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FERTILIZATION EXPERIMENTS WITH BURLEY TOBACCO PLANT BEDS

By B. C. NICHOLS and J. E. McMURTREY, JR.

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FERTILIZATION EXPERIMENTS WITH BURLEY TOBACCO PLANT BEDS

Results of cooperative investigations by the Tennessee Agricultural Experiment Station and the Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

By B. C. NICHOLS and J. E. McMURTREY, JR.*

The successful production of burley tobacco depends upon a great many factors, one of which is the necessity for an adequate supply of healthy, vigorous plants. In turn, successful plant production depends upon a number of things such as favorable soil and climatic conditions; control of weeds, insects, and diseases; proper fertilization; and, sometimes, irrigation. This publication deals with fertilizer tests in tobacco plant beds conducted at the Greeneville Tobacco Experiment Station during the period 1949-1952.

Much emphasis is placed upon producing early plants with a high rate of livability when transplanted to the field. Tobacco set early in the transplanting season usually produces a more satisfactory crop than that set late. When early plantings are made, the soil is normally cool and moist, which helps obtain good stands. The later the transplanting, the more difficult it becomes to get plants to live because of less favorable temperature and moisture conditions. Finally, early-set tobacco matures and is harvested at a time when full advantage can be taken of the good curing weather that usually occurs in late summer and early fall.

WEATHER CONDITIONS

The important part that weather conditions — particularly rainfall and temperature — play in tobacco plant production is well known. Tobacco seeds are usually sown in the cool weather of late winter or early spring. The seeds soon germinate and some cold injury to the young seedings will occur in most years. Unless temperatures become abnormally cold, however, the plants recover from such injury and resume normal growth with the advance of spring. The probability of cold injury can be lessened in this area by delaying seeding until after the first of March.

The soil must be moist in order for tobacco seeds to germinate, and it must remain in a moist condition for several days thereafter if the seedlings are to develop strong root systems and survive. The roots of young tobacco plants are very near the soil surface, and a period of drought or of drying winds soon after germination may cause crusting of the soil and an eventual disappearance of the stand. Therefore, keeping the soil moist is desirable and

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necessary during the critical period between germination and getting the plants well established. In some years it may be necessary to supplement natural rainfall with irrigation one or more times. Water requirements of the plants, of course, must be supplied throughout the plant bed season by one means or another.

Excessive rainfall or irrigation may cause fertilizer nutrients, particularly nitrogen, to leach beyond the root zone of tobacco plants, resulting in a deficiency of the nutrient involved. When such a condition is recognized, a supplementary fertilizer application can be made as a topdressing to correct the deficiency.

The distribution of rainfall for 10-day intervals at the Greeneville Tobacco Experiment Station during the plant bed seasons of 1949-1952 is presented in Table 1. The 1951 plant bed season was an excellent one as far as moisture was concerned. The 1952 season, however, was much too dry, requiring supplementary water applications to plant beds.

Table 1.—Rainfall at Greeneville, Tennessee, in inches for 10-day intervals during plant bed seasons 1949-1952.

Month and 10-day interval	1949	1950	1951	1952
Feb. 21-29	0.37	0.33	1.25	0.11
Mar. 1-10	0.27	1.74	1.83	1.52
11-20	1.48	2.38	1.23	0.59
21-31	0.39	1.42	2.14	1.00
Apr. 1-10	0.57	0.52	1.48	0.46
11-20	0.65	0.42	1.47	0.18
21-30	3.08	0.25	0.71	2.07
May 1-10	1.38	2.41	0.92	0.46
11-20	0.54	3.06	0.59	1.80
21-31	1.48	3.46	1.28	1.04
June 1-10	0.10	3.57	3.75	0.70
11-20	3.08	1.35	0.78	0.25

FERTILIZER MATERIALS USED AND METHODS FOLLOWED IN CONDUCTING EXPERIMENTS

Analyses of fertilizer materials used in the tests reported are given in Table 2. The composition of cottonseed meal was determined by chemical analysis. The composition reported for the other materials is the guaranty of the manufacturer.

Table 2.—Sources and composition of fertilizer materials used in tobacco plant bed experiments.

Fertilizer Material	Percent Nitrogen	Percent Phosphate	Percent Potash
Nitrate of Soda	16		
Ammonium Nitrate	33		
Ammonium Sulfate	20		
Urea (Uramon)	42		
Cottonseed Meal	5.4	2	2
Superphosphate		20	
Sulfate of Potash			48
Muriate of Potash			60
Manure	Unknown	Unknown	Unknown

All plant beds were plowed and harrowed in the fall. The beds were sterilized to control weeds by steaming in 1949 and 1950, and by methyl bromide gas in 1951 and 1952. Fertilizers were mixed in the proper proportions, applied broadcast, and dug in to a depth of 2 to 3 inches just prior to seeding. Topdressings of nitrate of soda were made in water solution when plant leaves were about one inch in length, and followed with two or more sprinklings of water to minimize the danger of injuring the plants. The manure used was rendered sterile of weed seeds by the same method as was used to sterilize the soil in that particular year.

Seed of the Kentucky 16 variety were sown at the rate of 3 level teaspoons, or approximately 6.5 grams, per 100 square yards of bed area. The seed were mixed with an inert clay to make proper distribution easier. Individual plots were two square yards in area. One square yard was harvested from each plot to obtain records of plant production. Treatments were replicated 4 times in a randomized block design in all tests.

