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THE UNIVERSITY OF TENNESSEE

AGRICULTURAL EXPERIMENT STATION

FIFTY-SEVENTH ANNUAL REPORT

1944

Experimental flock of sheep on button-clover pasture at the Middle Tennessee Experiment Station.

KNOXVILLE, TENNESSEE

THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
KNOXVILLE

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J. L. VANDIVER, Asst. Agron.[1], Tobacco Experiment Sta., Greeneville.
B. P. HAZLEWOOD, Superintendent, West Tennessee Experiment Station, Jackson.

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[1]Cooperative with U. S. Department of Agriculture.

[2]On military leave.

Bulletins of this Station will be mailed free to any farmer in the State. Write Agricultural Experiment Station, University of Tennessee, Knoxville, Tennessee.

CONTENTS

LETTER OF TRANSMITTAL

Knoxville, Tennessee, January 1, 1945

To His Excellency, Jim McCord, Governor of Tennessee.

Sir: I have the honor to transmit herewith, on behalf of the Board of Trustees of The University of Tennessee, a report of the work and expenditures of the Agricultural Experiment Station for the year 1944. This report is submitted in accordance with the law requiring that the Board having direction of the Experiment Station shall annually submit to the Governor of the State a report of its operations and expenses.

Very respectfully,

JAMES D. HOSKINS, President

FINANCIAL STATEMENT

THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION

In account with

The United States Appropriations under the Hatch, Adams, Purnell, and Bankhead-Jones Acts, and Non-Federal Funds, 1943-44.

	Federal Funds				Non-Federal Funds
	Hatch	Adams	Purnell	Bankhead-Jones	
Receipts					
From United States Treasurer	$15,000.00	$15,000.00	$60,000.00	$77,136.04	
From other sources					$180,479.51
Expenditures					
Personal services	12,029.78	12,744.50	53,785.94	60,664.57	78,485.27
Travel	59.92	0.00	611.12	1,034.88	1,161.14
Transportation of things	126.28	21.26	119.93	862.08	2,266.79
Communication service	430.56	6.00	31.83	42.57	877.32
Rents and utility services	26.69	14.98	151.79	314.47	1,540.67
Printing and binding	764.56	0.00	123.14	674.96	919.68
Other contractual services	137.93	114.31	823.16	490.47	12,993.54
Supplies and materials	1,173.05	1,776.84	3,474.50	9,962.58	48,326.41
Equipment	247.90	322.11	878.59	2,872.50	12,447.49
Lands and structures	3.33	0.00	0.00	216.96	21,461.20
Total	$15,000.00	$15,000.00	$60,000.00	$77,136.04	$180,479.51

FIFTY-SEVENTH ANNUAL REPORT OF THE AGRICULTURAL EXPERIMENT STATION OF THE UNIVERSITY OF TENNESSEE FOR 1944

INTRODUCTION

C. A. Mooers, Director

While the war has inevitably interfered with most lines of endeavor, the Agricultural Experiment Station has been able to keep its research program essentially intact. This applies alike to work at the main Station at Knoxville, and the substations. Shortage of labor and materials prevented the hoped-for development of the Highland Rim and Cumberland Plateau Stations, but substantial progress was made in improving fields and providing important facilities for future growth.

Increase in acreage was made this year at two places; 136 acres being purchased for the Highland Rim Station and about 40 acres for the West Tennessee Station.

The acreages now in use at the several Stations are approximately as follows:

	Acres
The main Station, at Knoxville	138
West Tennessee Station, near Jackson	653
Middle Tennessee Station, near Columbia	805
Tobacco Station, near Greeneville	485
Highland Rim Station, near Springfield	327
Plateau Station, near Crossville	590

In addition, a few acres of the farm recently acquired by the University in Blount County are being utilized by the Experiment Station.

The pages which follow show the scope of the Station's work and indicate the year's progress in the various departments. Bulletins and circulars issued by the Station and articles published in science journals may be consulted for more complete accounts of some of the lines of investigation.

AGRONOMY

GENERAL

J. B. Washko

WEATHER CONDITIONS AT KNOXVILLE

The 1944 crop season at Knoxville was characterized by abnormal weather conditions. The early spring season was cool and wet. This was followed by the worst late-spring and summer drouth in the 74-year history of the Weather Bureau. The lowest temperature recorded was 13° F., on February 13; the highest was 99° F., on June 18. Temperatures for May and June were higher than those recorded in other years, while for April they were lower. The last

killing frost in the spring occurred on April 6, and the first killing frost in the fall on October 28, making a growing season of 205 days. The drouth began the latter part of May and was not broken until August 5.

The cool, moist weather in early spring, followed by sunny, dry weather in May, was ideal for the growth of small grains and early hay, such as alfalfa. The drouth caused severe damage to corn and other summer crops, particularly hays and pastures. The annual lespedezas for the most part made insufficient growth for hay. Late corn, alfalfa, and pastures recovered considerably under the influence of fall rains, which were ample in August and September. The rains came too late for hay, which continued to be short, so that hay had to be shipped into the State for winter feeding of livestock. These fall rains, however, encouraged farmers to seed winter annual legumes and small grains for pasture, which helped alleviate the feed shortage. The yields of summer crops have been adversely affected by the 1944 drouth and the yield data for the 1944 season, therefore, are lower than in normal seasons.

CROPS

During the past year, in addition to the experiments with commonly grown field and forage crops, work was continued with such war-emergency crops as hemp and soybeans.

Hemp.—This crop is not grown for its fiber in Tennessee, but rather for its seed. Fertilizer and date-of-planting experiments, started in 1943, were continued. Highest seed yields were obtained when the crop was planted from April 15 to May 15. The yield from the June 1 planting was not only lower but of poorer quality—many of the seed set failed to mature properly. In spite of the drouth, this crop showed considerable response to fertilization. Seed yields were increased from 45 percent to 85 percent by moderate amounts of a mixed fertilizer.

Soybeans.—This is still one of the most important oil-bearing crops grown during the year. Its oil is making a very important contribution to the edible-fats-and-oils program of the Nation. The Tennessee Station, therefore, continues to test soybean varieties, not only for their seed yield, but also for their oil content. Again, in addition to the regular variety tests at the Knoxville, Columbia, and Jackson Stations, 20 soybean varieties, composed of the leading ones in the Southern States, were tested as part of a regional soybean study cooperative among the Southern States Experiment Stations and the Division of Forage Crops and Diseases of the U. S. Department of Agriculture.

Yields were obtained and chemical determinations were made for oil content, oil quality, and protein at each location as in 1943. The average seed yield and oil content for 1943-44 of 9 varieties grown in these tests both years are given in table 1. The Ogden variety developed by this Station out-yielded the others for the 2-

Table 1—*Seed yields and oil content of soybeans grown at Knoxville, Columbia, and Jackson,* 1943-44.

Variety	Seed yields per acre Average 1943-44			Oil content of seed Average 1943-44			Maturity	
	Knoxville	Columbia	Jackson	Knoxville	Columbia	Jackson		
	Bushels	Bushels	Bushels	Percent	Percent	Percent		
Ogden	33.6	22.5	19.2	20.7	21.0	21.3	Medium	late[1]
Arksoy 2913	23.4	17.4	15.1	20.4	19.2	19.9	"	"
Ralsoy	20.8	16.9	13.1	20.5	19.3	20.0	"	"
P. I. 97066	20.1	17.3	15.5	18.6	18.5	19.7	"	"
Mamredo	19.6	18.6	15.1	19.5	19.7	20.2	"	"
Magnolia	16.4	14.2	16.8	20.6	19.9	20.0	"	"
S100	21.3	8.2	14.7	18.2	18.4	19.1	Early[2]	
Macoupin	16.7	6.7	12.4	21.6	19.8	22.1	"	
Boone	12.1	4.7	12.8	20.1	18.7	21.0	"	

[1]Matures October 5-12.
[2]Matures September 10-25.

year period at all locations. The best of the early varieties was S100. In general, the seed yields of the medium-late-maturing varieties were greater than those of the early-maturing varieties.

Not only was the Ogden variety a high seed yielder, but it also had a high oil content, averaging over 20 percent. The Macoupin had the highest oil content of the early varieties, averaging slightly better than the Ogden at 2 out of the 3 locations. On an acre basis, however, Ogden would produce more oil because of its greater seed production.

Sweet Sorghums.—The sorgos, as they are called, are grown both for sirup and in combination with corn for silage in Tennessee. During the past two years several varieties of sweet sorghum were tested for yield. Sugar Drip and Kansas Orange produced the highest tonnage of cane, as shown in table 2.

Table 2—*Cane production by varieties of sweet sorghums, Knoxville,* 1943-44.

Variety	Production per acre					
	Green cane			Dry matter[1]		
	1943	1944	Average	1943	1944	Average
	Tons	Tons	Tons	Tons	Tons	Tons
Sugar Drip	20.82	10.77	15.80	5.65	3.67	4.66
Kansas Orange	19.76	9.87	14.82	5.74	3.34	4.54
Red Amber	18.65	8.44	13.55	4.62	2.67	3.65
Rox Orange	15.43	8.82	12.13	4.20	2.97	3.59
Rex	11.39	9.25	10.32	2.95	2.98	2.97

[1]Air-dry basis.

OTHER CROP EXPERIMENTS

Emergency Hay Crops.—Because of unforeseen developments, such as drouths or seeding failures with perennial hay species, farmers are often confronted with a shortage of hay. This situation can be alleviated by fast-growing forage plants, such as Sudan grass and millet. During the past two years, Tift and common Sudans and Tennessee German and browntop millets were grown alone and in combination with hay-type soybeans for hay. Data in table 3 indicate that the Sudan grasses, either alone or in combination with soybeans, are better hay grasses than the millets—Tift Sudan pro-

ducing the highest yields of hay per acre. Tift is to be preferred to common Sudan, not only because of its better yields, but because it has a high degree of resistance to the foliar disease of Sudan grass known as red spot, or "rust." The hay produced by these grasses is rather coarse, browntop being less so than the others. Growing soybeans in combination with these various grasses increases the hay yield per acre and improves the nutritive value and quality of the hay because of the higher protein content and leafiness of the soybeans.

Table 3—*Hay yield of various millets and Sudan grass alone and in combination with soybeans, Knoxville,* 1943-44.

Crop and variety	Production of hay[1] cuttings 1943			Per-acre cuttings 1944			2-year average
	1st	2nd	Total	1st	2nd	Total	
	Tons	Tons	Tons	Tons	Tons	Tons	Tons
Grown Alone							
Tift Sudan	2.78	.81	3.59	1.28	1.89	3.17	3.38
Common Sudan	2.48	.73	3.21	1.15	1.05	2.20	2.71
Tenn. German millet	1.97	.00	1.97	.70	.00	.70	1.34
Browntop millet	1.72	.00	1.72	.61	.93	1.54	1.63
Grown with Soybeans							
Tift Sudan	2.71	.81	3.52	1.38	2.14	3.52	3.52
Common Sudan	2.66	.73	3.39	1.50	1.15	2.65	3.02
Tenn. German millet	2.10	.00	2.10	.81	.00	.81	1.46
Browntop millet	1.63	.00	1.63	.86	.83	1.69	1.66

[1] Air-dry basis.

Button Clover (*Medicago orbicularis*).—This winter annual legume is comparatively new in the State. It first appeared in Wilson County in 1936-37, and at present its culture is spreading to other parts of the State. It is related to the bur clovers, but is more winter-hardy than the spotted or toothed bur clovers. Button clover has the following characteristics: It is non-hairy, yellow-flowered, hard-seeded, and bears its seed in spineless coiled pods. It sets seed profusely and reseeds itself successfully. Its hard seed enables it to reseed itself for several years from one seed setting.

Preliminary trials with this legume indicate that for best results it should be seeded during the month of August. The first week in September is as late as it should be seeded alone. In order to insure a good stand the first year, seed scarification is necessary because of its hard seeds (Fig. 1). Button clover is not adapted to poor soils. When compared with crimson clover, its soil-fertility and lime requirements have been found to be higher. (The plant characteristics of these two legumes are apparent in figure 2.) It is later-maturing than crimson clover, so that it furnishes pasturage over a longer period. Button clover is non-hairy and hence makes a good-quality hay, especially when seeded with Italian ryegrass. The ryegrass makes a suitable companion crop for button clover, since it helps prevent lodging during the later stages of maturity of the clover. This legume can be used for green manure,

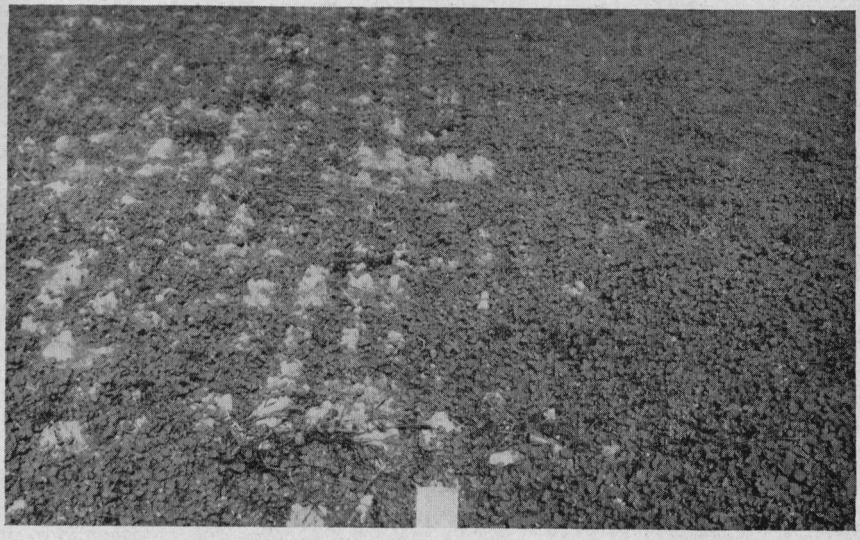


Fig. 1—Stands of button clover secured from unscarified seed (left) and scarified seed.

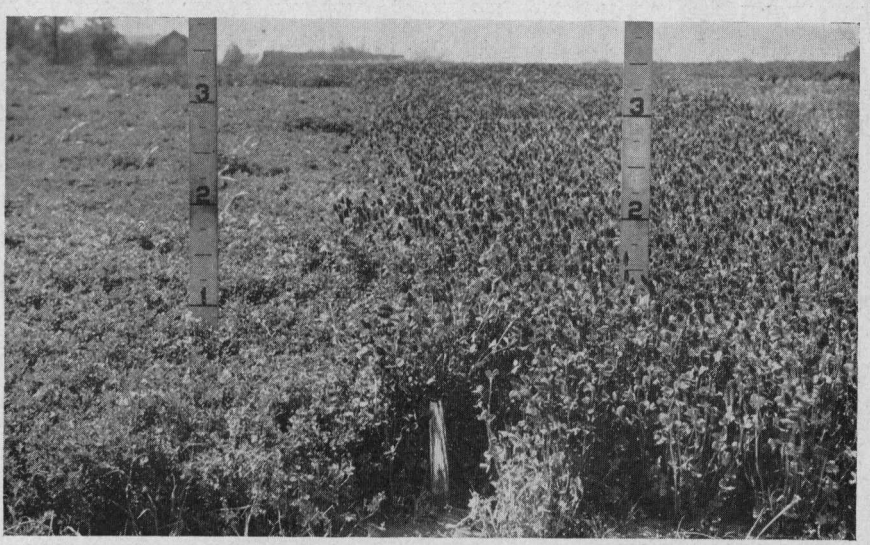


Fig. 2—A comparison of button clover (left) and crimson clover.

pasture, and hay, either alone or in combination with winter annual grasses or the small grains.

Winter Annual Legumes.—Winter annual legumes are recommended for Tennessee to (1) control erosion; (2) add organic matter, which conserves moisture and helps the physical condition of the soil; (3) furnish pasturage and feed for livestock; and (4) add

nitrogen to the soil for succeeding crops. During the past 3 years button clover, crimson clover, hairy vetch, and Austrian winter peas were compared for production of dry matter when seeded at the same time. These legumes were seeded the first week in September, the exact date depending upon soil-moisture conditions. For the 3-year period, button clover produced the highest yield of dry matter, followed by crimson clover, hairy vetch, and Austrian winter peas, in that order, as shown in table 4. The yields of Austrian winter peas were cut by root and stem blights, the damage being most severe in 1942. For maximum yields of dry matter per acre the data in table 5 indicate that the earlier, small-seeded legumes—button and crimson clover—are better than the large-seeded, later legumes—hairy vetch and Austrian winter peas.

Table 4—*Production of dry matter by various winter annual legumes, Knoxville,* 1942-44.

Legume	Yields of dry matter per acre				
	1942	1943	1944	Average	
	Pounds	Pounds	Pounds	Pounds	Tons
Button clover	3534	3876	6655	4688	2.34
Crimson clover	1822	4029	3975	3275	1.64
Hairy vetch	1580	3078	2444	2367	1.18
Austrian winter peas	900	2276	2696	1957	.98

Time of Turning Austrian Winter Peas and Hairy Vetch for Green Manure.—When winter annual legumes are grown for green manure, the question often arises as to the most desirable time to turn them under for corn from the standpoint of largest additions of organic matter and nitrogen to the soil. Austrian winter peas and hairy vetch were fall-seeded and turned under on 4 different dates in the spring—April 1, April 15, May 1, and May 15—for the past 3 years. This schedule of turning dates was followed as closely as weather and soil conditions permitted. Table 5 gives the amount of dry matter and the pounds of nitrogen added per acre by the two legumes at different dates of turning. Irrespective of date of turning, the hairy vetch produced the higher yields of dry matter and added the larger amounts of nitrogen to the soil. The data indicate that the longer these green manures are allowed to grow before turning, up to May 15, the greater will be the amounts of

Table 5—*Dry-matter production by Austrian winter peas and hairy vetch when turned on different dates, Knoxville,* 1942-44.

Date of turning	Legume	Dry-matter production per acre[1]					Nitrogen added per acre
		1942	1943	1944	Average		
		Pounds	Pounds	Pounds	Pounds	Tons	Pounds
April 1	Hairy vetch	(Insufficient growth for yield determinations)					
April 1	Austrian winter peas	(Insufficient growth for yield determinations)					
April 15	Hairy vetch	1200	827	1052	1026	.51	31.8
April 15	Austrian winter peas	1180	585	722	829	.41	19.7
May 1	Hairy vetch	1580	2708	1642	1977	.99	61.3
May 1	Austrian winter peas	900	1707	1490	1366	.68	32.5
May 15	Hairy vetch	1000	3078	2444	2174	1.09	67.4
May 15	Austrian winter peas	860	2276	2696	1944	.97	46.3

[1]Air-dry basis.

dry matter and nitrogen added to the soil. However, from the standpoint of the corn crop to follow, May 1 is the preferred date of turning. This is because a 2-to-3-weeks period usually is recommended for seedbed settling and the partial decomposition of the organic matter before corn planting. On this basis, land turned May 1 would permit the planting of corn from May 15 to 22, whereas May 15 turning would delay planting until June 1 to 8, which is usually too late for best results.

Dates for Seeding Pastures.—The question often arises as to the best time to reseed permanent pastures to grasses and clovers on a well-prepared seedbed. A permanent pasture mixture containing the following grasses and legumes was therefore seeded at 2-week intervals in the fall and spring:

	Pounds seed per acre
Kentucky bluegrass	10
Orchard grass	6
Redtop	3
Italian ryegrass	2
White clover	2
Black medic (fall)	2
	25

In the spring seedings, the black medic was replaced by a like amount of Korean lespedeza. The fall seedings began August 15 and continued through November 15, and the spring seedings began March 1 and continued through April 15.

