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Tobacco Cultural and Fertility Tests

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M. A. BACHTELL, R. M. SALTER, AND H. L. WACHTER

TOBACCO IN OHIO

In total tobacco acreage Ohio stood seventh in the United States during the 5-year period, 1928 to 1932. The states which exceeded Ohio were those in the southern group of Kentucky, Tennessee, Virginia, North Carolina, South Carolina, and Georgia. Each one of these states, however, reported a smaller average yield per acre than Ohio. Other northern states, such as Massachusetts, Connecticut, New York, Pennsylvania, Wisconsin, and Minnesota, showed a considerably higher yield per acre. But, of this latter group with higher acre yields, Pennsylvania was the only one with a total production greater than that of Ohio.

During this 5-year period the average price of 13 cents per pound for Ohio tobacco compared very closely with that from the southern states. It was about one-third higher than that from other northern states (except Connecticut and Massachusetts, where shade-grown tobacco is produced).

This average of 13 cents represents crops selling from 22 cents per pound in 1928 down to 6.9 cents in 1932. It includes 36 per cent of Burley (Type 31) at an average of 17.1 cents per pound, 61 per cent of cigar filler (Types 42-44) at 10.2 cents, and 3 per cent of miscellaneous (Type 70) at 6.1 cents per pound. A further study of statistics shows an Ohio 5-year average yield for the same period of 824 pounds per acre for Burley and 843 pounds for cigar filler. Thus, there was an average acre value for the Burley of approximately $140 and of $85 for the cigar filler. But, in 1932 when the extremely low price of 4 cents for cigar filler coincided with a less than average yield, 60 per cent of the tobacco growers of Ohio had acre values of not far from $30. Any one familiar with the many arduous tasks connected with growing, harvesting, and marketing tobacco will realize the impossibility of producing the crop for such a figure. Growers rapidly reduced acreage, so that in 1934 and 1935 the crop occupied only about one-half the acres of 10 years previous.

Because of the higher selling price per pound for Burley, which is used for cigarettes and chewing tobacco, the question well may be raised as to why this is not grown more extensively in substitution for the lower selling cigar filler type. No complete answer is available for this problem, but in attempts to grow Burley at the Southwestern Experiment Farm it has been the judgment of tobacco men that the crop contained too heavy a leaf and lacked the color necessary for a satisfactory Burley grade. The reason usually given for this is that the heavier upland soil does not produce a rapid enough growth for fine texture and good color. In years past when all tobacco was bringing a fair price, the question of substituting something for cigar filler varieties was not an important one. Perhaps it will assume increasing importance in the next few years.

At some time or other in the past 60 years tobacco has been reported growing in approximately three-fourths of the counties of Ohio. The greatest number of counties was in the period centering around 1880, although the largest number of pounds of tobacco grown in the State was not reached until

30 years later. However, by 1910, when the maximum State production was reached, local production was nil in several counties that at some time in the past had reported small amounts of tobacco.

The agricultural census of 1935 reported tobacco in 51 counties, but there were only 19 counties that totalled 50 acres or more. Several of the other 32 counties reported less than a half dozen farms; some, even as low as one farm on which tobacco had been produced the previous year.

Of the 19 counties that produced over 50 acres of tobacco in 1934, there were seven that had a total production of less than 100,000 pounds. The other 12 counties produced over 97 per cent of all the tobacco grown in the State. These 12 counties, together with parts of bordering ones, usually are classified in three groups: (a) Miami Valley section, (b) Southern Ohio or Burley section, and (c) Southeastern Ohio or miscellaneous section. Recently there has been a heavy shifting to Burley in this miscellaneous or former export section, caused by the price of export tobacco dropping to an extremely low level. The Medina-Wayne wrapper district, which 40 years ago produced close to a million pounds of Connecticut Havana and Seedleaf, is now practically out of the picture.

In general, the Miami Valley has produced nearly two-thirds of all tobacco grown in the State. Production throughout all districts has fluctuated considerably from year to year. Although a high price any one year has not noticeably tended to rapid expansion in acreage the next, any unduly low price usually has been reflected in decreased acreage the following year. Recent low acreage, therefore, is perhaps merely a reflection of the past few years of depression prices.

Will these diverted acres, at least in the principal tobacco areas, come back into tobacco culture or will there be a further decline in total acreage? The following data are given, not in an attempt to answer this question, but rather for a more complete understanding of the problems involved. The 1936 Yearbook of Agricultural Statistics issued by the United States Department of Agriculture lists 55 countries in which tobacco is grown. The United States has by far the largest acreage devoted to tobacco, but India has approximately the same total production by reason of much larger acre yields on fewer acres. Of these 55 countries there are 26 with larger average acre yields than the United States and seven more with yields practically as large. Some of these countries produce from two to nearly three times as much tobacco per acre as Ohio growers. Mere size, of course, is not proof of greater efficiency on the part of growers or that the tobacco is of the type required by the trade, but the figures do show that apparently there is a large area of the world adaptable to tobacco culture. Much of it is in countries where agricultural workers have lower standards of living than those of Ohio farmers. The latter probably have no natural advantages of soil or climate not possessed by farmers in many other sections of the world.

From time to time inquiries regarding tobacco culture come to the Experiment Station from individual farmers far from the recognized Ohio tobacco areas. Such inquiries were more numerous when depression prices ruled for corn, wheat, and other farm products. They were, perhaps, merely an indication that farmers were searching for something more profitable than what they were then growing. If so, the history of the last half century would indicate that tobacco probably is not the answer. Its culture has tended not to spread but rather to become more and more restricted to certain areas in which, because of possible soil, climate, or marketing facilities, the crop has been able to compete successfully with other farm activities.

Tobacco growing for home consumption is impractical, because to get the desired taste and aroma, tobacco must be put through a process of fermentation which cannot be done satisfactorily with a small quantity. The small amount involved for home consumption would not get sufficiently hot in bulk sweating, and it would dry out too much in a sweat room.

TOBACCO INVESTIGATIONS

The tobacco investigations of the Ohio Agricultural Experiment Station are centralized at the Southwestern Experiment Farm at Germantown in the Miami Valley tobacco district. The work at this substation, where tobacco investigations were started in 1903, has covered a wide range of fertility and cultural practices with the result that now there is available information concerning most of the phases of tobacco growing from the time the plant beds are started in the spring until the mature plants are cut and hung in the barn.

VARIETIES

The Miami Valley is known as a cigar filler district. The most important varieties in this district have been of the Zimmer Spanish type for the uplands with their more silty type of soil and some Seedleaf variety for the bottoms, where more gravelly soil types predominate. The Southwestern Experiment Farm, having upland soil, quite naturally followed the prevailing practice of growing Zimmer Spanish, and this type has been used in most of the fertility work. Both types have been used in cultural work. In long-time fertility work it is considered desirable to use the same variety from year to year so that the results from different periods may be more or less comparable. The exact variety used since 1910 is Ohio Hybrid 224 developed by crossbreeding at this Farm and described in detail in Bulletin 239 of the Ohio Experiment Station. It was developed by crossing varieties in such manner as to produce a hybrid variety with a parentage three-fourths Zimmer, one-eighth Cuban, and one-eighth Connecticut Seedleaf. Quoting from the above bulletin, "This hybrid shows a very close resemblance to Zimmer Spanish, the chief difference being a slightly taller stalk bearing several more leaves and in being, perhaps, from 5 to 7 days later in blooming and ripening. The leaves themselves are practically indistinguishable from those of Zimmer Spanish, both while on the growing plant and in the cured tobacco. Ohio Hybrid 224 is less troublesome to sucker than Zimmer Spanish and is not blown down so readily by the wind. The suckers show much less tendency to develop on the lower portion of the stalk than is the case with Zimmer Spanish. In the field, up until the time of coming into bloom, it is practically impossible to distinguish the hybrid from Zimmer Spanish. About the time the latter variety begins to blossom, Hybrid 224 rapidly shoots up from 4 to 6 inches higher with the development of a correspondingly larger number of leaves and comes into bloom about a week later than the Zimmer. The smoking quality of Hybrid 224 is very good and while very closely resembling Zimmer Spanish in flavor and aroma it has been almost unanimously pronounced superior to that variety by those who have tested it. The resemblance to Zimmer Spanish is so close that a sample of this hybrid at a tobacco show was picked by a well known and capable tobacco merchant as being a pure, fine type of that variety".

The Experiment Farm has not carried on enough variety testing to enable it to compare Hybrid 224 with all other varieties grown in the Miami Valley. Therefore, no claim is made that it is the best variety. However, it has been very satisfactory over a period of years in that it possesses high quality and is a very good yielder. Yield comparisons made several years ago showed it to outyield Zimmer Spanish by from 20 to 25 per cent.