Control methods are usually attempted for two plant bed diseases, wildfire and blue mold. For the control of wildfire, a so-called "fixed" copper, marketed as Copper "A" Compound, was used as a spray when the plants were in the two-leaf stage and again about 10 days later. The commercial product Dithane (Zineb) was employed for control of blue mold, with 2 to 4 sprayings or dustings required each year. DDT in the form of a wettable powder was incorporated in the Copper "A" and in some of the Dithane treatments for the control of flea beetles.

Plants were pulled when they were of sufficient size for transplanting. Three pullings were made in each of the years 1949, 1950, and 1951. Two pullings were made in 1952. All photographs in this publication were made just prior to the first pulling of the plants in each bed.

FERTILIZER TREATMENTS

In selecting fertilizer treatments for tobacco plant bed experiments, the primary purpose was to determine the growth response to nitrogen, phosphorous, and potassium — the three elements commonly applied in commercial practice—and to nitrogen source. Also, consideration was given to method of application, potash source, and rate of fertilization.

Fertilizer nitrogen is marketed in several forms. These may differ in their availability to plants, in the secondary elements carried in chemical combination, and in the ease with which they are leached from the soil. Since tobacco beds are sown during the cool weather of early spring when nitrification processes in the soil are operating slowly, the availability of the nitrogen at the disposal of the young seedlings is an important consideration. Several sources of nitrogen, therefore, were included in the experimental fertilizer treatments.

Nitrate of soda, ammonium nitrate, urea (uramon), and ammonium sulfate were each applied singly and in mixture. Since nitrate nitrogen is the form most likely to be lost by leaching, all nitrogen in one treatment was added as a topdressing of nitrate of soda after the plant stand had been established. Also, an extra 3 per cent nitrogen was topdressed as nitrate of soda to one treatment to test the possible effects of supplementary nitrogen. In one other treatment, half of the nitrogen was applied in organic form as cottonseed meal.

Superphosphate containing 20 per cent available phosphoric acid is a quickly available source of phosphorous and was the only source of this element used in all tests.

Sulfate of potash is generally recommended for supplying the potash requirements of tobacco plants, and this form was used in all but one treatment. In areas where tobacco types other than burley are grown, the application of potash in the muriate (chloride) form has sometimes resulted in chlorine injury to the plants. One treatment was included in which the potash was supplied as muriate to determine the deleterious effects, if any, that the chlorine in this source may have on tobacco plant production in the burley area.

Tobacco growers sometimes use barnyard manure to supplement commercial fertilizers in tobacco beds. One treatment consisted in applying manure at the rate of 10 tons per acre in addition to ¼ pound per square yard of 3-9-6 fertilizer.

In addition to the fertilizer treatments already noted, the matter of fertilization rate was considered. Rates of complete fertilizer (3-9-6) tested in 1949 were ¼, ½, and 1 pound per square yard. A rate of 2 pounds per square yard was also included in 1950, 1951, and 1952.

EXPERIMENTAL RESULTS

Tobacco plant production records are reported for a total of 6 experiments. Individual plant beds are designated by letters A to E. Records were obtained from bed C in 2 separate years. All plant production records are reported in terms of usable plants per square yard.

1949 EXPERIMENTS

Plant Bed A

Plant bed A was located on Cumberland Silt Loam soil. Tests had shown this soil to be low in available phosphate, medium in available potash, and medium in acidity. The area had been cropped to corn in 1946, to rye in 1947, and to barley and red clover in 1948. An excellent red clover sod was present when the bed site was plowed in the winter of 1948-1949. Previous crops had been ferti-

Table 3.—Fertilizer treatments and number of usable plants produced per square yard on Bed A in 1949.

Fertilizer		SOURCE OF NITROGEN									
Rate/ sq. yd.	Formula	Nitrate of Soda	Ammonium Nitrate	Urea (Uramon)	Ammonium Sulfate	Cottonseed Meal	Manure	(May 20) 1st pulling	(May 28) 2nd pulling	(June 6) 3rd pulling	Total
0	0-0-0	0	0	0	0	0		0	0	28	28
½ lb.	3-9-6	¼	¼	¼	¼	0		189	117	126	432
"	3-9-6	4/4	0	0	0	0		124	140	146	410
"	3-9-6	0	4/4	0	0	0		122	175	143	440
"	3-9-6	0	0	4/4	0	0		118	175	105	398
"	3-9-6	0	0	0	4/4	0		84	200	124	408
"	3-9-6*	4/4	0	0	0	0		135	138	135	408
"	6-9-6**	⅝	⅛	⅛	⅛	0		182	106	116	404
"	3-9-6	¼	¼	0	0	½		124	139	77	340
"	3-0-6	¼	¼	¼	¼	0		0	31	169	200
"	3-9-0	¼	¼	¼	¼	0		117	152	135	404
"	0-9-6	0	0	0	0	0		38	131	144	313
"	3-9-6M	¼	¼	¼	¼	0		119	149	120	388
¼ lb.	3-9-6	¼	¼	¼	¼	0		154	161	121	436
"	3-9-6	¼	¼	¼	¼	0	10 tons/A	105	186	130	421
1 lb	3-9-6	¼	¼	¼	¼	0		160	125	120	405
							L.S.D. (.05)	57	41	55	85

* Nitrogen topdressed.
** Three percent of nitrogen topdressed as nitrate of soda.
M Muriate used as source of potash.