For the past 3-year period the fall seedings gave much more satisfactory stands than the spring seedings. The best stands of grasses and legumes with fall seeding were obtained from August 15 through September 15. The seedings made October 1 and October 15 had satisfactory stands of grass, but no legumes the year after seeding. November 1 and November 15 were too late for seeding this mixture, and the seed was largely wasted. In the spring the best stands were obtained from March 1 and March 15 seedings. April 1 and April 15 were unsatisfactory because weeds choked out the desirable species.

Grazing Small Grains.—A grazing experiment involving the 4 small grains—oats, barley, wheat, and rye—was initiated in the fall of 1942. Each grain was represented by two varieties—an upright type and a decumbent type. These grains were grazed with sheep. A measure was obtained of the dry forage removed, as well as the effects of such grazing on yield of grain, plant height, tillering, and date of maturity. Preliminary results indicate that date of seeding is a very important consideration if small grains are to be grazed before harvesting for grain. If fall grazing is desired, seeding should be made well in advance of the dates usually recommended for grain. Seedings made the first week in September permitted grazing in early November, whereas mid-October seed-

Fig. 3—Effects of grazing wheat: Ungrazed on left; grazed on right.

Fig. 4—Fulcaster No. 612 wheat—no nitrogen applied.

ings did not permit grazing until early March. Rye furnished the largest amount of pasturage, barley and wheat furnished the next largest, and oats the smallest. Grazing was harmful to grain yields in all cases. The greatest reduction was in the rye and the smallest in the wheat. Varieties with upright habits of growth furnished more pasturage than the decumbent types and also suffered greater reductions in grain yields. Grazing also reduced plant height and amount of tillering (Fig. 3), and postponed ripening an average of 10 days. When given free choice in pasturing, the sheep preferred oats to all the other small grains. This experiment is being continued to provide further information on these points.

Nitrogen from Different Sources.—The synthetic-nitro-

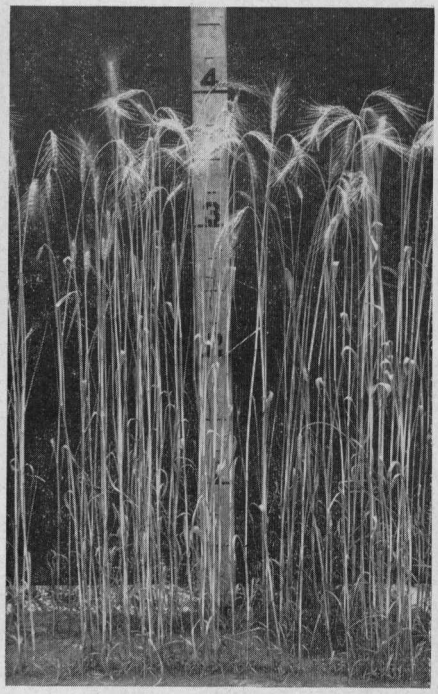


Fig. 5—Fulcaster No. 612 wheat top-dressed with ammonium nitrate at the rate of 16 pounds of nitrogen per acre.

were applied to wheat as a top-dressing in the early spring of 1944. These products were used at the rates of 16 and 32 pounds of nitrogen per acre. With the exception of the liquid ammonia which was applied with the Tennessee Liquid Fertilizer Distributor, these nitrogen carriers were broadcast by hand in solid form. The response of wheat to nitrogen fertilization is illustrated by figures 4, 5, and 6. All the nitrogen carriers used were about equally effective in increasing yields of wheat. It is recommended, however, that the acidity of the ammonium acid sulfate be neutralized with limestone before being applied,

gen capacity of our country has been greatly increased as a result of wartime need for munitions. The excess of nitrogen carriers not used in munitions and of those manufactured as by-products by ordnance plants or war industry are becoming available to agriculture. Experiments were conducted during the past two years to determine the value of several of these nitrogen carriers for crop fertilization. Ammonium nitrate and liquid ammonia were applied to wheat before planting and as a top-dressing in the fall of 1943. In another experiment, nitrate of soda, ammonium nitrate, ordnance nitrate, and ammonium acid sulfate

Fig. 6—Fulcaster No. 612 wheat top-dressed with ammonium nitrate at the rate of 32 pounds of nitrogen per acre.

since it was found to increase the soil acidity rapidly.

Liquid ammonia was also applied to corn in comparison with ammonium nitrate in both solid and liquid forms. Applications were made at the rate of 20 pounds of nitrogen per acre before corn planting and also as side-dressings. All forms of nitrogen, applied broadcast and as side-dressings, were put down in the soil to approximately 3 inches. Yield differences due to the various nitrogen carriers or methods of application were small and insignificant.

Preliminary data on both wheat and corn, therefore, indicate that nitrogen, pound for pound, in the various forms used in these experiments was of similar value in increasing crop yields.

CROP IMPROVEMENT

N. I. Hancock

COTTON

The season of 1944 was a normal one for comparison of cotton varieties at Jackson; but at Knoxville, as a result of abnormally dry conditions, the late, vigorous varieties became the leaders. Owing to war conditions, the test at Tiptonville was abandoned.

It was shown in the Annual Report for 1943 that no one variety excels in all the lint characters; and this holds true for 1944, as shown in table 6.

Table 6—*Rank of the first four varieties in yield of lint cotton, and in length, strength and fineness of fibers.*

KNOXVILLE		JACKSON	
Yield of Lint Cotton			
	Pounds per acre		Pounds per acre
Coker 100-Wilt, Strain 4	649	Deltapine 14	592
Deltapine 14	644	Stoneville 2C	588
Maretts White Gold, Strain 3	635	Coker 100-Wilt, Strain 8	536
Stoneville 2B	601	Stoneville 2B	521
Length of Fibers			
	32nds inch		32nds inch
Stoneville 2C	36	Stoneville 2C	35
Stoneville 2B	35	Stoneville 2B	34
Deltapine 14	34	Deltapine 14	34
Coker 100-Wilt, Strain 4	34	Coker 100-Wilt, Strain 4	33
Strength of Fibers			
	Lbs./mg.		Lbs./mg.
Washington 969	7.62	Washington 969	7.11
Bobshaw 1-948	7.53	Bobshaw 1-948	6.85
Washington 3070	7.35	Washington 3070	6.77
Stoneville 2B	6.95	Stoneville 2B	6.75
Fineness of Fibers			
	$Cm.^2/mg.$		$Cm.^2/mg.$
Stoneville 2C	3.03	Stoneville 2C	2.81
Stoneville 2B	3.02	Stoneville 2B	2.81
Coker 100-Wilt, Strain 8	2.97	Coker 100-Wilt, Strain 8	2.80
Washington 3070	2.93	Washington 3070	2.74

Stoneville 2C, a new strain of Stoneville, has lint 1/16 inch longer than that of Stoneville 2B, and has very nearly the yielding capacity of 2B. Coker 100-Wilt, Strain 4, continues to be the leading strain of the Coker 100 cottons. Delfos 9169, a new strain of Delfos, led the new-strains test and appears to be promising for Tennessee conditions. It has as large a boll as any of the Stoneville strains.

Empire, a selection of Stoneville made in Georgia, is earlier than Stoneville 2B or Deltapine 14, but is 1/16 inch shorter and does not yield as well. It has a large boll and a large seed, and lint turnout of around 36.5 percent.

Where cotton followed sericea there was considerable difference in defoliation between the potash and no-potash plots. Likewise there was a difference in yield, but no appreciable difference in lint characters, as shown in table 7.

Table 7—*Fiber characters of cotton grown on soil after sericea with and without potash treatments, at Jackson Station.*

Years in sericea	No potash			50 pounds potash		
	Length	Strength	Fineness	Length	Strength	Fineness
14	1.06	6.90	2.96	1.07	7.20	2.92
12	1.11	6.95	3.01	1.08	6.74	3.09
10	1.08	6.96	3.08	1.08	6.87	2.85

Where cyanamid was used as a defoliant, there was no difference in lint characters between the treated and untreated bolls, either upper or lower; but the upper bolls had finer and weaker lint than the lower bolls (see table 8).

Table 8—*Fiber characters of cotton defoliated with cyanamid, at two dates, upper and lower bolls.*

Position of bolls	No treatment			Treated with cyanamid		
	September 8					
	Length	Strength	Fineness	Length	Strength	Fineness
Upper	1.10	6.65	3.11	1.07	6.73	[1]
Lower	1.10	6.75	2.65	1.12	6.68	2.95
	September 20					
Upper	1.11	6.80	3.05	1.10	6.60	3.70
Lower	1.14	6.46	2.90	1.11	7.11	2.70

OATS

The winter of 1943-44 was not a severe one. The semi-winter varieties, such as Fulgrain, Lee, and Stanton, came through with normal stands. Their average yields for the three Stations at Knoxville, Columbia, and Jackson are given in table 9. It is seen that the three Tennessee winter-hardy varieties had superior yields even though the freezing out of stands did not enter as a factor.

Securing stiffness of straw, or ability of the variety to stand up for combining, continues to be the main problem in the breeding of oats. A number of Bond X 090 and Victoria X 090 strains give

Table 9—*Yields per acre of the winter-hardy varieties of Tennessee oats as compared with some semi-winter-hardy varieties,* 1934-44.

Variety	Columbia	Jackson	Knoxville
	Bushels	Bushels	Bushels
Tennex	69.4	95.1	80.0
Fulwin	67.2	91.1	78.9
Forkedeer	66.9	102.8	79.0
Lee	58.7	88.3	77.4
Fulgrain	54.3	93.4	79.1
Stanton	49.3	96.2	75.6

promise of retaining the yield and winter-hardiness of Fulwin and Forkedeer, while less likely to lodge. It will be recalled that the 090 Fulghum selection was most winter-hardy of all the Tennessee strains. But it did not yield as well as Forkedeer, Fulwin, and Tennex, and therefore was not released. The selection 090 has a dwarfy type of plant growth, and its characters apparently have blended well with Bond and Victoria, two very vigorous spring-type oats.

BARLEY

The smooth-awn barley Jackson No. 1 continues to lead all other varieties in the tests at the three stations. It will be recalled that Jackson No. 1 is a sister selection to Jackson, which was first released. Both varieties came from the cross of Tennessee No. 52, rough-awned, X Lion, a black smooth-awn barley from Russia. Jackson No. 1 has the stooling and plant-growth habits of No. 52, but has larger heads and grains and matures about one week later. It stands up better than No. 52 and probably will supplant this variety in Tennessee. With the object of developing stiff-strawed varieties that stand up for the combine, crosses have been made of the smooth-awn barleys with Polders and Wong; also crosses of the smooth-awn with the hooded barleys No. 6 and Missouri Beardless.

From these crosses, promising early smooth-awn strains have come. These early strains of barley will mature with crimson clover. Of the Missouri Beardless crosses, 977-8-1, 977-10, and 982-2-1 appear to be good yielders.

The seed dealers continue to bring in barleys from the West and Northwest for fall seeding in Tennessee. One such variety, called Colsess, was a typical spring type and was frozen out completely when the temperature went down to 20° F. Most of these western and northwestern barleys are of the spring type and should not be seeded in Tennessee.

CORN BREEDING

Frederick D. Richey

The corn-breeding program was continued in cooperation with the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture. The state-wide

drouth of 1944 interfered seriously with its progress. The production of single-cross seed stocks for the Tennessee white hybrids was cut severely just at a time when demand was increasing. Of 7 yield comparisons in different parts of the State, 4 were discarded entirely, the other 3 being harvested for such information as they might afford. The nursery was irrigated and reasonable quantities of hand-pollinated seed were obtained for continuing the program.

An encouraging result was the performance of 4 new experimental Tennessee yellow hybrids. These had the highest average yields among the 18 entries that were included in all 3 of the yield comparisons harvested. This was particularly significant as the new hybrids are closely related. On the other hand, it is of course possible that they will be less desirable in a more normal and favorable season. Seed stocks will be multiplied in 1945, however, looking toward small-scale production in 1946 if continued performance warrants it.

GRASS BREEDING

J. K. Underwood

Bluegrass.—Crosses of several isolates were made in 1941, looking to a study of the progeny for a possible increased number of variations in aggressiveness, coarseness, color, height, and seed production. Nothing outstanding resulted from the first generation. In 1943, a second generation (selfed) was produced from carefully selected plants. Variations were still marked within the lines.

First-generation crosses between Texas bluegrass and Kentucky bluegrass were set out for observation in the fall of 1943. A cross of the same grasses was obtained from the Missouri Experiment Station and set out in the spring of 1944. These crosses were made in an endeavor to find a vigorous and aggressive bluegrass that will withstand the drouths and heat of summer to the extent of furnishing an enhanced amount of grazing during July, August, and September. It is doubtful if the desired result will be attained, since the two species have the same characteristics of dormancy during protracted heat and drouth. There is this difference, however, that Texas bluegrass has more heat resistance than Kentucky.

Smooth Brome.—Breeding continues with a view to the isolation of lines adapted to our conditions. All but 6 lines have been eliminated. The 6 vary from the strictly bunch type to the aggressive sod formers, and from early- to late-flowering. These lines have not yet become stabilized.

Meadow Fescue.—This grass perhaps has a greater future in Tennessee than any other. Selections from an old field strain called "Kentucky 31" were made in 1941, and breeding material was established which shows better adaptability than the Kentucky 31.

Ryegrass.—Multiplication of the annual strain 8-10 for experimental purposes continues. The perennial strains 9-38 and 9-56 also are being multiplied for experimental purposes.

Orchard Grass.—Out of 22 lines isolated for their possibilities, only 3 have been selected as showing appreciable superiority in the nursery. Two of these are early and the other is late.

Timothy.—Of all the lines that have been isolated and of all the strains tried from out of the State, only one has the longevity desired. This is Timothy F. C. 12368, a U.S.D.A. late strain. Others will be tested in the nursery and on the Cumberland Plateau. Breeding continues with lines originating from escaped plants and old fields.

Rescue Grass.—Multiplication and testing of strain 4-40 continue. During severe winters the grass has shown a lack of hardiness in the upper East Tennessee area. In Mississippi and Florida, reports are favorable. Its reseeding qualities and its tendency toward the perennial habit are more pronounced in the states south of Tennessee. This grass in alfalfa provides a promising mixture.

Tall Oat and Harding Grass.—Breeding by selection in selfed lines continues with both species. Other grasses are of so much greater immediate promise that work on these two is being continued only to the extent of preserving what has been done. A strain of tall oatgrass having drouth resistance has been isolated. The nonshattering characteristic is still to be stabilized.

Yields of various grasses under trial at the West Tennessee Station, Jackson, are given in table 10.

Table 10—*Grass yields per acre at Jackson Station*,[1] 1944.

Variety	Date cut	Green weight	Dry weight	Stand
	1944	Tons	Tons	Percent
Harding grass	May 25	6.90	1.64	75
Tall oatgrass	May 19	3.45	1.12	50
Orchard grass	.....	.....	.....	....
Giant meadow fescue	May 25	7.20	2.34	....
Field brome	May 25	14.25	3.21	....
Smooth brome	May 25	2.25	.54	50
Rescue grass	May 8	10.12	3.54	....

[1]The area seeded to these plots was in barley last year. The land was plowed on June 25, 1943, and the plots were limed and prepared on August 24. All the grasses were seeded August 25, with the exception of orchard grass, which was not seeded till September 23. This grass failed to make sufficient growth for hay in 1944, though it did make a good stand.

EROSION CONTROL IN THE PRODUCTION OF TRUCK CROPS

N. D. Peacock, K. B. Sanders, and A. L. Kennedy

The effectiveness of (1) rotation of crops, (2) strip cropping, and (3) rough contour tillage versus level culture, in controlling erosion on truck-cropped land, is being studied at the Knoxville Station. Work began in the fall of 1937, with six 1/20-acre plots on Wolftever silt loam soil of 10-percent slope.

As shown in table 11, during the 5 years 1938-1942, plot 6 was kept in continuous cultivation; plots 4 and 5 were rotated, being alternately in sod and in cultivation; and plots 1, 2, and 3 were strip-

Table 11—*Cropping plan used in study of erosion losses,* 1938-1944.

Plot No.	1938, 1939	1940, 1941, 1942	1943, 1944
1	Six 20-ft. strips. Alternate cultivated and sod strips. Lower strip in cultivation.	Six 20-ft. strips. Alternate cultivated and sod strips. Lower strip in sod.	Sweet corn-rye sod mixture on all plots.
2	Four 30-ft. strips. Alternate cultivated and sod strips. Lower strip in cultivation.	Four 30-ft. strips. Alternate cultivated and sod strips. Lower strip in sod.	
3	Two 60-ft. strips. Alternate cultivated and sod strips. Lower strip in cultivation.	Two 60-ft. strips. Alternate cultivated and sod strips. Lower strip in sod.	
4	Sod	Cultivation	
5	Cultivation	Sod	
6	Cultivation	Cultivation	

cropped with alternate sod and cultivated strips, and, in addition, the strips were rotated. Spring and fall crops of Irish potatoes were grown on the cultivated areas during the 5 years 1938-42. All plots were cropped alike during 1943-44.

Rotation with the land alternately in sod and in cultivation caused reduction of soil losses to approximately one-half those from the continuous-cultivation plot during the 5-year period 1938-42. This effect was attributed jointly to (1) the soil-holding ability of the sod and (2) the residual effect of turning the sod. Soil loss was reduced to a negligible quantity during the first year after the sod was turned; to about one-fourth that from the continuous-cultivation plot during the second year; and to about one-half that from the continuous-cultivation plot during the third year. This remarkable residual effect of turning a sod and the fact that it persists over a period of 3 years on the Wolftever silt loam soil, have been verified during a subsequent 3-year period in which erosion losses from different plots were measured. Water losses also were decidedly reduced by the practice of rotation.

Strip cropping, together with rotation of the strips during this same 5-year period, caused a reduction of soil losses to somewhat less than one-fourth those from the continuous-cultivation plot, and to somewhat less than one-half those from the rotated plots. Water losses also were reduced by strip cropping.

The information obtained regarding the effect of strip width on erosion losses is inconclusive. The total length of slope of the experimental area was only 120 feet, and strips of 20-, 30-, and 60-foot widths were compared. For a continuation of this study it would be desirable to have a longer slope which would permit the use of wider strips and possibly a larger number of strips. It would be desirable also to have a large enough experimental area to permit adequate duplication of plots.

No reliable information has been obtained regarding comparative erosion losses with the lower strip in cultivation and with the lower strip in sod. The limited number of plots made it impossible

to have both conditions in the same year; and the variability of rainfall from year to year, especially as regards intensity, made it impossible to compare erosion losses in a year when the lower strip was in cultivation with those in a different year when the lower strip was in sod.

Rough contour tillage, in comparison with flat cultivation during fallow periods, was effective in reducing erosion losses until the ridges broke through, and thereafter was ineffective.

Examination of the erosion-loss data from the continuous-cultivation plot by months, for the 5-year period 1938-42, revealed the existence of erosion-free and erosion-hazard periods with the Wolftever silt loam soil at Knoxville. The 5-month period September to January, inclusive, was almost erosion-free. The 7-month period February to August, inclusive, was an erosion-hazard period. Severe erosion occurred during every month of this 7-month period, in one or more of the 5 years. These observations at Knoxville may possibly apply to a considerable area of the surrounding East Tennessee Valley, but not to other major areas of Tennessee which have widely different rainfall characteristics.

A relatively few heavy and intense rains caused the bulk of the erosion losses.