On the other hand, comparisons have shown that Seedleaf varieties very frequently yield from one-third to one-half more than Hybrid 224 even on the upland silty soil of the Experiment Farm. With many other farm crops such an increase probably would lead to a rather rapid adoption of the higher yielding variety. Mature corn of one variety, for example, has about the same feeding value as mature corn from any other variety and, therefore, the total bushels per acre goes a long way toward determining the selection of the variety to grow. Apple varieties, on the other hand, have to be selected more according to quality and what the market will take. In this connection tobacco, perhaps, is more comparable to apples than to corn. Mere weight of crop is not the entire answer to variety selection. During the early period of this Farm when considerable breeding work was done in the production of hybrid strains, it was comparatively easy to produce higher yielding varieties, but far too often the high yielding hybrid had some weakness which prevented its adoption as a popular variety.

The larger growing, heavier yielding Seedleaf types have the disadvantage of rather late maturity when grown on the uplands and are more subject to injury in storage, as they do not cure out as rapidly as the smaller, earlier maturing types. Also, on soil that is thin or poorly fertilized the larger growing varieties are reduced in yield relatively more than the smaller varieties. These objections do not seem to hold on the more fertile bottom soils with their better drainage, and there the Zimmer Spanish type is the one that is at a disadvantage. In the bottoms, both types are likely to rust and thus have to be cut before maximum yield and quality have been reached, but the loss under these conditions is relatively less with Seedleaf. For good and sufficient reasons, therefore, the Miami Valley section cannot be expected to limit its selection to a single variety. Whatever the selection, it must contain quality and be able to produce quantity yields.

SEED SELECTION

Many growers, perhaps most of them, gather their own seed. Tobacco bloom for the most part is self-pollinated, but if left uncovered a small proportion of the flowers are cross-pollinated by visiting insects. Since such cross-pollination brings hybrids of unknown value it cannot be expected to improve the variety. It is just as logical to expect some deterioration from it. Thus, to keep a good variety, such as Hybrid 224, from losing its high quality and uniformity it has always been the rule to prevent cross-pollination by covering the flowers with paper bags before the pollinating period arrives. As topping is done preferably when the buds show pink, the seed plants have to be selected early so that they may go untopped. The leaves above the point where the plant naturally would be topped are stripped off, and an ordinary 12-pound grocer's paper bag is slipped over the head. The paper top is gathered and tied around the stem at such height as will leave the bottom of the upturned sack an inch or so above the flower buds. Later on the stalk will elongate, and when the opening and expanding flower head pushes up against the bottom of the sack, the sack should be raised on the stem, which by this time has become strong enough to support the bag. In this manner the entire bag capacity can be made available for the expanding seed head. The use of too large a bag or putting on the proper sized one too early may result in the wind's breaking or twisting the stalk below the seed head and thus impairing its value for seed production.

Final selection of seed plants should not be made until leaf growth is completed. At this final selection some of the bagged heads probably will be discarded because of failure of the plant to come through with certain desirable characteristics. In selecting seed plants of Ohio Hybrid 224, the operator has in mind certain outstanding characteristics of the type desired. These may be summarized as follows:

1. Type of plant
   - (a) vigorous in growth
   - (b) average or above in size
   - (c) standing erect
2. Leaf characteristics
   - (a) small midrib
   - (b) small veins
   - (c) smooth
   - (d) long and broad
   - (e) uniform
   - (f) close together on strong stalk
3. Suckers
   - (a) few in number
   - (b) located near top with none on lower part of stalk

After the seed has matured in the field the seed head is cut off and thoroughly dried in a warm room. It is then threshed and the seed is run through a seed cleaner which separates the heavy from the light seed. This light seed is inferior and should be discarded. Fanning mills very similar in appearance to regular grain mills are available in midget size for cleaning tobacco seed and do the work in a very satisfactory manner.

PREPARING SEED FOR SOWING

Seed may be sown dry in the plant beds, but several years of tests have shown that nearly a week can be saved in the time of growing the plants if the seed is germinated prior to sowing. Germination is accomplished by tieing the seed loosely in thin muslin cloth and then suspending it in a glass fruit jar an inch or two above water. Handled in this way the seed will take up moisture, and in about 3 days the seed coat will burst and sprouts, appear. Seed sown in this condition will send up plants sooner, and the plants will be ready to set 5 or 6 days earlier than when dry seed is sown. Sprouting thus reduces the labor required to care for the seedbeds. A scant teaspoonful of seed is sufficient for 100 square feet of plant bed. At the Experiment Farm it is sown by putting the seed in water and sprinkling it over the required area. The water should be stirred frequently enough to prevent the seed from settling to the bottom of the can and causing heavy sowing at the very last.

PLANT BEDS

If vigorous, healthy plants are to be available for planting it is necessary that the plant beds receive special sanitary and fertility measures, but these are not so exacting as to prevent their being met on every farm. In fact, several years of tests have reduced them to a fairly simple basis.

In the Miami Valley section permanent plant beds are the rule. These are kept in condition by steaming to control disease and by the incorporation of sand and organic matter to secure tilth. The practice, customary in some other sections, of burning a brush pile and growing the plants on the soil thus sterilized has never been tried at the Experiment Farm. Thus, no comparison has been made between plants grown by this method and those from permanent plant beds. However, common observation would indicate that very good plants can be grown by the brush-pile method. For the isolated grower this probably is the preferable method, because permanent plant beds without adequate equipment for annually sterilizing the soil will not continue to supply the kind of plants that make possible a profitable tobacco crop.

TILTH IN PLANT BEDS

Adequate measures for securing tilth in permanent plant beds should be taken even before the sterilization process. Proper tilth not only permits better penetration during the steaming process but also makes it possible to pull the plants at setting time with a minimum breakage of the tiny root systems.

Tilth is promoted by a judicious use of sand and some form of organic matter. At one time tobacco stalks were used as a common source of organic matter, but several years ago the Experiment Farm, realizing the danger of introducing disease by the use of tobacco residues, changed to cornstalks.

The results of a single season's trial with peat moss in 1936 may indicate another early switch to that material in the future.

Cornstalks.—Tests at the Southwestern Experiment Farm have shown cornstalks to be equal to tobacco stalks in the conditioning of permanent plant beds. Cut stalks have been more easily worked into the soil and the results have been slightly better with them than with the whole stalks trenched in. This particular silt loam soil has been somewhat improved by adding ¾ to 1 inch of sand and working it into the soil. All measures to improve the tilth of plant beds should be taken prior to sterilization, so that any diseases or weed seeds that may be introduced can be prevented from doing any harm by the subsequent steaming process. The results of using cornstalks and sand are given in Table 1.

TABLE 1.—Cornstalks and Sand as Soil Conditioners in Tobacco Plant Beds, Average 1931-1934

	None	No sand		Three-fourth inch of sand	
		Whole cornstalks	Cut cornstalks	Whole cornstalks	Cut cornstalks
Seed sown	April 18	April 18	April 18	April 18	April 18
Plants up	May 4	April 30	April 30	April 30	April 30
Vigor	Medium	Good	Good	Good	Good
Plants diseased, per cent	15	None	None	None	None
Stand, per cent	75	100	100	100	100
Height at time set, inches	4	7	7½	8	8½
Color	Light green	Dark green	Dark green	Dark green	Dark green
Plants usable, per cent	50	90	90	90	90

Peat moss.—The test with peat moss in tobacco plant beds covers 1 year only and, therefore, must be regarded more as an indication than as positive proof. The experience of this 1 year, however, was so favorable as to indicate that peat moss has all the advantages of cornstalks or other home-grown material and some others in addition. Moreover, the cost is not prohibitive, as only a small area is involved in the necessary plant bed. One bale of peat moss is sufficient to cover 250 square feet of bed to a depth of 1 inch or one-half this area 2 inches deep. It is preferable to spread this long enough before spading to permit it to become thoroughly soaked by rains. Spading in before steaming will guard against any later trouble from sprouting weed seeds which the peat might carry.

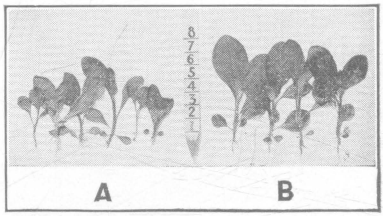

Fig. 1.—Effect of peat moss in tobacco plant beds

A—No peat moss
B—Two inches of peat moss

A plant bed of 250 square feet properly prepared should easily furnish a sufficient number of excellent plants to set 3 acres. On an acre basis, therefore, the cost of the peat moss would add not over a dollar or two to the total cost of the crop. Moreover, the peat moss will have an effect for more than 1 year; so the cost per acre of crop will be considerably less than the above amount. Future tests will have to determine how long a single treatment with peat moss will remain effective and how often new treatments will have to be made. Good judgment would indicate that on new plant beds where heavy soil is involved, more than 1 inch of peat moss probably would be beneficial; whereas on old beds already in a rather high condition, less than 1 inch might be entirely satisfactory.

