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Summary

● Sulfate and muriate of potash were compared over a 3-year period for the production of burley tobacco seedlings. They were used in mixtures containing 4% N, 12% P_2O_5, and 4%, 8%, 12%, and 16% K_2O. The effects of chlorine, supplied principally by muriate, were of primary interest. When applied at the rate of ½-pound per square yard, the various fertilizer mixtures supplied from about 4 to about 300 pounds of chlorine per acre.

● Slight chlorine-toxicity symptoms appeared on plants grown with 300 pounds of chlorine per acre in 1 of the 3 years. Overall results, however, indicate that sulfate and muriate of potash were of about equal value in producing burley tobacco seedlings when applied at rates considered adequate for potash requirements.

● Since excessive chlorine is detrimental to the quality of cured tobacco, the grower is cautioned not to attempt to apply the results reported here when selecting sources of fertilizer materials for the field crop.

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A Comparison of Sulfate and Muriate of Potash For Production of Burley Tobacco Seedlings

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Introduction

Sometimes it is more or less taken for granted that research findings and observations on some phase of producing a particular tobacco type can be arbitrarily transposed to the production of another tobacco type grown under different environmental conditions in respect to soil and climate. While such transpositions are sometimes justified, distinct exceptions occur. One possible exception concerns the role of chlorine in the nutritional phase of growing tobacco seedlings.

For many years the recommendations of all states that produce cigarette types of tobacco other than burley have cautioned against fertilizing tobacco seedlings with chlorides such as muriate of potash. The general experience in such areas is that use of chloride fertilizer salts in tobacco plant beds will result in stunted, malformed seedlings unacceptable for transplanting. In regard to fertilizing flue-cured tobacco seedlings, for example, recommendations of the Tobacco Workers' Conference state that plant bed fertilizers should contain "a minimum of chlorine" (5). Although this recommendation is undoubtedly based upon much sound research in the areas to which it applies, a similar recommendation has been carried over in regard to producing burley tobacco seedlings without apparent benefit of research. The Burley Tobacco Workers' Conference recommends that "plant bed fertilizers should be relatively free from chlorine." The senior author is not aware of any research results in the burley area that justify such a recommendation.

Nichols and McMurtrey (3) reported in 1953 that burley tobacco seedlings showed no chlorine-toxicity symptoms when grown with ½-pound per square yard of 6% potash in the muriate (chloride) form. Since then the senior author has observed many plant beds on farms without detecting chlorine injury to seedlings, although many farmers admit to having used mixed fertilizers left over from

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fertilizing corn and other commonly grown crops. The potash in such fertilizers is almost invariably muriate, and tobacco plants so grown must have had considerable chlorine at their disposal.

During the 3-year period 1959-1961, an experiment was conducted at the Tobacco Experiment Station, to compare sulfate and muriate of potash for producing burley tobacco seedlings. The results obtained are presented and discussed in this bulletin.

Rainfall

When tobacco seed are sown in comparatively dry, loose soil it is important that enough moisture be added soon afterward to saturate the soil surface and to establish intimate contact between soil particles and seed. Otherwise, seed germination and seedling survival are likely to be poor. When rain fails to come soon after seeding water should be applied to the plant bed by other means.

Rainfall was adequate and well distributed for growing tobacco plants in 1959 and 1961 (Table 1). In 1960, however, very little rain came for about a month after seeding, and several applications of water were made.

Table 1. Rainfall at Greeneville, Tennessee for 10- or 11-Day Intervals and Monthly Totals During Plant Bed Seasons, 1959-1961.

Month and interval	1959	1960	1961	Normal
	Inches of rainfall			
March 1-10	.53	1.51	1.94	
11-20	.47	.31	.94	
21-31	1.77	.56	1.23	
Total	2.77	2.38	4.11	4.26
April 1-10	.97	.80	1.31	
11-20	3.69	—	1.05	
21-30	.54	1.09	.30	
Total	5.20	1.89	2.66	3.14
May 1-10	—	1.05	1.06	
11-20	1.79	.17	.53	
21-31	1.68	2.20	.84	
Total	3.47	3.42	2.43	3.32
June 1-10	.29	1.08	1.22	
11-20	.17	2.47	1.67	
21-30	1.53	3.02	1.19	
Total	1.99	6.57	4.08	3.38

Materials and Methods

The experiment was located on Dewey silt loam in 1959 and 1960 and on Nolichucky silt loam in 1961. These moderately acid soils are typical of the area concerned and they are known to be satisfactory for the production of tobacco seedlings (3, 4).