Correlation of rainfall intensity with erosion losses from the continuous-cultivation plot revealed the fact that with Wolftever silt loam soil there is a rough correlation between the annual soil losses and the annual quantity of rainfall of 2 inches per hour or greater intensity.

No correlation between crop yields and erosion losses has been noted. However, a fairly good correlation between sweet corn yields and surface-soil depth was obtained in 1943. In addition, sweet corn yield from the continuous-cultivation plot was decidedly lower than the yields from 4 of the 5 other plots.

STATE SOIL SURVEY

W. O. Whittle

During the year 1944, eight experienced soil surveyors were engaged in making a survey of the soils in the State. This is the smallest number regularly employed for some years. Eleven men who previously gave full time to the survey are now in war service, and two or three others resigned to take up work directly related to the war effort.

The survey of 324,208 acres was completed during the year, bringing the total to 6,756,665 acres. In the completed areas are 20 counties, parts of 2 counties, and 4 special areas. Field work continues in 4 counties, in 2 of which it is nearing completion.

Considerable time has been spent in writing reports of finished surveys; but on account of the heavy demand for printing incident to the war, no new reports have been made ready for distribution. In order that these surveys may be quickly available, the completed field sheets of each county are colored by hand and copies are placed in the offices of the county agent, the Tennessee Valley Authority, and the Agricultural Experiment Station.

We continue the acquisition of samples of the principal soils found in each county. These are analyzed for lime, phosphate, potash, and organic matter, and are preserved for observation and study.

To save the time of the field men in making acreage estimates, and the subsequent expense entailed in the use of the planimeter at Washington, we have undertaken the calculation of acres in the various soil types. This has been completed for 4 counties. The method used is known as the weight method. Each soil-type area on the map is cut out, the pieces are sorted into envelopes, and, by the use of accurate balances, the total weight of paper is found. The number of acres represented by each gram of paper is calculated, and the conversion into acres becomes a simple process. A table showing the exact acreage in any planimetric sheet eliminates consideration of shrinkage of the field sheets. Having secured for this purpose copies of field sheets that were all run at the same time and out of the same roll of paper, we have practically eliminated variation in weight. This method has proved more accurate than the use of the planimeter or grid and effects a great saving in time and expense.

The soil survey is being made with the assistance and cooperation of the Tennessee Valley Authority, at Knoxville; and the Bureau of Plant Industry, Soils, and Agricultural Engineering, Washington, D. C.

PHYSICAL PROPERTIES OF COTTON FIBER

K. L. Hertel

FIBER RESEARCH LABORATORY

The fiber research laboratory not only engages in research initiated by its staff, but serves other workers by making its fiber-testing facilities available to them. The testing service is supported by fees collected from those using the service. The number of fiber-property determinations has increased by 21 percent—from 23,529 in 1943 to 28,426 in 1944. Fewer samples were submitted this year, however, and by fewer firms than in 1943. The average number of determinations per sample has increased.

FIBER PROPERTIES

Fineness.—The arealometer is the instrument developed in this laboratory for measuring the specific surface of fibrous materials by means of air permeability. Since it was evolved in an effort to measure cotton-fiber fineness, its results have been compared with the results obtained from microscopic sections of cotton. These comparisons have been repeated on several samples after the lapse of some years. There were greater variations than expected, especially in the microscopic measurements. In the search for the cause of the variations, it was decided to test additional cottons covering a wide range of fineness but each being as homogeneous as practicable. Sixteen cottons[1] were obtained in addition to the cottons, rayon, nylon, and wools previously tested.

In the course of the development of the arealometer, several questions arose that seemed worthy of further investigation. The agreement between the microscopic and arealometer results was not as good as the reproducibility of the arealometer results indicated—the results for rayon were not in agreement with those for cotton; and density measurement, with the arealometer, varied from cotton to cotton, although giving the approximate values for other fibers.

There have been several bits of evidence that cast doubt on the accuracy of the microscopic results. Sectioning methods were studied and the best technic adopted. All known precautions for obtaining a representative sample were taken. Yet the microscopic and arealometer results disagreed. The results for rayon had been shown to disagree with those for cotton. A repetition and extension of these experiments showed that not only rayon measurements but also nylon and wool measurements disagreed with cotton measurements and yet agreed with each other. The disagreement could be explained on the hypothesis that some fine fibers were removed from cotton samples during the final preparation for microscopic sectioning. Samples of two cottons then were prepared for the arealometer in exactly the same way as for the microscope. The arealometer showed both to be coarser, in support of the hypothesis. This method did not eliminate the bias, but was an attempt to produce the same bias for the arealometer as for the microscope. It is unfortunate that the fibers must be paralleled before sectioning, for this operation apparently removes the finer, more tangled fibers.

The arealometer can be used to obtain values for the density of fibrous materials. Such values indicate that there is some tendency in cotton for the more mature, or plumper, fibers to have the greater apparent density. Plumpness is construed to be the ratio of the area of cross section to the area of a circle having an equivalent perimeter. The correlation between microscopic values of plumpness and arealometer values of density is improved materially when the values of plumpness are corrected for the removal of fine fibers.

[1]The Division of Cotton and Other Fiber Crops and Diseases, U. S. D. A., submitted samples of self-line cottons.

This is independent evidence that some bias is introduced in the preparation of samples for microscopic sectioning. It should be noted that the relation between the apparent density and the plumpness may be due to an actual difference in density, or possibly to the difference in fiber shapes.

It would be desirable to prepare microscopic sections without bias. With the best technic now known it seems doubtful if microscopic sections of cotton fibers can be produced free of bias.

Fabrics.—The School of Home Economics has been investigating trends in gingham fabrics purchased on the open market. Students have separated the fabrics into yarns, and these, in turn, into fibers. Over 1000 length, strength, and fineness determinations have been made on the fibers by this laboratory.

Milkweed Floss.—Milkweed floss has been used as a substitute for kapok during the war emergency. Various properties of the floss have been explored by the technics developed for testing textile fibers.

Fibrograph Using Colored Fibers.—A range of samples was prepared by having various colors dyed onto the fibers in various amounts. The apparent reduction in length seemed to depend more on the color than on the amount of the color.

AGRICULTURAL ENGINEERING

M. A. Sharp

IRRIGATION

Cooperative irrigation studies with farmers, started in 1942 by A. L. Kennedy, were continued during 1944. With the portable equipment and technics used, considerable work of reconnaissance type was done. Several different crops were irrigated and results checked. Studies were carried out on the transplanting of tobacco and other plants. The effects of irrigation on soil compactness and temperature were noted, and more than 100 soil-moisture determinations were made. Considerable study was given to the irrigation needs in Tennessee and to the design of equipment and adaptation of technics to meet these needs.

TRANSPLANTING TOBACCO AND OTHER CROPS

In the course of cooperative work with 13 farmers in setting tobacco plants, findings were made which, together with information secured in previous years, are considered conclusive.

1. Getting a stand of tobacco is a big problem and a time-consuming job. A fairly sure way to get the plants to live is to pour a pint or more of water on each plant in a hole. This washes and puddles soil around the roots. The objection to this procedure, of course, is the tremendous amount of labor entailed.

2. Soil puddling should take place at the roots. Covering the roots with a loose, unwetted soil and then having the surface beaten down by a hard rain is not effective.

3. Another factor of equal importance in saving the plant, its leaves, and vitality is shielding from the intense heat of the sun. Irrigation is beneficial in this respect, since a wet soil is much cooler for the plant than a dry soil. During the heat of the day, irrigated soil at the surface will be from 20 to 50 degrees cooler in the sun than unirrigated dry soil. The lower temperature lasts two or three days, or as long as the surface remains wet or moist. Typical data secured on temperatures are given in table 12. On June 13, at the Tobacco Experiment Station, Greeneville, tobacco land was harrowed in the morning; at noon, part of it was irrigated and part left unirrigated; the setting of plants was started at 2 o'clock; and temperature readings were taken at 2 and at 4:30.

Table 12—*Temperatures of air and soil surrounding transplanted tobacco plants, June 13.*

Time	Plot	Temperature in sun at and near the surface of the soil					Weather conditions
		1 inch above	On surface	1/8 inch below	1 inch below	3 inches below	
		°F.	°F.	°F.	°F.	°F.	Clear
2:00 p.m.	Irrigated	96	96	96	90	90	90° F.
	Unirrigated	114	134	127	118	96	Slight breeze
							Partly cloudy
4:30 p.m.	Irrigated	86	90	88	88	88	86° F.
	Unirrigated	94	103	106	104	100	Slight breeze

The results of a follow-up study on plants indicate that the temperature for the first few days after setting is the main factor responsible for the marked difference, frequently noticed, in the growth of adjacent plants set at different times. For one patch, a delay of only one day in irrigating and cooling the soil after setting tobacco plants resulted in the loss of 10 percent of the plants and the stunting of the remainder. This one day, May 29, that cooked the unirrigated plants was an average clear day. The maximum temperatures on the soil surface in the sun were 120° for the dry area and 95° for the irrigated area. Two months later these stunted plants were only one-third as large (by weight) as those irrigated immediately after setting. For this study, all the plants were select; they were set and their roots watered with a mechanical setter during the same period of time.

RESPONSE OF CROPS TO IRRIGATION

On 6 farms, in different parts of East Tennessee, 2 or more applications of water for tobacco, during the latter part of the season, resulted in doubled yield on 3 farms and slightly decreased yield on one, while no check was made at the others. On 2 farms the irrigation was given credit for making the total yield 2500 pounds per acre or more. The quality was above average. The slightly decreased yield on one farm resulted from early maturing of plants after 2 applications and the omission of later applications that were needed. A re-check on this tobacco after marketing showed that the quality was better and the income more for the irrigated. Figure 7 shows the amount of growth of tobacco resulting from 1 inch of water.

For alfalfa the response to water applied after the month of May was quick and very good in all tests. This was further evidence in support of the conclusion that the irrigation of this crop would be profitable even in normal seasons. Figure 8 shows the response of alfalfa to water applied by "wild" flooding on a Hagerstown soil near Murfreesboro.

For tests made in 7 fields of corn, irrigation more than doubled the yield in 3. In 2 cases plenty in rain fell the next day, which nullified the effects of irrigation.

Wt. 365 grams, about 3/4 lb. Wt. 960 grams, about 2 lbs.

Fig. 7—An application of 1½ inches of water July 7 made the difference in these tobacco plants.

The response of Korean lespedeza to irrigation on 2 fields, one in McMinn County and the other on the Station's vegetable plots in Jefferson County, was very interesting. In McMinn County on a Fullerton type soil, one application of 3 inches of water on July 29, 2 weeks before the severe drouth was broken, increased the

Fig. 8—Flood irrigation of alfalfa, with unwatered strips, on a Hagerstown soil near Murfreesboro.

Equally good results were obtained during the more normal year of 1943.

yield of hay about 1 ton per acre. The yield data secured showed 217 pounds of air-dry hay per acre for the unirrigated area and 2,157 pounds per acre for the watered area.

Lespedeza on a 30-foot strip of land bordering the Station's irrigated vegetable plots received several small applications of water throughout the dry summer. The yield of hay for this area was 2,950 pounds per acre, while that of the unirrigated area farther down the slope was 473 pounds.

Several gardens and truck areas were given one or more applications. In most cases sweet corn, cantaloup, squash, okra, cabbage, Irish potatoes, and some other vegetables gave good returns for the emergency type of irrigation used. Delayed watering of beans on 2 farms failed to increase the yield. Two applications on Irish potatoes on one farm early in the season with later-needed water left off resulted in bigger vines and a large number of very small potatoes, but no increase in yield.

SUMMARY OF SOIL-MOISTURE STUDIES

The field capacity of most East Tennessee soils, as found about one day after a soaking rain, is approximately 24 percent, ranging from 18 percent for the lowest tested to 30 percent for the highest on the common types of soil. During the hot summer weather this 24-percent moisture content for the top 6 inches will be lowered to from 10 to 13 percent in from 7 to 10 days after a rain. Subsequently the moisture content is lowered at a much slower rate, and the soil and crop become larger factors in the reduction.

Soil moisture is lost from the top 6 inches of soil much faster than it can be replenished from lower depths. Occasionally, tests reveal that the surface soil may be near the wilting point while the second foot will have nearly all the moisture it can hold.

FARM MACHINERY AND EQUIPMENT

H. A. Arnold

SEED SCARIFIERS

Results with different types of seed scarifiers, and the construction details of an improved disk type, have been written up for early publication in bulletin form. Some unique features of the new disk scarifier (Fig. 9) are (1) its ability to hull practically all the seed and effectively scarify them in one run through the machine, and (2) the visible effects it produces on the ends of the seed that indicate the amount of scarifying action or the adjustment of the machine.

A pneumatic elevator-cleaner developed for castor-bean shellers was adapted for use with a disk scarifier (Fig. 10). Satisfactory results were reported by agricultural extension agencies using this machine in field trials.

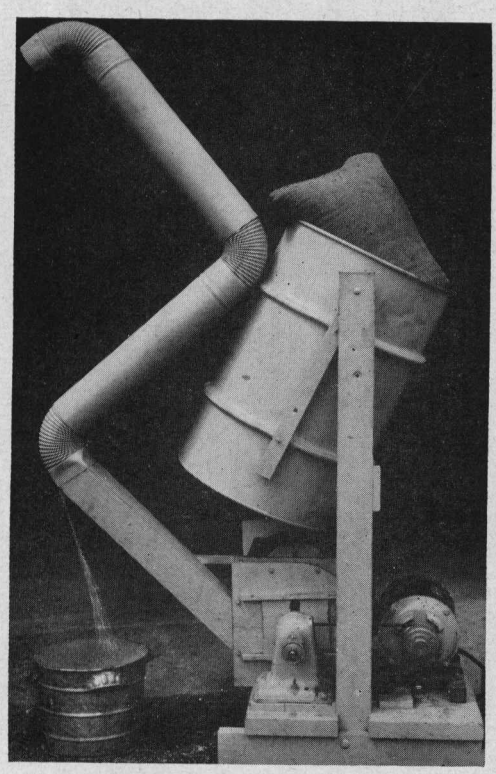


Fig. 9—The disk scarifier with pneumatic zigzag cleaner.

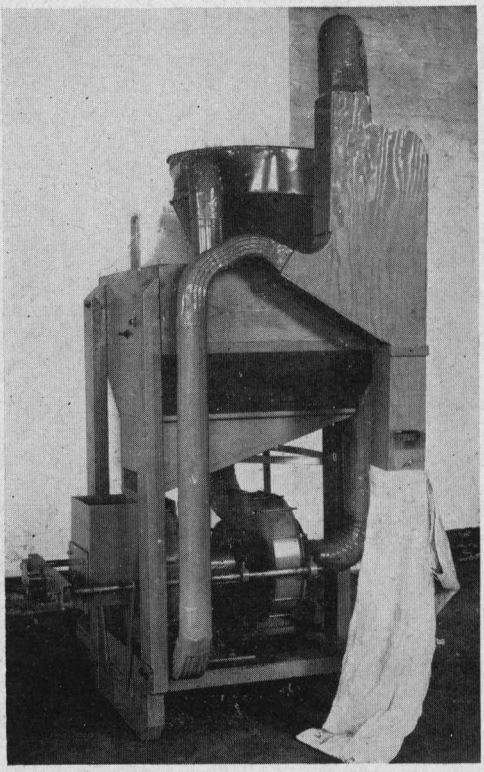


Fig. 10—The disk scarifier with pneumatic elevator cleaner.

HOSE PUMP

A unique application of the hose pump is described in Station Circular 87, "The Tennessee Liquid Fertilizer Distributor," by M. A. Sharp, February 1944; and in an article entitled "A New Liquid Fertilizer Distributor," by the same author, published in *Agricultural Engineering*, page 58, February 1944. Patent rights, as revised, were assigned to the University of Tennessee Research Corporation.

FORAGE PROCESSOR

Development of forage-processing equipment for labor saving in the harvesting and storing of hay is a project cooperative with the Tennessee Valley Authority. The production, in 1939, of 2,200,000 tons, valued at $30,000,000, ranks hay among the three major agricultural crops of the State. The 50-percent increase in hay tonnage within a decade, plus the more recent acute labor and milk shortage, increased the demand for quality hay, as well as for labor-saving facilities for harvesting and storage. Rainy weather accounts for considerable loss in such early hay crops as alfalfa when they must be cured completely in the field. Farmers who have adopted the forced-air system for curing hay in the barn, as developed at this Station some years ago, reported appreciable savings. For uniform and complete curing with this system, the partially cured hay from the field must be distributed evenly over ducts on the mow floor.

To eliminate the labor and difficulty of distributing hay evenly by hand, a rotary-type gravity-powered distributor was constructed for use in a round bin and tested with chopped hay. Bin capacities, as related to height or hay densities, were determined by laboratory methods. Air velocities through compressed hay were approximated in preliminary tests. Various types of chain attachments were checked for the possibility of removing or pulling cut

hay from the bottom of a compressed stack. These preliminary studies preceded the designing of a 45-ton-capacity mechanized hay bin, or "forage processor," for construction in 1945. Its efficiency in saving labor, in producing quality hay, as a hay-storage unit, and as a centralized hay-curing system for use with existing storage space; and its adaptation for use with artificial heat or for curing uncut hay, are to be determined by field trials and tests.

The bin as designed is an inexpensive round, weatherproof structure with a funnel-shaped concrete floor. A fan connected to the bottom of a vertical air duct, with adjustable air outlets extending up the center of the bin, provides for the forcing of air radially outward through the hay. The rotary distributor at the top of the bin provides for even distribution of the hay around the duct as the bin is filled. The mechanical removal of the hay from the bottom of the bin is contingent upon further development.

HOT-WATER SEED TREATMENT

Internal smut (*Ustilago nuda*), a fungus common to barley and wheat, is effectively controlled only by the modified hot-water seed treatment, according to agronomists. A critical temperature range of 126-129° F. and the excessive time and labor required for bulk treatment and drying of the grain, preclude its general use by hand methods.

Thermostatically controlled heating elements and forced air to insure effective treatment and quick drying of the grain are being investigated. Barley, after 6 hours' soaking at room temperature, as required by this treatment, increased in moisture content from 13 to 41 percent. Infrared lamps used as a heat source, although effective in drying grain in 13 minutes, involved problems of even-temperature distribution and evaporating efficiencies. Drying of grain in a partial vacuum was more successful. This project is continued cooperatively with the Tennessee Valley Authority.

CASTOR-BEAN SHELLER

A revised experimental-model castor-bean sheller was forwarded to a manufacturer as a sample. Assistance was rendered in the construction and testing of the first machine fabricated by that concern. Demand for this sheller continues, according to inquiries from South and Central American countries. Manufacturers, however, report difficulties in supplying the machines, due to labor and material shortage. Patent rights of the castor-bean sheller with the pneumatic elevator-cleaner were assigned to the University of Tennessee Research Corporation, and assistance was rendered in the execution of the application.

PLYWOOD SILOS

Because of drouth or shortage of forage, the plywood silos constructed in 1942 were not refilled last year. Articles by M. A. Sharp on "Plywood Silos" and "Tests of Plywood Panels" were published in

Agricultural Engineering, page 58, February 1944, and page 350, September 1944.

INTER-AMERICAN COOPERATION

Cooperative efforts to promote inter-American relations were made at the instance of the Coordinator of Inter-American Affairs, Institute of Inter-American Affairs, Washington, D. C., including both the Food Supply and Educational Training Divisions.

