other two (K3, K3-1) had the potash derived equally from the two sources. The growth in 1928 was uniform but light on account of the heavy rains during the growing season. No differences were observed during the summer between the various plots except for a trace of sand-drown on the K1 plots just before harvest but this never became of any importance. It was not observed at any time during the preceding five years. When the tobacco from these six plots was sorted, no signs of magnesia hunger were observed, all the tobacco being rated as satisfactory and of good quality.

Table 7, showing sorting results of the season of 1928, indicates a somewhat higher yield from the use of the two potash carriers in combination but a somewhat higher grade index from the use of high grade sulfate alone. Table 8, showing yields during six years of this experiment, indicates only a very slight difference (about 1%) in favor of the combination. Table 9, showing the grade index for 5 years, shows a very slight higher average for the high grade sulfate.

Differences in chemical composition. In order to see whether any chemical changes in the composition of the leaf had been caused by the substitution of double manure salts for high grade

TABLE 8. COMPARISON OF HIGH GRADE SULFATE WITH DOUBLE MANURE SALTS. ACRE YIELDS FOR SIX YEARS

Source of potash	Plot No.	Grade index by years 1923	1924	1925	1926	1927	1928	Plot Ave.	Average 12 replications
High Grade Sulfate	K1	2056	1333	2054	1739	1223	1309	1619	1630
	K1–1	2056	1387	2061	1832	1223	1280	1640	
Double Man. Salts	K2	1966	1413	1932	1831	1355	1313	1635	1622
	K2–1	1966	1413	1892	1833	1234	1318	1609	
Half from each	K3	2039	1467	2029	1712	1364	1341	1669	1638
	K3–1	2039	1333	1929	1648	1382	1378	1618	

sulfate, samples of seconds and darks for all plots were analyzed by the Station Chemistry Department. Since in double manure salts, considerably more magnesia and sulfur are added to the soil it was anticipated that a larger percentage of these elements would be found in the leaf. In view of the importance of potash in the burn, it also seemed desirable to learn whether the amount of

TABLE 9. COMPARISON OF HIGH GRADE SULFATE WITH DOUBLE MANURE SALTS. GRADE INDICES FOR 5 YEARS

Source of potash	Plot No.	Grade index by years 1924	1925	1926	1927	1928	Plot Ave.	Average 12 replications
H. G. Sulfate	K1	.281	.475	.471	.356	.529	.422	.436
	K1-1	.291	.475	.505	.457	.516	.449	
Double Manure Salts	K2	.281	.476	.479	.468	.517	.444	.433
	K2-1	.273	.471	.500	.383	.481	.422	
Half from each	K3	.316	.461	.475	.466	.488	.441	.425
	K3-1	.270	.483	.461	.357	.472	.409	

potash absorbed had been affected. Since calcium and magnesium have a somewhat complementary relation in the tobacco plant it was also decided to determine the percentage of calcium. The results of the chemical analyses for crop of 1926 are summarized in Table 10.

From these analyses it is apparent that the use of double manure salts has greatly increased the magnesia content of the leaves and correspondingly reduced the calcium. Both total sulfur and sulfate sulfur have been increased. The percentage of potash absorbed was slightly reduced, especially in the seconds.

Effect on the burn. Since it is generally conceded that burn is roughly proportional to the potash which may form combinations with the organic acids after the mineral acids(sulfuric, hydrochloric, nitric, phosphoric) have been neutralized, it would be anticipated that the small increase in sulfate sulfur and reduction in potash would be reflected in a corresponding reduction in fire holding capacity. Burn tests on these same samples of 1926, published in Bul. 10, Table 5 (before the chemical analyses were made) show that such was the case. This is confirmed by tests for two more years reported on p. 168 of the present bulletin.

TABLE 10. SUMMARY OF CHEMICAL ANALYSES OF TOBACCO FROM HIGH GRADE SULFATE AND DOUBLE SULFATE PLOTS. CROP OF 1926

Averages of duplicate plots

Source of potash	Grade of leaf	Percentage in water free leaf				
		Potash (K_2O)	Total Sulfur	Sulfate Sulfur	Lime (CaO)	Magnesia (MgO)
H. G. Sulfate	Darks	7.23	0.84	0.72	5.81	1.17
	Sec.	8.07	0.72	0.58	6.84	1.41
	Both	**7.65**	**0.78**	**0.65**	**6.32**	**1.29**
Double manure salts	Darks	7.05	1.00	0.87	4.76	1.97
	Sec.	7.54	0.81	0.69	5.94	2.28
	Both	**7.30**	**0.90**	**0.78**	**5.35**	**2.13**
Half from each	Darks	6.98	0.86	0.73	5.84	1.49
	Sec.	7.33	0.70	0.59	6.88	1.64
	Both	**7.16**	**0.78**	**0.66**	**6.36**	**1.56**

Character of soil. The soil on which these plots are located is a Merrimac sandy loam with some fragments of red sandstone in the surface. It has never leached seriously nor does it suffer excessively from dry weather. It produces a heavier and better crop on a relatively dry year than on a wet year. It is not the type of soil which suffers excessively from sand-drown.

Conclusions from the six year experiments. The original purpose of this experiment was to find whether any advantage would accrue from the substitution of sulfate of potash-magnesia (25% K_2O) for high grade sulfate (48% K_2O) as a source of potash in the tobacco mixture. At the end of six years we believe this question has been answered for this particular type of soil as nearly as it can be answered by field and laboratory tests. Two of these years were excessively wet (conducive to sand-drown), one was excessively dry, one just a little too dry, and the other two about optimum in rainfall.

When the records of the six years are averaged, the differences in yield and quality are found to be very small—probably too small to be important. Offsetting a somewhat larger yield from the use of the combination of the two carriers, there is a small advantage in grading and fire holding capacity from use of high grade sulfate. It may be stated definitely that there is no advantage in taking **all** the potash from double manure salts. On this type of soil there has been no advantage in getting **any** of it from that source. In more sandy, "leachy" locations, however, it is conceivable that the use of 100 or 200 pounds of double sulfate per acre might result in some advantage unless there are other sources of magnesia present. If our tobacco mixtures of the future are to include a smaller amount of vegetable organics (which contain magnesia)—as seems likely from present trends—it is certain that some carriers of magnesia must be included.

The disadvantages attending the use of double manure salts are (1) somewhat higher cost of the potash, (2) handling of a greater bulk of low grade material, (3) raising the sulfur content of soil and leaf, (4) lowering the potash content, and (5) consequent reduction of fire holding capacity.

COMPARISON OF SULFATE, CARBONATE AND NITRATE OF POTASH

This experiment was begun in 1925. Results of first two years are given in Tobacco Sta. Bul. 6, p. 25 and Bul. 8, p. 39. The object of the experiment is to compare the effect of these three carriers of potash on the yield and quality of tobacco. Using our standard formula as a base and with all other ingredients the same in all, the following five sources of potash, or combinations of sources were used:

PLOT
K1, all potash in H. G. Sulfate.
K5, all potash in carbonate.
K7, 2–3 of the potash in nitrate*, the other 1–3 in carbonate.
K8, ½ of the potash in sulfate, ½ in carbonate.
K9, potash derived equally from sulfate, carbonate and nitrate.

The exact formula for each of these plots is tabulated in Bul. 6. The quantity of ammonia, phosphorus and potash was the same for all plots. The experiment was begun with 10 plots on Field V where the soil is very sandy and the yield is never large. Each treatment is in duplicate on these original plots.

Since growth on this part of the field is usually not as good as might be wished and since results can be obtained more quickly and with more certainty by using a larger number of replications, the experiment was enlarged in 1927 by repeating the same treatments in triplicate on Field I. These two sets of plots give us five replications of each treatment every year. It is believed that this number is sufficiently large to ensure reliable data in a few years.

It will be noted from the above that the two series of plots (series of 1925 and series of 1927) are on somewhat different types

*In explanation of the K7 formula, it did not seem desirable to derive all the potash from nitrate because this would make a greater proportion of the nitrogen from mineral sources (in nitrate form) than we had in the other formulas and would thus introduce another variable.

of soil, the first being Merrimac coarse sandy loam with rapid drainage and therefore suffering from dry weather and from leaching, the second series on Merrimac sandy loam with a tighter subsoil giving slower drainage and therefore better for a dry year but too slow for a wet year. It is not prone to leaching. It will be most convenient to discuss these two series separately.

Series of 1925. Composition of the fertilizer mixtures applied to these plots is described in Bul. 6, p. 27. Significant differences in growth between the various plots were not observed during the summer of any of the four years of this test.

Sorting results for 1928 are presented in Table 11. These data indicate somewhat the best yield for the combination of sulfate, carbonate and nitrate and the best grading for nitrate and carbonate. The differences, however, are quite small. Carbonate alone has the lowest grading, due to the very poor showing of the single plot, K5. Yield on all plots was unusually light due to the very wet season.

TABLE 11. COMPARISON OF SULFATE, CARBONATE AND NITRATE OF POTASH. SERIES OF 1925. YIELD AND GRADING FOR CROP OF 1928

Carriers of potash	Plot No.	Acre yield lbs.		Percentage of Grades							Grade Index	
		Plot	Ave.	L	M	LS	SS	LD	DS	F	Plot	Ave.
Sulphate	K1-2 K1-3	1095 1234	1169	19 17	10 12	5 5	18 18	27 32	13 8	8 8	.449 .446	.447
Carbonate	K5 K5-1	1077 1190	1134	7 28	10 14	11 3	14 15	25 20	20 13	13 7	.366 .520	.443
⅔ Nitrate ⅓ Carbonate	K7 K7-1	1126 1190	1158	21 17	14 15	9 11	11 11	28 27	6 9	11 9	.488 .468	.478
½ Sulphate ½ Carbonate	K8 K8-1	1139 1220	1179	14 21	9 14	14 7	17 17	20 26	17 6	9 9	.432 .486	.459
⅓ Carbonate ⅓ Sulfate ⅓ Nitrate	K9 K9–1	1178 1221	1199	13 22	9 16	12 5	18 17	31 30	8 1	9 9	.428 .498	.463

In Table 12 the yield and grading data on these plots for 4 years are summarized. The low average for both yield and grading on the sulfate and carbonate plots are due to the poor showing of plots K1-2 and K5. These two plots are in one corner of the field where a building previously stood. As a result, these two plots have not grown as well as the others of this series. If, for the sake of fairness, these two plots were excluded from our calculations the average yield for the K1 plots would be 1,325 lbs. and grade index, .405. For the carbonate plots the corresponding figures would be 1,305 and .425. Carbonate would thus have the highest grade index but lowest yield, which is in accord with our previous observations. The excellent showing which the triple combination (K9) has shown both in yield and grading throughout the series leads us to favor this as the best source of potash.

TABLE 12. COMPARISON OF SULFATE, CARBONATE AND NITRATE OF POTASH. SERIES OF 1925. YIELD RECORDS AND GRADE INDEX FOR 4 YEARS.

Source of potash	Plot No.	Acre yield by years 1925	1926	1927	1928	Ave. of Treat-ment	Grade index by years 1925	1926	1927	1928	Ave. of Treat-ment
Sulfate	K1-2	1418	1135	1099	1095	1256	.316	.307	.276	.449	.371
	K1-3	1553	1294	1222	1234		.412	.351	.409	.446	
Carbonate	K5	1425	1325	1089	1077	1267	.317	.331	.273	.366	.373
	K5-1	1545	1312	1176	1190		.405	.343	.430	.520	
⅔ Nitrate	K7	1434	1350	1100	1126	1305	.407	.328	.337	.488	.392
⅓ Carb'ate	K7-1	1695	1393	1155	1190		.409	.381	.317	.468	
½ Sulfate	K8	1458	1362	1164	1139	1308	.381	.353	.322	.432	.392
½ Carb'ate	K8-1	1497	1403	1222	1220		.396	.388	.377	.486	
⅓ Sulfate	K9	1563	1372	1152	1178	1316	.369	.364	.411	.428	.399
⅓ Carb'ate	K9-1	1524	1424	1093	1221		.382	.388	.350	.498	

TABLE 13. COMPARISON OF SULFATE, CARBONATE AND NITRATE OF POTASH. SERIES OF 1927. ACRE YIELD AND GRADING OF CROP OF 1928

Carriers of potash	Plot No.	Acre yield Plot	Ave.	Percentage of grades L	M	LS	SS	LD	DS	F	Grade index Plot	Ave.
	K1-4	1410		13	16	16	12	21	12	10	.455	
	K1-5	1335		..	3	39	11	35	3	9	.405	
Sulfate	K1-6	1476	1397	3	6	36	9	34	2	10	.425	.437
	K1-7	1366		3	5	33	11	32	5	11	.408	
	K1-8	1356		10	9	26	11	31	2	11	.511	
	K1-9	1442		6	6	31	10	27	7	13	.420	
	K5-2	1320		11	5	24	16	20	15	9	.431	
Carbonate	K5-3	1261	1333	16	10	21	8	32	2	11	.481	.470
	K5-4	1419		15	13	24	9	30	1	8	.499	
⅔ Nitrate	K7-2	1394		6	8	26	14	28	8	10	.416	
⅓ Carbonate	K7-3	1330	1380	20	11	18	11	29	2	9	.507	.438
	K7-4	1416		0	4	37	15	24	9	11	.392	
½ Carbonate	K8-2	1331		2	4	40	11	25	6	12	.416	
½ Sulfate	K8-3	1391	1389	3	5	28	19	25	9	11	.389	.421
	K8-4	1445		12	9	22	15	31	3	8	.458	
⅓ Carbonate	K9-2	1194		3	3	28	21	27	7	11	.385	
⅓ Sulfate	K9-3	1353	1347	5	6	37	8	31	3	10	.441	.426
⅓ Nitrate	K9-4	1495		9	11	26	12	30	2	10	.452	

Series of 1927. This series is a duplicate of the 1925 series (three additional replications of each treatment) on Field 1 as explained above. The fertilizer treatment for 1928 was identical with that for the previous series but ground limestone at the rate of 400 lbs. per acre was added because this soil was considered too acid for best results. Growth was satisfactory and uniform but yield was much reduced by the extremely wet season.