The comparison made in 1936 was on a permanent bed that ordinarily would have been considered in fairly good condition. Cornstalks had been added in 1934 and sand, in 1935. However, judged by the standards at the Southwestern Experiment Farm, it was beginning to show the need for additional treatment. Many growers, however, would have been satisfied with the bed as it was. One end was left without additional treatment; whereas the other had peat moss spread 2 inches thick and worked in uniformly to a depth of 5 or 6 inches as the bed was spaded.

The plants came up more quickly on the peated end and made a better stand. On the unpeated end some small spots had a relatively thin stand as compared with an even, dense stand on the peated end. Growth on the peated end was more rapid, and as a result, plants from seed sown at the usual time made such rapid development that it was necessary to remove the canvas covering a week earlier than normal.

Watering plant beds also is an item in the cost of producing plants. In spite of an unusually dry period, the peated bed in 1936 was watered fewer times than has been the custom in previous years. The superintendent stated that in his opinion the lessened time required for watering paid for a considerable part of the cost of the peat.

Plants from both ends were set in the field during a very dry period. Those from the peated end showed from 90 to 100 per cent successful stand; those from the unpeated end, only about half as much. Neighbors, who, perhaps, used less care both in the handling of their own plant beds and also in the process of field setting, took some of the peat-grown plants and secured from 80 to 90 per cent perfect stands as compared with considerably less than half a stand from their own plants. Perhaps a plausible reason is that less injury was done the tiny root systems when plants were pulled from the peat-treated end of the bed. It was noticed that the plants came out with a very light pull and that the roots seemed to be largely intact with considerable soil clinging to them. On the other end the more compact soil made it necessary to exert a harder pull on the plants, and the roots showed more damage. Whether or not peat moss is the final answer to plant bed tilth, the experience of 1936 would indicate the very great need of using some material which secures this highly desirable condition whereby plants can be transferred from plant bed to field soil with a minimum breakage to root systems and a minimum check in growth.

In this single year's test at the Southwestern Experiment Farm, 1 inch of peat moss spaded in produced very nearly as good results as those obtained from 2 inches. As a result, partly of this 1 year's test and partly from information received from other sources, the following rough recommendations are made regarding the amount of peat moss to use:

1. New beds with soil containing a medium amount of humus, ½ to ¾ bale
2. Old beds, somewhat low in humus, 1 to 1½ bales
3. Old beds with heavy clay or light sandy soils, 1½ to 2 bales

Judgment of the grower will have to be the final guide. Amounts given in each case are for 250 square feet of plant bed.

PLANT BED STERILIZATION

Sterilization of the plant bed soil by steaming with commercial outfits that do custom work is the usual practice in the Miami Valley. The beneficial effects in the promotion of seedling growth, the destruction of weed seeds, and the control of soil-borne diseases and pests are generally appreciated. However, there often is a tendency to try to lessen the cost of sterilization by lowering the pressure and shortening the time of steaming. Results of tests at the Southwestern Experiment Farm have proved that any slight saving secured from curtailing either time or pressure under the minimum required for satisfactory results is more than offset by the loss in lowered quality and number of plants. This is indicated in Table 2, which gives the results of one experiment on seedbed sterilization, and in Figure 2.

TABLE 2.—Time and Pressure Required for Steaming

Test*	Pressure	Time	Vigor	Plants diseased	Height at time set	Color	Plants usable
	Lb.	*Min.*		*Pct.*	*In.*		*Pct.*
A	None	None	Poor	50	3½	Light green	None
B	75	20	Medium	15	5	Light green	65
C	100	20	Fair	None	6	Green	75
D	100	25	Good	None	7	Dark green	90
E	125	20	Good	None	7½	Dark green	90
F	125	25	Good	None	8	Dark green	90
G	150	20	Good	None	8	Dark green	90

*The letters in this table correspond to those in Figure 2.

The best plants were obtained by steaming either for 25 minutes at a pressure of 125 pounds or for 20 minutes at 150 pounds. With either combination the steam will penetrate into well-conditioned plant bed soil sufficiently far to remove disease danger from the developing plants. Unsatisfactory plants and a low proportion of usable plants too often can be traced to a poor job of steaming as measured by either the pressure reached or the time of steaming.

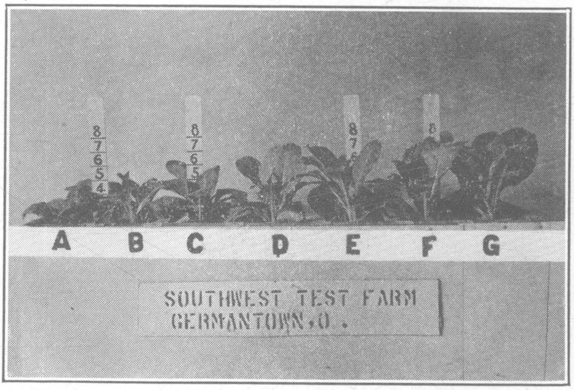

Fig. 2.—Effect of time and pressure in steaming plant beds for tobacco plants

(For treatments, see Table 2).

However, a good job of steaming may be more or less nullified by poor sanitary measures after steaming. For example, disease may be introduced and spread to the young plants if infected tobacco trash is introduced or even if such trash is handled promiscuously by men who are working around the plant bed. All cleanup measures and the removal of trash, therefore, should be accomplished before the plant beds are sterilized. Even the chewing of natural leaf tobacco by workers who are weeding the beds or pulling the plants is very likely to cause considerable mosaic to show up in the field at a later date.

In spite of the fact that tobacco has been grown on the Southwestern Experiment Farm for over 30 years, some even in continuous culture for that period, there is remarkably little disease present. Perhaps a large part of this is due to the care used in selecting seed from healthy stalks and to sanitary measures around the plant beds.

FERTILIZING PLANT BEDS

Tobacco plants respond to a liberal supply of plant food, and as the area involved is small, the expense of supplying this in commercial form is almost negligible. As little as 20 pounds of commercial fertilizer per 1000 square feet of plant bed seems to be an adequate amount. A satisfactory analysis is 4 per cent of nitrogen and from 8 to 10 per cent of potash, with any reasonable percentage of phosphoric acid that comes with the above analyses of nitrogen and potash. As shown later in this bulletin, potash seems to be one of the most important elements required by tobacco, and reducing the supply of this shows its effects even in the plant bed. Thus, cutting the potash to 4 per cent has decreased the size of plants from 8 to 7½ inches at setting time.

TIME OF SETTING TOBACCO

In the Miami Valley, tobacco ordinarily is set sometime during June. A time of setting test has been conducted for 6 years and in 5 of these years the best yields have come from one of the three dates, viz., June 10, June 20, or June 30. Only in 1931 when there was an abnormal growing season was the best yield secured from any other date, and that year the results were slightly in favor of June 1. Too often, tobacco set as early as June 1 at the Southwestern Experiment Farm matures at an unfavorable time in dry, hot August weather with a resulting lower yield. Tobacco set after July 1 may make large yields, but the quality is likely to be lowered from late maturity and possible frost injury. On the average, the results shown in Table 3 indicate the best time to be somewhere around June 15 to 25.

TABLE 3.—Time of Setting Tobacco

	Six-year average yield, 1929-1934
	Lb. per A.
June 1	885
June 10	1138
June 20	1240
June 30	1191
July 10	1060

TOPPING TOBACCO

The best and easiest time to top tobacco is when the first buds are showing pink. The recommended practice is to go over the field twice, to top those plants that are ready first and then repeat the operation 4 to 5 days later. If topped too early, the small buds are difficult to pinch out without injury to the leaves. On the other extreme, if topping is delayed until the tobacco is in flower, the yield and quality are reduced and the labor of topping is increased. In any case topping should be completed in this area by September 1, regardless of the stage of maturity. Only as many leaves should be left as will ripen properly. Permitting too many leaves to remain frequently results in the loss of the upper leaves through failure to ripen and subsequent failure to cure. Topping, therefore, requires good judgment on the part of the worker. The results of topping tests are shown in Table 4.

TABLE 4.—Stage of Topping Tobacco

	Seven-year average yield, 1928-1934
	Lb. per A.
At bud	941
First buds show pink	1124
Full bloom	1103

SUCKERING TOBACCO

The main reason for suckering tobacco is to secure good quality through the better development of the remaining leaves as induced by the removal of suckers. Tobacco not suckered has but medium quality; whereas tobacco suckered once has been of good quality. When tobacco is suckered twice the yield and quality are improved still more but some good growers question whether the improvement due to the second suckering is sufficient to justify the cost.