Table 4.—Fertilizer treatments and number of usable plants produced per square yard on Bed B in 1949.

Fertilizer		SOURCE OF NITROGEN									
Rate/ sq. yd.	Formula	Nitrate of Soda	Ammonium Nitrate	Urea (Uramon)	Ammonium Sulfate	Cottonseed Meal	Manure	1st pulling (May 23)	2nd pulling (May 31)	3rd pulling (June 6)	Total
0	0-0-0	0	0	0	0	0		0	11	57	68
½ lb.	3-9-6	¼	¼	¼	¼	0		95	164	148	407
"	3-9-6	4/4	0	0	0	0		76	120	219	415
"	3-9-6	0	4/4	0	0	0		128	173	145	446
"	3-9-6	0	0	4/4	0	0		71	172	175	418
"	3-9-6	0	0	0	4/4	0		139	124	175	438
"	3-9-6*	4/4	0	0	0	0		121	207	132	460
"	6-9-6**	⅝	⅛	⅛	⅛	0		148	176	113	437
"	3-9-6	¼	¼	0	0	½		114	137	120	371
"	3-0-6	¼	¼	¼	¼	0		4	65	119	188
"	3-9-0	¼	¼	¼	¼	0		70	171	160	401
"	0-9-6	0	0	0	0	0		21	53	163	237
"	3-9-6M	¼	¼	¼	¼	0		118	124	172	414
¼ lb.	3-9-6	¼	¼	¼	¼	0		23	146	163	332
"	3-9-6	¼	¼	¼	¼	0	10 tons/A	84	138	204	426
1 lb.	3-9-6	¼	¼	¼	¼	0		173	141	119	433
							L.S.D. (.05)	58	73	62	75

* Nitrogen topdressed.
** Three percent of nitrogen topdressed as nitrate of soda.
M Muriate used as source of potash.

lized so that some fertilizer residues were undoubtedly present in this bed. Also, the red clover crop could be expected to furnish a part of the nitrogen requirements of the tobacco plants. Seeding of the plots was made on March 17.

Results presented in Table 3 show the number of usable plants obtained at each of three pullings and the total number of plants produced in plant bed A. Stand counts taken as soon as the plants were well established showed evidence of damping off where cotton seed meal was used in the fertilizer.

Plant Bed B

Plant bed B was located on Nolichucky Silt Loam soil, which tests had shown was low in available phosphate and strong in acidity. This area had been cropped in a three-year rotation of tobacco, small grain, and red clover for several years. The 1948 crop which immediately preceded the plant bed was tobacco, which had been fertilized with 750 pounds 3-9-6 fertilizer and 10 tons manure per acre. Some fertilizer residues were present in this soil, taking the previous cropping history into consideration. The bed was seeded on February 24.

The plant production record of bed B is presented in Table 4. Stand counts indicated that damping-off occurred in plots receiving cottonseed meal.

1950 EXPERIMENT

Plant Bed C

In 1950 plant bed C was established on Dunmore Silt Loam soil. Soil tests showed this area to be low in available phosphorous, medium in available potash, and medium in acidity. The site of bed C had been cultivated for several years. Red clover had been the crop on the land for the preceding two years. Seedings were made on February 21. It was planned to continue bed C in the same location for two or more seasons.

Results given in Table 5 show the number of usable tobacco plants obtained from this bed. Stand counts indicated that both cottonseed meal and the 2 pounds per square yard fertilizer rate were damaging to plant stands.

1951 EXPERIMENTS

Plant Bed C

Plant bed C was continued in 1951 and plots were seeded on March 22. The plant production record for the second year (1951) of this bed is given in Table 6.

Plant Bed D

Another experiment with fertilizer treatments identical to those of bed C was initiated on a virgin area of Nolichucky Silt

Table 5.—Fertilizer treatments and number of usable plants produced per square yard on Bed C in 1950.

Fertilizer		SOURCE OF NITROGEN									
Rate/ sq. yd.	Formula	Nitrate of Soda	Ammonium Nitrate	Urea (Uramon)	Ammonium Sulfate	Cottonseed Meal	Manure	(May 19) 1st pulling	(May 27) 2nd pulling	(June 2) 3rd pulling	Total
½ lb.	3-9-6	¼	¼	¼	¼	0		94	123	60	277
"	3-9-6	4/4	0	0	0	0		101	96	75	272
"	3-9-6	0	4/4	0	0	0		124	98	71	293
"	3-9-6	0	0	4/4	0	0		113	75	52	240
"	3-9-6	0	0	0	4/4	0		145	46	73	264
"	3-9-6*	4/4	0	0	0	0		109	90	75	274
"	6-9-6**	⅝	⅛	⅛	⅛	0		111	99	70	280
"	3-9-6	¼	¼	0	0	½		107	96	53	256
"	3-0-6	¼	¼	¼	¼	0		0	0	56	56
"	3-9-0	¼	¼	¼	¼	0		102	66	77	245
"	0-9-6	0	0	0	0	0		98	79	73	250
"	3-9-6M	¼	¼	¼	¼	0		74	103	71	248
¼ lb.	3-9-6	¼	¼	¼	¼	0		84	108	54	246
"	3-9-6	¼	¼	¼	¼	0	10 tons/A	77	76	79	232
1 lb	3-9-6	¼	¼	¼	¼	0		131	60	76	267
2 lbs.	3-9-6	¼	¼	¼	¼	0		137	63	66	266
							L.S.D. (.05)	37	85	NS	53

* All nitrogen topdressed.
** Three percent of nitrogen topdressed as nitrate of soda.
M Muriate used as source of potash.