Sorting results on this series, presented in Table 13, indicate slightly highest yield for the sulfate plots and best grading for the carbonate plots.

Summary of results for two years in Table 14 also show the best grading for the carbonate plots but the lowest yield. The triple combination (K9) had somewhat the best average yield.

TABLE 14. COMPARISON OF SULFATE, CARBONATE AND NITRATE OF POTASH. SERIES OF 1927. SUMMARY OF 2 YEARS

Source of potash	Plot No.	Acre yield			Average for Treatment.	Grade index			Average for Treatment.
		1927	1928	Ave.		1927	1928	Ave.	
Sulfate	K1-4	1273	1410	1342		.394	.455	.425	
	K1-6	1261	1476	1318	1342	.372	.425	.399	.417
	K1-8	1276	1356	1316		.345	.511	.428	
Carbonate	K5-2	1230	1320	1275		.410	.431	.421	
	K5-3	1246	1261	1254	1297	.394	.481	.438	.439
	K5-4	1307	1419	1363		.421	.499	.460	
⅔ Nitrate	K7-2	1271	1394	1333		.419	.416	.418	
⅓ Carbonate	K7-3	1250	1330	1290	1330	.380	.507	.444	.407
	K7-4	1318	1416	1362		.326	.392	.359	
Sulfate	K1-5	1250	1335	1293		.389	.405	.397	
	K1-7	1258	1366	1312	1329	.413	.408	.411	.403
	K1-9	1320	1442	1381		.380	.420	.400	
½ Sulfate	K8-2	1319	1331	1325		.396	.416	.406	
½ Carbonate	K8-3	1280	1391	1336	1352	.369	.389	.379	.415
	K8-4	1345	1445	1395		.463	.458	.461	
⅓ Sulfate	K9-2	1292	1394	1343		.414	.385	.400	
⅓ Carbonate	K9-3	1319	1353	1336	1356	.365	.441	.403	.410
⅓ Nitrate	K9-4	1284	1495	1390		.403	.452	.428	

TOBACCO STEMS AS A SOURCE OF POTASH

Tobacco stems (midribs of the leaf) contain about 6% of potash and for many years have been used by some growers for tobacco land. Besides potash, they also contain around 2.1% nitrogen, .5% phosphoric acid and about 4% of lime. They also add organic matter to the soil.

In order to see whether they can be used to advantage as the only source of potash, three plots were included in the potash series of Field 1 in 1927. The formula for these plots was as follows:

Carrier	Pounds per acre	Nutrients per acre		
		NH_3	P_2O_5	K_2O
Stems	2810	73.1	14	179.8
Cottonseed meal	1060	86.9	30.7	20.2
Nitrate of soda	212.7	40.0		
Total.........		200	44.7	200

The stems were applied at the same time as the fertilizer in 1927. The yield and sorting data are presented in Table 15.

TABLE 15. YIELD AND SORTING DATA ON STEMS PLOTS. CROP OF 1927

No. of plot	Yield per acre		Percentage of grades								Grade index	
	Plot	Ave.	L	M	LS	SS	LD	DS	F	B	Plot	Ave.
K14	1222		9	7	12	8	40	4	13	7	.376	
K14-1	1186	1266	4	4	25	5	39	3	12	8	.372	.394
K14-2	1390		12	7	19	7	41	1	9	4	.435	

The replicates in this series are not very consistent since the K14-2 plot was very much higher than the others both in yield and quality. The average of both yield and grade index is about the same as for the sulfate of potash plots (K1-5, K1-7, K1-9) which were immediately adjacent to them.

This series of three plots on Field 1 was continued in 1928, the fertilizer being the same except for the addition of 400 lbs. of limestone per acre. The stems were plowed under in the spring.

The sorting data for 1928 are presented in Table 16 along with corresponding data from the sulfate and carbonate plots for comparison. From these data it is apparent that there has been as good yield and quality as where other sources of potash have been used. The grading is particularly good.

TABLE 16. STEMS AS A SOURCE OF POTASH. ACRE YIELD AND GRADING OF CROP OF 1928

Source of potash	Plot No.	Acre yield		Percentage of grades							Grade index	
		Plot	Ave.	L	M	LS	SS	LD	DS	F	Plot	Ave.
	K14	1292	....	11	11	24	14	24	8	8	.498	
Stems	K14-1	1369	1346	..	..	..	..	..	..	..	....	.486
	K14-2	1378	....	15	12	18	12	31	4	8	.475	
Sulfate	6 plots		1397	..	..	..	..	..	..	..	....	.437
Carbonate	3 plots		1333	..	..	..	..	..	..	..	....	.470

EFFECT OF DIFFERENT POTASH CARRIERS ON REACTION OF THE SOIL

In order to see whether the continuous application of any one or any combination of these potash carriers would shift the reaction of the soil, samples were taken from the ten plots in the 1925 series, (1) before sowing the fertilizer each year and (2) just after harvesting the crop. The reaction was determined electrometrically with results as follows:

TABLE 17. SOIL REACTION (pH) OF POTASH PLOTS. SERIES OF 1925

Source of potash	Plot No.	1925		1926		1927		1928		
		May	Sept.	May	Aug.	May	Sept.	May	July 13*	Aug. 7
Sulfate	K1-2 K1-3	6.02 5.09	5.84 5.00	6.03 5.21	5.73 4.65	6.08 5.10	5.94 4.75	5.81 5.08	5.74 4.67	5.79 4.82
Carbonate	K5 K5-1	5.53 5.21	5.45 5.25	5.72 5.31	5.45 5.11	5.89 5.32	5.42 5.25	5.59 5.24	5.51 4.99	5.39 5.02
⅔ Nitrate ⅓ Carbon.	K7 K7-1	5.31 5.30	5.40 5.03	5.47 5.12	4.93 4.41	5.62 5.19	5.09 4.71	5.31 5.10	5.04 4.93	5.03 4.87
½ Sulfate ½ Carbon.	K8 K8-1	5.26 5.10	5.27 5.05	5.41 5.04	4.93 5.19	5.54 5.18	5.29 4.81	5.40 5.08	5.05 4.92	5.23 4.96
⅓ Sulfate ⅓ Carbon. ⅓ Nitrate	K9 K9-1	5.05 5.05	5.15 5.12	5.19 4.95	5.02 4.84	5.47 5.33	5.06 5.05	5.16 5.02	5.09 4.95	5.15 5.00

* Crop two-thirds grown.

Although the reactions have varied considerably during the four years of this test, there seems to be no definite trend in any one direction for any of the plots. Comparing the reactions of May, 1925 with those of May, 1928, they are found to be almost identical in all cases. The result is the same when the reactions of September, 1925 are compared with those of August, 1928. We may conclude from this that when such potash carriers in these quantities are applied annually to this type of soil there is very little if any permanent change in reaction.

EFFECT OF POTASH CARRIERS ON THE CHEMICAL COMPOSITION OF THE TOBACCO

For reasons previously mentioned it is desirable to get the plant to absorb as much potash as possible and to keep the sulfur content low. In order to see whether the potash carrier has any effect on the quantity of these elements absorbed, samples from the ten plots of the series of 1925 were analyzed by the Station Chemistry Department. Two grades, seconds and darks of the crop of 1926, were taken from each plot. Summary of the analyses are presented in Table 18.

TABLE 18. POTASH AND SULFUR CONTENT OF TOBACCO TREATED WITH DIFFERENT CARRIERS OF POTASH. AVERAGES OF DUPLICATES

Source of potash	Grades	Total Sulfur	Potash
Sulfate	Darks	0.57	8.31
	Seconds	0.57	8.66
	Both	**0.57**	**8.49**
Carbonate	Darks	0.50	7.76
	Seconds	0.43	8.47
	Both	**0.46**	**8.13**
⅔ Nitrate ⅓ Carbonate	Darks	0.43	8.38
	Seconds	0.43	8.62
	Both	**0.43**	**8.50**
½ Carbonate ½ Sulfate	Darks	0.53	8.09
	Seconds	0.51	8.18
	Both	**0.52**	**8.13**
⅓ Sulfate ⅓ Carbonate ⅓ Nitrate	Darks	0.57	7.97
	Seconds	0.51	8.32
	Both	**0.54**	**8.15**

It will be noted in this table that the most sulfur is found in the leaf when sulfate of potash is used as the source of potash. The least amount of sulfur is found when nitrate or carbonate are used. Increase in the sulfur content of leaves following increase in fertilizer sulfur has been noted in our previous experiments at this station (Bul. 10, p. 46) as well as by other investigators there mentioned. The differences in the potash content of the leaves are perhaps too small to be of importance.

CONCLUSIONS FROM ALL POTASH EXPERIMENTS TO DATE

1. There are about 35,000 pounds of potash per acre in the upper eight inches of soil on the experiment station farm. This soil is typical of a large part of the tobacco section.

2. This supply of potash is not sufficiently available to meet the needs of a tobacco crop and yearly additions of fertilizer potash are necessary.

3. When all potash is omitted from the fertilizer, the grading of the tobacco is affected, beginning with a decline the first year and rendering the leaves worthless in about three years.

4. Such leaves are thick, dry, non-elastic (boardy) yellow and of very inferior quality generally.

5. One hundred pounds of potash per acre is not sufficient to maintain the quality of the leaf.

6. Up to the present there has been no benefit from raising the quantity of potash to 300 pounds in the fertilizer.

7. Reducing the potash has not seriously affected the acre yield of tobacco.

8. It has had an injurious influence on the fire holding capacity.

9. Reducing the quantity of potash in the fertilizer has materially reduced the percentage of potash in the leaf.

10. The substitution of sulfate of potash-magnesia for high grade sulfate of potash has been of no advantage on the soil where tested but may be beneficial in preventing sand-drown in lighter soils.

11. Its use has lowered the grading and fire holding capacity. It has not increased the yield.

12. It increased greatly the magnesia content of the leaves but reduced the calcium and to a less degree, the potash.

13. It increased the sulfur content of the leaves.

In comparing sulfate, carbonate and nitrate of potash:

14. Carbonate gave the best grading but the lowest yield. It also gave the best fire holding capacity.

15. Nitrate was satisfactory from all standpoints but should not be used in excess on account of its high nitrate content.

16. Most consistently good results were secured from a combination of the three sources of potash, deriving one-third of the required potash supply from each carrier.

17. The quantity of potash absorbed has not been influenced by the carriers used.

18. The use of sulfate has increased the sulfur content of the leaves. The use of carbonate or nitrate gave a smaller quantity of sulfur in the leaves.

19. The reaction of the soil has not been changed perceptibly by using any of these carriers for four years.

20. Tobacco stems have also been a favorable source of potash for tobacco.

Effect of Fertilizers on the Combustion of Tobacco

In the Report of the Tobacco Station for 1927 (Tob. Sta. Bul. 10) an introductory article on this subject was published and all data on the crops of 1925 and 1926 were presented. The present report is a continuation of that account and gives results of burn tests on the crop of 1927.

When the Havana Seed crop of 1927 was sorted, sample hands of the four grades were taken from each plot, labelled and fermented for six to eight weeks in the sweat room of the W. S. Pinney warehouse in Suffield. The case of samples was left undisturbed to undergo a natural sweat at the warehouse until October, 1928 when it was taken to the Station where strip burn tests were made

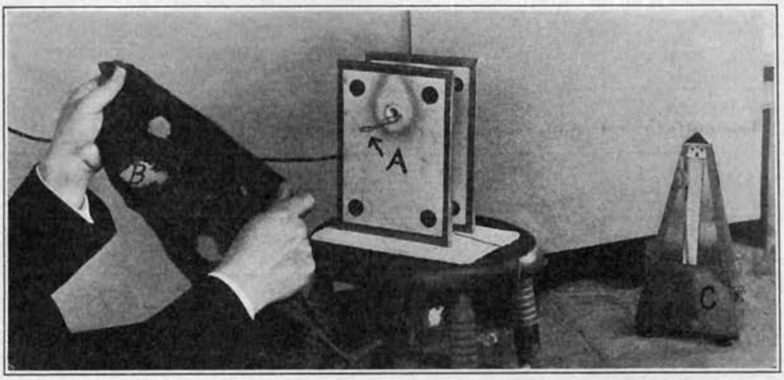

FIG. 16. Making strip tests on combustion. A, Electrically heated coil for ignition. B, Holes burned in leaf. C, Metronome for timing.

with an electrically heated filament. Five leaves were tested from each hand, each in four different places making a total of 20 tests from each hand. The leaves were just moist enough to handle well without breaking. The leaf was ignited near the midrib and held in such position that the flame progressed straight upward between the lateral veins. A metronome was used for counting and 60 seconds was considered the maximum, i. e., the count was stopped at 60 even though the leaf continued to burn.

The crop as a whole had an unusually long fire holding capacity. On most of the plots so many of the tests ran to 60 seconds that the averages showed only very small differences. The unusually long duration of burn—longer than any station crop yet tested—is probably due to the wet growing season of 1927.

THE POTASH SERIES

There are five series of potash plots, each of which will be discussed separately.