TABLE 5.—Effect of Suckering Tobacco

	Quality	Five-year average yield, 1928-1932
		Lb. per A.
Not suckered	Poor	879
Suckered once	Good	968
Suckered twice	Very good	1018

TIME OF CUTTING

Both yield and quality are influenced by the time of cutting. The yield of tobacco increases up to a certain point through the thickening of the leaves and then decreases because of the dying of the lower leaves. The best quality occurs some time in advance of the period of maximum yield. After this time the leaves gradually lose their glossy finish. On the Experiment Farm it is considered time to cut when the leaves show a slight yellowish spotting and the small veins crack when the leaf is bent. Tobacco cut too early shows a greenish color and is very likely to damage when packed; cut too late it shows poor quality, greater injury, mixed colors, and a low oil content. Tobacco cut at the indicated normal time shows best quality and a comparatively good yield.

TABLE 6.—Time of Cutting Tobacco

	Seven-year average yield, 1928-1934
	Lb. per A.
Cut 5 days before normal	885 (low in both yield and quality)
Cut at normal time	1079 (best quality)
Cut 5 days after normal	1146 (larger yield offset by poorer quality)

FERTILITY STUDIES

QUALITY INCREASES WITH YIELD

Tobacco is a crop that apparently justifies heavy fertilization, as such treatment makes possible not only higher yields but also better quality. At the Southwestern Experiment Farm there is a very close correlation between high yields and high average quality, since a large part of the increased yield comes from longer and larger leaves which tend to throw a larger proportion of the crop into the higher selling classification. Thus, two adjoining plots have 33-year average yields of 1288 and 525 pounds, respectively. Reference to Table 7 shows that Plot 14 with a yield only 40 per cent as large as Plot 13 produced nearly 80 per cent as much low-value trash as the higher yielding plot. It had left only 34 per cent as much of the higher value wrapper and filler. Although this comparison is between two extremes in yield, the lesson still applies as the yields come more closely together.

TABLE 7.—Correlation of Yield and Quality in Tobacco Crop, 33 Years, Southwestern Experiment Farm

Plot	Average	Percentage			Pounds per acre		
		Wrapper	Filler	Trash	Wrapper	Filler	Trash
	Lb. per A.						
13, fertilized...	1288	70	16	14	902	206	180
14, unfertilized.	523	56	17	27	293	89	141

A further interesting correlation between yields and quality is illustrated by 3 years' results in a test involving increased amounts of fertilizer in the row. A study of Table 8 shows that (a) in this comparison the trash per acre is actually less with the higher yields and (b) the length of leaf (and therefore the width also) increases with the increase in yield. No single crop has as many separations in wrapper size as appear in Table 8, but when several crops, some better than others, are averaged together these extremes do occur.

TABLE 8.—The Relationship of Yield to Quality as Measured by Size of Leaf, Southwestern Experiment Farm

Plot No.	Treatment 4-12-4 in row	Three-year average yield per acre (1933-1935)							
		Wrapper—leaf lengths and weights					Filler	Trash	Total
		13-15 inches	15-17 inches	17-19 inches	19-21 inches	21-23 inches			
	Lb. per A.	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*	*Lb.*
1..............	0	189	325	108	40	....	162	279	1103
2..............	100	175	340	149	40	....	176	251	1131
3..............	200	....	377	336	67	....	168	239	1187
4..............	400	....	303	452	157	....	176	208	1296
5..............	600	....	289	443	236	62	167	198	1395
6..............	800	....	219	418	352	99	182	214	1484

It has been shown that low yields are accompanied by a high proportion of trash and a low value per acre. High yields, on the other hand, have a low proportion of trash, and the high value proportions increase as the yield increases. Tobacco growers, therefore, perhaps more than most other farmers, are justified in trying for reasonably high yields. Although it costs slightly more per acre to grow and harvest a big crop, it tends to cost less per pound of tobacco harvested, and the resulting crop sells more readily and at a higher price per acre.

LONG-TIME YIELD TRENDS

The underlying principles of soil fertility appear to apply to tobacco culture in very much the same way as to other cultivated crops. Thus, with tobacco grown in continuous culture for 33 years without fertilizers, manure, or any soil building practices, the yield declined to the point where the crop was not worth harvesting. The two plots reported in Table 7 occur in a rotation of tobacco, wheat, clover. Aside from seasonal effects, the unfertilized plots have shown a consistently low yield throughout the 33-year period. The average per acre yield during the first 5 years was 581 pounds as compared with 523 pounds for the entire period and 487 pounds for the 5-year period, 1928 to 1932. The extreme low occurred in 1929 when the untreated plots reached the almost worthless yield of 173 pounds per acre. But in 1930, when the drouth was broken in midseason and followed by exceptionally favorable tobacco weather, the untreated plots averaged 868 pounds per acre. The same thing happened again in the 1934 drouth season and the untreated plots gave an average yield of 832 pounds per acre.

The heavily fertilized plot, on the other hand, continues to produce crops as large as those in any earlier period. As a matter of fact, the largest individual yearly yields and the highest average (1464 pounds) occurred in the last 5-year period. Doubtless, some of the credit must be given to favorable seasons in this period, but the high yields nevertheless show that the soil is in a very fertile condition after 33 years of tobacco culture.

The early tests with fertilizers for tobacco were with broadcast applications, but during the last few years these have been replaced rather largely by ones involving row applications. Accordingly, the discussion of fertility work will be presented in two sections; the first deals with the older broadcast applications, and the second, with the newer row treatments.

THE LONG-TIME EXPERIMENTS WITH FERTILIZERS AND MANURE APPLIED BROADCAST

Nitrogen, phosphoric acid, and potash all are important in tobacco culture and must be supplied through crop residues, manure, or commercial fertilizers. Table 9 gives the comparative yields, increases, and grades from a few plots illustrating the results from different fertilizing materials.

TABLE 9.—Effect of Various Fertilizing Materials on Yield and Grade of Tobacco

Plot	Treatment*	33-year average			Notes on grade of wrapper Last 3 years only		
		Yield per acre	Increase per acre	Trash in crop	U. S. Grade	Color	Leaf length
		Lb.	*Lb.*	*Pct.*			
Checks ..	None	523	....	28	C4 or C5	Dark green to mottled	Short
2.......	P	697	174	29	C4 or C5	Mottled to mixed	Short
5.......	NK	711	188	20	C4	Mottled to dark brown	Medium
6.... ..	NP	891	368	23	C4	Mottled	Medium
3.......	PK	1054	531	15	C3 or C4	Mixed to reddish	Fair
8.......	NPK	1143	620	14	C3	Brown to chestnut br.	Good
32.......	M	1028	495	14	C2 or C3	Reddish	Good
35.......	MP	1178	655	16	C2 or C3	Reddish	Good

*Note:
N equals 240 pounds of nitrate of soda.
P equals 480 pounds of 16 per cent superphosphate.
K equals 180 pounds of muriate of potash.
M equals 10 tons of shed manure.
MP equals 10 tons of shed manure and 400 pounds of superphosphate.

Phosphorus apparently has shown the greatest influence on yield, and potash assumes the most important role in the determination of grade. Apparently 10 tons of shed manure carries sufficient potash for a satisfactory crop and grade. In this long-time experiment in which fairly good crops of mixed legumes have regularly preceded the tobacco crop, nitrogen, although exerting a minor influence, still has been of considerable importance.

NITROGEN

Tobacco is a crop which makes its total field growth in a period extending (at the Southwestern Experiment Farm) from about the middle of June to the last of August or perhaps the middle of September. Moreover, with unfavorable weather it can make very little growth during the first two-thirds of this period, and then if rainfall and temperature become favorable it can make almost a maximum yield in the last third or even last quarter of the growing season. Such a condition would seem to demand a liberal supply of nitrogen either from crop residues or commercial sources.

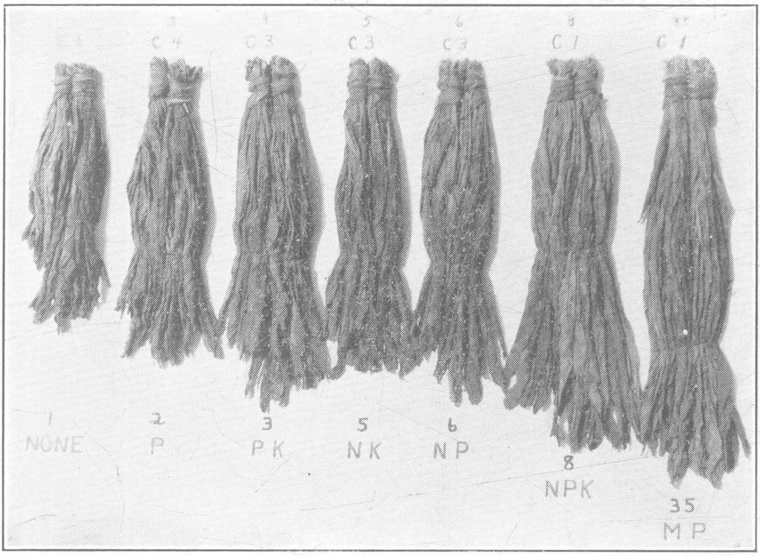

Fig. 3.—Effect of fertility treatments

P equals 480 pounds of 16 per cent superphosphate.
K equals 180 pounds of muriate of potash.
N equals 240 pounds of nitrate of soda.
M equals 10 tons of shed manure.
MP equals 10 tons of shed manure and 400 pounds of superphosphate.