Table 6.—Fertilizer treatments and number of usable plants produced per square yard on Bed C in 1951.

Fertilizer		SOURCE OF NITROGEN									
Rate/ sq. yd.	Formula	Nitrate of Soda	Ammonium Nitrate	Urea (Uramon)	Ammonium Sulfate	Cottonseed Meal	Manure	1st pulling (May 28)	2nd pulling (June 5)	3rd pulling (June 12)	Total
½ lb.	3-9-6	¼	¼	¼	¼	0		137	179	197	513
"	3-9-6	4/4	0	0	0	0		63	146	205	414
"	3-9-6	0	4/4	0	0	0		112	171	208	491
"	3-9-6	0	0	4/4	0	0		118	133	208	459
"	3-9-6	0	0	0	4/4	0		119	126	184	429
"	3-9-6*	4/4	0	0	0	0		165	109	238	512
"	6-9-6**	⅝	⅛	⅛	⅛	0		171	173	158	502
"	3-9-6	¼	¼	0	0	½		111	119	167	397
"	3-0-6	¼	¼	¼	¼	0		0	0	63	63
"	3-9-0	¼	¼	¼	¼	0		70	134	166	370
"	0-9-6	0	0	0	0	0		10	61	198	269
"	3-9-6M	¼	¼	¼	¼	0		148	135	193	476
¼ lb.	3-9-6	¼	¼	¼	¼	0		68	127	182	377
"	3-9-6	¼	¼	¼	¼	0	10 tons/A	134	111	173	418
1 lb.	3-9-6	¼	¼	¼	¼	0		173	174	167	514
2 lbs.	3-9-6	¼	¼	¼	¼	0		180	144	170	494
							L.S.D. (.05)	41	65	80	117

* All nitrogen topdressed.
** Three percent of nitrogen topdressed as nitrate of soda.
M Muriate used as source of potash.

Loam soil. No fertilizer materials had been applied previously to this area. On the basis of chemical tests, this soil was very low in available phosphate, high in available potash, and slightly acid. Seedings were made on March 23. Stand counts taken about one month later showed that the 2 pounds per square yard fertilizer rate was damaging to the plant stand. Rainfall distribution was very favorable during the spring months (Table 1), and there was an adequate stand of plants on all plots in spite of the tendency of the highest fertilizer rate to be injurious. Data obtained on plant bed D are recorded in Table 7.

1952 EXPERIMENT

Plant Bed E

Plant bed E was located on a virgin area of Nolichucky Silt Loam soil adjacent to bed D of the previous year. Seedings were made on March 14. Stand counts taken on April 14 showed the highest fertilizer rate (2 pounds per square yard) to be injurious to plant stand. Rainfall during the plant bed season was less than usual and poorly distributed, so that it became necessary to apply about ½ inch of water on three different occasions. Generally speaking, 1952 was an unfavorable season for tobacco plant production and only two pullings were made. The number of usable plants produced by the various fertilizer treatments on bed E are shown in Table 8.

DISCUSSION OF RESULTS

In carrying on fertilization tests with tobacco plants, only nitrogen, phosphorous, and potassium have been considered as constituents of the fertilizer materials used. Other elements that occur in soils and are necessary for plant growth—calcium, magnesium, sulfur, iron, manganese, copper, zinc, boron, and perhaps molybdenum—must be present in adequate quantities to meet the needs of the plants. Some of these elements are present as impurities or in chemical combination with the ordinary inorganic fertilizer materials. Any or all may occur in organic fertilizers such as cotton seed meal or barnyard manure. To date, however, deficiencies of the necessary elements other than nitrogen, phosphorous, and potassium have not been observed in the Tennessee burley area. If such deficiencies do occur, at least they are not critical at this time, although they may become so at some future date.

In some areas of tobacco production, soils are so lacking in necessary fertilizer materials that there is small chance of growing satisfactory plants without the addition of one or more of the elements necessary for plant growth. Soils fertile enough to grow some of the common farm crops successfully may not necessarily be fertile enough for the production of tobacco plants. In the two experiments (beds A and B) where a no-fertilizer treatment was

Table 7.—Fertilizer treatments and number of usable plants produced per square yard on Bed D in 1951.

Fertilizer		SOURCE OF NITROGEN									
Rate/ sq. yd.	Formula	Nitrate of Soda	Ammonium Nitrate	Urea (Uramon)	Ammonium Sulfate	Cottonseed Meal	Manure	1st pulling (May 26)	2nd pulling (June 5)	3rd pulling (June 13)	Total
½ lb.	3-9-6	¼	¼	¼	¼	0		172	102	141	415
"	3-9-6	4/4	0	0	0	0		116	91	115	322
"	3-9-6	0	4/4	0	0	0		128	94	174	396
"	3-9-6	0	0	4/4	0	0		149	116	270	535
"	3-9-6	0	0	0	4/4	0		153	98	150	401
"	3-9-6*	4/4	0	0	0	0		158	123	137	418
"	6-9-6**	⅝	⅛	⅛	⅛	0		212	94	280	586
"	3-9-6	¼	¼	0	0	½		87	74	108	269
"	3-0-6	¼	¼	¼	¼	0		0	0	0	0
"	3-9-0	¼	¼	¼	¼	0		140	53	124	317
"	0-9-6	0	0	0	0	0		0	12	48	60
"	3-9-6M	¼	¼	¼	¼	0		150	126	118	394
¼ lb.	3-9-6	¼	¼	¼	¼	0		62	38	154	254
"	3-9-6	¼	¼	¼	¼	0	10 tons/A	93	88	97	278
1 lb.	3-9-6	¼	¼	¼	¼	0		184	99	221	504
2 lbs.	3-9-6	¼	¼	¼	¼	0		208	94	219	521
							L.S.D. (.05)	73	53	86	120