High Grade Sulfate of Potash vs. Double Sulfate of Potash-Magnesia. The crop of 1927 was the fifth consecutive crop raised on these six plots. Burn records for the two preceding crops are recorded and discussed in Tobacco Station Bul. 10, p. 30. Burn records for the 1927 crop and three year average are presented in Table 19 below.

TABLE 19. SULFATE OF POTASH VS. SULFATE OF POTASH-MAGNESIA. STRIP BURN TESTS FOR 1927 CROP

Plot No.	Source of potash	Duration of burn in seconds						
		Darks	Mediums	Lights	Seconds	Ave. of all grades	Both plots	3 year average
K1 K1-1	High grade sulfate	59.5 55.0	58.4 59.4	.... 54.6	58.8 57.8	58.9 56.7	57.7	41.2
K2 K2-1	Sulfate of Pot. Magn.	59.9 52.1	58.8 56.7	.... 57.3	52.6 59.2	57.1 56.3	56.7	36.6
K3 K3-1	One half from each	55.0 56.9	58.8 59.3	59.5 55.8	60.0 57.2	55.8 57.3	56.6	38.7

The fire holding capacity of all grades on all six plots was very high and the differences are probably too small to be significant. Comparing the three year averages (each figure representing 480 tests) there appears to be a small but constant difference in favor of high grade sulfate. It is questionable whether this difference is sufficiently large to offer serious objection to the use of double manure salts.

TABLE 20. CARBONATE, NITRATE AND SULFATE OF POTASH. SERIES OF 1925. STRIP BURN TESTS FOR 1927 CROP

Plot No.	Source of potash	Duration of burn in seconds.						
		Darks	Mediums	Lights	Seconds	All grades	Ave. for treat-ment	3 year average
K1-2 K1-3	Sulfate	58.2 51.5	54.3 47.7	56.6 54.3	48.3 49.5	54.4 50.7	52.6	44.2
K5 K5-1	Carbonate	54.9 58.0	56.6 49.8	54.8 59.6	53.5 59.3	55.0 56.7	55.8	49.9
K7 K7-1	⅔ Nitrate ⅓ Carbon.	55.5 56.3	55.5	48.1 49.7	57.2 49.7	54.1 51.9	53.1	45.9
K8 K8-1	½ Sulfate ½ Carbon.	55.3 53.5	56.4 56.9	57.4 56.7	53.4 53.9	55.6 55.3	55.4	45.2
K9 K9-1	⅓ Sulfate ⅓ Carbon. ⅓ Nitrate	59.6 59.2	50.2	50.1 58.0	58.8 52.1	54.7 56.4	55.4	47.8

Comparison of carbonate, sulfate and nitrate of potash. Ten of these plots were started in 1925, the other 22 in 1927. Burn tests on the series of 1925 are recorded in Bul. 10, p. 32. No previous report on the 1927 series has been made. Strip burn tests for the 1927 crop are presented in Table 20 and Table 21.

The results agree with those of the two previous years. The carbonate plots have a slightly higher fire holding capacity than the others while the sulfate tobacco is lowest. These differences, however, are quite small. It will be noted that the heavier grades have a somewhat longer fire holding capacity which in general is not in agreement with results of previous years. This is partly due to the fact that the light grade leaves were so thin that the line of fire consumed to the margin of the leaf before 60 seconds elapsed, thus lowering the average.

TABLE 21. CARBONATE, SULFATE AND NITRATE OF POTASH. SERIES OF 1927. STRIP BURN TESTS FOR 1927 CROP

Source of potash	Plot No.	Duration of burn in seconds					
		Darks	Med'ms	Lights	Seconds	All grades	Average for treatment.
	K1-4	....	51.7	48.3	56.9	52.3	
	K1-5	34.9	49.5	46.6	55.9	46.5	
	K1-6	57.8	55.8	47.3	58.5	54.8	
Sulfate	K1-7	53.7	54.3	55.6	57.6	55.3	53.4
	K1-8	55.1	56.9	....	....	56.0	
	K1-9	58.1	57.2	53.4	57.7	56.6	
	K5-2	56.4	60.0	58.7	58.9	58.5	
Carbonate	K5-3	58.6	59.2	59.8	58.0	58.9	56.0
	K5-4	51.9	52.8	46.9	51.2	50.7	
⅔ Nitrate	K7-2	59.0	....	51.7	58.0	56.2	
⅓ Carbonate	K7-3	55.8	57.7	55.2	54.6	55.8	56.2
	K7-4	59.3	....	55.6	55.7	56.9	
½ Sulfate	K8-2	56.7	54.3	57.7	59.7	57.1	
½ Carbonate	K8-3	52.7	53.8	51.7	59.2	54.3	56.5
	K8-4	56.3	59.9	56.8	59.3	58.1	
	K9-2	51.2	54.6	47.0	57.5	55.1	
⅓ Sulfate	K9-3	53.9	51.3	56.9	54.8	54.2	
⅓ Carbonate	K9-4	51.6	49.6	54.7	56.3	53.1	
⅓ Nitrate	K9-5	57.3	57.7	55.8	59.5	57.6	55.4
	K9-6	56.6	52.0	51.3	57.2	54.3	
	K9-7	52.6	56.1	58.3	58.6	56.4	
	K9-8	58.7	58.1	54.8	55.5	56.8	

As shown in Table 21, the fire holding capacity of the series of 1927 was somewhat the lowest on the sulfate plots but practically the same in all the others.

Tobacco Stems. In the 1927 series of potash plots, there were three plots which received all their potash from tobacco stems.

These were the N4 plots of previous years (1922-26) which received the largest application of sulfate of ammonia and consequently had the poorest burn (Bul. 10, p. 24). It is not unlikely that there was a carry-over effect from previous treatment and this should be kept in mind in judging the tests of at least the first year.

Results of the tests on the 1927 crop are presented in Table 22.

TABLE 22. STEMS PLOTS. STRIP BURN TEST ON CROP OF 1927

Plot No.	Duration of burn in seconds					
	Darks	Med'ms	Lights	Seconds	All grades.	Average for treatment.
K14	51.1	52.3	45.8	53.4	50.7	
K14-1	45.9	59.6	57.1	58.2	55.2	53.8
K14-2	56.5	55.9	52.5	57.5	55.5	

The average burn of all (53.8 seconds) is practically the same as for the adjacent sulfate of potash plots.

Quantity of potash. In order to determine the optimum quantity of potash which should be applied in the fertilizer, six plots were started in 1926. The 1927 crop was therefore the second one. Burn tests for this year, presented in Table 23, show that there has been a decided drop in fire holding capacity where no potash has been applied for two years but that otherwise 100 pounds per year has been just as effective as 200 pounds in keeping up the burning quality. Whether this will be true for a longer period of years is yet to be tested.

TABLE 23. QUANTITY OF POTASH, SERIES OF 1926. STRIP BURN TESTS ON THE 1927 CROP

Quantity of potash	Plot No.	Duration of burn in seconds.					
						Average of	
		Darks	Med'ms	Lights	Seconds	All grades	Both plots
None	K11	37.0	....	....	34.2	35.6	36.3
	K11-1	37.7	....	....	36.3	37.0	
100 lbs.	K12	57.1	58.8	57.1	58.4	57.8	57.0
	K12-1	55.6	53.8	55.9	60.0	56.3	
200 lbs.	K9	59.6	50.2	50.0	58.8	54.5	55.6
	K9-1	59.2	....	58.0	52.1	56.8	

Comparison of Table 23a with Table 23 shows that the reduction in fire holding capacity was not serious the first year.

TABLE 23A. QUANTITY OF POTASH; SERIES OF 1926. STRIP BURN TESTS ON THE CROP OF 1926

Quantity of potash	Plot No.	Duration of burns in seconds					
		Darks	Med'ms	Lights	Seconds	Average of All grades	Average of Both plots
None	K11	23.0	31.9	49.4	40.8	36.3	38.9
	K11-1	26.0	45.3	41.4	52.9	41.4	
100 lbs.	K12	22.0	46.4	50.6	40.6	39.9	39.9
	K12-1	18.1	35.9	57.2	48.8	40.0	
200 lbs.	K9	11.5	59.0	58.9	53.6	....	45.2
	K9-1	41.5	42.2	56.9	41.7	....	

In 1927 the series was extended by the addition of 18 plots on Field 1. Burn tests for the first year (presented in Table 24) show only a small reduction in fire holding capacity for the first year where all carriers of potash were omitted.

TABLE 24. QUANTITY OF POTASH; SERIES OF 1927. STRIP BURN TEST FOR 1927 CROP

Pounds of potash	Plot No.	Duration of burn in seconds					
		Darks	Med'ms	Lights	Seconds	Average of All grades	Average of Treatment.
None	K11-2	52.7	56.3	51.5	57.4	54.5	53.9
	K11-3	55.2	36.8	56.2	58.0	51.5	
	K11-4	53.6	60.0	60.0	54.4	56.5	
	K11-5	54.4	55.5	52.1	49.7	52.9	
	K11-6	53.6	52.5	58.1	55.1	54.8	
	K11-7	57.5	48.4	54.3	52.2	53.1	
100 lbs.	K12-2	49.7	....	58.5	58.3	55.5	57.2
	K12-3	53.9	60.0	58.6	58.8	57.8	
	K12-4	58.2	57.6	58.0	....	57.9	
200 lbs.	K9-5	57.3	52.7	55.8	59.5	57.6	56.2
	K9-6	56.6	52.0	51.3	57.2	54.3	
	K9-7	52.6	56.1	58.3	58.6	56.4	
	K9-8	58.6	58.0	54.8	55.5	56.7	
300 lbs.	K13	60.0	57.8	58.7	52.0	57.1	56.9
	K13-2	56.9	57.0	56.0	59.4	57.6	
	K13-3	58.5	55.0	55.5	....	56.3	
	K13-4	56.9	58.0	59.0	....	58.0	
	K13-5	51.0	58.0	57.8	57.1	56.0	

NITROGEN SERIES

In 1927 we had four sets of plots where nitrogen fertilizers were under comparison. Each is discussed separately below.

Urea plots. Burn tests for previous years on some of these plots were discussed in Bulletin 10, p. 29. Three plots received all their nitrogen from urea, three received one-half of their nitrogen supply from urea, while three others, which received none of their nitrogen from urea, served as controls. Total quantity of nitrogen as well as the other food elements were the same on all.

Strip burn tests on the crop of 1927, presented in Table 25 below indicate a slight reduction in fire holding capacity when the entire nitrogen supply was from urea but there was no reduction when one-half of the supply was from urea. The differences, however, are small and would probably not constitute serious objection to a full urea formula if it were desirable from all other standpoints.

TABLE 25. UREA PLOTS. STRIP BURN TESTS ON CROP OF 1927

Plot No.	Amount of urea	Duration of burn in seconds.						
		Darks	Mediums	Lights	Seconds	All grades	Treat-ment	3 year average
N1-5		53.6	58.8	55.8	56.4	56.3		
N1-6	None	60.0	57.3	....	60.0	59.1	57.7	33.1
N1-7		58.3	56.7	59.1	58.9	58.2		
N8	½ nitrogen	58.9	56.3	57.7	59.9	58.2		
N8-1	from urea	56.9	55.9	57.4	58.7	57.2	57.1	34.1
N8-2		57.3	50.4	57.2	58.7	55.9		
N9	All nitrogen	45.2	57.7	50.3	59.5	53.2		
N9-1	from urea	53.1	55.4	55.9	58.6	55.8	54.1	31.9
N14		52.6	59.8	53.5	47.3	53.3		

Single sources of nitrogen. On these plots (started in 1926) six different nitrogen carriers, each used in turn as the only source of nitrogen in the formula, are under comparison. Tests of the previous year are discussed in Bulletin 10, pp. 26 and 60. The strip tests of the 1927 crop presented in Table 26, show that sulfate of ammonia gave the lowest fire holding capacity. In this and other

TABLE 26. SINGLE SOURCE OF NITROGEN PLOTS. STRIP BURN TESTS ON CROP OF 1927

Plot No.	Sources of potash	Duration of burn in seconds.						
		Darks	Mediums	Lights	Seconds	All Grades	Ave. of treat-ment	2 year average
N11	C. S. Meal	50.6	......	......	55.1	52.9	52.9	43.5
N12	Nitrate Soda	56.1	......	......	59.9	58.0	58.0	47.5
N13	Sulfate Am.	44.3	......	......	55.6	49.9	49.9	35.4
N14	Urea	52.6	59.8	53.5	47.3	53.3	53.3	41.2
N22	Nitr. Lime	55.2	......	......	59.7	57.5	......	......
N23	Nitr. Lime	55.4	......	......	59.7	57.5	57.5	......
N24	Castor Pom.	57.7	......	......	59.7	58.7	58.7	......

tests of the same year it has been noted that the depression of fire holding capacity from the use of sulfate of ammonia was not so pronounced as in the two previous years. The heavy rainfall of 1927 may have had an influence. The fire holding capacity of the nitrate of soda plot is very high again in 1927, as it was in the preceding year. The same was true of the nitrate of lime plots. All of these plots showed distinct signs of nitrogen starvation during the latter part of the wet growing season and the cured tobacco was of poor quality. The long fire holding capacity may be due to the absence of hindering nitrogen compounds in the leaf rather than to any specific effect of the nitrates of lime and soda. Contrary to the popular impression, castor pomace had no unfavorable influence.

Concentrated formula. The trend of recent years is toward a very concentrated fertilizer. This has obvious advantages provided the quality and yield of the crop are not adversely affected. The concentrated formula (18-14-18) described in Bul. 6, p. 16, was slightly modified in 1927 and was composed as follows:

CONCENTRATED FORMULA (PER ACRE)

Urea	286 lbs.
Nitrate of potash	250 lbs.
Carbonate of potash	129 lbs.
Carbonate of magnesia	31.3 lbs.