Seedlings were grown following bluegrass sods in 1959 and 1960 and following a tall fescue sod in 1961. In each growing season the soil had been treated the fall before with methyl bromide gas to control weeds.

Sources of fertilizer materials used were ammonium nitrate, 20% superphosphate, and sulfate and muriate of potash. Fertilizer grades were compounded to supply approximately 4 to approximately 300 pounds of chlorine per acre (Table 2). All fertilizer grades were applied at the rate of ½-pound per square yard.

Table 2. Fertilizer Grades, Sources of Potash, and Approximate Pounds of Chlorine Applied per Acre.

Tmt. amt.	Fertilizer grade*	Potash source	Chlorine lb./acre
1	4-12-4	Sulfate	4
2	4-12-4	Muriate	75
3	4-12-8	Sulfate	8
4	4-12-8	Muriate	150
5	4-12-12	Sulfate	12
6	4-12-12	Muriate	225
7	4-12-16	Sulfate	16
8	4-12-16	Muriate	300

* All fertilizer grades applied at rate of ½ pound per square yard.

Plots of each experiment were arranged in a split-plot design with four replications. Each whole plot representing a particular fertilizer grade was divided in half for comparing sulfate and muriate of potash. Individual sub-plots were 2 square yards in area.

Burley 21 was the variety sown each year. Seed was sown at the rate of 3 teaspoons, or about 6.5 grams, per 100 square yards. The seed was mixed with an inert clay to facilitate distribution.

Stands were counted when germination had apparently ceased and when plants were in the 4- to 6-leaf stage.

A standard spray schedule was followed to control diseases and insects. Streptomycin sulfate was used to control blue mold and DDT to control insects, principally flea beetles.

Plants were pulled when large enough to transplant. Three pullings were necessary each year to obtain the maximum number of plants suitable for transplanting.

At the first pulling 25 representative plants were saved from each plot of two replications. These plants were washed, air-dried, and analyzed for chlorine by methods previously described (1).

All photographs were made just before the first pulling of plants in any given year.

Results and Discussion

Plant Stands. Plant population densities based on stand counts were within a satisfactory range in each of the 3 years (Table 3). In

Table 3. Stand Counts of Burley Tobacco Seedlings Grown With Different Fertilizer Grades and Sources of Potash.

Tmt. no.	Fertilizer grade	Potash source	1959	1960	1961	3-year average
			Plants per square foot			
1	4-12-4	Sulfate	63	52	59	58
2	4-12-4	Muriate	72	51	55	59
3	4-12-8	Sulfate	67	49	60	59
4	4-12-8	Muriate	63	55	56	58
5	4-12-12	Sulfate	60	53	60	58
6	4-12-12	Muriate	69	51	56	59
7	4-12-16	Sulfate	69	52	51	57
8	4-12-16	Muriate	71	53	56	60
L.S.D. (5%)			NS	NS	NS	NS
		Fertilizer Grades				
	4-12-4		68	52	57	59
	4-12-8		65	52	58	58
	4-12-12		65	52	58	58
	4-12-16		70	53	53	59
	L.S.D. (5%)		NS	NS	NS	NS
		Sources of Potash				
Sulfate			65	52	58	58
Muriate			69	53	56	59
L.S.D. (5%)			NS	NS	NS	NS

any single year stand counts for the various treatments were remarkably uniform. None of the differences among treatments were significant for individual years or for 3-year averages. The uniformity of data suggests that even the highest rates of fertilizer salts applied had no detrimental effects on germination or plant survival.

Figure 1. Tobacco seedlings grown with 4% K_2O as muriate (left) as compared with sulfate (right) 1959. Note similarity in appearance of plants.

Figure 2. Tobacco seedlings grown with 8% K_2O as muriate (left) as compared with sulfate (right) 1959. Note similarity in appearance of plants.

Plant Production. Considerable emphasis is usually placed on obtaining the maximum number of plants at the first pulling, since weather conditions are normally favorable for transplanting at about the time the first plants are ready.