* All nitrogen topdressed.
** Three percent of nitrogen topdressed as nitrate of soda.
M Muriate used os source of potash.

Table 8.—Fertilizer treatments and number of usable plants produced per square yard on Bed E in 1952.

Fertilizer		SOURCE OF NITROGEN								
Rate/ sq. yd.	Formula	Nitrate of Soda	Ammonium Nitrate	Urea (Uramon)	Ammonium Sulfate	Cottonseed Meal	Manure	(May 20) 1st pulling	(June 4) 2nd pulling	Total
½ lb.	3-9-6	¼	¼	¼	¼	0		184	156	340
"	3-9-6	4/4	0	0	0	0		123	144	267
"	3-9-6	0	4/4	0	0	0		174	126	300
"	3-9-6	0	0	4/4	0	0		136	134	270
"	3-9-6	0	0	0	4/4	0		184	134	318
"	3-9-6*	4/4	0	0	0	0		278	67	345
"	6-9-6**	⅝	⅛	⅛	⅛	0		189	158	347
"	3-9-6	¼	¼	0	0	½		178	101	279
"	3-0-6	¼	¼	¼	¼	0		0	58	58
"	3-9-0	¼	¼	¼	¼	0		169	136	305
"	0-9-6	0	0	0	0	0		59	125	184
"	3-9-6M	¼	¼	¼	¼	0		252	77	329
¼ lb.	3-9-6	¼	¼	¼	¼	0		133	127	260
"	3-9-6	¼	¼	¼	¼	0	10 tons/A	182	150	332
1 lb.	3-9-6	¼	¼	¼	¼	0		149	131	280
2 lbs.	3-9-6	¼	¼	¼	¼	0		189	77	266
							L.S.D. (.05)	89	66	83

* All nitrogen topdressed.
** Three percent of nitrogen topdressed as nitrate of soda.
M Muriate used os source of potash.

included, plant production was practically non-existent without fertilizers, although satisfactory yields of other crops had been obtained on these two sites the previous year. On plant bed A in particular, where an excellent growth of red clover was plowed under, tobacco plants made very little growth without fertilizer (Fig. 1); and red clover is not normally considered to be a crop that can be grown on impoverished soils.

Figure 1.—Showing effects of fertilization on tobacco plants in plant bed A in 1949; ½ pound per square yard 6-9-6 (left) and no fertilizer (right).

While the present study is primarily concerned with fertility problems in tobacco plant beds, the physical properties of soil in their relation to plant growth cannot be ignored. Plant roots require nutrients, water, and air for growth. Favorable soil physical conditions are necessary for the efficient absorption of nutrients by plant roots. The mere abundance of nutrients in the soil does not assure good crop growth if exceedingly heavy texture or poor structure excludes air or impedes water penetration and retention.

Little, if anything, can be done to change the texture of the soil, but certain management practices are known to affect structure. Favorable soil structure is promoted by addition of organic matter, by growing sod crops, and by refraining from tillage any more often that is absolutely necessary. Conversely, poor soil structure and accompanying unsatisfactory water and air relations result from depletion of organic matter, clean cultivation, and frequent tillage. Also, stirring the soil when its moisture content is too high, and the packing effect of heavy farm implements are conducive to poor soil structure. Soils on newly cleared areas or those that have been in sod or weed crops for several years are likely to have good structure, and such soils normally provide favorable sites for tobacco plant beds. Heavy soils which have been continuously planted to row crops are generally unsatisfactory.

Apart from providing inadequate water and air penetration, soils with poor structure crust over badly and prohibit the emergence of seedlings, especially when very small seeds such as those of tobacco are planted. Soil physical conditions were not so unfavorable as to limit the successful production of tobacco plants in any of the tests reported, but the unusually large number of plants obtained from bed D (1951) on a virgin area suggests that it would be well to choose such areas for plant beds whenever possible.

EFFECTIVENESS OF NITROGEN AND SOURCES THEREOF

From the standpoint of nitrogen nutrition, a desirable tobacco plant is one which has received a minimum amount of nitrogen consistent with adequate plant growth. Too little nitrogen brings about stunting and yellowing of the plants, rendering it difficult to obtain suitable growth for transplanting. On the other hand, too much nitrogen stimulates growth to the point that plants become overly soft and succulent, which reduces greatly their livabality when transplanted in the field. It is, therefore, highly desirable that the nitrogen fertilization of tobacco plants be regulated to supply enough to produce plants of suitable size, but not an excess that will bring about the undesirable features outlined. The use of legumes to precede tobacco plants may supply part of the nitrogen requirements, but even then supplementary commercial nitrogen may be mandatory as evidenced in plant bed A (Table 3). Figures 2 and 3 show the type of nitrogen response obtained on plant beds B and D, respectively.