Reference to Table 9 shows that the difference in the increases on Plots 3 and 8 is only 89 pounds. This amount represents the increase for nitrogen over phosphate and potash. But 14 per cent of this is trash which has a very low commercial value and which growers for the good of the industry now are urged to discard as waste. This leaves only 77 pounds of marketable tobacco from drilling 240 pounds of nitrate of soda broadcast before the plants were set. Broadcasting an extra 120 pounds or a total of 360 pounds per acre made a further increase of 59 pounds of marketable tobacco (wrapper and filler) or a total of 136 pounds. There may be some difference of opinion as to whether these increases justify such an extravagant use of commercial nitrogen, but there can be no doubt that they do indicate the need for growing tobacco on a soil plentifully supplied with nitrogen from some source.

Unfortunately, in the continuous culture test, which has run nearly as long as the one in rotation, no provision was made for a plot receiving only phosphoric acid and potash. Hence, the increase from nitrogen cannot be ascertained, but a comparison of the increases from the different amounts applied indicates that, as might be expected, commercial nitrogen has been somewhat more effective on tobacco grown continuously than on that which follows a clover sod.

Used without limestone, 240 pounds of nitrate of soda applied on tobacco in the 3-year rotation has produced 31 pounds more total tobacco than an equal amount of nitrogen in sulfate of ammonia. With limestone, sulfate of ammonia is ahead by 9 pounds. The soil at the start of the test was rather well supplied with lime and even now the reaction on the sulfate of ammonia plots is not sufficiently acid to depress seriously the yields of mixed clovers.

POTASH

As already stated, potash is important in securing a high-grade tobacco at harvest time. It also plays an important part in determining the burning quality, which is important to both the manufacturer and the smoker of cigars.

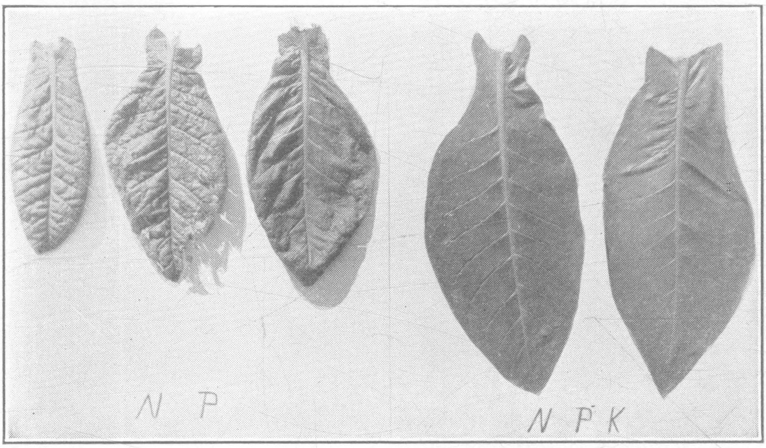

Fig. 4.—Effect of potash on tobacco leaves
Left—Nitrogen and phosphorus
Right—Nitrogen, phosphorus, and potassium

Table 10 shows that muriate of potash has been somewhat more effective on yield than the sulfate. But early experiments with test cigars at the Southwestern Experiment Farm showed that the sulfate produced tobacco which when made into cigars gave a longer fire-holding capacity and an ash that did not flake and fall off as readily as that of cigars made from the muriate-treated tobacco. (See Bulletin 285, Ohio Agricultural Experiment Station). When a considerable amount of potash is used, it is probable that a mixture of muriate and sulfate will give satisfaction to all concerned, to the grower, the manufacturer, and the smoker.

In continuous culture 120 pounds of muriate of potash applied annually has produced 46 pounds more tobacco than 60 pounds of muriate, or about ¾ pound of tobacco for each pound of the second 60-pound increment of muriate of potash. With tobacco usually selling at several times the cost of muriate, the larger application of potash seems justified.

TABLE 10.—Comparison of Muriate and Sulfate of Potash for Tobacco

Plot	Treatment	33-year average	
		Yield per acre	Increase
		Lb.	*Lb.*
8	Nitrate of soda 240 lb. Superphosphate 480 lb. Muriate of potash 180 lb.	1143	620
23	Nitrate of soda 240 lb. Superphosphate 480 lb. Sulfate of potash 190 lb.	1112	589

The fertilizer plots in rotation unfortunately do not contain any with as little as 60 pounds of muriate of potash. The applications start at 120 pounds and increase to 300 pounds. Reference to Table 11 shows that there has been no appreciable increase in yields from applications larger than 120 pounds per acre.

TABLE 11.—Varying the Quantity of Potash on Tobacco

Plot No.	Treatment per acre	Yield per acre Lb.	Increase Lb.
	Continuous culture—30 years		
8	320 pounds of nitrate of soda 320 pounds of superphosphate* 60 pounds of muriate of potash	956	638
9	320 pounds of nitrate of soda 320 pounds of superphosphate* 120 pounds of muriate of potash	1002	684
	In tobacco, wheat, clover rotation—33 years		
12	240 pounds of nitrate of soda 480 pounds of superphosphate* 120 pounds of muriate of potash	1144	621
8	240 pounds of nitrate of soda 480 pounds of superphosphate* 180 pounds of muriate of potash	1143	620
9	240 pounds of nitrate of soda 480 pounds of superphosphate* 300 pounds of muriate of potash	1162	639

*16 per cent grade.

The results of the two tests would seem to indicate that a maximum crop of tobacco requires more potash than that carried in 60 pounds of muriate of potash, but they do not necessarily prove that such a crop requires as much as 120 pounds.

PHOSPHORUS

Phosphorus has long been recognized as one of the most important fertilizer constituents for Ohio soils. This is as true when tobacco is the crop to be fertilized as it is for most other farm crops. The results given in Table 12 seem to be ample justification for the very liberal use of superphosphate on tobacco. It usually will be applied as part of a mixed fertilizer.

TABLE 12.—Varying Amounts of Superphosphate on Tobacco

Plot No.	Treatment	33-year average	
		Yield per acre	Increase
		Lb.	*Lb.*
19	240 pounds of nitrate of soda 320 pounds of superphosphate* 180 pounds of muriate of potash	1121	598
8	240 pounds of nitrate of soda 480 pounds of superphosphate* 180 pounds of muriate of potash	1143	620
13	240 pounds of nitrate of soda 720 pounds of superphosphate* 180 pounds of muriate of potash	1288	765

*16 per cent grade.

FINANCIAL RETURN

Thus far the increases from various treatments have been in terms of pounds of tobacco. A dollars-and-cents return can be computed by each reader according to values considered suitable, or the figures in Table 13 may be taken as showing the general trend. In each case the tobacco crop shows a very definite return on the investment in fertility items.

TABLE 13.—Financial Returns from Tobacco Fertilization*
Tobacco, wheat, clover rotation, 33 years

Plot No.	Treatment per acre	Increase per acre		Value of increase	Fertilizer cost	Value less fertilizer cost
		Wrapper and filler	Trash			
		Lb.	*Lb.*	*Dol.*	*Dol.*	*Dol.*
2	480 pounds of superphosphate...	124	50	13.40	4.80	8.60
3	480 pounds of superphosphate. 180 pounds of muriate of potash	451	80	46.70	6.60	40.10
8	240 pounds of nitrate of soda... 480 pounds of superphosphate. 180 pounds of muriate of potash	533	87	55.04	11.40	43.64
13	240 pounds of nitrate of soda... 720 pounds of superphosphate. 180 pounds of muriate of potash	658	107	67.94	13.80	54.14
35	10 tons of shed manure .... 400 pounds of superphosphate.	550	105	57.10	9.00	48.10

*Values: wrapper and filler, 10¢ per pound; trash, 2¢ per pound. 16 per cent superphosphate, $20 per ton; muriate of potash, $50 per ton; nitrate of soda, $40 per ton; manure, 50 cents per ton to cover cost of hauling.