Results obtained for the first pulling (Table 4) and for total plant production (Table 5) indicate that sulfate and muriate of potash were about equally satisfactory for producing burley tobacco seedlings. Also, the lowest rate of potash applied was evidently sufficient for maximum production on these particular soils. Previous experimentation indicated that potash is not as limiting to tobacco plant production on a number of soil types in the area as nitrogen or phosphorus (3, 4).

In 1959 plant growth was excellent and the general appearance of plants was practically identical in all fertilizer treatments (Figs. 1 to 4). The same was essentially true in 1961. In 1960, however, plants grown with ½-pound per square yard of 4-12-16 with the potash derived from muriate showed slight chlorine-toxicity symptoms (Fig. 5). The toxicity symptoms were manifested by slightly lighter color and a tendency toward thickening and curling of the leaves. The plants were not appreciably restricted in growth, however, and

Table 4. Number of Plants Obtained at the First Pulling With Different Fertilizer Grades and Different Sources of Potash.

Tmt. no.	Fertilizer grade	Potash source	1959	1960	1961	3-year average
			Plants per square yard			
1	4-12-4	Sulfate	195	156	164	172
2	4-12-4	Muriate	201	181	124	169
3	4-12-8	Sulfate	155	175	137	156
4	4-12-8	Muriate	174	206	180	187
5	4-12-12	Sulfate	195	162	131	163
6	4-12-12	Muriate	145	190	176	170
7	4-12-16	Sulfate	189	190	147	175
8	4-12-16	Muriate	172	190	168	177
L.S.D. (5%)			NS	NS	NS	NS
		Fertilizer Grades				
4-12-4			198	168	144	170
4-12-8			165	190	158	171
4-12-12			170	176	154	167
4-12-16			180	190	157	176
L.S.D. (5%)			NS	NS	NS	NS
		Sources of Potash				
Sulfate			183	171	145	166
Muriate			173	192	162	176
L.S.D. (5%)			NS	NS	NS	NS

Table 5. Total Number of Plants Obtained With Different Fertilizer Grades and Different Sources of Potash.

Tmt. no.	Fertilizer grade	Potash source	1959	1960	1961	3-year average
			Plants per square yard			
1	4-12-4	Sulfate	486	341	377	401
2	4-12-4	Muriate	484	344	336	388
3	4-12-8	Sulfate	452	336	372	387
4	4-12-8	Muriate	466	345	376	396
5	4-12-12	Sulfate	470	336	373	393
6	4-12-12	Muriate	471	316	390	392
7	4-12-16	Sulfate	506	339	360	402
8	4-12-16	Muriate	500	354	400	418
L.S.D. (5%)			NS	NS	NS	NS
		Fertilizer Grades				
4-12-4			485	343	356	395
4-12-8			459	340	374	391
4-12-12			470	326	381	392
4-12-16			503	345	380	409
L.S.D. (5%)			NS	NS	NS	NS
		Sources of Potash				
Sulfate			478	338	370	395
Muriate			480	339	375	398
L.S.D. (5%)			NS	NS	NS	NS

Figure 3. Tobacco seedlings grown with 12% K_2O as sulfate (left) as compared with muriate (right) 1959. Note similarity in appearance of plants.

Figure 4. Tobacco seedlings grown with 16% K_2O as sulfate (left) as compared with muriate (right) 1959. Note similarity in appearance of plants.

Figure 5. Tobacco seedlings grown with 16% K_2O as sulfate (left) as compared with muriate (right) 1960. Note mild chlorine-toxicity symptoms on plants grown with muriate as shown by lighter color and slight cupping of some of the leaves.

there was nothing to indicate that they were inferior for transplanting.

In a supplementary observation in 1960, tobacco seedlings were grown with a 4-12-16 mixture derived from ammonium chloride,

20% superphosphate, and muriate of potash. When applied at the equivalent rate of ½-pound per square yard this mixture supplied about 500 pounds of chlorine per acre. Plant growth on a plot receiving chlorine at the 500-pound rate was compared with that in an adjacent plot fertilized with a standard 4-12-8, which supplied about 8 pounds of chlorine per acre (Fig. 6).