Differences in plant production resulting from adding equal amounts of nitrogen in different forms are secondary in nature. Such secondary effects are due primarily to variation in elements combined with the nitrogen, in availability, and in tendency to leach from the soil. The latter two effects are considered to be of most importance in these tests.

As shown in a summary of all tests (Table 9), ammonium nitrate ammonium sulfate, and a mixture of nitrogen sources are about equal in their effects on early plant growth. Urea and cottonseed meal are just slightly less effective. Nitrate of soda applied alone at seeding is apt to leach to the point that an insufficient supply of nitrogen remains. When nitrate of soda was applied as a topdressing some weeks after seeding, however, its effects in stimulating plant growth became more pronounced than any other nitrogen source used under the conditions of these tests.

Considering total plant production, ammonium nitrate, urea, ammonium sulfate, and a mixture of sources were about equally

Figure 2.—Showing response to nitrogen on plant bed B in 1949: ½ pound per square yard 6-9-6 (left) and ½ pound per square yard 0-9-6 (right).

Figure 3.—Showing response to nitrogen on plant bed D in 1951: ½ pound per square yard 0-9-6 (left) and ½ pound per square yard 3-9-6 (right).

effective. Again, nitrate of soda applied at seeding was behind the other inorganic nitrogen sources in producing tobacco plants, but was equal to or superior to any source when used as a topdressing. Cottonseed meal was the poorest source of nitrogen represented because of its apparent low availability and its tendency to cause damping off under some conditions.

Topdressing the equivalent of ½-pound per square yard of 3 percent nitrogen in addition to ½-pound per square yard of 3-9-6 applied at seeding produced the largest number of plants of usable size both at the first pulling and in total for all pullings. It should be emphasized, however, that such plants tended to be overly succulent and, therefore, were not as desirable for transplanting as those grown without the additional nitrogen.

Table 9.—Increase in the number of usable tobacco plants per square yard obtained from various sources and rates of nitrogen (summary of all tests).

Fertilizer			Increase over control (no nitrogen)	
Formula	Rate/sq. yd.	Source of Nitrogen	1st pulling	Total all pullings
3-9-6	½ lb	Inorganic mixture	107	178
3-9-6	½ lb.	Nitrate of soda	63	131
3-9-6	½ lb.	Ammonium nitrate	93	175
3-9-6	½ lb.	Urea (Uramon)	80	168
3-9-6	½ lb.	Ammonium sulfate	99	157
3-9-6	½ lb.	½ cottonseed meal, ½ inorganic	82	100
3-9-6	½ lb.	Nitrate of soda (topdressed)	123	184
6-9-6	½ lb.	3 percent mixture, 3 percent topdressed as nitrate of soda	131	207

EFFECTS OF PHOSPHATE

Tobacco plants deprived of enough available phosphorus grow very slowly, and the leaves become abnormally dark-green in color and narrow in width. Generally speaking, the soils of eastern Tennessee are exceedingly deficient in phosphorus, and the addition of this element to such soils often produces very striking effects on plant growth. Unless phosphorus is used on plant beds, either as commercial preparations or as some plant or animal product, few plants suitable for transplanting are likely to be obtained. The phosphorus requirement may be at least partially met with farm manures or with wood ashes often applied incidentally in sterilizing beds with burning brush. The surest and most satisfactory method of supplying phosphorus to plant beds, however, is by use of commercial fertilizer containing quickly available phosphorus. Both 20 per cent superphosphate and 48 per cent triple superphosphate are satisfactory sources for tobacco plants. The more slowly available forms should not be depended upon.

The amount of phosphate needed for tobacco plants will vary, of course, with the past cropping and fertilization history of the site selected. Cultivated soils which have received fertilizers over a period of years are likely to contain more available phosphorus than those newly cleared. Figures 4 and 5 show the response of tobacco plants to phosphate on previously cultivated soils; Figure

Figure 4.—Showing effects of phosphate on plant bed A in 1949: ½ pound per square yard 3-0-6 (left) and ½ pound per square yard 3-9-6 (right).

6 indicates the response obtained on a soil not previously cultivated or fertilized.

Of the three fertilizer elements, nitrogen, phosphorus, and potassium, considered in these tests, by far the greatest response in plant growth was obtained from phosphorus. In the no-phosphate plots, the number of plants large enough for transplanting at the first pulling was negligible and only in 3 of the 6 tests were there any plants at all obtained at the second pulling. On beds A and B, both of which were located on old soils, a fair number of plants grown without phosphate were of usable size at the third pulling. No plants ever became large enough for transplanting in bed D on a new ground soil when phosphate was lacking in the fertilizer. In Table 10 is presented a summary of the results for all experiments comparing the number of plants at each of three pullings and total plants produced with ½ pound per square yard of 3-0-6 and 3-9-6 fertilizers. From this it is evident that under the conditions of these tests, the addition of phosphate was entirely

Table 10.—Average number of plants per square yard obtained with and without phosphate (summary of all tests.)

Fertilizer		PLANT PULLING			
Formula	Rate/sq. yd.	First	Second	Third*	Total
3-0-6	½ pound	0	26	81	94
3-9-6	½ pound	145	140	134	397

*For 5 tests only.