This extremely concentrated formula (28.5-0-28.5) contained no phosphorus because experiments on this field indicated no benefit from use of phosphorus.

Since no previous report on the burn tests of tobacco from these plots has been made, records for the crops of three years are presented in Table 27. There is a small reduction in fire holding

TABLE 27. CONCENTRATED FERTILIZER. STRIP BURN TESTS ON CROPS OF 1925-26-27

Plot No.		Duration of burn in seconds													
		Darks			Mediums			Lights			Seconds			3 yr. ave.	
		1925	1926	1927	1925	1926	1927	1925	1926	1927	1925	1926	1927	Plot all Gr.	Treatment
N1-3	Stand	49.3	9.7	54.4	48.1	23.3	59.9	49.4	56.8	59.2	56.1	52.4	59.0	48.2	46.8
N1-4		49.0	9.9	50.9	42.1	33.0	58.4	41.9	45.9	59.4	48.1	49.0	57.9	45.5	
N10	Conc	34.8	6.9	57.4	44.0	32.2	56.8	40.5	47.3	53.6	46.9	45.0	59.6	44.0	41.0
N10-1		32.2	19.1	50.7	21.8	13.0	44.5	44.3	47.3	54.2	40.2	45.2	47.1	38.3	

capacity due to the concentrated formula. Since, however, it is not certain just which constituent of this fertilizer is responsible, one would not be justified in concluding that other concentrated mixtures would have the same effect.

Nitrate of soda *vs.* **nitrate of lime.** The object of this series of eight plots was to compare nitrate of soda with nitrate of lime as the source of mineral nitrogen of the fertilizer. In the first comparison one-fifth of the nitrogen was in mineral form, while in the second, one-half was in mineral form. The series was begun in 1927. Results of the burn tests of the first crop, presented in Table 28, indicate that the burn was excellent on all plots and there were no significant differences where the two kinds of nitrate were compared.

TABLE 28. NITRATE OF LIME PLOTS. STRIP BURN TESTS ON 1927 CROP

Plot No.	Nitrogen Source	Duration of burn in seconds					
		Darks	Med'ms	Lights	Seconds	All grades	Average of treatment
N1-8 N1-9	⅕ N. in Nitr. Soda	47.0 58.4	52.7 57.3	58.5 59.0	55.9 57.4	53.5 58.0	55.8
N16 N16-1	⅕ N. in Nitr. Lime	60.0 58.1	58.5 59.8	59.2 58.7	60.0 60.0	59.4 59.1	59.2
N2-3 N2-4	½ N. in Nitr. Soda	58.8 52.0	54.4 59.8	56.4 59.3	58.9 56.7	57.1 57.0	57.0
N18 N18-1	½ N. in Nitr. Lime	59.8	59.2 58.3	56.3 55.9	58.9 58.9	58.5 57.7	58.2

LIME SERIES

Field VIII was heavily limed each year up to 1925. Since the soil was then found to have a reaction somewhat above neutral no more was applied. Strip tests on the crops of 1925 and 1926 are recorded in Bulletin 10, p. 33. Tests on the 1927 crop, recorded below in Table 29 agree with those of preceding years in showing a

TABLE 29. LIME PLOTS. STRIP BURN TESTS ON FIELD VIII TOBACCO COMPARED WITH NO-LIME PLOTS. CROP OF 1927

Plot No.	Lime treatment	Duration of burn in seconds					
		Darks	Med'ms	Lights	Seconds	All grades	Treatment average
L1 L2 L3 L4	Lime	47.1 .... 46.0 55.3	.... 42.6	....	34.0 54.6 43.5 42.7	40.6 54.6 44.8 46.9	45.7
N1-5 N1-6	No Lime	53.6 60.0	58.8 57.3	55.8	56.4 60.0	56.3 59.1	57.3

distinct reduction in fire holding capacity where lime is heavily applied.

On another series of plots on Field I where the effect of different fertilizers on black rootrot was being tested, one-half of each plot was heavily limed each year beginning with 1924. Burn tests for 1925 and 1926 were recorded in Bul. 10, p. 33. Those for the 1927 crop, given in Table 30 below, show some depressing effect of lime

TABLE 30. LIME PLOTS. STRIP BURN TESTS ON LIMED AND UNLIMED ENDS OF THE BLACK ROOTROT SERIES. CROP OF 1927

Plot No.	Lime treatment	Duration of burn in seconds					
		Darks	Med'ms	Lights	Seconds	Treatment Ave.	Three year Average
Tla Tlax	 Lime	.... 34.1	....	....	.... 7.5	20.8	
T1b T1bx	No Lime	52.9 53.6	57.5 43.9	.... 57.2	56.8 57.0	54.1	
T2a T2ax	Lime	.... 55.4	....	....	34.2 42.3	43.9	
T2b T2bx	No Lime	60.0 60.0	.... 59.4	.... 56.3	58.8 58.7	58.9	
T3a T3ax	Lime	37.4 42.2	....	....	42.8 22.9	36.3	
T3b T3bx	No Lime	59.7 59.9	59.5 60.0	58.1 59.7	59.4 58.3	59.2	
Average of all lime plots....................						35.4	26.5
Average of unlimed plots.....................						56.5	39.8

when measured by the strip test. In this table it will be noted that the acid fertilizer (T1) still further reduced the fire holding capacity. This effect, which is probably due to sulfate of ammonia, was also very evident in the preceding years.

Reasons for the depressing effect of lime are discussed on p. 198.

UNFERTILIZED TOBACCO

There are two small plots on the station farm where tobacco has been grown continuously since 1924 but without the addition of any fertilizer. The tobacco grown here has been short and very inferior, in fact, not worth harvesting. In order to see what effect the fertilizer as a whole has on burn, the crops of 1926 and 1927 were tested. The results, presented below in Table 31, show that the fire holding capacity of this tobacco was just as inferior as the quality. This was probably due to the potash shortage because the plants in the field showed symptoms of shortage of this element and also because other tests have not shown such a depression from shortage of either nitrogen or phosphorus in the fertilizer.

TABLE 31. UNFERTILIZED PLOTS COMPARED WITH STANDARD FERTILIZED PLOTS. BURN TESTS ON CROPS OF 1926-27

Plot No.	Fertilizer	Duration of burn in seconds								
		Darks		Mediums		Lights		Seconds		Average for treatment
		1926	1927	1926	1927	1926	1927	1926	1927	
Ntr1	None	4.6	....	5.4	....	....	....	7.2	....	16.4
Ntr 2		8.0	....	....	42.0	....	25.8	5.4	33.	
N1	Standard	10.6	....	16.2	....	39.8	....	44.0	....	37.1
N1-5		....	34.9	....	48.5	....	46.6	....	55.9	

INFLUENCE OF THE SEASON ON COMBUSTION

In making the fire holding capacity tests on the crop of 1927 it was observed that, irrespective of fertilizer treatment, all the tobacco had a much better fire holding capacity than the tobacco of the preceding year. In order to check on our impressions, an average of all burn tests on crops of the two seasons was calculated. The average of 7,460 tests for 1927 was 54.6 seconds as compared with an average of 27.4 seconds for 5,400 tests on the 1926 crop. Since the fertilizer treatment, except for a small number of plots, had been the same and the tests were made in the same way at the same time of year and under the same conditions, the conclusion seemed warranted that the difference was due to the season. Inquiry among tobacco dealers disclosed the general opinion among them that the crop of 1927 was an unusually free burning one.

When the weather records for the two seasons, as recorded at the station farm, were compared, the most apparent difference was found to be in rainfall. During the period from the application of the fertilizer to the last day of harvesting the rainfall in 1926 was 6.33 inches and in 1927 for the same period it was 13.26 inches, i. e., when the rainfall was doubled, the fire holding capacity was also doubled.

In order to see whether this same rule would apply to the preceding years, the rainfall for 1924 and 1925 was tabulated (Table 32) along with the average burn. As indicated in this table the correlation in the extremely dry year 1924 was about as anticipated, viz., extremely poor fire holding capacity. It is a matter of history well known to all dealers that the 1924 crop was the poorest burning crop in many years. The correlation in 1925, however, is not so good, i. e., the fire holding capacity was lower than expected. This may be partially explained by the fact that some of the burn tests for that year were made before sweating the tobacco, and unsweat tobacco never burns as well, but even when allowances are made for this, it is apparent that the 1925

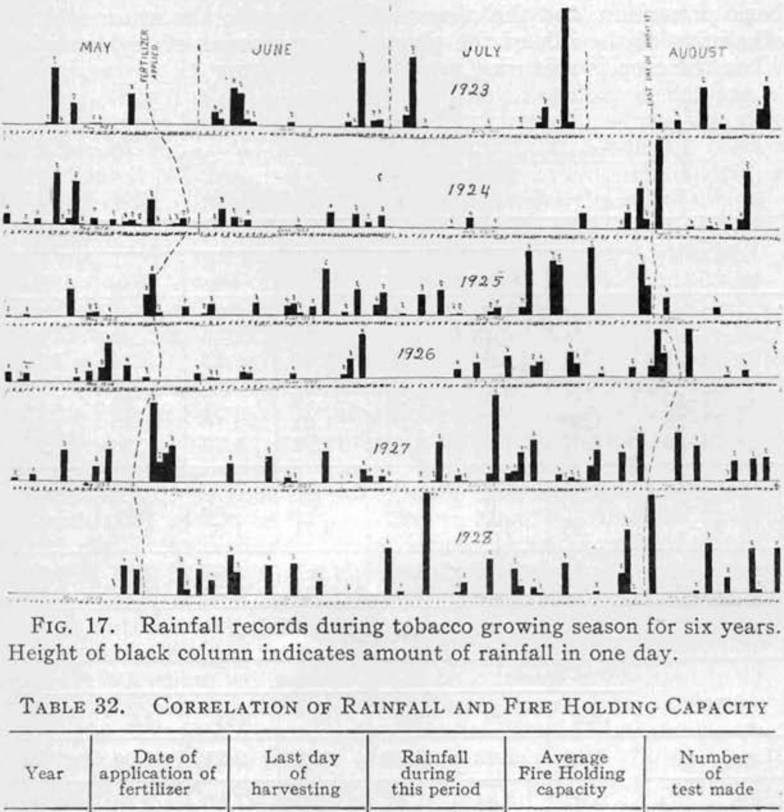

FIG. 17. Rainfall records during tobacco growing season for six years. Height of black column indicates amount of rainfall in one day.

TABLE 32. CORRELATION OF RAINFALL AND FIRE HOLDING CAPACITY

Year	Date of application of fertilizer	Last day of harvesting	Rainfall during this period	Average Fire Holding capacity	Number of test made
1924	June 1(?)	Aug. 12	3.57	9.2	720
1925	May 25	Aug. 10	12.02	32.1	4,360
1926	May 23	Aug. 16	6.33	27.4	5,400
1927	May 20	Aug. 10	13.26	54.6	7,460
1928	May 22	Aug. 10	12.66	....	....

crop did not burn so well as that of 1927. The explanation probably lies in the **distribution** of the rainfall particularly the time of occurrence of leaching rains and a record of the leaching for each season might be instructive. Distribution of rainfall at the station in Windsor (supplemented where necessary by the U. S. Weather Bureau in Hartford) is presented in Tables 33, and Figure 4.

This same relation of rainfall to fire holding capacity has been observed by Haley and Olson (Rpt. Dir. Pa. Agr. Exp. Station for 1927). They explain it as due to the greater absorption of basic potassium, and the consequent increase in the water soluble alkalinity of the ash of the plant during seasons of high rainfall when the crop is maturing.

TABLE 33. DISTRIBUTION OF RAINFALL IN INCHES ON TOBACCO EXPERIMENT STATION FARM. 1922-28*

By 10 day Periods

Period	Year						
	1922	1923	1924	1925	1926	1927	1928
May 1–10	3.01	1.24	1.44	.08	.43	.83	.....
May 11–20	2.20	.45	1.35	.73	1.66	.97	.6
May 21–31	.21	.64	.91	1.55	.22	3.24	1.70
June 1–10	.87	2.05	.71	.49	.37	.39	1.62
June 11–20	1.38	.07	.01	1.61	.10	1.33	1.57
June 21–30	4.67	1.72	.90	1.28	1.39	.56	.97
July 1–10	2.28	1.77	.01	1.02	.....	.87	2.20
July 11–20	1.39	.01	.22	.27	.93	2.51	1.64
July 21–31	.89	3.24	.31	3.71	1.33	1.79	1.08
Aug. 1–10	.85	1.17	1.41	3.5	.26	2.57	1.88
Aug. 11–20	3.60	1.40	1.99	.35	2.73	1.77	3.18

By Months

Month	Year						
	1922	1923	1924	1925	1926	1927	1928
May	5.42	2.33	3.70	2.36	2.21	5.04	2.30
June	6.92	3.84	1.62	3.38	1.86	2.28	4.16
July	5.16	5.02	.54	5.00	2.26	5.17	4.92
Aug. 20	4.45	2.57	3.40	3.85	2.99	4.34	5.06

*Records of 1922-23-24 and May and June of 1925 from the Hartford Station of the U. S. Weather Bureau.