At the request of W. C. Brister, Director of the Food Supply Division, detailed plans of the castor-bean sheller were forwarded for translation and distribution in other American republics. Other illustrations, with descriptions in Spanish, were published in an article entitled "Nueva descortezadora de semillas de recino," in *La Hacienda,* page 192, April 1944, a publication with a South American circulation. A similar article in Portuguese, "Descascadora de Mamona," by Julio Nacimento, appeared in a Brazilian Government publication, *Boletim Agricola,* page 39, April-September 1944.

At the request of Director M. L. Wilson, and through arrangements by the Tennessee Agricultural Extension Service, two Brazilian representatives, Julio Nacimento, and Cincinnatus Mascarenhas, were given assistance for about three months in the experimental development of farm machinery adapted to conditions in Brazil. Simple, inexpensive equipment was developed, including a flax deseeder for threshing fiber flax and a pneumatic seed separator and cleaner. Tests were made with lime spreaders, in a study of factors affecting uniformity and rate of distribution.

ANIMAL HUSBANDRY

H. R. Duncan

EXPERIMENTS AT KNOXVILLE STATION

CORN SILAGE COMPARED WITH SORGHUM SILAGE ON AN ACRE BASIS FOR FATTENING TWO-YEAR-OLD CATTLE

The third trial in the experiment with corn and sorghum silages was finished in March 1944. An average of the 3 trials is presented in table 13.

The corn and sorghum used for silage were grown on alternate strips in the field to provide as uniform a test as possible of the relative productivity of the land for the two crops. During the 3 years, favorable and unfavorable conditions for seeding, drouth and excellent growing conditions, and storms just before harvest, were experienced. All of these conditions had their influence, but the results were representative of what farmers may expect. Yields by years for the two silages as weighed out of the silo are shown in table 14.

Table 13—*Three years' comparison of corn silage with sorghum silage on an acre basis for fattening two-year-old steers,* 1942-44.

Item	Lot 1 Corn silage, full feed, plus 5.5 lbs. cottonseed meal daily	Lot 2 Corn silage, full feed, plus 2.0 lbs. cottonseed meal daily	Lot 3 Sorghum silage, full feed, plus 5.5 lbs. cottonseed meal daily	Lot 4 Sorghum silage, full feed, plus 2.0 lbs. cottonseed meal daily
Number of steers per lot	9.3	9.0	9.3	9.3
Number of days fed	120	120	120	120
Average daily ration (lbs.):				
Corn silage (ad libitum)	45.3	49.6	.....	.....
Sorghum silage	.....	.....	53.7	57.2
Cottonseed meal (41%)	5.5	2.0	5.5	2.0
Salt	.040	.045	.061	.079
Average initial weight of steers (lbs.)	946.9	939.1	940.7	943.8
Average final weight of steers (lbs.)	1174.4	1121.4	1136.3	1088.6
Average gain per head, 120 days (lbs.)	227.5	182.3	195.6	144.8
Average daily gain (lbs.)	1.896	1.519	1.630	1.207
Feed for 100-lbs. gain (lbs.):				
Corn silage	2446	3301	.....	.....
Sorghum silage	.....	.....	3330	4796
Cottonseed meal	295.2	134.9	339.3	167.7
Salt	2.16	3.20	3.93	6.86
Average dressing percentage (final exp.-wt. and chilled-carcass-wt. basis)[1]	56.16	54.99	55.38	53.33
Initial cost of cattle per cwt.	$10.88	$10.88	$10.88	$10.88
Initial cost per head	$103.02	$102.17	$102.35	$102.69
Appraised value per cwt. of finished cattle	$14.05	$13.55	$13.48	$12.80
Actual margin	$3.17	$2.67	$2.60	$1.92
Value of finished cattle per head (3% off final exp.-wt. for selling wt.)	$160.05	$147.39	$148.58	$135.16
Gross returns per head	$57.03	$45.22	$46.23	$32.47
Value of feeds fed other than silage[2]	$15.34	$5.63	$15.37	$5.66
Cattle-returns from silage, per head	$41.69	$39.59	$30.86	$26.81
Tons of silage fed, per head	2.721	2.973	3.218	3.431
Acres of silage fed, per head[3]	.267	.292	.240	.256
Cattle returns per ton silage fed	$15.32	$13.32	$9.59	$7.81
Cattle returns per acre silage fed	$156.14	$135.58	$128.58	$104.72
Percentage acre returns, with lot 1 as 100 percent	100	86.8	82.3	67.7

[1]Based on first two years.
[2]With cottonseed meal at $46.33 per ton and salt at $20.00 per ton.
[3]Based on average yields of 10.19 tons for corn and 13.38 tons for sorghum.

In growing the crops and making the silage, more difficulties were experienced with sorghum than with corn. It was more difficult to secure a good stand of sorghum in dry weather. The crop grew off more slowly than corn, and was harder to cultivate while little. Under favorable soil and moisture conditions the sorghum grew much ranker than the corn, and hence was more likely to go down in a storm. On the more fertile areas, it grew so rank and heavy that it was difficult to harvest, even with a good heavy-duty, tractor-drawn corn harvester. This was the case for 2 years. The third year it was so badly tangled that most of it had to be cut by hand. Corn knives and mowing machines were used to harvest the crop, and a considerable part of it was wasted in the field. This

Table 14—*Yields of corn and sorghum silages by years.*

Year	Corn silage	Sorghum silage
	Tons	Tons
First	10.39	14.66
Second	8.18	13.63
Third	11.99	11.86

condition accounts for the reduced yields of sorghum silage the third year. The corn stood up fairly well and was harvested with a corn harvester without much difficulty. The cost of harvesting the sorghum this year was about three times that of the corn.

Each year the corn silage produced faster gains on the cattle than the sorghum silage. The 3-year average shows the gains of cattle on the sorghum silage to be, respectively, 93 and 80 percent as fast as those on the corn silage for the two levels of cottonseed-meal feeding used.

Although the sorghum yielded 31 percent more tons of silage per acre than the corn, the acre returns on the corn silage were $27.66 and $30.72 greater, respectively, for the two direct comparisons made.

In view of the additional expense and difficulties involved in growing sorghum, and the slower gains and lower returns on the cattle fed sorghum silage, it appears that corn as grown and fed in these trials at the Knoxville Station is superior.

EXPERIMENTS AT MIDDLE TENNESSEE STATION

Columbia

TENNESSEE-GROWN BARLEY VERSUS CORN FOR HOG FEEDING

The development of improved varieties of winter barley for Tennessee and the increased emphasis placed upon winter cover crops have brought about an increase in acreage of barley. The acreage jumped from 6000 in 1920 to 98,000 in 1944. At this time it appears that barley will become available in increasing quantities for livestock feeding in the State and offer a substitute for corn. Considerable experimental work in feeding barley to various classes of livestock has been done in this country, but it was with barley produced in other sections of the country where conditions probably are more favorable for the production of barley than in Tennessee.

The following setup was planned to compare Tennessee barley with corn, and a mixture of barley and wheat with corn, for hog feeding:

Lot 1—Shelled corn, protein supplement, and mineral mixture, self-fed on pasture.

Lot 2—Ground Tennessee barley, protein supplement, and mineral mixture, self-fed on bluegrass pasture.

Lot 3—Equal parts ground Tennessee barley and ground "government" wheat, protein supplement, and mineral mixture, self-fed on bluegrass pasture.

The results of these trials are shown in table 15.

With corn at $1.40 per bushel, or 2.5¢ per pound, the Tennessee barley fed in these trials was worth 1.88¢ per pound, or 90¢ per bushel. If the slower gains are not considered, the barley was worth 75 percent as much as the corn on a pound-for-pound basis.

Table 15—*Comparison of shelled corn, Tennessee barley, and equal parts of Tennessee barley and "government" wheat for hog feeding.*

Average of three trials

Item	Lot 1	Lot 2	Lot 3
Average number of hogs	9.33	9.33	8.67
Average number days of experiment	109	109	109
Average initial weight (lbs.)	65.32	64.50	62.04
Average final weight (lbs.)	222.25	197.93	216.25
Average gain per head (lbs.)	156.93	133.43	154.21
Average daily gain (lbs.)	1.43	1.23	1.42
Average feed requirements for 100 lbs. gain:			
Shelled corn	336.39	.....	.....
Ground barley	.....	415.06	.....
Ground barley and wheat	.....	.....	382.42
Protein supplement[1]	63.33	82.08	66.85
Average total feed for 100 lbs. gain	399.72	497.14	449.27
Average cost of 100 lbs. gain (exclusive of pasture)[2]	$10.30	$13.50	$11.24

[1]The protein supplement was composed of tankage 1 part and soybean or cottonseed meal 1 part.

[2]Corn was charged at $1.40, ground barley at $1.27, and ground wheat at $1.30 per bushel; and protein supplement at $60.00 per ton. The bluegrass pasture used for these trials varied from excellent to poor, depending upon season of year and weather conditions.

Fig. 11—Hogs finished on Tennessee barley and a protein supplement of equal parts tankage and soybean-oil meal, self-fed on bluegrass pasture.

These hogs made market toppers, but gained more slowly and cost $3.20 more per 100-pounds gain than those fed corn and the same supplement. The barley was worth only 75 per-cent as much per pound as corn in these trials.

A mixture of barley and wheat was superior to barley, but not as efficient as corn (Fig. 11).

PROTEIN SUPPLEMENT FOR FEEDING HOGS ON BLUEGRASS PASTURE

One trial was conducted comparing a 50-50 tankage-soybean oil meal protein supplement with a supplemental mixture composed of 70 percent ground wheat, 20 percent soybean oil meal, and 10 percent tankage for feeding with shelled corn to fattening hogs on bluegrass pasture. Results are shown in table 16.

Table 16—*Results of protein supplement test with hogs.*

Item	Lot 1 Corn and 50-50 mixture of tankage and soybean oil meal	Lot 2 Corn and supplement mixture
Number of hogs	8	10
Number of days of trial	97	97
Average initial weight of pigs	101.5	95.2
Average final weight of pigs	235.0	225.0
Average gain per pig	133.5	129.8
Average daily gain	1.37	1.34
Feed for 100 lbs. gain:		
Corn	378.07	328.12
Wheat	.....	35.05
Tankage	20.81	5.01
Soybean-oil meal	20.81	10.01
Total feed	419.69	378.19
Cost of 100 lbs. gain	$10.57	$9.24

The gains were practically equal, but the interesting feature was the small amount of animal protein consumed by lot 2 as compared with lot 1. This test indicates that a considerable saving of tankage can be made by combining it with other feeds.

THE COW-CALF HERD

A grade herd of beef cows has been maintained at the Station for 14 years. The cows carry considerable Shorthorn blood, though a number of heifers from the herd have been introduced that were sired by Hereford bulls. They have been mated to purebred Shorthorn and Hereford bulls (see table 17).

Table 17—*Results with a herd of grade beef cows mated to purebred bulls.*

A 14-year average, 1931-1944.

Number of cows in herd	37.7
Percent calf crop born	92.8
Percent calf crop weaned	85.9
Birth weight (lbs.)	65.7
Average birth date	Feb. 26
Weaned weight (lbs.)	393.2
Age at weaning (days)	240.5
Appraised price per cwt. of weaned calves	$8.54
Appraised value per head of weaned calves	$33.58
Feed consumed per cow (8-year average for 158 days):	
Good mixed hay (lbs.)	279.3
Rough hay and straw (lbs.)	2206.0
Sorghum silage (lbs.)	2873.3
Cottonseed meal (lbs.)	65.2

The pasture used by these cows and calves was mixed bluegrass, bermuda grass, and white and hop clover. During the later years of the study, the pasture became heavily sodded with bermuda and the gains on the calves were not quite so good as during the earlier years when they had more bluegrass and possibly a larger acreage of pasture per cow and calf. During the recent years a cow and calf have been carried on 1¼ acres of mixed legume, bluegrass, and bermuda pasture.

McFALL GRAZING EXPERIMENT WITH BEEF STEERS

A slightly rolling 43.4 acres of permanent pasture, with bluegrass predominating, known as the "McFall" pasture, has now been

used through the sixth year as year-round subsistence for beef steers. Enough hay is made from the pasture for winter feed, and the cattle are wintered in the pasture by the feeding of hay when necessary. Calves are added each fall, run through two winters and two summers, and sold in September or October as grass steers without having tasted concentrates or having seen the inside of a barn. This land requires lime, but is abundantly supplied with phosphate, and in addition to bluegrass supports a good growth of white clover, hop clover, and some wild grasses.

The average results of the 6 years' work are shown in table 18.

Table 18—*Results of McFall grazing experiment.*

Item	Calves	Yearlings
Average number carried per year	7.83	8.00
Average winter gain (lbs.)	57.50	35.57
Average summer gain (lbs.)	335.50	233.40
Average gain for year (lbs.)	393.00	[1]269.97
Average days involved during year	359.50	310.67

[1]These cattle are usually sold early in September, as they are well finished by that time. If they had been kept the full year as the calves were, the yearly gains probably would be more comparable.

The beef gains per acre from this system of utilizing pasture average 120.48 pounds for the 6 years. This is on year-round subsistence and cannot be compared with most acre gains reported, as they are for the grazing period only, and the cattle are wintered on feed from additional acreage. The average acreage necessary to support one steer for the entire year was 2.74. These cattle go off grass weighing 1000 pounds or more and are well finished for grass cattle.

ALFALFA-BLUEGRASS GRAZING AND FEEDING EXPERIMENT WITH BEEF STEERS

The area devoted to what is known as the alfalfa-bluegrass experiment consists of 8.75 acres in bluegrass, hop clover, and white clover; and 4.4 acres in alfalfa. The alfalfa area furnished hay for wintering and some grazing during dry periods. The cattle are on the bluegrass continuously, being fed alfalfa hay in outside racks during the winter. Calves are added each fall so as to perpetuate the project. The cattle are sold at approximately 2½ years of age. Seven trials have been completed, with results as shown in table 19.

Table 19—*Results of alfalfa-bluegrass grazing and feeding experiment.*

Item	Calves	Yearlings
Average number steers carried	3.14	3.66
Average winter gain (lbs.)	137.60	96.81
Average summer gain (lbs.)	285.00	180.17
Average total gain for year (lbs.)	422.60	276.98
Average number of days involved during year	360.7	[1]303.4
Average gain per head while in project	699.58 lbs.	

[1]These cattle are sold in September; hence, are handicapped in gains when compared with the calves carried the full year.

The average production of beef per acre from this system for the 7 years was 178.12 pounds, and the carrying capacity 1.93 acres, per steer. The pasture land used for these cattle is not quite as good as that used by McFall cattle, but this system produced 48 percent more beef and had a 42-percent greater carrying capacity than the McFall plan.

The cattle produced by this plan have consistently been the fattest cattle marketed from the Station, even though some of the others received grain on pasture. They produced very satisfactory beef from grass and hay without any grain.

EWE-TYPE STUDY

The fifth year's comparison of Northwestern and Cumberland Plateau ewes was completed, with results as shown in table 20.

Table 20—*The performance of Cumberland Plateau and Northwestern ewes for* 1944.

Items	Cumberland Plateau ewes	Northwestern ewes
Number ewes bred, 1943	37	52
Average date of lambing	Jan. 19	Jan. 25
Average birth weight of lambs (lbs.)	8.33	8.44
Percent lambs raised of ewes bred	97.3	107.6
Average weight of lambs at marketing (lbs.)	83.5	83.6
Average age of lambs at marketing (days)	145.5	138.3
Average daily gain per lamb (lbs.)	.516	.542
Average land returns per ewe bred	$11.17	$12.82
Average wool clip per ewe (lbs.)	5.84	7.99
Average annual wool returns per ewe	$2.98	$3.52
Average annual gross returns per ewe	$14.15	$16.34

The Cumberland Plateau ewes were top ewes from the area, showing a predominance of Hampshire blood, but still retaining many earmarks of the common native sheep. They were generally a little fine-boned, un-uniform in fleece, alert, and motherly in their disposition. The Northwestern ewes were obtained from cuts of shipments of Hampshire X Rambouillet yearling ewes from some of the best sources in the Northwest. These ewes came in as yearlings weighing about 90 pounds and grew into good, big ewes, which weigh 150 to 180 pounds, in good condition at maturity. They are gentle, prolific, good milkers, and have a distinct advantage over any other ewe used generally in Tennessee in weight and value of fleece.

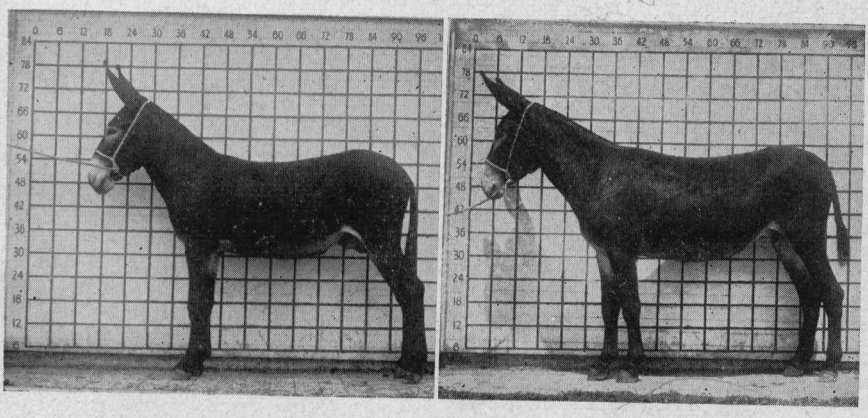
The Northwestern ewes, since 1940, when the project was initiated, have consistently given better performance and greater returns than the Plateau ewes. The Plateau type used in this experiment is not available in very large numbers at this time, and is disappearing as a source for spring-lamb-production flocks. This ewe is not as good as the "mountain," or native, ewe upon which spring-lamb producers have relied for the past 75 years.

The two flocks of ewes were run on the same pasture, handled in the same way, and bred to the same Hampshire rams; and as the initial cost of the ewes was about the same, the Northwestern were more profitable than the Plateau ewes and offer a good source of

ewes for Tennessee sheepmen. These data also indicate clearly that spring-lamb production offers very promising returns for investment and labor. Neither the ewes nor the lambs had any grain. The wool and lambs were produced entirely on pasture, with a small amount of hay during the winter.

JACKSTOCK AND MULE BREEDING

The jackstock and mule-breeding project, initiated in 1937, was continued through the year. The main objectives are to conserve and improve jackstock and to study various phases of mule production. A meeting, attended by representatives of the U. S. Bureau of Animal Industry, University of Missouri, Mississippi State College, and the University of Tennessee, was held at the



U. T. Marvel 35685 as a yearling, by U. T. Logan Again 34361.

U. T. Mona 34818 as a 4-year-old, by Limestone U. T. Monarch 32973.

Fig. 12—Two top offspring from the same jennet (Quality Ezell 34353), produced in the jackstock and mule breeding project.

Middle Tennessee Station in the fall of 1944, for the purpose of studying the progress of the work and discussing plans for the future. Both Tennessee and Mississippi reported that there was a great lack of uniformity in the jackstock produced and a need for continuing the projects to produce a more prepotent breed of jacks. It was generally agreed also that the mule was the ultimate end of a jack and that mule production was a very important phase of the projects. The chief handicap, outside of finances and personnel, seemed to be the lack of any yardstick for measuring the value of a mule. It was decided that some method of determining basic differences in mules must be developed before a mule-breeding project can be carried out in a scientific manner. The Tennessee and Missouri Stations agreed to work individually and cooperatively on this problem.

During 1944, 3 grade draft mares were added to the project for mule production, since most of the mules produced come from

this type of mare. Several mule and jackstock offspring are now reaching maturity and can be appraised more accurately than at younger ages. Observations, weights, measurements, and photographs were made of all stock. Several different families of jackstock are now taking definite form, and with 7 years' experience and records in the project it appears that definite progress has been made (Fig. 12).