Figure 6. Tobacco seedlings grown with 8 pounds of chlorine per acre (left) as compared with 500 pounds per acre (right) 1960. Note severe chlorine injury to plants grown with 500 pounds of chlorine.

Plants grown with the 4-12-8 or 8 pound rate were normal in appearance, whereas those grown with the high rate of chlorine or 500 pounds per acre showed severe chlorine-toxicity symptoms. As compared with normal plants, the high-chlorine plants were severely stunted and lighter in color and the leaves were thickened and cupped upward at the edges. At the first pulling the standard 4-12-8 produced 217 usable plants per square yard, whereas the high-chlorine plot contained no plants large enough to transplant. This observation served to demonstrate the possibility of applying too much chlorine in the area concerned, although it was necessary to resort to a rather extreme situation in doing so.

While it was possible to show that too much chlorine can be supplied to burley tobacco seedlings on the comparatively heavy soils in the burley-producing area, the results reported indicate that part or perhaps all of the potash in plant bed fertilizers can safely be derived from muriate at ordinary rates of application. Since muriate

is usually the cheapest source of commercial potash, its substitution for higher priced materials in burley tobacco plant bed fertilizers should represent a saving to the fertilizer manufacturer and to the farmer.

Domestic cigarette types of tobacco other than burley are grown in areas of predominantly sandy soils of comparatively low buffer capacity where the chlorine content of plant bed fertilizers must be kept at a minimum. Burley, on the other hand, is grown primarily on silt loams and sometimes on even heavier soils. This difference in physical properties and probable associated chemical properties of soils in the different areas of production possibly accounts for the differences in susceptibility of tobacco seedlings to chlorine injury.

There is always the possibility that certain management procedures can influence the results of a study of this type. For example, tobacco seedlings were grown following grass sods, and it was not determined what the influence of high-chlorine fertilizers would be under a system of continuous culture as practiced on some farms. Also, it is not known whether the results would differ if plant beds were treated with methyl bromide in the spring rather than in the fall, or if some other chemical were used to control weeds.

That the field crop of smoking tobacco types including burley should not be grown with excessive chlorine is a well-recognized principle. Therefore, the implications stated in this publication in regard to the use of high-chlorine sources of fertilizers on burley tobacco seedlings should in no way influence the standard recommendations for fertilizing burley in the field.

Chlorine Content of Seedlings. While there was some variation from year to year, the percentage of chlorine in the tobacco seedlings varied approximately with the amount of this element applied in the fertilizer (Table 6). Chlorine percentages were generally higher in 1960 than in the other years. This possibly explains the slight toxicity symptoms observed in 1960 on plants grown with 16% potash derived from muriate.

According to stand counts (Table 3) and total plants produced (Table 5), the number of plants occupying a given area of soil was less in 1960 than in either of the other years. Thus, each individual plant in 1960 had more chlorine at its disposal than in the other years. Also, less leaching of chlorine and other fertilizer materials probably occurred in 1960 than in 1959 and 1961, since rainfall was comparatively light during the early part of the growing season in 1960 (Table 1).

Table 6. Chlorine Content of Tobacco Seedlings Grown With Different Fertilizer Grades and Different Sources of Potash.

Tmt. no.	Fertilizer grade	Potash source	1959	1960	1961	3-year average
			Percent of chlorine			
1	4-12-4	Sulfate	0.42	0.65	0.73	0.60
2	4-12-4	Muriate	0.82	2.93	2.90	2.22
3	4-12-8	Sulfate	0.42	0.68	0.66	0.59
4	4-12-8	Muriate	1.46	4.10	3.78	3.11
5	4-12-12	Sulfate	0.58	0.68	0.74	0.67
6	4-12-12	Muriate	1.76	6.20	5.75	4.57
7	4-12-16	Sulfate	0.51	0.73	1.12	0.79
8	4-12-16	Muriate	4.31	7.58	5.65	5.85
		Fertilizer Grades				
4-12-4			0.62	1.79	1.81	1.41
4-12-8			0.94	2.39	2.22	1.85
4-12-12			1.17	3.44	3.24	2.62
4-12-16			2.41	4.15	3.38	3.31
		Sources of Potash				
Sulfate			0.48	0.69	0.81	0.66
Muriate			2.09	5.20	4.52	3.94

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