However, the complete picture cannot be seen by looking at the tobacco only, for wheat and hay both respond well to the treatments that produce good tobacco yields. In the tobacco, wheat, clover rotation the wheat and clover are not fertilized but nevertheless they provide very substantial increases to credit to the treatment given the tobacco.

Fig. 5.—Wheat produces excellent crops after heavily fertilized tobacco.

The residual effects on wheat and hay are given in Table 14. In view of the fact that many livestock and grain farmers use from 300 to 400 pounds of fertilizer on wheat, an application of from 600 to 1000 pounds per acre on tobacco does not seem impractical when it is considered that this amount provides not only for the tobacco but also for the wheat and clover which complete the rotation.

TABLE 14.—Increases in Wheat and Hay Yields Following Fertilized Tobacco. No Fertilizer on Wheat or Hay*

Plot No.	Treatment per acre, all on tobacco	Wheat 25 years		Hay 26 years		Value of increases
		Yield	Increase	Yield	Increase	
		Bu.	*Bu.*	*Lb.*	*Lb.*	*Dol.*
2	480 pounds of superphosphate	24.8	12.0	3065	1110	15.15
3	480 pounds of superphosphate 180 pounds of muriate of potash	28.3	15.6	3610	1660	20.78
8	240 pounds of nitrate of soda 480 pounds of superphosphate 180 pounds of muriate of potash	28.8	16.1	3445	1490	20.33
13	240 pounds of nitrate of soda 720 pounds of superphosphate 180 pounds of muriate of potash	31.4	18.7	3765	1810	24.01
35	10 tons of shed manure 400 pounds of superphosphate	31.9	19.1	4145	2190	26.23

*Values: wheat, 80¢ per bu.; hay, $10 per ton.

The increases in tobacco, wheat, and clover given represent average differences in yields on land treated in the same very definite manner for over 30 years and other land without any treatment other than rotation. This latter land, as a consequence, tends more or less to decrease gradually in fertility value, so that each year the fertilized plot is compared with a base which very likely decreases during any long-time test. Therefore, a grower starting on land of high fertility would hardly expect immediate increases equal to those already reported in this bulletin.

MANURE

Although manure is an effective treatment for tobacco, reference to Table 13 shows that it cannot compete with commercial fertilizer except as the manure is produced on the farm and the cost is considered largely that of a by-product which has to be removed from the building where it is produced.

The figures in Table 15 show that in tobacco culture the first few tons of manure applied are by far the most valuable. This principle holds good for other farm crops also. Applied to the clover sod in the rotation, 10 tons have produced an increase of 495 pounds of tobacco, or 49½ pounds per ton of manure. The second 10 tons produced a further increase of only 124 pounds, or 12.4 pounds per ton. In continuous culture the extra 5 tons on Plot 16 produced 67 pounds more tobacco than grew on Plot 12. This gives 13.4 pounds for each of the extra tons applied. Thus, there seems to be good evidence that any part of a manure application above 8 or 10 tons per acre gives a very small return in tobacco yield.

TABLE 15.—Effect of Manure on Tobacco

Plot No.	Treatment per acre	Yield per acre Lb.	Increase Lb.
	Continuous culture—30 years		
Checks	None	318	....
11	8 tons of shed manure	875	557
12	8 tons of shed manure 160 pounds of superphosphate	1026	708
16	13 tons of shed manure 160 pounds of superphosphate	1093	775
13	8 tons of shed manure 160 pounds of superphosphate 60 pounds of muriate of potash 160 pounds of nitrate of soda	1139	821
	In tobacco, wheat, clover rotation—33 years		
32	10 tons of shed manure	1028	495
33	20 tons of shed manure	1142	619
35	10 tons of phosphated shed manure*	1178	655
36	10 tons of phosphated yard manure*	1019	496

*40 pounds of 16 per cent superphosphate per ton of manure.

The principle of supplementing manure with superphosphate is so well understood that it needs no particular comment. However, it is well to point out that the addition of 160 pounds of superphosphate annually in continuous culture increased the yield over manure alone by 151 pounds of tobacco. Furthermore, in rotation the addition of 400 pounds to 10 tons of manure gave an increase of 160 pounds over manure alone. These figures compare closely with the increase of 174 pounds of tobacco in rotation from 480 pounds of superphosphate applied alone on Plot 2 (Table 9).

In continuous culture, additional supplemental treatments of potash and nitrogen on Plot 13 gave an increase of 113 pounds in tobacco yield over that obtained from manure and superphosphate on Plot 12. The plot arrangement does not permit a definite answer as to what part the potash and nitrogen individually had in producing this extra yield.

LIMESTONE

Throughout the 33 years of the test there have been five pairs of plots; each pair has had identical treatments except that one plot of each pair was given 1000 pounds of limestone per acre every 3 years. All five pairs have performed consistently in that the limed plot has produced less tobacco than the unlimed one. The average of the five pairs shows 44 pounds less tobacco on the limed plots. Wheat and hay, on the other hand, both show consistent slight increases on the limed plots; that for wheat is 1.3 bushels, and that for clover is 450 pounds per acre. Soil tests taken in 1935 showed the limed plots to be very close to neutrality (pH 7.0) and the unlimed ones to be slightly acid with a pH value just under 6.0.

THE MORE RECENT FERTILITY TESTS

A study of the results presented in the previous section, dealing with the 33 years of broadcast applications, discloses convincing evidence of the practicability of large fertility treatments in tobacco culture. The largest amount applied, 1080 pounds per acre on Plot 13, produced not only the largest yield but also the most profitable crop. Evidence is lacking as to what still larger applications would have done.

Fig. 6.—Tobacco grown on good soil
Left—Eight hundred pounds of fertilizer in row
Right—No fertilizer

A few years ago tests were started to determine facts concerning the row application of fertilizer to tobacco. This later work has been carried out on land in a high state of fertility, and the untreated plot yields are considerably larger than those reported in the previous section dealing with broadcast applications. One of these later tests involved applying increasing amounts of fertilizer in the row. It started with 100, and increased to 800 pounds per acre. This test has been one of the most interesting to watch. Every year, without exception, the tobacco yields have increased at a rather uniform rate as the fertilizer application was increased.

Reference to Table 16 shows that each 200 pounds of fertilizer has produced approximately 100 pounds of tobacco. Moreover, the last 200 pounds were just as effective as the first 200 pounds; this indicates that more than the 800 pounds would need to have been applied before the law of diminishing returns began to function. In 1936 the row treatment was increased to 1600 pounds per acre, but the unparalleled drouth of that season made moisture the limiting factor and the light rains that finally came were too long delayed to permit much late season growth. Fertilizer response, accordingly, was the lowest ever recorded on the Southwestern Experiment Farm. Consequently, about the only value of this test was the interesting observation that the application of this extremely large amount had no detrimental effect on stand or appearance of the young plants during weather so dry that in many fields on near-by farms from one-half to three-fourths of the plants failed to survive.

TABLE 16.—Increasing Row Applications of Fertilizer

Plot	Treatment per acre, 4-12-4, all in row	Yield per acre 6 years 1930-1935	Increase per 200-pound increment
	Lb.	*Lb.*	*Lb.*
1 and 7	None	1151	....
2 and 8	100	1199	48*
3 and 9	200	1248	97
4 and 10	400	1351	103
5 and 11	600	1444	93
6 and 12	800	1546	102

*From 100-pound increment.

During the same 6 years that row applications were being tested, the tobacco on Plot 13 in the long-time fertility test was getting its regular broadcast treatment of 1080 pounds per acre. The row tests were located on blocks which had been given previous good treatment but not as heavy fertilizer applications as Plot 13 had received. Therefore, it is probable that Plot 13 had the higher residual fertility. This should be kept in mind in reviewing the yields given in Table 17. The results clearly indicate the greater efficiency of row treatments.

TABLE 17.—Broadcast versus Row Applications on Tobacco

Treatment	Method of application	Yield per acre 6 years 1930-1935
		Lb.
240 pounds of nitrate of soda* 720 pounds of superphosphate* 180 pounds of muriate of potash*	Broadcast	1438
400 pounds of 4-12-4	Row	1351
800 pounds of 4-12-4	Row	1546

*Total application approximately equivalent to 1000 pounds of a 4-12-9 analysis.

The apparent efficiency of row treatments raises the question whether it is better to put the fertilizer entirely in the row or to split it between row and broadcast applications. This comparison has been made for only 2 years, and the results given in Table 18 perhaps should be taken as merely indicative. The plots were long and narrow and no effort was made to determine the effect on the wheat following. However, no very definite streaking of the wheat showed up following the all-row treatments, but this may not tell what would happen on less fertile soil.