MAGNESIA HUNGER, OR SAND-DROWN

This malnutrition trouble has been more prevalent during the season of 1928 than any other year the writers recall. Many growers who never saw it before are now quite familiar with it. In the field it has very distinct symptoms which are easy to diagnose after one has seen it a few times. The leaves fade out between the veins to a light yellow or almost white, contrasting strongly with the dark green pattern of the vein system. They do not crinkle or turn down at the margins, as is the case with potash hunger, but remain smooth and feel thick and stiff between the fingers. The lower leaves are affected first but afterward the symptoms may advance up the plant, even to the top leaves in extreme cases. In very advanced stages the yellow areas between the veins may die and turn brown. The most serious damage, however, comes from checked growth of the plant and the lifeless character of the cured leaves. On the sorting bench we have found these sand-drown leaves characterized by "double colors", a serious defect in tobacco. The areas between the veins which were yellow or white in the field now are either brick red or yellow, contrasting with the greenish brown of the remainder of the leaf.

The trouble occurs only during the years of heavy rainfall and almost always on porous sandy parts of the field where leaching may be expected. Hence the popular name, "sand-drown".

The malady is caused by the inability of the tobacco plant to get from the soil its required amount of magnesium, an element which is just as essential to the proper development of tobacco as nitrogen, phosphorus or potassium. Like salt for the human being, a very small amount will suffice but it is absolutely essential. The fact that in Connecticut we have rarely been troubled with magnesia shortage is due to its presence, in small amounts, in other ingredients of the fertilizer. Unintentionally we have been giving the plant a sufficient ration for ordinary seasons in cottonseed, castor pomace, linseed, stems, manure and the like. All vegetable organic fertilizers contain small quantities of magnesia. Until the present year we have never observed sand-drown on our station plots where we used as much as a ton of cottonseed meal or a ton of combined meal and pomace per acre. But the occurrence of heavy rains for two years in succession has apparently so depleted the available supply of magnesia that in 1928 we have found trouble even under these conditions on light land. Another possible explanation of its prevalence in 1928 may be the *frequency* of leaching rains during the growing season resulting in constant removal of the magnesia as fast as it came into solution.

The substitution of concentrated synthetic products for a part of the vegetable organics may have made the trouble more wide spread this year, since these materials contain little if any magnesia. At the station we observed sand-drown to be worst where sulfate of ammonia was the only source of nitrogen. It is probable that the sulfate united with the magnesia and in this very soluble form was leached away. This would account for the severity of the trouble immediately after heavy rains. It was also quite common on the nitrate of soda and nitrate of lime plots. Where a large part of the nitrogen was in urea it was also common in 1928 but not in 1927 and never so severe as on the sulfate of ammonia plots.

The obvious remedy lies in putting more magnesia in the fertilizer ration. Up to the present year we have thought that 15 pounds of magnesia per acre—about the amount in a ton of

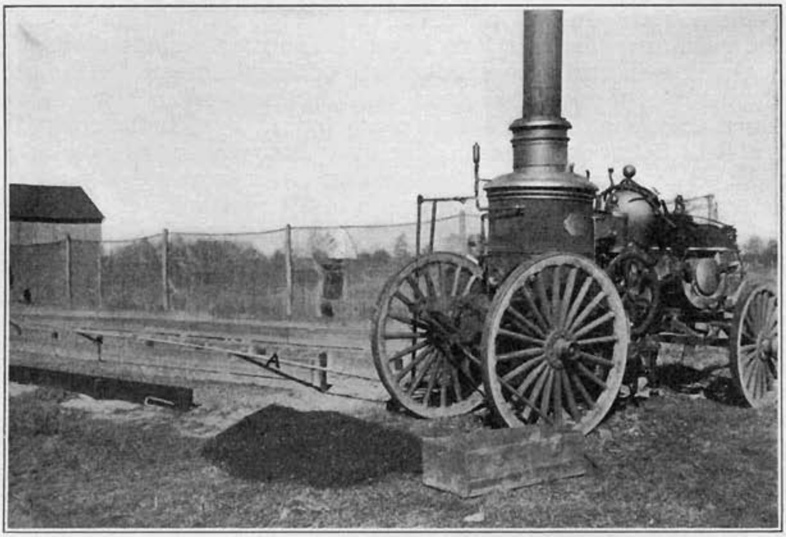

FIG. 18. Steam sterilizing the seed beds with the antiquated town fire engine. Soil can be sterilized to a depth of six inches in 20 minutes with this outfit. Steam supply line at A goes to pan.

cottonseed—was sufficient. As a matter of precaution against the unusual year, however, it may be a good policy for those who have observed this trouble or who have unusually sandy land to add more—perhaps double the dose.

There are a number of materials which may be used. Magnesian lime or limestone (dolomitic limestone) may be applied to lands which are acid enough to stand it. A hundred pounds of double manure salts contain 10 to 12 pounds of magnesia. Cottonhull ashes contain about the same amount. Wood ashes or other vegetable ashes contain a somewhat smaller but valuable supply. A ton of stems contains about 10 pounds.

The Effect of Sulfur, Ammonium Sulfate, and Aluminum Sulfate on the Reaction of Soils

In previous work at the Tobacco Station in Windsor (Tobacco Station Bulletins 6 and 8) it has been shown that on account of the danger of black rootrot it is desirable to keep tobacco soils fairly acid. The safety point was determined to be near 5.6 pH. Soils less acid than this (above 5.6 pH), especially during cold wet summers, are favorable to black rootrot.

On many tobacco soils where lime and wood ashes have been used too freely the reaction has reached a point far beyond the limit mentioned, i. e., too alkaline, to produce a .good crop of tobacco. Hence, it would be beneficial to the grower if some method could be found to increase the acidity of such soils. With this in mind the present investigations were made.

Numerous workers (see Bul. 189 of Rhode Island station with extensive references and Tobacco Station Bul. 10) have found that ammonium sulfate increases the acidity of soils. Doran (2), Hibbard (3), de Long (6), Lipman and co-workers (4, 5), Simon and Schollenberger (7) also found that sulfur caused considerable increase in acidity.

Aluminum sulfate is found to be useful in controlling soil reaction as reported by Amsler (1). To what extent, however, the reaction is affected is not mentioned.

LABORATORY EXPERIMENTS*

In preliminary tests, where 100-gram samples of sandy soil were used, sulfur (fine powder) applied equivalent to 200 pounds per acre, decreased the pH value about one-half unit. The results were corroborated with similar treatments on 500-gram samples of the same soils. The equivalent of 500 pounds of sulfur per acre caused a decrease of about one unit. Increased application of sulfur did not seem to decrease the pH value correspondingly. This preliminary test seemed to indicate that an application at the rate of 500 pounds per acre would be the optimum quantity for an optimum increase in acidity.

Another set of laboratory experiment was made in which three different kinds of soil were used and having the following original pH values:

Clay soil	6.27
Organic soil	6.25
Sandy soil	5.42

*Credit is due to Dr. A. B. Beaumont, Mass. Agr. College, for suggesting the laboratory phases of this work.

As previously, 100-gram samples of these various soils were made up to furnish four non-treated and triplicates of the following treatments:

		Pounds per acre			
1.	Sulfur...............	250	500	750	1000
2.	Ammonium Sulfate....	1032	2060	3090	4120
3.	Aluminum Sulfate.....	1732	3465	5197	6930
4.	Sulfur...............	500	500	500	500
	Ammonium Sulfate....	1030	2060	3090	4120
5.	Sulfur...............	500	500	500	500
	Aluminum Sulfate.....	1732	3465	5197	6930

The amount of sulfur represents low, medium, high, and very high applications Ammonium sulfate and aluminum sulfate are taken in chemically equivalent amounts of sulfate, i. e., in the first three treatments the quantities of sulfur is the same in the various applications. In treatments 4 and 5, combinations of sulfur with the other materials, 500 pounds of sulfur has been taken as a medium constant amount of sulfur to use together with the other two materials.

The samples were kept at normal moisture (most suitable for growing conditions) during the course of the experiments. Reactions were determined electrometrically after four and eight weeks and the results are recorded in Tables 34, 35 and 36. Abbreviations used in the tables are:

S =Sulfur
AIS =Aluminum Sulfate
AmS =Ammonium Sulfate
1, 2, 3, 4, =low, medium, high, and very high applications of the various treatments.

Influence of treatments on clay soil. From Table 34 it is seen that the original pH value of the clay soil was 6.27 (the figure in parenthesis). Receiving nothing but distilled water, the pH had decreased to 5.84 after four weeks and to 5.82 after the lapse of eight weeks, thus showing practically no change after the first decrease. In this case sulfur had apparently been oxidized, although not added. Simon and Schollenberger (7) in sulfofication studies obtained a similar result in a field test, where no sulfur was supplied. They report that the acidity was increased by 0.4 pH as compared with 0.45 obtained in the results above. In computing the actual decrease in pH values, it seemed most reasonable to consider the difference between the value of the checks after eight weeks and those of the various treatments after the same time interval.

Applying *sulfur* at a rate of 250 pounds per acre decreased the pH by 0.48; 500 pounds of sulfur gave exactly the same results in four weeks, but at the end of eight weeks the difference between the two applications was hardly significant, since the actual decrease in the latter case was 0.54. Applying 750 pounds did not seem to work as quickly as the previous treatment, but had decreased the pH by 0.65 at the end of eight weeks. A similar result was obtained in four weeks by an application of 1,000 pounds per acre, which after eight weeks had caused a decrease of 0.74.

TABLE 34. REACTIONS OF CLAY SOIL TREATED WITH SULFUR, ALUMINUM SULFATE AND AMMONIUM SULFATE AFTER FOUR AND EIGHT WEEKS

Treatments	Average pH of triplicate treatments			Treatments	Average pH of triplicate treatments		
	After 4 weeks	After 8 weeks	Decrease in pH		After 4 weeks	After 8 weeks	Decrease in pH
Check (6.27)	5.84	5.82	0.45				
S1	5.77	5.34	0.48				
S2	5.36	5.28	0.54	Combined	Treatments		
S3	5.50	5.17	0.65				
S4	5.22	5.08	0.74				
AlS1	5.47	5.15	0.67	S+AlS1	5.23	4.95	0.87
AlS2	5.17	5.20	0.62	S+AlS2	5.09	4.96	0.86
AlS3	5.15	5.07	0.75	S+AlS3	4.86	4.83	0.99
AlS4	4.76	4.84	0.98	S+AlS4	5.24	5.11	0.71
AmS1	6.16	5.38	0.44	S+AmS1	5.33	4.97	0.85
AmS2	5.72	5.44	0.38	S+AmS2	5.22	4.86	0.96
AmS3	5.68	5.41	0.41	S+AmS3	5.31	4.98	0.84
AmS4	5.76	5.37	0.45	S+AmS4	5.41	4.89	0.93

An application of *aluminum sulfate* at a rate 1,732 pounds per acre resulted in a decrease of 0.67 after eight weeks. The same result was obtained in four weeks when 3,465 pounds were used. At the end of eight weeks, however, the total decrease of the latter treatment did not quite measure up to the result obtained by the lower application. Applying at a rate of 5,197 pounds showed about the same result as for 3,465 pounds, although the final results showed a decrease of 0.75. The highest application of aluminum sulfate (6,930 pounds) decreased the pH value by more than a unit after four weeks, after which time the maximum decrease apparently was reached as the values increased after the lapse of eight weeks, making the final result 0.98.

Using 500 pounds of *sulfur* in *addition* to the various applications of *aluminum sulfate*, the same relationship seemed to occur between the individual treatments, with exception of the highest application which markedly deviated from the rest. The sulfur added, on the average caused a decrease in pH values of about 0.2 unit below the aluminum sulfate alone at various applications save the maximum application. Unless some error in the procedure unnoticed crept in, it is hard to explain that the highest application showed a lower result than the lowest amount applied, or 0.87 as compared with 0.71 pH decrease after eight weeks.

With respect to ammonium sulfate the various amounts applied did not show significant differences in results after eight weeks as the average decrease after this time was close to 0.40. Sulfur added to the treatments about doubled the effect, but showed the same general trend.

The ammonium radical in these cases may have had a buffering effect, as very little ammonia could have escaped during the experiment.

Influence of the treatments on the organic soil. In Table 35 the results from the various treatments on the organic soil are listed. It is shown that the original pH value of this soil, 6.25, after four weeks was 6.12 and after eight weeks 5.59. Here the untreated soil had turned more acid than the clay soil.

With respect to the various treatments, 250 pounds of *sulfur* had practically no desirable effect on the reaction; 500 pounds a very slight effect and 750 pounds were able to decrease the pH value only 0.3, and the highest application, 1,000 pounds, 0.55 pH.

On the other hand, *aluminum sulfate*, applied at a rate of 1,732 pounds per acre decreased the pH value by 0.38 after eight weeks. The double amount, however, was not more effective, neither was the next higher application. Using the rate of 6,930 pounds, caused a decrease of 0.85 after four weeks, but the total decrease after eight weeks amounted to practically the same as for the lowest application.

TABLE 35. REACTIONS OF ORGANIC SOIL, TREATED WITH SULFUR, ALUMINUM SULFATE AND AMMONIUM SULFATE, AFTER FOUR AND EIGHT WEEKS

Treatments	Average pH of triplicate treatments			Treatments	Average pH of triplicate treatments		
	After 4 weeks	After 8 weeks	Decrease in pH		After 4 weeks	After 8 weeks	Decrease in pH
Check (6.25)	6.12	5.59	0.66				
S1	6.18	5.70	0.00				
S2	5.92	5.51	0.08	Combined Treatments			
S3	5.65	5.29	0.30				
S4	5.46	5.04	0.55				
AlS1	5.77	5.21	0.38	S+AlS1	5.44	5.04	0.55
AlS2	5.74	5.32	0.27	S+AlS2	5.37	5.20	0.39
AlS3	5.65	5.28	0.31	S+AlS3	5.22	5.03	0.56
AlS4	5.27	5.18	0.41	S+AlS4	5.79	4.83	0.76
AmS1	5.80	5.65	0.00	S+AmS1	5.19	5.18	0.41
AmS2	5.67	5.53	0.06	S+AmS2	5.24	5.12	0.47
AmS3	5.75	5.04	0.55	S+AmS3	5.30	4.99	0.60
AmS4	5.77	5.08	0.51	S+AmS4	5.53	4.94	0.65

FIG. 19. Steam pan in position. A, Pan; B, Steam supply line; C, Cross bars for lifting pan; D, Sides of seed beds. Steam beyond pan is rising from soil from which pan has just been removed.