Inventory of Jackstock, Mares, and Mules in the Project:

Jackstock	Jan. 1, 1944	Dec. 31, 1944
Mature jacks	5	5
Young jacks	4	5
Jennets 2 yrs. old and over	20	17
Jennet foals and yearlings	5	6
Horses		
Tennessee Walking stallions	1	1
Tennessee Walking mares	7	6
Percheron mares	4	4
Grade draft mares	1	4
Mules		
4 yrs. old and over	1	5
3 yrs. old	5	5
2 yrs. old	6	8
Yearlings	9	10

EXPERIMENTS AT WEST TENNESSEE STATION

Jackson

A COMPARISON OF VARIOUS PROTEIN SUPPLEMENTS FOR FINISHING HOGS ON CRIMSON CLOVER PASTURE

An experiment was planned and carried out in 1944 to study the possibilities of crimson clover pasture for hogs in the winter and early spring, and various protein supplements with crimson clover (table 21).

PLAN OF EXPERIMENT

Lot 1—Shelled corn, self-fed on crimson clover pasture.

Lot 2—Shelled corn and cottonseed meal, self-fed on crimson clover pasture.

Lot 3—Shelled corn and soybean oil meal, self-fed on crimson clover pasture.

Lot 4—Shelled corn and 60-percent tankage, self-fed on crimson clover pasture.

Lot 5—Shelled corn and a 50-50 mixture of cottonseed meal and tankage, self-fed on crimson clover pasture.

Lot 6—Shelled corn and a 50-50 mixture of soybean oil meal and tankage, self-fed on crimson clover pasture.

Table 21—*Comparison of protein supplement for hogs[1] on crimson clover pasture.*

Item	Lot 1	Lot 2	Lot 3	Lot 4	Lot 5	Lot 6
Number of pigs per lot	6	5	6	6	6	6
Average initial weight of pigs 1/19/44 (lbs.)	66	64	70	63	66	58
Average final weight of pigs 4/18/44 (lbs.)	238	235	250	249	264	263
Average gain in 90 days (lbs.)	172	171	180	186	198	205
Average daily gain (lbs.)	1.99	1.90	2.00	2.07	2.20	2.28
Average feed requirements per 100-lbs. gain:						
Shelled corn (lbs.)	321	303	276	294	277	260
Cottonseed meal (lbs.)	.....	50	.....	.....	26	.....
Soybean meal (lbs.)	.....	.....	45	.....	.....	26
Tankage (lbs.)	.....	.....	.....	39	26	26
Average cost of 100-lbs. gain, exclusive of pasture[2]	$8.01	$8.83	$8.26	$8.96	$8.68	$8.39

[1]See Plan of Experiment for protein supplement fed each lot.
[2]With corn at $1.40 per bu., cottonseed meal at $50.00 per ton, soybean oil meal at $60.00 per ton, and tankage at $84.00 per ton.

One-half acre of July-sown crimson clover was used for each lot. The clover formed a good sod and furnished an abundance of grazing at all times. The pigs were thrifty and were given a worm treatment just prior to the beginning of the trial. All the lots made unusually fast gains and produced gains economically.

The corn and crimson clover lot (1) did unusually well, showing that lush crimson clover will supply vitamins, proteins, and minerals sufficient to do a good job of pork production when other protein supplements are not available. This lot made acceptable hogs and at the lowest cost. They consumed more clover, however, than the other lots.

Mixtures of tankage and cottonseed meal and soybean oil meal produced faster gains than either of these supplements fed by itself.

ONCE-DAILY VERSUS TWICE-DAILY FEEDING FOR FATTENING YEARLING CATTLE

The second trial in the test of once-daily and twice-daily feeding of yearling cattle was begun on November 20, 1943, and concluded March 20, 1944, a period of 120 days. The object was to determine the effect of twice-daily feeding, as compared with once-daily, on rates and cost of gains. Each group was fed sorghum-corn silage, cottonseed meal, and corn-cob-shuck meal. The methods of feeding for the different lots were as follows:

Lot 1—Fed twice daily.

Lot 2—Fed once daily.

Two uniform lots of steers were used. They were native cattle of good grade. For both years of the experiment, once-daily feeding gave slightly better gains than twice-daily feeding. The gains this year were approximately 82 percent of those last year, owing partly to the low grade of corn used.

Tables 22 and 23 give detailed information covering this year's trial.

Table 22—*Cost of feeds and average daily ration for fattening yearling steers.*

Feeds	Lot 1 Fed twice daily	Lot 2 Fed once daily
Sorghum-corn silage, @ $8.00 ton (lbs.)	37.50	37.50
Corn-cob-shuck meal, @ $50 ton (lbs.)	3.75	3.75
Cottonseed meal, @ $50 ton (lbs.)	3.75	3.75

Table 23—*Weights, gains, and cost of gains, yearling steers.*

Item	Lot 1 Fed twice daily	Lot 2 Fed once daily
Number of steers	6	6
Number of days of experiment	120	120
Average initial weight Nov. 20, 1943 (lbs.)	691	689
Average weight at end of 120-day period, March 20, 1944 (lbs.)	870.0	879.0
Average gain per steer 120 days (lbs.)	179.0	190.0
Average daily gain per steer 120 days (lbs.)	1.491	1.583
Cost per 100-lbs. gain	$22.62	$21.31

FINISHING PLAIN YEARLINGS UNDER WAR CONDITIONS

The war has brought the cattle feeders many new problems. Cottonseed meal, the old stand-by for Southern feeders, is high in price and limited in available supply. The same is true of corn. Since unusual feed conditions prevailed and feeders were urged to produce beef, but not to make the cattle fat, the Station undertook a study of cattle fattening involving a minimum amount of concentrates. The rations fed for this trial are shown in table 24.

Table 24—*Daily rations fed in finishing of plain yearlings.*

Feed	Lot 1	Lot 2	Lot 3
Sorghum-corn silage (lbs.)	44.1	43.3	41.0
Alfalfa hay (lbs.)	.....	.....	5
Cottonseed meal:			
1st 30 days (lbs.)	2	3	2
2nd 30 days (lbs.)	2	4	2
3rd 30 days (lbs.)	2	5	2
4th 30 days (lbs.)	2	6	2

These cattle were appraised at the beginning of the trial and at the end of the 60-day, the 90-day, and the 120-day period. Tables 25 and 26 give detailed results of this year's trial.

Table 25—*Weights, gains, and cost of gains.*

Item	Lot 1	Lot 2	Lot 3
Number of steers	9	9	9
Number of days of experiment	60, 90, 120	60, 90, 120	60, 90, 120
Average initial weight of steers Nov. 20, 1943	697	692	719
Average weight at end of 120-day period (lbs.)	668	895	896
Average gain per head for 120-day period (lbs.)	171	203	177
Average daily gain per head for 120-day period (lbs.)	1.425	1.691	1.475
Cost of 100-lbs. gain for 120-day period (with silage @ $8.00, CSM @ $50.00, and alfalfa hay @ $40.00 ton)	$15.90	$16.89	$21.29

The cattle were appraised at 60, 90, and 120 days. On these rations it appeared advisable to feed for at least 120 days. The cattle in lots 1 and 3 were sufficiently fat to find a ready market

Table 26—*Financial statement.*

Item	Lot 1	Lot 2	Lot 3
Initial cost per head @ $10.00	$69.70	$69.20	$71.90
Average feed cost per head for 120 days	27.18	34.30	37.68
Total cost per steer (initial and feed)	96.88	103.50	109.58
Appraised price at end of 120-day period	12.00	12.00	12.00
Average value per head of finished cattle w/3% off final exp. wt. at appraised price of $12.00 (120 days)	101.04	104.16	104.28
Profit or loss if sold on above basis at 120 days	4.16	.66	—5.30

in this area. The most significant results were that the addition of alfalfa hay did not increase the gains in a silage-cottonseed meal ration, but did increase the cost of gain and decrease the profit as compared with lot 1, which received only silage and 2 pounds of cottonseed meal daily. The ration and system followed with lot 1 appeared practical for fattening cattle under war conditions.

SORGHUM-CORN SILAGE VERSUS CHOPPED SWEETPOTATOES IN RATIONS FOR FATTENING YEARLING CATTLE

This trial was begun on November 20, 1943, and concluded March 20, 1944, a period of 120 days. The object was to determine the comparative feeding value of sorghum-corn silage and chopped whole sweetpotatoes when fed with corn-cob-shuck meal and cottonseed meal in a winter fattening ration for yearling steers. The rations for the two lots were as follows:

Lot 1—Sorghum-corn silage, cottonseed meal, and corn-cob-shuck meal.

Lot 2—Chopped whole sweetpotatoes, cottonseed meal, and corn-cob-shuck meal.

In this trial, 2 uniform lots of 6 steers of good grade were used. This report covers the second trial in the experiment. In the first trial the chopped potatoes gave faster and cheaper gains than the sorghum-corn silage. Further work will be necessary before definite conclusions can be drawn.

Tables 27 and 28 give detailed information covering this year's trial.

Table 27—*Cost of feeds and average daily ration.*

Feed	Lot 1	Lot 2
Sorghum-corn-silage, @ $8.00 per ton (lbs.)	30	.....
Chopped sweetpotatoes, @ $12.00 per ton (lbs.)	.....	21.7
Corn-cob-shuck meal, @ $50.00 per ton (lbs.)	8.04	8.04
Cottonseed meal, @ $50.00 per ton (lbs.)	2.0	2.0

Table 28—*Weights, gains, and cost of gains.*

Item	Lot 1	Lot 2
Number of steers	6	6
Number of days of experiment	120	120
Average initial weight of steers 11/20/43 (lbs.)	692	732
Average weight at end of 120-day period (lbs.)	888	905
Average gain per steer, 120 days (lbs.)	196	173
Average daily gain per steer, 120 days (lbs.)	1.633	1.441
Cost per 100-lbs. gain	$21.87	$25.47

EXPERIMENTS AT MINERAL-DEFICIENCY FARM

Crossville

In 1944, all the land used in the mineral-deficiency project received an application of 800 pounds of ground limestone per acre, with the exception that the 15 acres seeded to crimson clover July 1944 received 2 tons per acre. The low-phosphate area received an application of superphosphate equivalent to 140 pounds of 16-percent phosphate, and the high-phosphate area an application at the rate of 400 pounds per acre on the same basis.

The initial seeding of this land, made in the spring of 1940, consisted of red clover, lespedeza, orchard grass, and redtop. By 1944 the red clover and most of the orchard grass had disappeared from the stand, leaving volunteer lespedeza and redtop as the main sources of pasture and hay. The lespedeza did not come very strong or early, and not enough nitrogen was gathered to supply nitrogen for the grasses. Owing to the low fertility of the land, drouths, heavy pasturing, and the disappearance of some of the important pasture species, the production of this land, in pasture and hay, had declined. The amount of hay obtained from the pasture areas had decreased until it failed to meet the needs of the cattle for winter feed. Roughage had to be secured from other Plateau areas to winter the cows in 1943 and 1944. This situation was due partly to a bad drouth in 1943.

In an attempt to improve the feed situation, three changes were made:

1. Representative areas of 5 and 10 acres, respectively, for the high- and low-phosphate areas were seeded to white clover.

2. Other strips of the same acreages were seeded to hop clover on both areas.

3. Five acres of the high and 10 acres of the low boundaries were set aside for crimson clover, the land being turned in June and seeded in August.

The hop clover seeded in the fall of 1943 made an appreciable growth in 1944, and shows considerable promise in this pasture-study program.

The main objective of this experiment was to study the influence of phosphorus and calcium on performance and growth of beef cows through land and feed-trough applications of these elements. The land used consisted of a farm which had been cleared for years and was semi-abandoned. Cumberland Plateau soils are naturally low in these elements, and this land, after years of cropping and sheet erosion, was in an exhausted and badly rundown condition. After the farm was cleared of brush, fenced, ditched in places, and seeded, the following setup with beef cows was established:

Lot 1—Cows grazed and wintered on forage from an area receiving a "low" application of phosphate (72 pounds of 20-percent superphosphate annually).

Lot 2—Cows managed the same as lot 1, plus 2 ounces of dicalcium phosphate daily.

Lot 3—Cows grazed and wintered on forage from an area receiving a "high" application of phosphate (266 pounds of 20-percent superphosphate annually).

Tables 29, 30, and 31 show the weights and gains of cows, heifers, and calves for the 1943-44 season.

Table 29—*Weights and gains of cows and heifers.*

Item	Cows			Two-year-old heifers		
	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
Number included	4	4	4	4	4	3
Average weight 10/31/43 (lbs.)	956	931	937	574	618	684
Average weight 11/1/44 (lbs.)	917	907	917	593	651	738
Average gain for year (lbs.)	—39	—24	—20	19	33	54

Table 30—*Weights and gains of* 1944 *calf crop.*

Item	From cows			From 2-year-old heifers		
	Lot 1	Lot 2	Lot 3	Lot 1	Lot 2	Lot 3
Number obtained	4	3	4	4	3	3
Average birth weight (lbs.)	71.5	80.3	71.0	55.5	60.0	69.0
Average weight Nov. 1, 1944 (lbs.)	360.6	348.3	433.0	233.5	212.0	311.0
Average age Nov. 1, 1944 (days)	158	154	167	140	121	147
Average weight calculated to age of 167 days (same as calves for lot 3) (lbs.)	376.1	370.8	433.0	267.6	277.1	342.8

Table 31—*Weights and gains of* 1944 *calves from cows and 2-year-old heifers combined.*

Item	Lot 1	Lot 2	Lot 3
Number obtained	8	6	7
Average weight Nov. 1, 1944 (weighted average) (lbs.)	297.5	282.6	380.7
Average weight Nov. 1, 1944, calculated to 167-days age (weighted average) (lbs.)	321.8	323.7	393.8

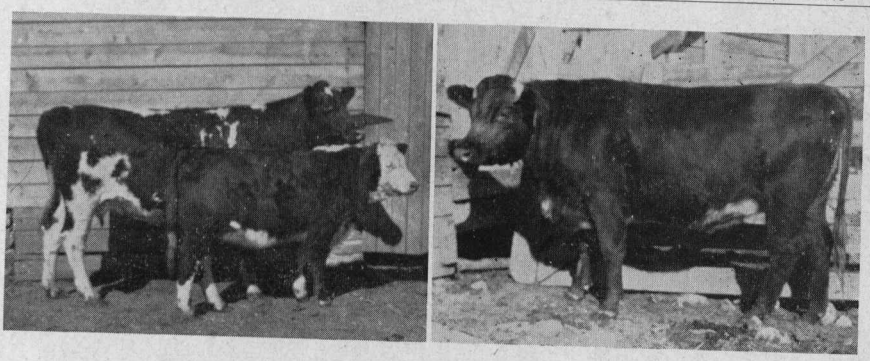


Fig. 13—Cattle fed at Mineral-Deficiency Farm.

Left: A 3-year-old cow from lot 3 with her second calf, which weighed 392 pounds at 6 months. The cow weighed 909 pounds when the picture was taken. Right: Heifer from lot 2 at 30 months of age—weight 975 pounds. Lot 2 was on the low-phosphate area and received a supplement of dicalcium phosphate. These cattle were developed entirely from the forage produced on the Mineral-Deficiency farm and show the possibilities of the Cumberland Plateau for cattle production.

The most noticeable difference in the weights on the cows and heifers is that the 2-year-old heifers in lot 3 have grown out better, being 145 and 87 pounds heavier than those of lots 1 and 2, respectively. The feeding of dicalcium phosphate to the heifers in lot 2 may have improved the weights and gains slightly (Fig. 13).

The calves produced from lot 3 for this year average 60 pounds more in weight at weaning than those of lots 1 and 2. The feeding of dicalcium phosphate to lot 2 apparently did not affect the calf weights.

The results of blood analysis made November 1944 are shown in table 32.

Table 32—*Blood analysis.*

Item	Calcium mg. per 100 ml. blood plasma	Phosphorus mg. per 100 ml. blood plasma
Mature cows, November 7, 1944:		
Lot 1	6.20	3.98
Lot 2	6.52	2.68
Lot 3	6.30	2.62
Two-year-old heifers, November 7, 1944:		
Lot 1	5.65	4.12
Lot 2	6.16	3.67
Lot 3	5.67	3.81
Sixteen-months-old heifer calves from mature cows, November 7, 1944:		
Lot 1	6.23	5.57
Lot 2	6.69	6.65
Lot 3	7.53	3.77
Six-month-old calves, November 28, 1944:		
Lot 1	6.52	4.00
Lot 2	6.73	3.51
Lot 3	5.74	5.62

The work above reported on the Animal Husbandry projects at various stations was made possible by the cooperation of the men directly responsible for it. Mr. L. R. Neel, Superintendent of the Middle Tennessee Station; Mr. Ben P. Hazlewood, Superintendent of the West Tennessee Station; Mr. J. J. Bird, of the Crossville Station; Mr. John N. Cummings, Assistant Superintendent of the Jack and Mule Breeding Farm at Columbia; Professor George W. Bible, of the Animal Husbandry Department; Mr. K. B. Sanders, of the General Chemistry Department, and others gave valuable assistance in carrying out the year's program.

FUSED TRICALCIUM PHOSPHATE AS AN ANIMAL-FEED SUPPLEMENT

COOPERATIVE WITH TENNESSEE VALLEY AUTHORITY

Dorothy E. Williams, Elise Morrell, and Pauline Jones

EFFECTS ON GROWTH TO MATURITY

Rat-feeding tests have been continued with fused tricalcium phosphates of different fluorine content as sources of phosphorus in the diet. Procedures are described in the Annual Report for 1943.

Results of these experiments, as evidenced by growth and phosphorus retention over 30-, 60-, and 90-day periods, as well as by reproductive performance, were summarized in February 1944, in Circular of Information No. 70. Since that time, analytical data for the period of growth to maturity have been completed and the breeding experiments continued. The completed portion extends and verifies the data given in last year's report. The conclusions presented tentatively at that time can be stated now with more assurance:

1. When fused phosphate having a fluorine content as high as .3 percent are included as 1 percent of the total diet and at a minimal phosphorus level, it is shown that the phosphorus of the fused phosphates is about 80 percent as available as that of an Osborne and Mendel salt mixture.

2. When, however, the fused phosphates are fed at the 1-percent level over a longer experimental period, 60 or 90 days, the difference in availability of the phosphorus between the control and experimental diets is no longer evident, owing probably to the decreased need for phosphorus as growth rate of the animals declines with age.

3. The phosphorus of fused phosphates with fluorine content up to and including .3 percent is as available to white rats as the phosphorus of a dicalcium phosphate containing .04 percent fluorine when fed under the conditions of this experiment.

4. There is no detrimental effect on growth to maturity and phosphorus retention in the rat when fluorine is present in the diet as sodium fluoride to the same extent as in any of the fused phosphates studied here. The only effect noted was in tooth structure. The characteristic chalky or striated appearance was evident whether the fluorine was fed in the form of sodium fluoride or as found in the fused phosphates.