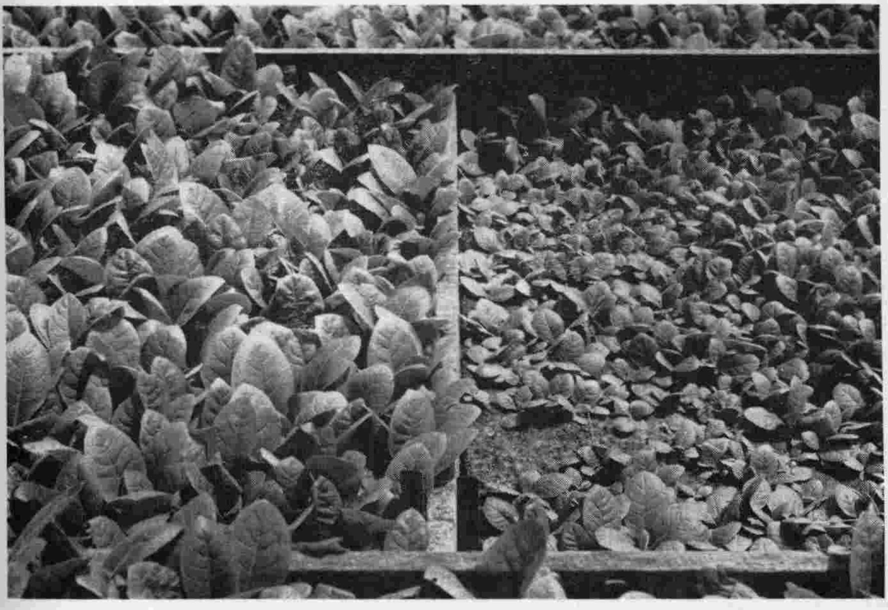

Figure 5.—Showing effects of phosphate on plant bed B in 1949: ½ pound per square yard 3-9-6 (left) and ½ pound per square yard 3-0-6 (right).

Figure 6.—Showing effects of phosphate on plant bed E in 1952: ½ pound per square yard 3-9-6 (left) and ½ pound per square yard 3-0-6 (right).

necessary for satisfactory tobacco plant production. Although several plants on the no-phosphate plots were large enough for transplanting at the third pulling, such plants were usually pulled on a date too late for setting the field crop under the best of conditions.

EFFECTS OF POTASH

Tobacco plants have a relatively high potassium requirement, but this element is probably not as limiting in tobacco plant production in eastern Tennessee as either nitrogen or phosphorus. In addition to the potash normally present in newly-cleared soils or that which has been added in commercial form to cultivated soils, potash is applied incidentally to many plant beds in wood ashes since most growers still burn brush on bedsites for killing weed seeds. Potash deficiencies in plant beds are observed occasionally, however, particularly where the beds are sown following a crop of very high potash requirement such as alfalfa. Potash deficiency symptoms of tobacco plants are manifested by a stunting of the plant, and by the appearance of a yellow mottling around the margins and tips of the leaves. Also, the leaf margins curve downward, giving a cupped appearance; and, in severe cases, dead spots appear in the mottled areas of the leaf.

Since chemical tests indicated that the soils of all plant beds contained at least a medium supply of available potash, relatively little response could be expected from supplying this material. That this was true is brought out in Table 11. While the addition of potash gave a definite over-all increase in the number of early plants, this increase was much smaller than that given by either nitrogen or phosphate. In any particular experiment where a response to potash was obtained, only in one instance were potash deficiency symptoms observed. That was in the second year of bed C (1951), when plants receiving no potash had a slight curling of the leaves and a somewhat roughened appearance.

Table 11.—Average number of plants per square yard obtained without potash and with the two sources sulfate and muriate of potash. (Summary of all tests).

Fertilizer		PLANT PULLING			
Formula	Rate/sq. yd.	First	Second	Third*	Total
3-9-0	½ lb.	111	119	132	340
3-9-6S	½ lb.	145	140	134	397
3-9-6M	½ lb.	144	119	135	375

* For 5 tests only.
S Sulfate as source of potash.
M Muriate as source of potash.

The use of potash in the muriate (chloride) form in burley tobacco plant bed fertilizers has generally been discouraged on the basis of work done on other tobacco types grown in areas where comparatively light textured soils predominate. In such areas, an excess of chlorine in the fertilizer has caused a thickening and a curling under of tobacco leaves. No such effect was noted in any of the tests under consideration where muriate had been used to supply ½ pound per square yard of 6 per cent potash. Furthermore, it is shown in Table 11 that sulfate and muriate of potash were about equally effective in tobacco plant production, although it should be noted that the soils of all tests were fairly well supplied with potash in the beginning. It appears, therefore, that the problem of chlorine toxicity on tobacco plants may be less acute on the heavier soils of the burley belt than on the lighter soils that generally prevail in other areas where tobacco is grown. Further investigations are warranted on this particular problem.

EFFECTS OF FERTILIZER RATE

Fertilizers should be applied to tobacco beds at rates consistent with both the nutritional needs of the plants and with the precaution of avoiding excesses which will be detrimental to seed germination or which will produce weak, overly succulent plants. Particularly in dry seasons, when beds are not irrigated, germination may be greatly impaired by relatively heavy applications of fertilizer. When as much as 2 pounds per square yard of complete fertilizer was applied, a reduction of germination was observed in some years. Likewise, the practice of topdressing beds with soluble nitrogen to force early growth, if overdone, can result in plants of low livability in the field.