It is interesting to note that although *sulfur*, added to the various applications of *aluminum sulfate*, considerably increased the acidifying effect, the relation between the individual treatments is somewhat similar to that of aluminum sulfate alone.

The lowest two applications of *ammonium sulfate* had practically no effect on the reaction after eight weeks, while the two higher ones caused a decrease of about half a unit in the same time.

Sulfur added to the various applications of ammonium sulfate caused a decrease of about 0.40, while at the two highest applications the decrease below the results from ammonium sulfate alone was hardly 0.1 of a unit.

Influence of the treatments on sandy soil. Of the three soils included in this study, the sandy soil untreated having an initial pH value of 5.42, had increased in acidity the least, only 0.17 after eight weeks. This soil, being relatively poor in content of buffering substances, showed the largest response to the various treatments, as may be seen in Table 36.

Sulfur at the lowest application resulted in a decrease less than half a unit pH, but doubling the application, more than doubled the decrease. Although further decreases were noted at higher applications, they were not in proportion to the materials supplied.

TABLE 36. REACTIONS OF SANDY SOIL TREATED WITH SULFUR, ALUMINUM SULFATE AND AMMONIUM SULFATE ATFER FOUR AND EIGHT WEEKS

Treatments	Average pH of triplicate treatments			Treatments	Average pH of triplicate treatments		
	After 4 weeks	After 8 weeks	Decrease in pH		After 4 weeks	After 8 weeks	Decrease in pH
Check (5.42)	5.47	5.25	0.17				
S1	5.18	4.82	0.43				
S2	4.87	4.31	0.94	Combined	Treatme	nts	
S3	4.84	4.17	1.08				
S4	4.74	4.00	1.25				
AlS1	4.95	4.60	0.65	S+AlS1	4.83	4.33	0.92
AlS2	4.66	4.62	0.63	S+AlS2	4.58	4.30	0.95
AlS3	4.42	4.37	0.88	S+AlS3	4.29	4.01	1.24
AlS4	4.11	4.12	1.13	S+AlS4	4.15	4.00	1.25
AmS1	4.86	3.94	1.31	S+AmS1	4.86	4.25	0.99
AmS2	4.94	4.08	1.17	S+AmS2	4.94	4.30	0.95
AmS3	5.01	4.61	0.64	S+AmS3	5.01	4.29	0.96
AmS4	5.11	4.32	0.93	S+AmS4	5.11	4.23	1.02

The low and medium applications of *aluminum sulfate* seemed to have about equal effect after eight weeks. With the two higher applications the actual decrease was reached after the first four weeks as after this time the reaction was not markedly changed.

Adding sulfur to the treatment of *aluminum sulfate* had a marked effect at the low, medium and high applications. The highest application caused a decrease about similar to the high one after eight weeks.

The low application of *ammonium sulfate* to this soil resulted in the largest decrease in pH value recorded in this experiment as a whole. Doubling the application, however, did not measure up to the effect of the former and trebling the low application had only half of the effect of this one, while the effect of the highest application falls between these two.

On the other hand, when *sulfur* was added to the various applications of *ammonium sulfate* the effect was not nearly so great as in the case of the two first applications of ammonium sulfate alone, but instead the sulfur added seemed to balance the reaction, so as to give about equal effect of the four treatments.

Discussion of results from laboratory experiments. In the preliminary study it was found that sulfur applied at a rate of 500 pounds per acre would be about the proper amount to cause an optimum increase of acidity in sandy soils. As a similar result was obtained on the sandy soil in a later experiment, it seems reasonable to assume that in this case 500 pounds of sulfur would best serve the purpose of increasing the acidity.

No optimum application of sulfur could be established for the clay soil or the organic soil as the increased acidity quite uniformly corresponded to the amounts applied. Results from sulfur treatments in Tables 34 and 35 may thus serve as an indication of the difficulties that occur in highly buffered soils. The fact, emphasized by Lipman and co-workers (8), that sulfur is oxidized more rapidly in the absence of organic matter may also have played an important part in case of the organic soil. In general, however, the buffer action of this soil is prominent for all of the treatments used.

The results obtained with ammonium and aluminum sulfate and the combinations of these with sulfur, considering the large quantities used, do not favor a competition with sulfur alone for any of the soils used. The important factor of leaching was entirely eliminated in these experiments. A field study of the treatments discussed is thus needed to justify recommendations for practical purposes.

FIELD EXPERIMENTS

Field experiments on soil acidification by the use of sulfate of ammonia and inoculated sulfur were made in co-operation with the Hartford County Farm Bureau. The experiment was begun in the spring of 1927. Three fields were chosen where the reaction was known to be nearly or quite neutral. Eight plots, each 2 x 4 rods (1/20 acre) were measured and treated as follows:

Plot 1. No sulfate of ammonia or sulfur.
3. 300 lbs. sulfate of ammonia per acre
3. 500 lbs. " " "
4. 800 lbs. " " "
5. 200 lbs. inoculated sulfur
6. 400 lbs. " "
7. 600 lbs. " "
8. 800 lbs. " "

In applying the fertilizer, the nitrogen of the formula was reduced on the sulfate of ammonia plots so that each of the eight plots received the same amount of nitrogen. On the 800 lb. plot only 500 lbs. were applied at first, the 300 being applied to the crop later.

Location of fields and times of application in 1927 were as follows:

1. Farm of R. E. Distin, Unionville. Field not previously in tobacco. Chemicals applied on June 13th. Land had previously had a heavy coat of manure. The soil showed a content of 7.43% organic matter. Plot 8 received the second application of sulfur on July 11th.

2. Farm of E. H. Sloan, Broadbrook. Field many years in tobacco; content of organic matter, 6.18%. Chemicals applied on June 8th. Second application on July 11th.

3. Farm of W. G. Phelps, Glastonbury. Old tobacco field; had a content of 6.72% organic matter. Chemicals applied on June 2d. Second application July 11th.

Organic matter was determined by Mr. Jacobson of the Station Soils Department.

At the time of the second application of sulfate of ammonia no differences in growth could be observed; neither were consistent

TABLE 37. REACTIONS OF SOILS TREATED WITH SULFATE OF AMMONIA AND SULFUR

Plot No.	Lbs. chemicals per Acre		Reaction of soil in the fall (pH)					
	Sulfate of ammonia	Inoculated sulfur	Sloan		Phelps		Distin	
			1927	1928	1927	1928	1927	1928
1	0	...	6.58	6.62	6.21	6.00	6.34	6.03
2	300	...	6.73	6.86	5.77	5.77	6.37	6.18
3	500	...	6.58	6.79	5.70	5.60	6.28	6.18
4	800	...	6.56	6.69	5.61	5.40	6.35	6.10
5	...	200	6.18	6.18	5.99	6.01	6.11	6.00
6	...	400	6.07	6.01	6.10	5.67	5.96	6.00
7	...	600	5.83	5.93	5.79	5.60	5.70	5.77
8	...	800	5.81	5.77	5.87	5.50	5.66	5.93

differences noticed later in the season. Therefore, the tobacco was not kept separate at time of harvest.

On May 9th and 10th in 1928 all the plots were treated as in previous year and chemicals applied all at one time before plowing. Also in the growing season of 1928 no differences in growth could be observed between the various treatments.

Both in the late fall of 1927 and 1928 soil samples were taken from the different plots and their reactions determined electrometrically. The results are presented in Table 37.

In regard to the effect of the chemicals on soil reaction a glance at Table 37 shows that sulfate of ammonia did not increase the acidity on the Sloan and Distin farms but had some effect on the Phelps farm. On the other hand, inoculated sulfur in every case increased the acidity. However, it is also apparent that continued applications of sulfate of ammonia and sulfur do not increase the acidifying effect. With respect to sulfur, the optimum effect seems to fall between 400 and 600 pounds per acre which is in fairly good agreement with the laboratory tests, previously discussed. The high content of organic matter in all these soils is probably one reason why they were so slightly affected by the treatments.

In order to observe the effect of aluminum sulfate adapted to field conditions, two 1/80 acre plots were laid out on a field* at the Tobacco Station in Windsor in the spring of 1928. In addition to general fertilizers the plots each received aluminum sulfate at a rate of 250 lbs. per acre. During the growing season no significant difference in the growth of tobacco was observed between these and adjacent check plots.

Reactions of the soil was determined in the spring before applying sulfate and in the fall after harvest and were as follows:

Adjacent check	Spring	5.77 pH	Fall	5.70 pH
Plot 1.	"	5.77 "	"	5.38 "
Plot 2.	"	5.72 "	"	5.17 "

This relatively low application of aluminum sulfate was thus able to increase the acidity considerably.

Discussion of results from field experiments. The use of sulfur, ammonium sulfate and aluminum sulfate has been tried out under field conditions. Sulfur has increased the acidity in all instances, the optimum effect being obtained by applications between 400 lbs. and 600 lbs. per acre. On the average, 500 lbs. of sulfur will cause a decrease in acidity of about 0.5pH. On many soils, however, a decrease of only 0.2 to 0.3 pH would be beneficial in order to approach the safety point from black rootrot. Laboratory as well as field tests have shown that up to 500-600 lbs. of sulfur per acre the acidity increases rather uniformly with the amounts

*Classified by the Soils Dept. as Merrimac loamy coarse sand.

applied. Hence there is no object in applying more sulfur than needed, especially since it is shown that sulfur may impair quality and burn, as discussed in Tobacco Station Bulletin 10.

The same bulletin also contains data on the use of ammonium sulfate in fertilizer for tobacco. An extensive use of sulfate of ammonia injures the burn, hence it should be used cautiously. Its greatest effect as acidifying agent would be on sandy soils, low in organic matter and also where lumps of limestone are not visible in the surface soil.

As for aluminum sulfate, its use still being in the experimental stage, no recommendations can be made at this time. However, since this chemical is now put on the market as a comparatively inexpensive product it may be advisable to make trials on a small scale, using up to 500 lbs. per acre.

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SUMMARY OF PROGRESS ON PROJECTS

There are a number of lines of investigation on which distinct progress has been made during the year but which cannot be discussed in detail in the present report. These are briefly summarized below without citation of supporting data. They will be presented more completely in later publications.

UREA AND CALUREA AS SOURCES OF NITROGEN IN THE FERTILIZER

Results of urea tests during three years have been reported in previous bulletins from this station. Results for 1928 are in line with those of the preceding three years. When one-half of the nitrogen of the formula is derived from urea the resulting yields and quality have been just as satisfactory as for a standard formula in which four-fifths of the nitrogen is from cottonseed meal and castor pomace. When all the nitrogen is from urea the tobacco is not of such good quality. Sand-drown also affected the all-urea plots. More recently, another urea compound, calurea has appeared on the market and experiments were begun with calurea in 1928. Calurea has 4/5 of its nitrogen from urea and the other 1/5 from calcium nitrate. Tests of one year on calurea are in line with the results from urea. It is a less expensive source of nitrogen than urea because of the high import duty on the latter. Nitrogen in both of these carriers is quickly available and has shown no signs of serious leaching. In this form, nitrogen costs less than half of what it does in cottonseed meal and is much less bulky in handling. Up to the present there has been found no good reason why these cheaper synthetic products should not be used to supplant a part of the more expensive vegetable organic constituents of the fertilizer, but more data are needed before definite recommendations can be made.

NITRATE OF LIME AS A SOURCE OF MINERAL NITROGEN

It is a generally recognized principle that the tobacco fertilizer mixture should have a minor part of its nitrogen in a mineral carrier. The purpose of this is to furnish nitrogen in a quickly available form and thus function as a "starter" when the plants are first set in the field. Nitrate of soda is most extensively used for this purpose because of the immediately available nitrate it contains and because it is cheap and always plentiful on the market. Two objections to the use of nitrate of soda are: (1) during heavy rains the nitrogen in it leaches away very quickly, and (2) the sodium which it contains may raise the soil reaction. We have shown elsewhere that it causes the soil to become alkaline.

Within recent years, another quickly available mineral nitrate, nitrate of lime (calcium nitrate), has come into the market as a competitor of nitrate of soda. This material contains the same amount of nitrogen as nitrate of soda, is just as reasonable in cost (quoted somewhat lower in 1927 and 1928) and otherwise is very similar to nitrate of soda. It has the disadvantage of being somewhat more deliquescent than nitrate of soda. In our experience of 1927-28 we have not found that this property has caused the mixture in which it was used to "cake" or become lumpy even when it was used to supply as much as one-half of the nitrogen and permitted to stand for six weeks after mixing. It is marketed in paper-lined bags to prevent its becoming over-damp or hard during storage. From a theoretical standpoint it should be more suitable for use on tobacco because it contains calcium which is used in large amount by the tobacco crop and because calcium salts are known to give a desirable white color to the ash.

These two materials have been tested side by side for two years on the station farm deriving, (1) 1/5 of the nitrogen from these mineral sources and (2) ½ of the nitrogen from them. Averaging the results of the two years we find no significant differences between them in yield, grading, or fire holding capacity. There appeared to be serious leaching of the nitrogen from both when they were used to supply one-half the fertilizer nitrogen. There did not seem to be any great difference between them in this respect. When the soil was tested one year after starting the series, the nitrate of soda plots were slightly more alkaline than the nitrate of lime plots. Cigars from these plots have not yet been tested; hence we have no data as to the effect of each on ash color.