EFFECTS ON BREEDING

Procedure.—In the breeding experiments, two fused phosphates containing .2 percent and .3 percent fluorine, respectively, have been compared with the Osborne and Mendel salt mixture of the control diet as a source of phosphorus. To distinguish between

Table 33—*Effect of phosphorus level on reproduction of rats.*

	Control		Fused phosphate, .2% fluorine	
	Born	Raised	Born	Raised
	Number	Number	Number	Number
Minimum P	523	254	319	229
Adequate P	617	423	581	348
Increase	94	169	262	119
Percent increase	18	67	82	52
			Fused phosphate, .3% fluorine	
Minimum P	172	79	176	112
Adequate P	235	117	263	175
Increase	63	38	87	63
Percent increase	37	48	49	56

the problems of phosphorus availability and fluorine toxicity, two phosphorus levels were adopted. One, at .2 percent, is about the minimal level for normal growth to maturity; the other, at around .4 percent, was designed to meet reproductive needs as well. Records have been kept of the number of young born and raised to weaning and the weights at birth and weaning (table 33).

Results.—Raising the total phosphorus of the diet from .2 percent to .4 percent caused increases in reproductive performance in rats of from 18 percent to 82 percent whether the source of phosphorus was Osborne and Mendel salt mixture or a fused phosphate containing as much as .3 percent fluorine.

Table 34—*Comparison of fused phosphates with Osborne and Mendel salt mixture at the adequate phosphorus level.*

Source of phosphorus	Born	Raised	Wt. at birth	Wt. at weaning
	Number	Number	Grams	Grams
O. & M. salt	587	409	4.8	29.1
Fused phosphate, .2% fluorine	502	297	5.0	32.6
Percent availability of fused phosphate compared with control	86	73	.....	.....
O. & M. salt	226	117	4.7	28.5
Fused phosphate, .3% fluorine	206	149	4.4	29.2
Percent availability of fused phosphate compared with control	91	139	.....	.....

When the rats receiving the fused phosphates are compared with those receiving the control diet—the phosphorus in all diets being at a level adequate for normal reproduction—the numbers born to the animals receiving the .2 percent and .3 percent fluorine fused phosphates were 86 and 91 percent, respectively, of the control number; and the numbers raised were 73 percent and 139 percent, respectively (table 34). Average weights at birth and at weaning are approximately the same.

Conclusion.—Fused phosphates containing as high as .3 percent fluorine, when incorporated as about 1 percent of the diet and raising the total phosphorus level to one adequate for normal reproduction, are very good sources of phosphorus for reproduction in white rats as compared with the readily available phosphorus of Osborne and Mendel salt mixture.

NUTRITIVE EVALUATION OF PHOSPHATES

COOPERATIVE WITH U. S. DEPARTMENT OF AGRICULTURE

Feeding tests on white rats, using 5 different defluorinated phosphates and one sample of bonemeal sent by K. D. Jacob, of the Bureau of Plant Industry, Soils, and Agricultural Engineering, were made in collaboration with N. R. Ellis and others. Results have been submitted for publication in the *Journal of the Association of Official Agricultural Chemists.*

FEEDING THE DRY COW

C. E. Wylie and S. A. Hinton

There is a question in the minds of some farmers whether a dry cow needs concentrates. There are two methods of feeding dry cows today. One is to feed them concentrates, and the other is to give them only roughage, including pasture when available.

Formerly it was a common practive among dairymen to reduce a cow's feed as her milk production declined. The theory was that there should be a dry period of from 6 to 8 weeks for the cow to replenish her system after producing milk for 10 months or a year. As a consequence she was often in poor condition as she reached the end of her lactation period and approached the time for dropping her next calf. It was apparent to many dairymen that this method depleted the cow's vitality, caused her definite injury, and reduced her milk flow during the subsequent lactation period.

These conclusions led to many programs for handling the dry cow, including the feeding of a considerable amount of concentrates. Results were both good and bad. The feeding of various grain mixtures during the dry period put the cow in better physical condition in some respects, especially as to her weight and the amount of flesh that she carried. On the other hand, poorly planned grain feeding during this period tended to cause congestion in the udder at the time of calving, as well as certain related troubles.

Close observation of animals in the University of Tennessee herd led to the trial of another system. The question was, whether concentrates should be fed over the entire lactation period and the dry period or only while the cow is in milk. The total amount of feed was not a point at issue. The method adopted was to feed all concentrates during the lactation period and none during the dry period. No concentrates have been fed to dry cows in the University herd for a number of years. Through the latter months of the lactation period there has been an increase in the amount of concentrates, and consequently in the rate of feeding in proportion to milk production; but during the dry period, say two months, the cow receives an ample supply of roughage with no concentrates.

Results have been very favorable. There are fewer difficulties at calving time, with notably less inflammation of the udder. The method described is now an established practice with the University herd. That it has merit is evident from the fact that our Jersey herd holds the highest Herd Improvement Registry record among all the Land-Grant colleges in America—576 pounds of butterfat per cow—and that our Holstein herd has almost as high a record.

POULTRY HUSBANDRY

B. J. McSpadden

PASTURES FOR LAYING HENS

An exploratory trial on the ability of green feed to compensate for a protein deficiency in rations for laying hens was reported in the 1943 Annual Report. The experiment was expanded for the 1943-

44 season to include limited and unlimited protein groups. The amount of protein supplement, the pasture allowed, and the results are shown in table 35. Because of the peculiar weather conditions

Table 35—*The effect of pasture on egg production with rations of varying protein content.*

Pen No.	Period	Daily amounts of protein supplement per hen	Pasture	Protein in ration	Egg production	Feed required per dozen eggs
		Grams		Percent	Percent	Pounds
C-1	Dec. 28-Apr. 17	9	No	13.8	40.4	6.60
	Apr. 18-Aug. 7	9	No	14.3	30.5	6.43
C-2	Dec. 28-Apr. 17	9	Yes	14.1	42.5	5.85
	Apr. 18-Aug. 7	9	Yes	14.3	40.3	5.48
C-3	Dec. 28-Apr. 17	18	No	15.0	42.8	6.48
	Apr. 18-Aug. 7	18	No	15.5	40.4	5.54
C-4	Dec. 28-Apr. 17	18	Yes	14.8	51.3	6.21
	Apr. 18-Aug. 7	18	Yes	14.4	46.9	4.76
C-5	Dec. 28-Apr. 17	Free choice	No	17.8	46.7	6.53
	Apr. 18-Aug. 7	Free choice	No	17.7	26.3	7.24
C-6	Dec. 28-Apr. 17	Free choice	Yes	16.2	48.6	6.27
	Apr. 18-Aug. 7	Free choice	Yes	18.1	38.3	5.48

of the spring and summer of 1944, this report is divided into two periods. The first, from December 28 to March 17, with the exception of one cold period, comprises near-normal winter weather. The second, from March 18 to August 7, comprises a period from an unseasonably cold, wet April to a record drouth from June and July.[2] Since the lots were fall-seeded to winter Tennex oats and crimson clover, the drouth affected the availability of green feed for the second period. To supplement this lack of green feed, each pasture pen was given a daily feeding of 2 pounds of chopped green alfalfa. This alfalfa, however, had also been affected by the drouth and was lacking in greenness and succulence.

It appears that greater benefit from pasture occurs if the protein intake is restricted to a point that is below the normal of about 15 percent. In pen C-6 the intake of protein from the supplement was greater during the period of drouth, or when the available green feed was at the minimum.

Owing to the limited number of pens, this trial does not indicate the extent to which pasture may supplement the protein in a ration for laying hens.

PASTURE FOR GROWING CHICKENS

An analysis of the data in table 36 indicates a lack of significant differences between the pasture and the bare-lot pens. Although not in accord with previous observations, these data confirm the statement in the 1942 Annual Report (p. 31) that growing chickens

[2]"May, June, and July have been the three driest summer months in the 73-year history of the local Weather Bureau."Weather report for July 31, 1944.

Table 36—*Feed consumption, feed per pound gain, and rate of growth, as influenced by type of pasture.*

Type of Pasture	Feed consumption		Feed per pound of gain		Average weight per pullet	
	Age in weeks		Age in weeks		Age in weeks	
	0-12	13-20	0-12	13-20	0-12	13-20
	Pounds	Pounds	Pounds	Pounds	Pounds	Pounds
Bare	755.0	383.0	4.62	5.04	1.67	3.21
Oats	681.9	394.5	4.37	4.95	1.68	3.34
Lespedeza	689.5	304.2	5.0	5.74	1.77	3.39
Alfalfa	679.0	394.0	5.5	4.61	1.65	3.29

receive benefits from pastures. This apparent discrepancy in results may be attributed to two factors: (1) the severe drouth of the summer of 1944 and (2) the feeding of a very simple ration.

During the first 12 weeks that the chickens were on pasture, the total rainfall was less than 2 inches. The result was that little or no green feed was available. Thus, in the final analysis, the chickens on what was intended to be pasture were under conditions not unlike those of the bare lot. When the 1944 data are considered on this basis, the results are not far different from those of the previously reported bare lots.

A mash[3] of ground grains and meat meal was fed during the entire period. At 8 weeks, whole yellow corn was fed ad libitum. The objective of this feeding program was to determine the extent to which green feed might compensate for probable vitamin and mineral deficiencies.

Because of the adverse growing conditions, any conclusion from this trial might be erroneous.

CHEMISTRY: SOILS AND FERTILIZERS

W. H. MacIntire, W. M. Shaw, and S. H. Winterberg

In recognition of the importance of liming and the distinctive reactions of different calcic and magnesic materials within the soil, several long-standing lysimeter studies are in progress at this Station. Because of inadequacy of personnel and facilities, certain projected modifications of the older experiments have been delayed. Supplemental to the analyses of the lysimeter leachates, considerable time was devoted to the study of the composition and distinctive chemical properties of the several types of calcium silicate slags, which have become important in the liming program of several states, including Tennessee.

DECOMPOSITION OF CALCIC AND MAGNESIC CARBONATES IN SOILS

A primary objective of this experiment was to determine the saturation capacities of soil and subsoil for calcium and magnesium supplied by heavy incorporations of the several types of liming materials. A brief summary of results through 1942 was given in the

[3]Ground yellow corn, 29 pounds; ground wheat, 25 pounds; ground oats, 25 pounds; meat meal (50-percent protein), 20 pounds; salt, 1 pound.

last annual report, and subsequent leachings of Ca and Mg show no striking change in the trend then indicated. The soils which had received the 8-ton CaO-equivalent additions of calcic and magnesic materials are still saturated with bases. They show a net Ca + Mg outgo equivalent to 400 to 500 pounds of $CaCO_3$ per 2,000,000 pounds of soil, and mostly in the bicarbonate form, since the current losses of nitrate and sulfate from the limed soils did not differ greatly from those of the unlimed control. The components of the leachings from the surface soil are still being arrested by the subsoil.

ECONOMIC ADDITIONS OF LIMING MATERIALS

This lysimeter experiment deals with the merits of full, divided, and repetitive additions and modes of incorporation of 4 types of liming materials and is duplicated at the Virginia Experiment Station. The Ca + Mg outgo during the 20th year was affected somewhat by the innovation of a uniform addition of K_2SO_4 to supply K_2O at the per-acre rate of 50 pounds. The objective of this treatment was to ascertain whether the residual calcium and magnesium would affect the outgo of additive potassium salts, since the K outgo from natural supplies had tapered to the level of from 5 to 6 pounds, although an 8-pound increment was supplied by rainwater. The 50-pound addition of K_2O applied to the surface therefore appears to have been retained by the soils, regardless of previous treatments, and the outgo of Ca + Mg indicates some release of these elements through basic interchange with the applied K. There was no indication of a present effect of liming upon the nitrogen outgo, which was in the range of from 6 to 10 pounds per acre per annum. The addition of K_2SO_4 did cause some increase in outgo of sulfate sulfur, which was in 60- to 70-pounds range.

QUENCHED CALCIUM SILICATE SLAG VERSUS LIMESTONE

This lysimeter experiment is conducted in cooperation with TVA. Among its several objectives were dissolubility of the slag, its conversion to carbonate, and attendant chemical and biochemical changes induced in the soil under outdoor conditions, together with the query as to whether the use of the slag will impart an undue concentration of fluorides in ground waters. The current results are those of the fourth year in which the effects induced by single incorporations at variant rates and fineness are compared with those induced by 4 annual applications.

The calcium outgo from single incorporations of 100-mesh and 20-mesh limestone and slag at the 2-ton rate is about 500 pounds for each material, whereas the Ca outgo from the 4-mesh limestone at the 5-ton rate was proximately 20 percent beyond that from the companion incorporation of slag. In comparisons as to outgo of calcium from 4 annual incorporations of the fines of the two materials, the maximal $CaCO_3$-equivalent outgo from limestone appears

to be 1100 pounds, as against 2000 pounds from the slag. The dissolubility and behavior of slag and limestone in the soil system may be stated as follows: When both materials are fine and are incorporated at rates beyond the soil's immediate sorptive capacity, the slag yields a bicarbonate solution of much higher concentration and, hence, a greater outgo of calcium. But, when the heavy-rate incorporations are comprised of coarse material, the outgo from the limestone exceeds that from the slag. Since the larger particles of limestone are not protected by a deposition of protective coating, such as that formed on the surface of the slag particles, their dissolution is not retarded. After the soil effects complete sorption of the Ca from both limestone and slag, the outgo of calcium is virtually identical for the two sources.

Because of its potential effects upon plants and animal nutrition, fluorine is an important component of slag. Where no further additions of slag were made during the year, the order of fluorine outgo was similar to that of the previous year, the concentration in the leachings being from 1 to 15 p.p.m., and respectively proportionate to the amounts of the original incorporations. Where the slag additions had been repeated to an ultimate 4-fold of the single treatment, the fluorine concentration in the leachate waters was 26 p.p.m.

CHEMICAL STUDIES OF CALCIUM SILICATE SLAGS

The laboratory approach on slags during the past year has been chiefly along two lines—(a) further studies on methods for the determination of the potential neutralization value, and (b) investigation of procedures whereby the distinctive types can be classified and evaluated as to their liming effectiveness.

The initial phase of the approach was embodied in a paper presented at the 1944 meeting of the A.O.A.C., and dealt with the specific sources of error that preclude determination of the neutralization value of a calcium silicate slag by means of the method prescribed for liming materials. The findings led to the adoption of a new tentative procedure for the determination of the potential neutralization value of blast-furnace slags by the potentiometric titration of the acidic solution of the slag to pH 4.8. Further effort has been made to simplify the titration procedure by means of certain indicators that were considered only briefly in the original study. Since the difficulty of obtaining a sharp observable endpoint was overcome by bringing the acidic solution of the slag to a volume of 150 ml. with CO_2-free water, the potential neutralization value of blast-furnace slag can be determined through direct titration of the slag solution to pH 5.2 by matching the methyl red tint in a phthalate buffer solution of identical pH.

STUDIES ON LABORATORY METHODS FOR THE EVALUATION OF CALCIUM SILICATE SLAGS AS LIMING MATERIALS

Published reports have dealt with relative effectiveness of limestone and calcium silicate slags from the blast furnace and from the phosphate-reduction furnace, as indicated by the use of a limited number of samples in field and pot-culture studies. For such comparisons to be conclusive, however, the slags should be identified by their distinctive chemical and physical properties. Calcium silicate slags vary in reactivities according to type, and a quenched slag will possess properties quite different from those of an air-cooled identical. Potential neutralization value is the one indicated by overall calcium content. This value is not, however, an absolute index to liming effectiveness, and reliance upon it may prove misleading, since undue proportions of alumina serve to inactivate the calcium present in the Ca-Al-SiO_2 combination. It seemed imperative to devise a laboratory method to register degree of slag availability and to establish a standard by which such availability may be expressed.

Considerable study has been devoted to the dissolution of various types of slags in CO_2-saturated water. The experimental work conveniently falls into these headings:

(a) Maximal concentration attainable from dissolutions of various types of slags, when the slag charges are finely divided and in substantial excess.

(b) Maximal percentage dissolution of finely divided slags, when the charge is within stipulated solution/solid ratios.

(c) Relation of particle size to rate of dissolution.

When slags of minus 200-mesh were agitated for 24 hours continuously in CO_2-saturated water, 1 gram to 100 ml., the resultant bicarbonate concentrations ranged from 20 to 115 ml. of 0.1 N. The low value represented the extractions from the blast-furnace slags, quenched and unquenched, and from wollastonite. The high values were from Wilson Dam slags, quenched and unquenched, and from a laboratory-prepared calcium metasilicate. When the extraction technic was continued for various periods up to 20 days, there was only a slight increase in the concentrations of the bicarbonate extract of the initially more soluble slags, whereas the concentrations of the extracts from the wollastonite and the quenched blast-furnace slag rose steadily to respective titrations of 66 and 45 ml. of 0.1 N per 100. The maximal bicarbonate concentration of the extract of the unquenched blast-furnace slag required a 22-ml. titration against 0.1 N acid. Any of the more concentrated bicarbonate titration results at a given period might have been vitiated by the concomitant precipitation of $CaCO_3$ during the progressive dissolution of the silicate.

In another series of experiments with the same slag materials, the ratio of solid to solution was limited to 0.5 gram per 100 ml. to circumvent the factor of $CaCO_3$ precipitation that is encountered

during the carbonatated-water digestions of larger charges of slag. After 24-hours contact, the resultant 0.1 N titration values per 100 ml. of extract were: 39 for Wilson Dam slag, unquenched; 35 for Wilson Dam slag, quenched; 75 for the laboratory-prepared silicate; 27 for the blast-furnace slag, quenched; 17 for the blast-furnace slag, unquenched; and 12 for wollastonite. After 30 days of extraction, the respective changes in titrations of 0.1 N per 100 ml. were 39 to 49; 35 to 59; 75 to 42; 27 to 53; 17 to 24; and 12 to 48. Hence, the alignment as to the degree of dissolubility of the several silicate materials in carbonated water is not the same for the two periods of extractions. It cannot be stated now at which particular ratio of charge to dissolvent and period of extraction the results on dissolution in CO_2-water are representative of the activities of the several silicate materials in the soil system. It may be, however, that the extraction of 0.4- to 0.5-gram charges of minus 200-mesh slag per 100 ml. of continuously CO_2-saturated water could be utilized as a feasible and dependable technic for the evaluation of the reactivity, or degree of dissolubility, of calcium silicate slags. More definite information as to the applicability of such method of evaluation will have to come from integrated laboratory and pot-culture studies.

When several screened separates of the quenched and unquenched Wilson Dam slags were compared by means of 1-day extractions in carbonated water, the unquenched slag showed the higher rate of dissolution, but the quenched slag separates yielded the higher bicarbonate concentration when the extraction period was extended to 5 days.

When the coarser separates ($-$ 20 $+$ 40, and $-$ 40 $+$ 60) of quenched and unquenched Wilson Dam slags were compared with similar separates of calcite in 1-day and 2-day periods of extraction in carbonated water, the calcite proved more dissolvable than either of the slags. This apparent relationship does not obtain, however, when the comparison is made with finer separates or when the period of extraction extended to 5 days or beyond. Although these results may appear contradictory, they can be reconciled by a consideration of the two factors that govern the phenomenon of dissolution. These are relative rates of speed of dissolution per unit surface area and the ultimate specific capacity for dissolution, or dissolubility, in carbonated water. It appears that, although the slags impart calcium bicarbonate concentrations from 3 to 6 times greater than the concentration induced by calcite in CO_2-water, the speed of dissolution within the limits of the concentrations obtained from calcite is greater than for the calcium silicate slags. These comparisons will be developed in a forthcoming paper.

LIME-POTASH STUDIES

Several experimental setups are pointed to the various aspects of lime-potash relationships, such as effect of light incorporations of liming materials upon native and additive potash, effect of heavy incorporations upon absorbed potassium in the soil, and the vari-

ance in outgo of Ca + Mg as an influence of the form in which the potassium is supplied. In addition to the effect of liming on potassium outgo, it is essential to consider reciprocal relationship of K absorption upon outgo of calcium and magnesium, and the mobilities of the acid radicals, the sulfates in particular.