TABLE 18.—Row versus Split Applications of Fertilizer on Tobacco

Treatment per acre	Method of application	Yields per acre		
		1934	1935	Average
		Lb.	*Lb.*	*Lb.*
200 pounds of 4-12-4	Row	1140	1387	1264
400 pounds of 4-12-4	Row	1290	1525	1408
200 pounds of 4-12-4 400 pounds of 0-14-6	Row Broadcast	1330	1437	1384
600 pounds of 4-12-4	Row	1360	1662	1511
400 pounds of 4-12-4 400 pounds of 0-14-6	Row Broadcast	1440	1587	1514
800 pounds of 4-12-4	Row	1470	1762	1616

The larger yields obtained in 1935 would seem to indicate that season to be superior to 1934, but on other blocks the yields for the 2 years were practically equal. The superintendent who watched these plots in 1934 reported that the tobacco on this block was not doing as well as that on other portions of the Experiment Farm but the cause could not be determined. This is mentioned because the 1935 results may be more typical of what may be expected. The average of the 2 years is favorable to putting all of the fertilizer on as a row application. This is the more economical method, as less fertilizer is required for a given yield and the laborious and tiresome work of drilling a broadcast application is eliminated.

WHAT ANALYSIS?

To answer the question of what analysis to use for row fertilization of tobacco it will be necessary to consider two separate experiments. The first is in continuous culture with all plots receiving an annual treatment of 8 tons of manure per acre. Early in the fertility tests at the Southwestern Experiment Farm it was easily apparent that tobacco yields on manure-treated plots were increased appreciably by using commercial plant food to supplement that carried in the manure. In line with the findings on other farm crops, superphosphate was most generally the supplement added and this was effective in both continuous culture and rotation. One plot (Table 15) in continuous culture received nitrogen and potash in addition, and the response was an increased yield over the manure-superphosphate combination. Thus, the results of the long-time broadcast tests gave evidence that justified expecting favorable results from supplemental row treatments.

The comparisons given in Table 19 indicate that with the inclusion of nitrogen in the row treatment there is a sharp increase in yield. Moreover, practically all of this increase comes in the high-value wrapper grade. The filler and trash show but little variation. On the other hand, the commercial potash in this test apparently has produced an insignificant effect. Because of the importance of potash in tobacco fertility this may seem surprising, but it must be remembered that the row treatment is supplemental to a basic treatment of 8 tons of shed manure. In discussing the data given in Table 9 the statement was made that 10 tons of shed manure apparently carried sufficient potash for a tobacco crop grown in a tobacco, wheat, clover rotation. Consequently, it may be that the annual application of 8 tons of shed manure furnished sufficient potash for tobacco grown continuously on this soil.

TABLE 19.—Row Fertilization with Different Analyses on Manure-treated Land

Plot	Treatment	Yields per acre				Increase from row treatment Lb.
		Wrapper Lb.	Filler Lb.	Trash Lb.	Total Lb.	
In continuous culture—3 years						
14 and 17	8 tons of manure.............	837	168	205	1209	....
15	8 tons of manure......... 400 pounds of 0-12-0 (row) ..	952	170	198	1320	109
16	8 tons of manure .... 400 pounds of 0-12-4 (row) ..	953	153	217	1323	116
18	8 tons of manure ...... 400 pounds of 4-12-4 (row) ..	1029	167	223	1419	216
In rotation of tobacco, wheat (clover mixture)—6 years						
2 and 12	6 tons of manure .... 350 pounds of 0-20-0 (broadcast)	824	183	198	1205	....
3 and 13	6 tons of manure .... 350 pounds of 0-20-0 (broadcast) .... 400 pounds of 4-12-4 (row) ..	979	195	190	1364	159

A further comparison of analyses can be made from the results of a test which has been conducted for 6 years in which the tobacco is produced in a 2-year rotation of tobacco, wheat (clover). In this test the land is not manured but instead it receives a very liberal broadcast treatment of 0-14-6 prior to the setting of tobacco. The results as given in Table 20 show that the total yields from the different analyses have not varied greatly. The addition of nitrogen (in 4-12-4) has not produced as large an increased yield over the 0-12-4 as it did in the test on continuous tobacco, but it has shown the same tendency to put more of the total yield in the high-value wrapper grade. Although the total

TABLE 20.—Row Fertilization with Different Analyses on Unmanured Land

Rotation: tobacco, wheat (sweet clover)

Treatment	Method of application	Average yield per acre, 6 years (1930–1935)				Increase for row treatment
		Wrapper	Filler	Trash	Total	
		Lb.	*Lb.*	*Lb.*	*Lb.*	
500 pounds of 0-14-6.......	Broadcast	732	184	189	1105	... .
500 pounds of 0-14-6........ 400 pounds of 0-12-4	Broadcast Row	823	210	207	1240	135
500 pounds of 0-14-6........ 400 pounds of 4-12-4........	Broadcast Row	884	190	184	1258	153
500 pounds of 0-14-6....... 400 pounds of 4-12-8.......	Broadcast Row	884	201	192	1277	172

yield is only 18 pounds larger when the 4-12-4 is compared with the 0-12-4, the wrapper yield is 61 pounds larger. This larger yield of wrapper would seem to justify the recommendation of including nitrogen in the fertilizer for the row application.

Increasing the potash of the row fertilizer from 4 to 8 per cent was of doubtful value in this test in which the row treatment was supplemental to 500 pounds of 0-14-6 applied broadcast. The total yield is slightly larger, but the pounds in the wrapper grade remain the same. Failure to secure a considerable increase in yield from the larger percentage of potash perhaps is not inconsistent with results of the former long-time tests. The broadcast application of 500 pounds of 0-14-6 carried 30 pounds of potash, and the row treatment of 400 pounds of 4-12-8 carried 32 more, a total of 62 pounds. This is equal to that contained in 124 pounds of muriate of potash. Reference to Table 11 shows that the earlier work gave considerable reason to doubt the ability of a tobacco crop to utilize fully this amount of muriate of potash.

DELAYED SIDE-DRESSING WITH NITROGEN FERTILIZERS

A study of the effects of the long-time broadcast application of commercial forms of plant food leads to the conclusion that in a good system of tobacco culture commercial nitrogen is exceeded in importance by both phosphorus and potassium. Phosphorus is important for its effect on yield, potassium, for its effect on both yield and quality. The best crops, however, were obtained from applications including nitrogen with phosphorus and potassium. In the later work all nitrogen has been used either as part of a mixed fertilizer applied in the row at setting time or as a delayed treatment of sodium nitrate distributed through an attachment on the cultivator which spread it on both sides of the row during the cultivating process 2 or 3 weeks after setting. The results of a 6-year test of delayed nitrogen side-dressing are given in Table 21. They show that 100 pounds per acre of nitrate of soda applied as a delayed row treatment after the plants have started active growth has increased the yield by 102 pounds per acre. This is the most effective use of nitrogen ever obtained on tobacco in tests at the Southwestern Experiment Farm.

TABLE 21.—Effect of a Delayed Side-dressing of Nitrogen as Nitrate of Soda

Plot	Treatment	Yield of tobacco 6 years 1930–1935
		Lb.
5 and 15	500 pounds of 0–14–6, broadcast	1107
6 and 16	500 pounds of 0–14–6, broadcast 400 pounds of 4–12–4, row	1240
9 and 19	500 pounds of 0–14–6, broadcast 400 pounds of 4–12–4, row 100 pounds of nitrate of soda, delayed	1342

PRACTICAL RECOMMENDATIONS FOR FERTILIZING TOBACCO

The results herein reported do not answer with certainty all questions regarding tobacco fertilization. They do, however, provide a basis for tentative recommendations which, if followed, should lead to increased returns from the money spent for tobacco fertilizers on many Ohio farms.

Placing all of the fertilizer in the row is apparently preferable to applying all or part of it broadcast. This conclusion agrees with results obtained in tobacco fertilizer placement studies conducted since 1933 in five Eastern Seaboard states.[1] The latter studies indicate that row placement is more economical of fertilizer than broadcast applications and, further, that the actual position of the fertilizer in the row is important. The preferred placement appears to be in lateral bands 2 to 2½ inches on either side of the plants and in a vertical zone from the level of the base of the root crown to about 1 inch below. Placing the fertilizer in definite bands has given better results than mixing the fertilizer in the soil in the row and in contact with the roots. Transplanting machines are now available which place the fertilizer in the desired position (see Fig. 7).

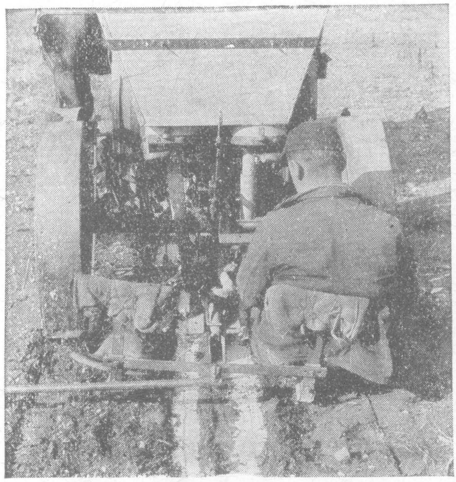

Fig. 7.—Modern tobacco transplanter showing two-band placement of fertilizer (Courtesy National Fertilizer Association)

Table 22 gives suggested acre rates and fertilizer analyses for tobacco under different soil conditions. All recommendations are for row application.