COMPARISON OF SINGLE NITROGEN SOURCES

Results on this series in 1928 were about the same as for 1927 (fully reported in Tob. Sta. Bul. 10, p. 60). The four sources tested at station farm were cottonseed meal, nitrate of soda, sulfate of ammonia and urea. All fertilizer was applied at one time before setting. The nitrate of soda leached so badly that the tobacco made less than half a crop and on the sorting bench was of such inferior quality it was not fit to sort. Besides nitrogen starvation it also showed severe sand-drown. Fire holding capacity, however, was excellent—possibly because of absence of hindering nitrogen compounds. Nitrogen also leached seriously from the cottonseed meal plots, growth was checked and the cured tobacco was yellow and lifeless. It was considerably better than the nitrate of soda tobacco, however. Fire holding capacity was good but was surpassed by nitrate of soda. The sulfate of ammonia plot showed no signs of nitrogen starvation but remained rank and green except for sand-drown which was especially prevalent here. The yield was highest of all the plots but the quality was poor because of the double colors previously mentioned. Fire holding capacity was less than that of the other plots. No leaching of nitrogen was apparent on the urea plot but there was considerable sand-drown. Growth was good, yield being only slightly less than that of sulfate of ammonia. The quality was best of all these four plots.

Monthly soil tests which have been made for a year on these plots show little change in the cottonseed meal plot; the nitrate of soda plot is progressively more alkaline, the sulfate of ammonia plot is the most acid, the urea plot is progressively slightly more acid than the cottonseed meal plot.

MANURE AS A SUPPLEMENT TO COMMERCIAL FERTILIZER

The 1928 tests confirm those of 1927 (fully discussed in Tob. Sta. Bul. 10, p. 62). The tobacco remained greener and somewhat larger in the field than on adjacent unmanured plots. On the sorting bench it was found to have a better grade index and higher yield. This was true both for stable manure and for artificial Adco manure. The differences, however, were not large.

FRACTIONAL APPLICATION OF NITROGEN

This experiment was continued on the same six plots as in 1927 (Tob. Sta. Bul. 10, p. 57). The extremely wet year was favorable for this kind of a test. One-half of the quickly available nitrogen (in nitrate of lime and nitrate of potash) was deducted from the

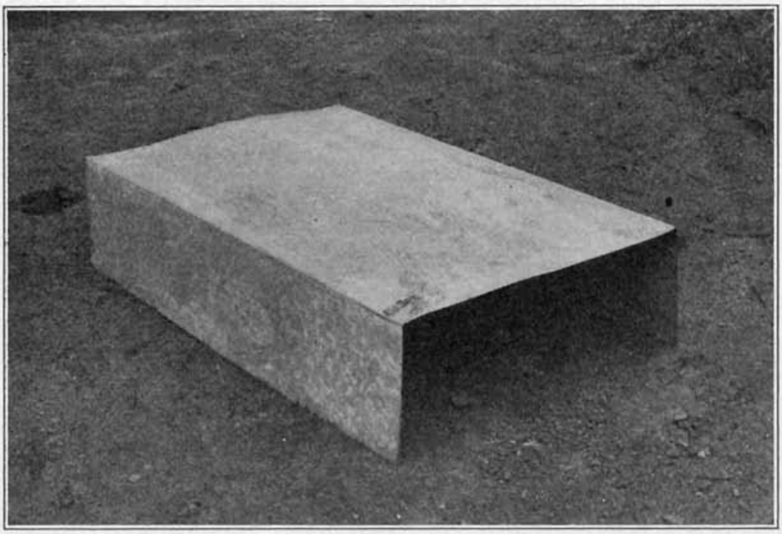

FIG. 20. Metal Fire Cover for spreading the heat.

first (broadcast) application and divided between two later applications. The second application (delayed by mistake) was made on July 2. On July 5 there was a heavy rain (over 2 inches) which caused serious leaching. The last application was therefore made on July 7. Within a few days the yellow color of the check plots showed that they did not have sufficient nitrogen. The fractional plots remained green. On the sorting bench the tobacco from the check plots was found to be yellow and lifeless, much inferior to the fractional plots. The yield was also less. The benefit from fractional application was unquestionable in 1928. This is the first year this has been true. It may be due to the fact that the later applications were made at exactly the critical time with respect to the heavy rains. The only objectional quality noted in the tobacco from the fractional plots was that the veins were somewhat prominent. This soil is very sandy and subject to easy leaching.

These results and the observations on many other fields in 1928 show that if later nitrogen applications are to be used, they should be made *immedately* after the heavy rains *before* any fading of the leaves appears. Delay until the leaves appear yellow results in checked growth from which the plant never entirely recovers and reduced yield results.

COVER CROP TESTS

Records for 1928 show that every cover crop used both increased the yield and improved the grading of the tobacco grown on it. Rye gave the highest yield closely followed by vetch and oats. These three also had the best grade index. Timothy, barley, red-top, alfalfa and wheat were not so beneficial as the others but were better than no cover.

ROOTROT RESISTANT STRAINS OF TOBACCO

Experiments have been continued with resistant strains of Havana Seed, Broadleaf and Shade Cuban.

Wisconsin Havana No. 142 has again been shown to be highly resistant to Black Rootrot and it produces a heavier yield of leaf than any of the ordinary Connecticut Havana Seed strains. On account of the thinner, larger leaves, set closer together on a larger stalk this appears to suffer more than the others from pole sweat. In setting this type it would be advisable to increase the distance between plants in the row by at least two inches. Packers and manufacturers do not agree among themselves as to the merits of this as compared with the ordinary Havana Seed strains.

Broadleaf tobacco is not as susceptible to rootrot as the other two types but still the reduction in yield from this cause is so serious on some fields that a resistant strain is much needed if one that is desirable from other standpoints could be found or developed. One promising strain has been under test on the station farm for the last two years. Compared with the John Williams strain it yielded more leaf and the quality appeared as good. It seems to be more subject to pole sweat, however, possibly on account of thinner leaves and unusually large succulent stalks. Tests have not been conducted long enough to state whether it will meet the requirements of the trade. It is undoubtedly much more resistant than the John Williams type.

In 1927, in a shade field which was badly dwarfed from black rootrot, fifteen scattered plants were found which were making perfectly normal growth. Seed was saved separately from each of these. After harvest, the roots of these and many adjacent plants were examined and relatively few lesions were found on these while the others about them were severely rotted. A row was planted from the seed of each one of these plants in 1928 and compared with alternate rows from common Cuban seed. Root-rot was not very severe on this field in 1928 and the contrast was not as marked as could be desired. Nevertheless it was apparent both from the growth and from the condition of the roots that some of these had considerably more resistance than the common Cuban plants. Further selections and tests are necessary and it is hoped that a satisfactory Cuban resistant strain may be secured from this chance find. Other resistant Cuban strains from another source are also under test but it is too early to predict what the results will be.

TOPPING AND SUCKERING EXPERIMENTS

Results of three years experiments at the station on these practices have just been published by N. T. Nelson as Bul. 297 of the Connecticut Agricultural Experiment Station.

FIRE CURING OF STALK TOBACCO

The importance of curing tobacco by charcoal fires is so fully recognized by the growers of shade tobacco that the practice is universal among them. The stalk tobacco growers, however, are inclined to "take a chance" on the weather and only a few of them practice charcoal firing.

Therefore when weather conditions are favorable for pole sweat —as they were in 1928—the amount of loss from this source is very large. A conservative estimate of the loss to the Connecticut growers this year is over a million dollars. With an expenditure of one-fifth of that amount, most of this could have been prevented.

Experiments which have been conducted in the experiment station sheds during the last four years and in the sheds of practical growers of both broadleaf and Havana Seed lead us to believe that fire curing should be practiced universally by stalk growers at least during seasons when the weather is conducive to sweat. In a later separate bulletin, full data on these experiments and more complete discussion of the practice will be published.

At this time, for the benefit of those who have not been accustomed to fire curing, the following recommendations are made, based on our experiments:

For every acre of tobacco a minimum of 50 bushels of charcoal should be on hand, *before* harvesting starts.

A larger number of small fires is better than a small number of large fires. The air drafts which are created by the fires are as important, if not more so than the actual heat produced. These drafts, therefore, should be distributed as much as possible over the shed. A large number of fires prevents "dead air pockets'. The same result is obtained by the use of metal "spreaders" or covers over the fires. They also prevent scorching the tobacco directly over the fires.

The temperature should be kept between 85° and 95° F in the second tier. In very warm weather it may be necessary to raise this to 100° at times.

Firing to wilt, i. e., within a few days after filling the shed and while the leaves are still green is a good practice but is not always necessary for prevention of sweat. Pole sweat never attacks leaves when they are in the green stage. The late yellow and early brown stages are the danger stages.

If the tobacco is in those stages and wet weather sets in, with high humidity preventing evaporation of moisture from the leaves, it is time to start firing. Don't wait until the leaves begin to "puff" and the midribs "strut".

The condition of the tobacco should be the guide in firing. The minimum period of firing should be thirty-six hours. Frequently two or three times as long is necessary. When the leaves become dry in the green or yellow stage it is a sign you are firing too much.

The temperature should then either be reduced or the firing stopped entirely for a day and then started again if weather conditions demand. Intermittent firing is better than continuous firing except where pole sweat has already started and rapid drying is required.

All brown parts of the leaf should be dry. This is the best guide by which to know that you are firing enough.

During firing, the ridge and gable ventilators should be open but the side ventilators (boards) should be closed.

Some have the impression that fire cured tobacco is not so elastic as that which is cured naturally. We believe that this is due to curing too rapidly. Tobacco properly fire-cured is just as good as naturally cured tobacco in this respect.

EFFECT OF LIMING THE SOIL ON COMPOSITION OF TOBACCO

Tobacco from limed soils exhibits characters of combustion which are different from those of tobacco grown on soils which have not been limed. Some of these characters, particularly the whiteness of ash and closeness of burn are desirable; others, such as the "flaking" of ash and reduction in fire holding capacity, are objectionable. These differences in burn are probably correlated with changes which liming produces in the chemical composition of the leaf. From the standpoint of good growth of tobacco, heavy liming of the soil is not desirable but it is not beyond the range of possibility that the good effects on combustion may be produced by application of some material other than lime. Whether or not there is such a possibility can be intelligently determined

Table 38. Analyses of Tobacco from Limed and Unlimed Plots. Crop of 1926. Water Free Basis

Plot No.	Grade	Lime	Percentage of minerals.						
			Total ash	P_2O_5	K_2O	CaO	MgO	Mn_2O_3	Al_2O_3
					Field VIII				
L	M	Lime	23.89	0.78	6.52	4.72	3.79	.01	.09
L1	M	Lime	23.05	0.73	6.38	4.82	3.58	.01	.08
L2	M	Lime	22.63	0.73	5.92	4.73	4.21	.01	.06
L3	M	Lime	22.90	0.74	6.06	4.79	3.89	.01	.08
L38	M	Lime	23.49	0.75	6.87	4.52	3.61	.01	.11
L39	M	Lime	21.83	1.05	6.37	4.13	3.12	.01	.08
C3-1	M	No lime	26.92	0.85	8.90	5.67	1.16	.10	.09
F6-1	M	No lime	28.15	0.87	8.36	6.55	1.19	.06	.21
N1-5	M	No lime	25.20	0.88	7.51	6.53	1.38	.06	.07
N1-6	M	No lime	25.22	0.93	7.62	6.13	1.29	.07	.07
					Poquonoc Field				
4A	All	Lime	24.57	0.77	6.79	4.98	3.11	.03	.17
15A	All	No lime	27.26	0.77	7.23	5.30	1.55	.21	.23
6A	All	No lime	28.19	0.85	7.80	5.84	1.18	.12	.31
					Thielavia Plots				
T1A	M	Lime	22.83	0.72	5.12	5.53	3.49	.01	.08
T1B	M	No lime	24.78	0.84	6.67	6.11	1.56	.29	.14
T1A	S	Lime	25.33	0.62	4.18	6.38	4.54	.02	.11
T1B	S	No lime	27.43	0.76	6.62	7.04	1.57	.28	.31
T2A	M	Lime	23.86	0.82	6.10	5.37	3.13	.01	.05
T2B	M	No lime	24.63	0.84	7.37	5.62	1.18	.04	.11
T2A	S	Lime	25.70	0.60	5.52	6.00	3.15	.02	.14
T2B	S	No lime	26.82	0.75	7.10	6.42	1.18	.04	.13
T3A	M	Lime	23.83	0.69	5.73	5.15	3.58	.01	.11
T3B	M	No lime	25.43	0.85	6.81	6.19	1.62	.06	.06
T3B	S	No lime	27.49	0.68	7.17	6.89	1.59	.09	.17

only after we have found out what changes lime has produced in the composition of the leaf.

Tobacco (of the crop of 1926) from limed and adjacent unlimed plots—which otherwise were identical in character of soil and previous treatment—was therefore analyzed by the Station Chemistry Department with respect to those elements which it was believed might be affected by liming. Three different series of plots were used in these Analyses as follows:

Limed plots on Field VIII. Beginning with 1922 these plots were limed heavily each year. With the last application in the spring of 1925 they had received during these four years five tons of hydrated lime per acre and the reaction of the soil was slightly above 7.0 pH.

Thielavia series. These consisted of three plots. One-half of each received an application of one ton of hydrated lime per acre each spring, beginning in 1924.