The effect of light incorporations of limestone upon the outgo of additive potassium was noted during the 4th year of a lysimeter study with a Cumberland silt loam and a clay subsoil, following an annual application of K_2SO_4 at the per-acre rate of 800 pounds of K_2O. The limestone was incorporated in 1940 at the rate of 3570 pounds of $CaCO_3$ per 2,000,000 pounds of soil. During the past year the retention of K by the unlimed and the limestoned surface soils was equivalent to 40 pounds and 125 pounds respectively. The acidic clay subsoil retained 180 pounds of K_2O; whereas, limestoned, it showed a 420-pound retention. The K_2SO_4 application supplied 680 pounds of SO_3 to the soil, in addition to about 125 pounds of SO_3 carried by the rainwater. Recovery of SO_3 from the limestoned clay subsoil was complete, but there was a shortage of about 40 pounds in the outgo from the unlimed clay. Total retention of the SO_3 brought to the clay control by rainwaters was registered by the fact that its leachates were virtually devoid of sulfates. Sulfate recovery from the limed surface soil was complete, against a deficiency of about 30 pounds from the unlimed. The enhancements in the Ca + Mg outgo induced by additive K_2SO_4 were proportionate to the fixation of K by the soil.

EFFECT OF HEAVY LIMING UPON OUTGO OF ABSORBED POTASSIUM IN SOIL LEACHATES

Duplicates of 4 surface soils and a clay subsoil were built up in K content in outdoor lysimeters by additions of K_2SO_4 over a period of years. In 1939, one unit of each pair received a heavy incorporation of hydrated lime and the current results show the outgo of K during the 4th year after that incorporation. The K recoveries continue to be low, and the repressive effect of the liming on K outgo is evident in every comparison. The sulfate ion recoveries from the original addition of K_2SO_4 were still at a slow rate, so that from 200 to 400 pounds of the added SO_3 remained in some of the unlimed soils. The sulfate recoveries from the limed soils were greater, but in most instances were far from absolute. Although all of the limed soils are rich in $CaCO_3$, derived from the hydrated lime, they vary in their releases of calcium to the rainwater leachings. The clay subsoil, which is almost devoid of organic matter to support biological activities, shows a per-acre per-annum outgo of about 300 pounds of $CaCO_3$ in the bicarbonate form, whereas the greater biological activities in the Crossville and Chickamauga soils are reflected by a much higher bicarbonate outgo.

COMPARATIVE ACTIVITIES OF POTASSIUM SULFATE AND POTASSIUM METAPHOSPHATE

This is a lysimeter study of the behavior of potassium supplied in the two indicated combinations. As pointed out in last year's report, only meager quantities of phosphate appear in the leachings, and the transformation of the meta form of the phosphate and its availability in the soil, as such or after transformation to orthophosphate, therefore, could not be determined through leachate analysis. The variance in the behavior of K_2SO_4 and KPO_3 in the soil during the initial year has been reported in a paper accepted for publication in *Soil Science*.

Because of unseasonable wetness of soil, the additions of 200 pounds of K_2O in the two forms could not be made on the anniversary of treatments and were omitted the past year. The date for subsequent additions was changed to July 7 to ensure more favorable conditions of weather and soil. The present results reflect the effects of the original 1000-pound and 200-pound additions of K_2O upon outgo during the second season. The mean net recoveries of K_2O from K_2SO_4 additions on the unlimed soils were 31 and 68 pounds for the 200- and 1000-pound applications, respectively, whereas the corresponding net recoveries of K_2O from the potassium metaphosphate additions were 39 and 170 pounds, respectively. The net recoveries of K_2O from the corresponding K_2SO_4 additions on the limestoned soils were 25 and 66; those from the added potassium metaphosphate parallels were 25 and 134 pounds. Thus it appears that the larger additions of metaphosphate (1000 pounds) yield potassium to the rainwater leachings more readily than do the corresponding additions of K_2SO_4.

LIME-PHOSPHATE STUDIES

One phase of the phosphate studies has been mentioned in connection with the potassium metaphosphate experiment. Since neither the meta ion (PO_3) nor the ortho ion (PO_4) appears in the lysimeter leachates, the degree of availability of the phosphorus introduced by the metaphosphate of potassium will be determined by extractions and pot cultures of the variously treated soils.

Another lysimeter experiment deals with the relationship of added calcium fluoride to various phosphates, with and without limestone and dolomite. Repetitive additions of CaF_2 have been continued, with no further additions of either a phosphate or a liming material. The highest concentration of fluorine in the leachings was 2 p.p.m. and came from joint additions of tricalcium phosphate and CaF_2. Fluorine concentrations of about 1.2 p.p.m. occur in the leachings from the di- and mono-calcium phosphates. There seemed to be no consistent influence of the limestone or dolomite additions upon the fluorine outgo. As stated, the condition of the built-up phosphate in these experiments will have to be determined by methods other than the analyses of the leachate waters.

COOPERATIVE EXPERIMENTS

The cooperative investigations were directed chiefly to responsiveness of experimentally produced phosphatic fertilizers and calcium silicate liming materials—quenched calcium silicate slag in particular. In one study, the factors that influence the ammoniation of superphosphates were investigated and further evidence was adduced to substantiate the concept that tertiary calcium phosphate combines with component calcium fluoride to form fluorphosphate of meager dissolubility. In the absence of calcium sulfate and fluoride, there was no formation of citrate-insoluble phosphates.

The influence of degree of defluorination upon dissolubility of the P_2O_5 content of fused tricalcium phosphate was studied in the laboratory upon the assumption that the well-known citric acid digestion (Wagner) method could be adapted to the control-laboratory evaluation of that TVA phosphate. Prescribed conditions for digestions in citric acid solution of 2-percent concentration gave "availability" values in accord with those computed for the content of the alpha form in the fused tricalcium phosphate, and in consonance with the "availability" values indicated by plant response in greenhouse cultures. The proposed modification of the Wagner method seems to make it the logical procedure for the chemical evaluation of the fused tricalcium phosphate.

A "reference" precipitated tricalcium phosphate was obtained by a new process and studied as to reproducibility of product by different operators. Upon chemical and X-ray comparisons of specimens produced by several individuals, the product proved to be constant in structure and properties and readily "available" by chemical procedures and by plant-growth response. The development of the process for the preparation of the phosphate means that workers in phosphate research can make or obtain a product having definite properties and characteristics, and thus assure a standard, or "reference," material for use in chemical and pot-culture studies as to the relative effectiveness of other phosphates. A simple chemical test was advahced as a means of differentiating normal and hydroxy tertiary calcium phosphates.

On moderately limed soils, TVA-concentrated superphosphate proved decidedly superior to Tennessee brown rock phosphate, in terms of immediate crop response, unless the raw rock phosphate was incorporated at rates unusually heavy and economically inadmissible. Incorporations of as much as 355 pounds of the superphosphate (160 pounds of P_2O_5) and 2 tons of the rock phosphate (1280 pounds of P_2O_5) per acre area and half-pot depth were required to enhance the P_2O_5 content of an initial crop of red clover. When that crop was grown on the Hartsells fine sandy loam of the Cumberland Plateau, P_2O_5 percentage contents of 0.39, 0.49, 0.42, 0.53, and 0.63 were registered, respectively, by the no-phosphate controls, and by increments of 40, 80, 160, 320, and 640 pounds of P_2O_5 from concentrated superphosphate. For the two succeeding crops, soybeans and Sudan grass, a substantial increase in P_2O_5 con-

tent was induced, in general, by the addition of P_2O_5 at the lower rates. When red clover and Sudan grass were grown subsequently as the fourth and fifth crops, respectively, their P_2O_5 percentage contents were less than when they had been grown as crops 1 and 3.

As aggregates for the five crops, the pound and the percentage recoveries of P_2O_5 from "triple" superphosphate were greater than corresponding recoveries from additions of rock phosphate at economic rates. At such rates, and under the ideal growing conditions imposed in the greenhouse, the aggregate recovery of P_2O_5 through 5 crops was less than half the amount supplied through "triple" superphosphate, whereas recoveries from heavy incorporations of superphosphate were less than a fourth of the amount added. It is important, however, to integrate the recoveries of phosphorus with quantity of plant response and its nutritional value. The P_2O_5 recovery from the 40-pound input, as "T.S.P.," was 16.4 pounds, whereas that from the 80-pound addition was 32 pounds, or virtually double. But, with the 100-percent increase in the uptake of P_2O_5 by the doubling of the input, the increase in plant growth was only about 50 percent, and hence the plants that came from the 80-pound increment of P_2O_5 were richer in their phosphorus content.

In another experiment the variance in the carbonatation of certain calcium silicate materials in soils was determined. As previously reported, adequate-rate incorporations of unground quenched slag from the phosphate reduction furnaces induced excellent response in pot cultures—response to the 4-ton additions of unground slag being equal to that from the joint use of 2 to 4 tons of limestone and 400 to 500 pounds of ordinary superphosphate. The unground slag can be used to advantage at heavier rates, whereas 100-mesh cannot. In contrast, the deleterious effect induced by heavy incorporations of 100-mesh slag is not induced by corresponding incorporations of the mineral calcium silicate, wollastonite.

In laboratory studies, it has been found that the mineral silicate and slag were dissolved readily in carbonated water and the expectancy, therefore, was that the several calcic materials would behave alike in the soil. Accordingly, these two types and others of calcium silicate were subjected to carbonatation studies in pot cultures, under both fallow and cropping. On the basis of periodic determinations of the amount of $CaCO_3$ generated in the slagged soils, (a) the unquenched slag was much less reactive than the quenched material; (b) the cumulations of carbonate were proportionate to rates of incorporation and also to particle size of the incorporated material; (c) the raw wollastonite was inert, as were its calcines; (d) the quenched melts of the wollastonite were reactive to CO_2 in the soil; (e) the inclusion of calcium fluoride in an experimental slag resulted in accelerated dissolution and carbonatation.

In comparisons between monoammonium phosphate and a TVA output of diammonium phosphate, there was no apparent toxicity induced by the more ammoniacal salt.

As in previous years, W. M. Shaw served the A.O.A.C. as Associate Referee on Liming Materials, and W. H. MacIntire served as Referee on Soils and Liming Materials and as designate on the Board of Governors of the Crop Protection Institute.

CHEMISTRY: GENERAL

G. A. Shuey

DEHYDRATED FOODS

Experimental work on home dehydration of fruits and vegetables was continued during the year 1944. The Agricultural Engineering Development Division of the Commerce Department of the Tennessee Valley Authority cooperated.

Fruits and vegetables were prepared and dehydrated in equipment designed by us for home use. The products were packed in different kinds of sealed containers—in some of which the air was displaced with carbon dioxide gas—and stored at 0° and 75° F. for 6 months. After refreshing and cooking, it was found that the quality was best retained by the dehydrated vegetables that had a moisture content of 5 percent or less, were packed in moistureproof containers, and were held at a low temperature. The advantage in quality of carbon dioxide-packed vegetables over the air-packed is not sufficient to justify the use of the gas in home packaging. Dehydrated vegetables and fruits packed in transparent containers—cellophane and glass—darkened upon prolonged exposure to light. The same containers protected the products well in the dark and at low temperature. Dehydrated carrots, snap beans, corn, apples, peaches, and pears retained their quality exceedingly well in zero storage. Other products stored at different temperatures are being tested for keeping quality. As a general rule, if vegetables are properly prepared, dehydrated to a moisture content of 5 percent or lower, sealed in moistureproof containers, and kept in a dark, cool place they will have fairly well preserved eating qualities for winter use.

Experiments were conducted to determine the comparative effects of sodium bisulfite solution and sulfur dioxide fumes on color and eating quality of dehydrated apples and peaches. It was found that freshly sliced fruits that were submerged in a 2-percent solution of sodium bisulfite for 3 minutes retained, after dehydration, about 85 percent of their natural color. The color retention was slightly better than that obtained by exposure of some of the same fruit to sulfur dioxide fumes for 30 minutes. This method simplifies the sulfuring of fruits prior to dehydrating. Then, too, it eliminates the fumes of burning sulfur, which are an unpleasant feature of the old method of treatment.

The effects of temperature and humidity on electric motors of air fans used in home dehydrators were tested. Four motors were

operated continuously for 160 days, under conditions existing in our home dehydrator, without injury to the motors, except normal wear. A new thermostat has been developed and is proving very satisfactory.

Chemical analyses including vitamin-C (ascorbic acid) determinations were made on a number of dehydrated fruits and vegetables. Data are being accumulated on the fate of vitamin C in the process of dehydration and storage of dehydrated foods.

Canning and freezing methods of preserving foods in the home require considerable effort and skill to be successful. The same is true if foods are to be preserved properly by dehydration, packaged well and stored under best conditions. Household equipment, such as washing machines, electric refrigerators, and electric stoves, did not gain general acceptance until they had been well developed. We believe the same will be true of home dehydrators. Work on dehydration is being continued with the object of further improving the home dehydrator unit so that it will produce dried foods with the following characteristics: (1) lower moisture content; (2) shorter drying time and at lower temperatures; (3) quicker refreshing; (4) better retention of flavor, vitamins, and other food values.

Fruits and vegetables gradually rise in temperature as they lose water in the mechanical dehydrator. Long exposure of such products to heat will result in impairment of quality. We have conducted preliminary experiments designed to remove the last 10 to 15 percent of water by placing the product, partially dried in the mechanical unit, in an enclosed space over a chemically inert, commercially available material of high moisture-adsorptive capacity. Results have been encouraging and the experiments will be continued.

FROZEN FOODS

Experiments in the preservation of foods by freezing were very active during the year. Various kinds of vegetables and fruits were prepared, frozen, and stored in the zero-degree room for 6 months or longer, after which they were cooked and judged for quality. After necessary equipment was obtained in early November, vitamin-C (ascorbic acid) determinations were made on a number of products that were held in zero-degree storage for different periods of time—6 months to 2 years. Data are being accumulated on the vitamin-C content of different vegetables and fruits at the time of processing and periodically during storage. Our experiments have shown that a small amount (.01%) of pure sodium bisulfite added to sugar sirup used for packing fruits is effective in the prevention of browning of sliced apples and peaches. We have found also that citric acid, lemon juice, or phosphoric acid added in small amounts to the sugar sirup helps to preserve color and flavor in frozen peaches and apples. Because of the shortage of granulated sugar for home use, our experiments included the preparation and use, for freezing purposes, of sirups—corn sirup being used as a substitute for part of the granulated sugar. It was found that a

mixture of equal parts of 50-percent granulated-sugar sirup and 50-percent white-corn sirup was entirely satisfactory for the freezing preservation of peaches. This blend of sirup appeared to give firmness to the fruit tissue, and to possess slight anti-oxidation properties.

Freezing is a good method of preserving many fruits and vegetables. In freezing preservation, if the correct procedure is carried out, the thawed, cooked product will closely resemble the fresh material in color, flavor, and nutritive value. When unharvested vegetables are caught in the garden by an early frost, they discolor and develop unpleasant flavors and generally are inedible. If vegetables are harvested and frozen without first being heated in boiling water or steam, the results will be similar to those experienced with vegetables frosted in the garden. The principal cause of this objectionable change in frozen vegetables that are not previously heated is the activity of enzymes naturally occurring in the vegetable tissues. Heating of vegetables and some fruits in boiling water or steam prior to freezing arrests enzyme activity and helps the product retain to a considerable extent its fresh characteristics. The terms "precooking," "steaming," "scalding," and "blanching" are synonymous as applied to the treatment of foods for freezing.

Blanching vegetables in boiling water perhaps is the most convenient method for the average home. A kettle should be used that is large enough to hold 1 gallon of water for each pound of vegetable to be blanched at one time. The vegetable then is placed in a wire basket, cloth sack, or other suitable container and submerged in the boiling water for the number of minutes prescribed for the vegetable. The blanching time is recorded from the time the water reaches full rolling boil after the product is submerged. While in contact with the boiling water, the product should be moved up and down at least three times to insure uniform heating of all pieces. Not more than 2 pounds of vegetables, such as snap beans, lima beans, corn on the cob, beets, vegetable soybeans, carrots, and broccoli, should be blanched at one time. Leafy vegetables, such as turnip greens, should not be blanched in quantities of more than 1 pound at a time in 2 gallons of boiling water. The number of minutes that the product is kept in contact with boiling water (blanched) is of vital importance. If underblanched, the product will not keep well; nor will the flavor and color be well preserved. At the end of the blanching period the vegetables are chilled by submerging in cold water for about the same period of time used for blanching. If cold running water is not available, ice may be added to produce quicker chilling of the blanched product. Quickly and thoroughly chilled vegetables will better retain their color, flavor, and nutritive value in the frozen condition. Chilled vegetables are removed from the water, allowed to drain for several minutes, placed in moistureproof packages, and frozen without delay. Rapid handling of all green-colored vegetables from the water-chilled condition to the freezer is very important if best quality is to be retained after several months in the frozen condition.

The crispness possessed by water-chilled green snap beans and other vegetables may be lost if the vegetables are not frozen promptly and protected from drying out (desiccation) while in low-temperature storage. Equal weights of red beet stems were placed in waxed and unwaxed cartons and held in zero storage for 12 months. Beet stems packed in waxed cartons lost 2 percent of their normal water content, and those packed in unwaxed cartons lost 70 percent. Satisfactory moistureproof, heat-sealing bags and waxed cartons are available for packaging fruits and vegetables for freezing. Our experiments show that glass jars and tinned cans also may be employed for home-freezing purposes. Containers should be completely filled with vegetables. Containers in which fruits are packed in sirup or sugar for freezing should be filled to within about one-half inch of the top to permit expansion without damage to the container on freezing.

Frozen fruits and vegetables retain their quality best if stored at a constant temperature of 0° F. If the temperature is allowed to fluctuate widely (0° to 10° above) from time to time, the frozen product will tend to deteriorate. Vegetable soybeans, peas, lima beans, cut sweet corn, red beets, and carrots will keep well for several years if properly packaged and stored at a fairly constant zero temperature. We have also found that certain green vegetables, such as asparagus, snap beans, broccoli, shredded cabbage, and turnip and mustard greens, keep well in the frozen condition from 6 to 12 months. They are best if eaten within the year. Summer squash, African squash, turnips, pulped pumpkin, rhubarb, and many fruits may be held for longer periods in zero storage if properly packaged to prevent drying out.

It should be borne in mind that fruits and vegetables must be harvested, prepared, and frozen when they have just ripened to prime condition for table use. At the best stage of maturity snap beans and broccoli are tender and of deep-green color; peas are juicy and sweet; red beets and turnips are crisp, not pithy; turnip and other greens are tender and of deep-green color; corn is in the milk stage and sweet; and fruits have developed full flavor but are still firm.

Fruits and vegetables must be prepared properly for table use before freezing. All materials must be sorted and washed to remove dirt and defective parts. It is very important that vegetables be prepared and frozen within a few hours after they are harvested, or kept in a cold place such as a refrigerator until they are prepared and frozen. Green vegetables held at room temperature in warm weather will rapidly lose vitamin C and, to some extent, carotene, which is the mother substance of vitamin A.

As a result of our experiments in the freezing preservation of fruits and vegetables over a period of 4 years, we are giving, in table 37, methods of preparing 14 different vegetables for freezing. This is a partial list of vegetables now under experimentation in our laboratory. Additional methods for other kinds of vegetables, and fruits, will appear in subsequent publications.