The needs of phosphate and potash can be easily supplied at seeding without undue fear of a slight excess being detrimental to germination or to the quality of the plants. Nitrogen, on the other hand, must be more carefully regulated. If a so-called adequate supply of nitrogen is added at seeding and leaching rains occur later, this element can be applied currently as a topdressing with the assurance of a quick response in plant growth. When the need of supplemental nitrogen becomes evident, of course, precaution should be taken not to add too much.

In Table 12 a summary is given of the average number of plants obtained per square yard for each pulling and for total production with the different rates of fertilizer used in these tests. The ¼ pound per square yard rate was obviously inadequate, especially in the production of early plants. When manure was applied in addition to the ¼ pound rate, plant production was improved. It should be pointed out, however, that the effectiveness of the manure may have been reduced by the sterilization procedures employed for killing weed seeds. The ½ pound rate gave satisfactory plant production both at the first pulling and in total plants. The 1-pound and 2-pound rates showed slight superiority in early plant production but not in total production. Here it is cautioned, however, that the higher nitrogen applications in the 1- and 2-pound rates did not necessarily produce the best quality of plants for transplanting. Any increase in plants obtained from the 1- and 2-pound rates over the ½ pound rate was most likely due to the additional nitrogen present in the higher rates rather than to phosphate and potash. That the latter statement is true is evidenced in Table 12 where it is shown that the equivalent of ½ pound of 6-9-6 gave a very similar number of plants at the first pulling and in total as that given by the 1- and 2-pound rates of 3-9-6.

Table 12.—Average number of plants per square yard obtained with various fertilizer rates. (Summary of all tests).

Fertilizer		PLANT PULLING			
Rate/sq. yd.	Formula	First	Second	Third	Total
¼ lb.	3-9-6	87	118	135	318
¼ lb.	3-9-6, 10 T. Manure/A	113	125	137	351
½ lb.	3-9-6	145	140	134	397
1 lb.	3-9-6	162	122	141	401
*2 lbs.	3-9-6	179	95	152	387
½ lb.	6-9-6	169	134	147	426

* Average of 4 tests only.

SUMMARY

The results presented in this publication deal with testing the effects of rates and sources of fertilizer materials upon production of tobacco plants suitable for transplanting. These tests were carried out on the Greeneville Tobacco Experiment Station farm during the period 1949-1952. Emphasis was placed on producing early plants of good quality.

The nitrogen sources tested were nitrate of soda. ammonium nitrate, urea (uramon), and ammonium sulfate, both singly and in mixture. In addition, the organic nitrogen source, cottonseed meal, was used to supply half the nitrogen in one treatment.

When applied at time of seeding, ammonium nitrate, ammonium sulfate, and a mixture of nitrogen sources were about equally effective in producing early plants. Nitrate of soda, urea, and cottonseed meal were somewhat less effective than the first three materials.

The ineffectiveness of nitrate of soda applied alone at seeding is due to its tendency to leach, although excellent results were obtained from this source when used as a topdressing after plants became established. Urea and cottonseed meal nitrogen are more slowly available than the other sources employed, which accounts for the over-all slower response in plant growth to these materials. The use of cottonseed meal was found to cause damping off in some seasons which makes the desirability of including such organic materials in tobacco plant bed fertilizers questionable.

Phosphorus was omitted from areas treated with a 3-0-6 mixture, and supplied on other areas treated with a 3-9-6 mixture.

This element was derived from 20% superphosphate. On the basis of these tests, phosphorus is the most limiting element on the soils concerned in the production of tobacco plants suitable for transplanting, and the importance of providing a readily available supply of this element is emphasized. The data given in regard to phosphate response were obtained on the low-phosphate soils of eastern Tennessee and are not necessarily applicable to the high-phosphate soils in the middle section of the State.

Little over-all response was obtained from potash in plant beds located on soils of medium to high available potash contents. However, attention to the needs of potash should not be neglected, especially when plant beds are sown following crops of high potash requirements. Muriate of potash was as effective in tobacco plant production as sulfate. No chlorine injury was observed from the use of muriate at the rate of ½ pound per square yard of 6 per cent potash, but further research with this material in the burley area is suggested.

The rates of complete fertilizer (3-9-6) tested were ¼, ½, 1, and 2 pounds per square yard. The ¼-pound rate proved insufficient. The ½-pound rate was adequate in most beds for the production of a relatively large number of plants of good quality. The 1- and 2-pounds per square yard rates were slightly superior to the ½-pound rate in early plant production, but such plants, particularly those grown at the 2-pound rate, were usually too succulent to be of the best quality for transplanting. Also, the 2-pound rate was injurious to germination in some beds.

Since ½-pound per square yard of 6-9-6 gave comparable response to the 1- and 2-pound rates of 3-9-6, it is suggested that any superiority of the latter two treatments to the ½-pound rate of 3-9-6 is due to their additional nitrogen content rather than to the larger amounts of phosphate and potash present in the higher rates.

It appears that under the conditions of these tests, ½ to 1 pound per square yard of 3-9-6 fertilizer, or its equivalent, with the nitrogen not entirely in the nitrate form, is adequate for the production of tobacco plants in the area concerned.

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