Poquonoc field. Plots on this field were limed at the same rate as the Thielavia series in the spring of 1925 and 1926.

The lime was not analyzed each year but it was commercial lime from western Massachusetts and unquestionably all of it had some magnesia in it. Some samples from that section have as high as 30% MgO.

Results of the analyses presented in Table 38 show that:

1. In every comparison, liming reduced the percentage of total ash, of calcium, phosphorus, manganese and potash. Aluminum was reduced in some cases but not in all.

2. In every case, liming approximately doubled the percentage of magnesium.

In experiments with tobacco in Ohio, Ames and Boltz (Ohio Sta. Bul. 285, 1915) also found that liming a soil reduced the percentage of calcium, potassium, manganese, phosphorus and sulfur but increased the magnesium.

Garner (U. S. D. A., Bur. Pl. Indus., Bul. 105) found that magnesium salts are injurious to fire holding capacity of tobacco (more so than the calcium salts). He also found that all magnesium salts produce a white ash.

Apparently the white ash and reduced fire holding capacity which we find on our limed plots are due to magnesium rather than to calcium.

The Effects of Magnesia, Sulphur and Chlorine on the Growth and Quality of Tobacco[1]

H. F. Murwin[2]

With the coming use of more concentrated fertilizers and syn-

[1]The plots were conducted on a cooperative arrangement between the United States Department of Agriculture and the Connecticut Agricultural Experiment Station.

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thetic nitrogen products in the tobacco growing industry it would be well to keep in mind the nutritional disturbances which may result. The trend today is toward the use of more concentrated mixtures which necessitates the use of more chemicals to replace some of the cottonseed meal or the like. We usually consider the value of a tobacco fertilizer in terms of nitrogen, phosphoric acid and potash. While these three elements are absolutely essential, the tobacco plant requires more than these three for normal growth. In this connection fertilizer tests have been conducted over a period of six years at the Tobacco Station in an effort to determine some specific effects of magnesia, sulphur and chlorine on the growth, quality and burn of Havana seed tobacco.

These fertilizer tests consisted of six treatments in duplicate on 1/40 acre plots. A basal ration which furnished only nitrogen, phosphoric acid and potash was applied on all plots. During the first three years of the experiment 40 pounds of nitrogen, 64 pounds of phosphoric acid and 80 pounds of potash were furnished annually in the basal ration. Starting with the 1925 season the quantities of nitrogen and potash applied annually were increased from year to year and in 1927 the basal mixture furnished about 200 pounds of nitrogen, 64 pounds of phosphoric acid and 200 pounds of potash per acre. The exact amounts and types of carriers used in this mixture are given in Table 39.

TABLE 39. COMPOSITION OF BASAL RATION. MAGNESIA, SULPHUR AND CHLORINE PLOTS—1927

Materials	Lbs. per acre	NH_3	P_2O_5	K_2O
Nitrate of potash	460.0	72.63	.....	199.6
Precipitated bone	166.5	.....	64.1	.....
Dried blood	200.0	31.56	.....	.....
Urea	119.0	65.45	.....	.....
Nitrate of soda	324.0	60.58	.....	.....
Total	1269.5	230.22	64.1	199.6

TABLE 40. PER ACRE AMOUNTS OF PURE CHEMICALS APPLIED IN MAGNESIA, SULPHUR AND CHLORINE TREATMENTS

Plot	Chemicals applied	Nutrients supplied
1 & 1+	Control	Control
2 & 2+	185 lbs. Magnesium Sulphate 88 lbs. Sodium Chloride	30 lbs. MgO; 60 lbs. SO_3 53 lbs. Cl; (50 lbs. Na_2O)
3 & 3+	185 lbs. Magnesium Sulphate	30 lbs. MgO; 60 lbs. SO_3
4 & 4+	150 lbs. Magnesium Chloride	30 lbs. MgO; 53 lbs. Cl
5 & 5+	185 lbs. Magnesium Sulphate 150 lbs. Magnesium Chloride	60 lbs. MgO; 60 lbs. SO_3 53 lbs. Cl
6 & 6+	107 lbs. Sodium Sulphate 88 lbs. Sodium Chloride	60 lbs. SO_3; 53 lbs. Cl; (96 lbs. Na_2O)

In addition to the basal ratio, magnesia, sulphur and chlorine were supplied annually as shown in Table 40. No magnesia has been applied on plots 1, 1+, 6 and 6+, no sulphur on plots 1, 1+, 4 and 4+, and no chlorine on plots 1, 1+ 3 and 3+ during the six years period. All other plots received applications of magnesia, sulphur and chlorine at the rates specified in the preceding table. Part of these fertilizers was uniformly drilled in the row a few days before transplanting the tobacco. The remaining portion was applied as top dressing at the time of the first hoeing. There were no great differences in field growth, but plots 1, 1+, 6 and 6+ were smaller and plots 4, 4+, 5 and 5+ were somewhat larger than the average.

The tobacco on all plots that received no magnesia in the fertilizer exhibited the light colored mottling characteristic of magnesium starvation during the seasons of 1922, '24, '25 and '27. Nearly one hundred percent of the leaves on some plots were mottled in 1927. This condition we term sand-drown. It might be well to briefly desciibe this malady. Magnesia deficiency results in a very characteristic mottling which ordinarily develops first on the lower leaves of the plant and usually begins at the tip and progresses inward toward the base of the leaf, more particularly between the veins and along the margins. When magnesia is not sufficiently available in the soil these symptoms appear and as magnesia is very mobile in the plant that which is already taken into the lower leaves is transferred to meet new needs in the growing region. Thus the malady progresses from the lower leaves upward as the season advances. The leaves do not become deformed as in the case of potash hunger because symptoms ordinarily develop on mature leaves.

It will be noted that no sand-drown was present in 1923 and '26. Sand-drown has not occurred in the Valley to any extent in the past except on sandy soil during seasons with heavy rainfall. This explains in part the irregularity of occurrence on these plots. Both surface and subsoil samples were analyzed for magnesia, sulphur and calcium in the Washington laboratories. These data show that the total magnesia content of this sandy soil was nearly equal to the content of calcium which is much higher than would be expected. There were no significant differences in treatments 1, 3 and 5 where 0, 30, and 60 pounds of magnesia, respectively, have been supplied annually for six years. Neither were there any differences in sulphur content but the total amount of sulphur was so low that accurate data could not be expected. With as high a total magnesia content as shown in these analyses evidently enough became available to the plant during the dry years to promote a normal growth. If the magnesia content of this soil had been depleted the absence of magnesia in the fertilizer would have greatly lowered both yield and quality. This has been shown by experiments in other sections. It has been reported by the Tobacco Station that fifteen pounds of magnesia per acre has prevented the occurrence of sand-drown on the Station fertilizer plots. A number of cases of sand-drown were reported during the past season resulting from a combination of two things, an insufficient amount of magnesia applied, together with the heavy rainfall. This is just an indication of what may happen in the future when less nitrogen is supplied from organic sources which carry magnesia. The point is, if a shortage does occur, it must be corrected in one way or another if yield and quality are to be expected. But if the rate of application is excessive there is a tendency to decrease the quality of leaf. These tests have shown that 30 pounds of magnesia has been sufficient to prevent sand-drown in any year during the experiment but a number of instances can be cited where 15 pounds was not sufficient during the past season. No effects of sulphur or chlorine were discernible in the field except for slight differences in growth.

Plants were selected at harvest in 1925 from treatments 1, 3 and 5. The cured leaf and stalk were analyzed for magnesia in the laboratories at Washington. The results are given in Table 41.

TABLE 41. MAGNESIA CONTENT OF CURED TOBACCO

Plot	Magnesia (MgO) supplied in Fert. per acre	Condition of leaf	% Magnesia (MgO) in water-free material Leaf	Stalk
1	None	Sand-drown	.30	.25
3	30 lbs.	Normal	1.40	.37
5	60 lbs.	Normal	2.07	.45
1+A	None	Normal	.57	.27
1+B	None	Sand-drown	.27	.23

These data show that the amount of magnesia taken up by the plant is influenced by the amount applied to the soil. In other words, if sufficient magnesia is available in the soil sand-drown will not occur. They also show that the leaf is influenced much more than the stalk because of the greater metabolic activity in the leaf as compared with the stalk.

TABLE 42. SUMMARY OF THE YIELDS PER ACRE

Plot	1924	1925	1926	1927	Average	Plots	Ave. of 8 replications.
1	880	1456	1368	1266	1242	1 & 1+	1192
1+	780	1290	1392	1105	1142	....	....
2	1140	1465	1392	1364	1340	2 & 2+	1302
2+	1000	1425	1342	1288	1264	....	....
3	920	1490	1488	1362	1315	3 & 3+	1293
3+	900	1490	1379	1314	1271	....	....
4	1000	1537	1414	1347	1324	4 & 4+	1345
4+	1000	1582	1534	1348	1366	....	....
5	960	1443	1466	1448	1329	5 & 5+	1344
5+	1000	1540	1534	1368	1360	....	....
6	900	1321	1388	1250	1215	6 & 6+	1286
6+	1067	1477	1533	1352	1357	....	....

Yield and quality data were obtained from these plots the last four years of the experiment. A summary of these yields are presented in Table 42. We could not expect great differences in yield of cured leaf from such treatments unless either magnesia or sulphur was so depleted or unavailable to the plant as to be a limiting factor in growth processes. From the data presented this appears to be the case on plots which received no magnesia. The yields from the control plots which received no magnesia, sulphur or chlorine are considerably lower than the rest. Where only one of the elements was lacking the effect was not as marked. It is quite evident from a comparison of treatments 3 and 4, however, that somewhat larger yields were consistently obtained from the application of chlorine in absence of sulphur than from the application of sulphur in the absence of chlorine.

The cured leaf was assorted into the various commercial grades at the Tobacco Station shop. As it is rather difficult to keep a number of figures in mind, such as the percentages of assorted grades, when comparing two treatments, a single figure was devised to represent the quality of cured leaf from the entire plot. This single figure is termed the average price per pound and was computed from arbitrary values given to assorted grades. The average prices over a four year period are summarized in Table 43.

TABLE 43. A COMPARISON OF THE AVERAGE PRICE PER POUND

Plot	1924	1925	1926	1927	3 yr. ave. 1925-1927	Plots	Ave. of 8 replications.
1	.179	.277	.395	.316	.329	1 & 1+	.327
1+	.158	.262	.427	.285	.325	....	....
2	.148	.258	.329	.398	.328	2 & 2+	.340
2+	....	.298	.383	.378	.353	....	....
3	.155	.320	.408	.403	.377	3 & 3+	.377
3+	....	.340	.406	.388	.378	....	....
4	.169	.310	.368	.372	.350	4 & 4+	.369
4+	....	.342	.404	.420	.388	....	....
5	.151	.288	.401	.383	.357	5 & 5+	.350
5+	....	.282	.369	.380	.344	....	....
6	.175	.313	.408	.329	.350	6 & 6+	.356
6+	....	.357	.346	.385	.362	....	....

If quality is considered on this basis we obtained the lowest average price per pound when no magnesia, sulphur or chlorine were supplied in the fertilizer, and the highest average price when magnesia and sulphur were applied in the absence of chlorine. It will be noted that the quality of cured leaf improved from year to year with the increased annual application of nitrogen and potash but the relative effects of magnesia, sulphur and chlorine remained the same aside from effects on quality when sand-drown occurred.

Burn tests were conducted on samples of sweated tobacco from the four principle commercial grades in each treatment. An electric resistance coil was used to initiate the burns in these tests. Two burns, one on either side of the mid rib and approximately in the center of the leaf were made on ten leaves from each grade.

TABLE 44. BURN TESTS ON THE 1925 SWEATED TOBACCO

Fire holding capacity of the leaf (Seconds)

Plot	Light Wrappers	Medium Wrappers	Light Seconds	Darks	Plot Average	Average of duplicate plots
1	13.7	....	14.5	11.8	13.3	11.2
1+	10.5	9.9	9.6	5.9	9.0	
2	3.0	3.2	3.1	3.1	3.1	3.1
2+	3.3	2.6	3.9	2.7	3.1	
3	12.4	16.0	15.5	9.5	13.4	13.8
3+	17.5	13.9	....	11.2	14.2	
4	2.8	2.4	2.9	2.9	2.8	3.4
4+	5.9	2.8	3.0	....	3.9	
5	3.2	3.4	5.2	3.5	3.8	3.8
5+	3.1	2.9	6.1	2.6	3.7	
6	3.5	3.0	3.9	3.4	3.5	3.6
6+	3.2	4.2	3.7	....	3.7	

Each plot average represents eighty burn tests.

The decidedly harmful effect of chlorine is demonstrated in Table 44 where the average length of burns is recorded on the 1925 crop. While the fire-holding capacity, as determined by leaf tests, was poor throughout the experiment in 1925 the burn was three to four times as great in the no chlorine treatments. At the rates supplied in these tests sulphur and magnesia failed to show any harmful effects on the burn.

SUMMARY

The necessity for including magnesia in the fertilizer mixture is demonstrated by these data. This is of special importance at this time when the trend is toward more concentrated fertilizers.

If magnesia is deficient in the soil and is not supplied in the fertilizer both yield and quality of cured leaf may be greatly lowered.

The amount of magnesia taken up by the plant is influenced by the amount applied to the soil.

Both chlorine and magnesia increased the yields to some extent in these tests.

The treatments do not show any great differences in quality, although the poorest quality resulted from the control plots where no magnesia, sulphur or chlorine were supplied in the fertilizer.

Chlorine almost destroyed the fire-holding capacity of the cured leaf in these tests. Sulphur or magnesia failed to show any harmful effects on the burn at the rates supplied.