TABLE 22.—Fertilizer Recommendations for Tobacco

Light-colored silt loams, clay loams, and clays		Dark-colored silt loams, clay loams, and clays	
Manured or clovered*	Neither	Manured or clovered*	Neither
2-14-4 or 2-12-6, 500-600 pounds†	4-10-6, 600-800 pounds†	2-12-6, 300-500 pounds†	2-8-10 or 2-12-6, 400-600 pounds†
15 pounds of nitrogen as side-dressing‡	25 pounds of nitrogen as side-dressing‡		

*"Manured" means the use of 8 tons or more of well-preserved farm manure. "Clovered" means the plowing under of a full crop of clover or other legume, green or mature.

†In general, the higher rates indicated should be used for White Burley, also on cigar filler when planted on soils of low fertility.

‡Nitrogen may be applied in the form of sulfate of ammonia, nitrate of soda, or other quickly available carrier. Sulfate of ammonia carries about 21 pounds of nitrogen, and nitrate of soda, 16 pounds of nitrogen in 100 pounds of the fertilizer. These materials should be applied when the plants have a spread of 6 to 8 inches. They may be applied through a fertilizer attachment on the cultivator, with a row fertilizer distributor, or by hand.

[1]Reported in the Proceedings of the National Joint Committee on Fertilizer Application for 1933, 1934, 1935, and 1936, published by the National Fertilizer Association, Washington, D. C.

TOBACCO ROTATIONS

Two problems regarding rotation confront the tobacco grower. The first is whether to grow the crop in continuous culture or in rotation. If the decision is in favor of the rotative method, then the second problem relates to the exact rotation to adopt.

If some manure is available and a policy of liberal fertilization is followed, tobacco will stand continuous culture better than many crops. Table 23 gives a 30-year comparison of the two systems as followed on plots fertilized rather similarly. The data indicate considerable advantage from the rotation system, as, not only are the tobacco yields larger, but also there is a rather high value from wheat and hay produced later in the rotation. These latter crops require no additional expense for fertilizer and but little effort for soil preparation, as tobacco leaves the land in such condition that it can be worked very easily into an ideal seedbed for wheat.

TABLE 23.—Tobacco in Rotation versus Continuous Culture, 30-year Average

System	Treatment	Average yields		
		Tobacco	Wheat	Hay
		Lb.	*Bu.*	*Lb.*
Continuous tobacco	320 pounds of nitrate of soda 160 pounds of superphosphate 60 pounds of muriate of potash	855	None	None
Continuous tobacco	8 tons of manure 160 pounds of nitrate of soda 160 pounds of superphosphate 60 pounds of muriate of potash	1125	None	None
Tobacco, wheat, clover rotation	240 pounds of nitrate of soda 480 pounds of superphosphate 180 pounds of muriate of potash	1205	32	4130

More recently a rather complete rotation test has been conducted, and 7 years' results now are available. These are given in Table 24. The data confirm those of Table 23 in that under continuous culture the yields fall considerably below those in rotation, at least when no manure is used.

TABLE 24.—Tobacco Rotations, 1929-1935

No.	Rotation	7-year average yields			
		Tobacco	Corn	Wheat	Hay
		Lb.	*Bu.*	*Bu.*	*Lb.*
1	Continuous tobacco*	1146	....	....	....
2	Tobacco*, wheat (sweet clover)	1395	....	32.4	....
3	Tobacco, corn, wheat (sweet clover)	1372	50.0	22.9	....
4	Corn, tobacco, wheat (sweet clover)	1285	51.3	29.7	....
5	Tobacco, wheat, clover	1440	....	33.9	4200
6	Corn, tobacco, wheat, clover	1263	50.7	32.3	3450

*Tobacco fertilized with 532 pounds of 2-12-6 in row; all other tobacco, 800 pounds of 2-12-6 in row.

The various factors involved, such as yield, soil conservation, and fertilizer efficiency, would seem to favor very strongly the rotational system for tobacco production. However, continuous production is possible, especially where manure is available; and a grower who has a certain area of land particularly well adapted to tobacco can, if especially desired, practice continuous culture for several years by paying proper attention to adequate fertility measures. However, halfway treatment probably will be disappointing. For example, reference to Table 23 shows that annual applications of 540 pounds of fertilizer failed to hold production at a satisfactory level. With smaller quantities of fertilizer applied, the yields decreased to very unprofitable levels.

In Table 24 it will be noted that Rotations 3, 4, and 5 each are 3 years in length. In Rotations 3 and 4 the tobacco and corn occur in reverse order; each one thus has the advantage of following the legume. The data show that the tobacco pays considerably more than the corn for the privilege of following the legume. This is confirmation of the principle worked out with several crops that the high-value crop deserves the most favorable place in the rotation. At the Southwestern Experiment Farm during the 7 years of the test, tobacco has produced 87 pounds more per acre after a legume catch crop than after corn. Corn, on the other hand, has averaged only 1.3 bushels higher when it followed the legume, as compared with a position 1 year later in which it followed tobacco. As far as these two crops are concerned, it is better to place tobacco directly after the legume and corn in second place 1 year later. Other factors, however, may have some weight in determining the particular crop sequence to be followed in any given case; for example, wheat does better after tobacco than after corn and in this test yielded 6.8 bushels more after tobacco than after corn. Thus, with average prices, the higher wheat yield after tobacco largely balanced the higher tobacco yield after the legume. The balance might swing either way, depending on the relative selling price of tobacco and wheat.

In Rotation 4 corn is omitted and the clover is permitted to occupy the land for a full year instead of being plowed down as a catch crop. Tobacco following the clover sod thus produced (second growth uncut) has yielded more than in any other rotation. The results thus point to the desirability of making the tobacco rotation a soil-building one. A catch crop of sweet clover every 2 years in Rotation 2 was superior to a similar catch crop every 3 years in Rotation 3. The clover sod every 3 years in Rotation 5 has shown a still greater degree of superiority. Lengthening the rotation to 4 years as in Number 6 and including two cultivated crops have resulted in a lower tobacco yield even though allowance is made for the fact that the crop follows corn in this rotation.

COVER CROPS

Results of 3 years with cover crops in the continuous culture of tobacco have shown an average increase of 47 pounds per acre from a winter coverage of wheat which made a moderate spring growth before being plowed under. The practice seems more favorable at the end of 3 years than it appeared at the beginning.

SUMMARY

Tobacco investigations of the Ohio Experiment Station are localized in the Miami Valley (cigar filler) District, which produces approximately three-fourths of all tobacco grown in Ohio.

In the seed-selection process the heads of desirable tobacco plants should be enclosed in paper bags at blooming time to prevent cross-pollination by visiting insects.

From 4 to 6 days may be saved in the production of plants by sprouting the seed before sowing.

Tobacco plants suffer less setback at transplanting time if grown in well-conditioned plant bed soil from which they may be pulled without serious damage to the tiny root systems.

Tobacco beds grew the best plants with annual steaming at 125 pounds pressure for 25 minutes or 150 pounds for 20 minutes.

Maximum yields of Ohio Hybrid 224 have been obtained from setting plants in the field during the period June 15 to 25.

Best quality and yields were obtained with two suckerings.

High quality is influenced by soil fertility, as well as by cultural practices. In general, the highest average quality is secured with the highest yield of an adapted variety.

Good fertility practices return a profit not only on the tobacco itself but also on the grain and hay crops which follow tobacco in the rotation.

Potash is of major importance in determination of grade.

Phosphoric acid, liberally applied, is conducive to large yields. It has paid to use as much as 720 pounds per acre of 16 per cent superphosphate supplemented with nitrogen and potash.

On soil with a pH of approximately 6.0, limestone has caused a small decrease in tobacco yields.

Row application of fertilizer has been more effective than applying broadcast. Eight hundred pounds per acre were applied in the row without any indication that this represented the maximum amount that could be used profitably.

Row-applied fertilizer may contain fairly liberal percentages of all the common plant foods, i. e., nitrogen, phosphoric acid, and potash.

A side-dressing of a quickly available nitrogen carrier when the plants have a spread of 6 to 8 inches has produced a profitable increase in tobacco yields.

It has been more profitable to grow tobacco in rotation than in continuous culture.

Tobacco yields more after a legume than after corn.

Wheat yields several bushels more after tobacco than after corn.