Table 37—*Preparation of vegetables for freezing.*

Fresh vegetable	Stage of maturity	Preparation	Blanching time in boiling water[1]
Asparagus	Tips tender	Cut young shoots to about 6" lengths	Small to medium: 3 min. Large: 4 min.
Beans: lima—bush and pole	Beans tender, green	Shell and wash	Small to medium: 1½ min. Large: 2 min.
Beans: snap—bush and pole	Pods tender	Snip and cut in 3/4" to 1" lengths	All: 3 min.
Beans: soybean	Beans well developed in pod, but still green and tender	Blanch whole pods in boiling water 4 to 5 min. and shell	All: 3 min.
Beets	Firm, crisp, good condition for table use	Trim, wash, and cook 28 min. Remove peel. Slice as desired	Small whole beets up to 1½ in. diameter 3 min. Larger beets: Cook until tender and slice or cube.
Broccoli	Tender, good condition for table use	Wash, cut heads lengthwise into pieces of desired size	Small to medium-sized pieces: 3½ min. Large pieces: 4½ min.
Carrots	Young, tender, medium size	Wash, peel, or scrape, cut into 1/4" slices, strips, or cubes	All shapes: 3 min.
Corn: sweet—on cob	Milk stage	Husk, trim, remove silk, bore hole lengthwise through cob, using 1/2" auger bit	Small to medium-sized ears: 9 min. Large ears: 11 min.
Corn: sweet—cut from cob	Milk stage	Husk, trim, remove silk, blanch on cob for time specified above. Cool, cut from cob, and pack	
Okra	Pods young	Wash, blanch whole pod as directed, then cut into 1" pieces if desired	Small to medium-sized pods: 3 min. Large pods: 4 min.
Peas: green	Full grown, yet still tender	Shell, clean, and remove overmature peas	Small peas: 1 min. Medium to large: 1½ min.
Rhubarb	Stems tender—early spring varieties	Cut stems into 1" lengths	Small stems: 1½ min. Large stems: 2 min.
Squash: African	Mature, thick flesh, and of deep yellow color	Cut open, remove seeds, and cut into strips 1" to 2" wide. Peel and cut into 1/2" slices or cubes	½" slices: 7 to 10 min. ½" cubes: 4 to 5 min.
Squash: summer, baking types.	Tender and of good color	Cut in half lengthwise as for baking, remove seeds	Medium-sized pieces: 4 min. Large pieces: 5 to 6 min.
Turnip and mustard greens	Young, best condition for table use	Remove coarse, fibrous leaves	All: 1½ min.

[1]At the end of the blanching period, all vegetables must be cooled in water and allowed to drain for several minutes before packing.

LEGUME SILAGE

Studies of the making and feeding of legume silage were continued at the Tobacco Experiment Station, Greeneville. Four silos were used of 10-tons capacity each. Two were filled with alfalfa, one with corn, and one with corn and sorghum. Blackstrap molasses was applied as a preservative to one silo of alfalfa. The other received no treatment. Corn and sorghum were ensiled without

added preservative, according to the usual practice for such crops. Samples from each silo were taken periodically for chemical analysis. Feeding trials of the silages were made during the fall and winter. Results are being compiled and will be reported in a later publication. Table 38 shows the chemical composition of the silage made in 10-ton experimental silos and fed to animals during the winter of 1943-44.

Table 38—*Composition of alfalfa, sericea, alfalfa-sericea, and corn-sorghum silages made in experimental silos of 10-tons capacity.*

Results given on 70-percent basis.

Constituents determined	Alfalfa silage		Sericea silage		Alfalfa-sericea silage		Corn-sorghum silage
	None[1]	Molasses[2]	None[1]	Molasses[2]	None[1]	Molasses[2]	None[1]
	Percent	Percent	Percent	Percent	Percent	Percent	Percent
pH value	4.86	4.38	4.60	4.71	5.01	4.75	3.92
Dry matter	30.00	30.00	30.00	30.00	30.00	30.00	30.00
Ash (mineral matter)	2.62	2.79	1.42	1.62	2.47	2.72	1.56
Crude protein (% N x 6.25)	5.73	6.04	4.25	4.29	4.80	5.78	2.25
Crude fat (ether extract)	1.24	1.34	.98	1.20	1.30	1.60	.87
Crude fiber	10.43	8.88	9.28	9.03	7.91	7.53	8.18
Nitrogen-free extract	9.98	10.95	14.07	13.86	13.52	12.37	17.14

[1]No molasses added.
[2]Blackstrap molasses added at rate of 5 gallons (60 pounds) per ton of green material.

If proper methods are employed, many green forage crops can be made into silage that will remain in good condition, without excessive loss of food nutrients. Forage crops should be of good quality when placed in the silo, and if properly handled they will be palatable and nutritious when removed from the silo for feeding. In Tennessee, many legumes can be grown cheaply and abundantly. Weather conditions, however, are sometimes unfavorable for curing them into hay. The silo is an excellent place in which to conserve such crops. Properly made silage of any legume crop usually has a higher content of carotene (pro-vitamin A) than the same crop cured in the field as hay, figured to the same moisture basis. Possibly some of the favorable results which have been obtained from feeding tests of good alfalfa silage should be attributed in part to the content of carotene.

When finely cut legumes are packed in the silo, the temperature rises for several days, because of respiratory activity, then gradually subsides. The rise in temperature is accompanied by fermentation processes caused by organisms resulting in the formation of some lactic and acetic acids. The formation of these acids, especially lactic, is necessary since they inhibit the growth of putrefactive organisms that cause decay. Then, too, these acids add to the quality of succulence.

Respiratory activity and mold growth are dependent upon the presence of oxygen. Consequently, a well-compacted mass of silage is less likely to undergo undesirable changes which result in the loss of nutrients and palatibility, and the growth of molds is less likely to occur. It is common to find spoiled silage at the top of the mass, where it is exposed to air.

In general, legumes possess insufficient carbohydrates from which lactic and acetic acids—beneficial in the preservation of silage are developed. For this reason greater care must be exercised in the making of legume silage than is necessary in the making of corn or sorghum silage.

It has been found that legumes may be successfully ensiled in the following ways:

1. In combination with crops containing carbohydrates, such as corn and sorghum.

2. By the addition of blackstrap molasses at the rate of 60 to 70 pounds per ton of crop material.

3. By the addition of cull sweetpotatoes at the rate of 4 to 4½ bushels per ton of crop material. Cull sweetpotatoes should be fed into the silage cutter with the crop material.

4. By the addition of 30 pounds of 50-percent orthophosphoric acid or a mixture consisting of 40 pounds of molasses and 15 pounds of 50-percent orthophosphoric acid, per ton of crop material.

5. By the addition of 125 pounds of corn meal, or 150 pounds of corn-and-cob meal, or 125 pounds of other finely ground cereal, per ton of green crop material.

While the addition of carbohydrates or acid preservative to leguminous crops at the time of ensiling is recommended, it is not impossible to make fairly good legume silage without adding such preservatives, provided the moisture content of the crop does not exceed 65 percent and other conditions are properly controlled.

In order to obtain good distribution of preserving materials, liquids should be added to the crop through a hole in the metal housing of the silage cutter, and solids should be distributed on the material as it passes into the cutter.

In general, grasses and legumes should have a dry-matter content of 32 to 36 percent at the time of ensiling. Leguminous crops having a moisture content in excess of 70 percent at the time of ensiling are likely to result in foul-smelling silage of inferior quality. Moist legumes, particularly soybeans, should be allowed to wilt slightly before being put into the silo.

On the other hand, if the crops are ensiled when too dry, excessive heat may develop and cause a loss of nutrients. In case the material to be ensiled has become too dry, water should be added to supply the deficiency of moisture so that it will remain cooler and pack well. If moisture-testing equipment is available, such as is used in the toluene distillation method, the moisture content of the crop can be determined, and water then may be added at the rate of 2½ gallons per ton of crop material for each percent of moisture below 65. If other conditions are controlled, material with 65- to 70-percent moisture (30- to 35-percent solids) usually will produce good silage.

FRUIT JUICES

Experiments in the preparation of fruit-juice concentrates were continued during the year. Juice concentrates were prepared from blackberries, red raspberries, strawberries, and cherries. Undiluted juices containing 10 percent added sugar were concentrated by removal of water as ice (freezing) and centrifugal separation of concentrates from ice. The concentrates were packaged in waxed paper cups and stored at 0° F. Raspberries, strawberries, and cherries produced concentrates that retained excellent flavors after 8 months in 0° F. storage. Blackberry concentrate developed a slightly bitter flavor during the same time in storage.

Expressed fruit juices to which 10 percent sugar was added yielded the following amounts of concentrate, based on the weight of fresh fruit used: Blackberry, 23 percent; strawberry, 30; red raspberry, 31; and red sour cherry, 43 percent. The concentrates were assayed for vitamin C (ascorbic acid) after 8 months in storage at 0° F. with the following results: Blackberry, 11.27 mgs. per 100 grams; cherry, 11 mgs.; red raspberry, 16.35 mgs.; and strawberry, 30.14 mgs. Juice concentrates held at ordinary kitchen refrigerator temperatures (not in the frozen condition) retained good flavor, but lost some vitamin C. The concentrates may be frozen in waxed containers of any size, or as cubes which are easy to handle.

With the advent of the home freezer-storage cabinet, fruit-juice concentrates may be prepared, stored, and used to good advantage for beverages and ice cream flavoring. Experiments are being continued with a view to making the home preparation of fruit concentrates more practical.

SWEETPOTATO DEHYDRATION

Experimental dehydration of sweetpotatoes was continued, with 6 of the 16 varieties studied the previous year. The fresh sweetpotatoes were peeled, cut into slices and cubes, and then blanched in steam. Some of these were preserved by dehydration and some by freezing. Another lot was partially dehydrated and then frozen. All were packaged in moistureproof containers.

It was found that blanched sweetpotatoes held very well in the frozen condition. Likewise, the blanched, partially dehydrated material retained good quality in 0° F. storage. The unblanched product lacked flavor and darkened somewhat in frozen condition. Completely dehydrated potatoes retained fair quality after 6 months' storage at room temperature, but those stored at 0° F. were of superior quality. Unblanched, dehydrated potatoes were starchy and flavorless.

Blanched, diced sweetpotatoes that have been partially dehydrated prior to freezing appear to have interesting possibilities and will receive further study. Experiments are under way to explore the food possibilities of mixtures of specially treated sweetpotatoes and pulverized oil-free peanuts, preserved by dehydration and by freezing.

MISCELLANEOUS CHEMICAL WORK

Analytical and cooperative services on a wide variety of subjects and materials have been rendered other departments of the Station, the Extension Service, and the College of Agriculture.

PROTEIN AND MINERALS IN FORAGE CROPS

K. B. Sanders

A final report on the project Protein and Minerals in Forage Crops was made to the Office of Experiment Stations and the project was revised. Further work will be related as closely as possible to the needs of the livestock industry.

The Tennessee Station has made considerable progress in developing practical methods whereby an adequate quantity of pasturage and hay for the livestock of the State can be provided. The need for an evaluation of the quality of forage crops as regards nutrient content was recognized many years ago, and the problem of quality of forage crops has been systematically studied by the Tennessee Station since 1932. Excepting in the case of the lespedezas, however, the information thus far obtained regarding the chemical composition of forage crops in Tennessee is not exhaustive. The composition of the lespedezas has been found to vary greatly in different sections of the State and under different conditions of culture; and probably the composition of other forage crops is likewise variable. It is believed that adequacy of forage crops with respect to quality may make the difference between success and failure in the production of livestock in any area of Tennessee. For these reasons, continued investigation of the nutrient content of Tennessee forage crops is necessary.

The work done under authorization of the original project dealt with the chemical composition of grasses and legumes, especially the lespedezas, as influenced by various environmental conditions and cultural practices. The major findings may be summarized as follows:

1. The chemical composition of the lespedezas was found to vary over a considerable range. This was due to various factors in their growth, such as soil type, degree of soil fertility, location, season, and stage of growth.

2. The annual lespedezas—Korean, Kobe, and Tennessee No. 76—may differ materially in chemical composition when grown under comparative conditions.

3. Leaves contain a much greater concentration of protein and of the ash elements, excepting potassium, than do stems in the case of both the annual and perennial (sericea) lespedezas.

4. Major areas of Tennessee in which the lespedezas are likely to be deficient in certain elements, notably phosphorus, have been roughly delineated.

5. The poorer soils wherever found produce lespedeza which is deficient in certain elements, particularly in phosphorus.

6. Light applications of phosphate-containing fertilizers on these poorer soils usually increase yields of the lespedezas, but seldom alter their phosphorus percentage appreciably; and, not infrequently, an increase in yield is accompanied by a decrease in phosphorus percentage.

7. Heavy applications of complete fertilizer containing nitrogen, phosphorus, and potassium cause decided increases in phosphorus concentration in the crop.

8. The composition of the lespedezas is influenced materially by the degree of fertility of a particular soil type and also by the balance of plant nutrients applied to the soil as fertilizers.

It also may be deduced from findings 5, 6, 7, and 8 above that the methods by which the quality of a particular species can be improved (7, 8) probably can be used to encourage the growth of successively more desirable species.

Publications resulting from this work include Bulletin 166, "Mineral and Nitrogen Content of Lespedezas and Other Hay Crops in Tennessee," by E. K. Weathers, and progress reports in the Station's Annual Report as follows: 1932, page 26; 1933, page 39; 1934, page 22; 1936, page 31; 1937, page 26; 1938, page 49; 1939, page 28; 1940, page 58; 1941, page 49; 1942, page 48; 1943, page 70.

The major studies which will be undertaken under authorization of the revised Bankhead-Jones project are as follows:

1. Important legumes and grasses produced in major areas of the State will be analyzed for those elements of greatest importance in animal nutrition—nitrogen (nitrogen $\times$ 6.25 = protein), calcium, and phosphorus. In particular the composition of alfalfa and of the annual summer hay and pasture plants—common Sudan, Tift Sudan, Tennessee German millet, and browntop millet—will be investigated.

2. In the areas where the calcium, nitrogen, and phosphorus content of forage crops is considered deficient for the economic production of animals, practical means will be sought for improving the quality of forages by—

a. The application of lime and fertilizers,
b. The gradual improvement of soil fertility, or
c. Other means.

3. The effect of borax applications on the chemical composition of legumes, especially of alfalfa, will be investigated.

The General Chemistry and Agronomy Departments are cooperating closely in these studies; and wherever possible it would be desirable to coordinate the work of this project more closely with related work in Animal Husbandry, Dairying, and Agricultural Engineering at the main Station at Knoxville and at the substations throughout the State.

ECONOMICS AND SOCIOLOGY[4]

C. E. Allred

Work on projects of the Economics and Sociology Department has again been oriented toward the shaping of an agricultural program for the State to fit the changed economic conditions brought about by war and the problems that are likely to occur in the postwar period.

AGRICULTURAL ADJUSTMENT

Cooperation was continued with the Federal Bureau of Agricultural Economics in setting up war-food-production goals. The study begun in 1943 to test response to the agricultural planning program, and to determine the feasibility of greater production on farms of varying size and resource combinations, was completed. Results are embodied in Monograph 163, "Production Capacity of Farms of Different Size Groups, Jefferson County, Tennessee."

Some aspects of production, by size of farm, in a county where land resources are low in relation to farm population, are reported in Monograph 173, "Farm Size in Relation to Land Use, Yields, Volume, Value of Production, and Total Nutrients, Overton County, Tennessee." Crops that occupy proportionately less tillable land, as farms became larger, are: corn, potatoes, garden and truck crops, sorghum, and orchard. On the other hand, acreage of wheat, hay, and idle cropland increased proportionately with size of farm. Tillable land represented 36.3 percent of the land in farms, in the group with less than 30 acres tillable; farms larger than this averaged about one-half tillable.

Induction of large numbers of men into the armed forces, and migration of civilians into expanded war industries, probably will result to some extent in a permanent shift in population, which must be taken into account in postwar planning for agriculture. As part of an adequate background for studies in agricultural adjustment, a report was prepared on "Population Situation and Trends in Tennessee as a Whole," Monograph 166.

Construction of Douglas Dam by the TVA, as a war measure, to generate electric power, created an artificial lake flooding approximately 31,000 acres. Since most of this previously was farmed, a number of problems in readjustment were raised. A postwar recession might find many farmers in the area with diminished land base. In view of present food needs, and of impending postwar readjustments, a study was made to determine how the flooded land had been used prior to the time that Douglas Dam was built. Monograph 176, "Former Use of Land Now in Douglas Reservoir," covers important phases of this study.

Jefferson County was selected as a sample area in which to study methods used by farmers in adjusting their cropping systems to different types of soil (Fig. 14). The results of this survey are

[4]The following staff members cooperated in carrying out the program reported herein: B. H. Luebke, H. J. Bonser, W. P. Ranney, F. N. Masters, C. C. Mantle, A. H. Chambers, and W. S. Rowan.

reported in Monograph 169, "Association of Crops with Soils and Other Factors, Jefferson County, Tennessee."

It was found that row crops and small grains are grown to a greater extent on soils weathered from limestone and crystalline rocks; hay, grass, and pasture crops are found more often on soils derived from acid rocks; while the greatest proportion of open non-cropland consists of soils weathered from shales. Row crops are planted on 57 percent of the class I open land; on 27 percent of class II; 17 percent of class III; 14 percent of IV; and 15 percent of V. Small grains dropped from 16 percent of class I land to 3 percent of class V.

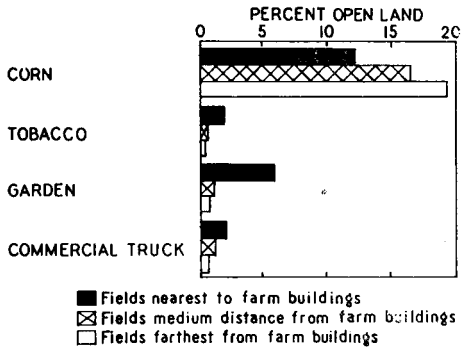


Fig. 14—Percent of open land in crops, by nearness of fields to buildings—176 farms, Jefferson County, 1939.

Study of the comparative advantages of 3 competing crops in West Tennessee, begun in 1943, was continued. The findings were reported in Monograph 168, "Possibilities of Sweet Potato Production in West Tennessee." In the commercial area about 40 percent of the growers applied commercial fertilizer, and 30 percent treated seed potatoes to control diseases. That good practices are profitable was indicated by the higher-than-average net income from sweetpotatoes on representative farms that followed improved practices.

Market varieties of sweetpotatoes produced almost 1.5 times as much feed per acre as corn, on the basis of average yields and usual practices in the commercial area in 1942; net return per acre for the labor used was slightly greater for sweetpotatoes; but return per hour of labor from sweetpotatoes was only about one-fourth of that from corn.

TYPES OF FARMING

Type-of-farming area 12, the Cumberland Plateau, received special attention in 1944. Rather rapid settlement of this area was taking place prior to the war, and it is expected that the movement will be resumed within the next few years. Experiment Station Bulletin No. 192, "The Cumberland Plateau in Tennessee," was published to make fundamental information regarding this area available to prespective settlers.

"How the Plateau Is Farmed on Sand Mountain, Alabama," Monograph 179, analyzes the agriculture of the southern part of the Plateau, which is similar in many respects to the Tennessee part, but better developed. The object was to see what might be learned that would be applicable in Tennessee.

Analysis was made of the management of 107 unit-test demonstration farms on the Cumberland Plateau. A perfect correlation

was found between the number of productive animal units and labor earnings. Also, the larger the income from Irish potatoes the larger the labor earnings of the farm. Results were reported in Monograph 165, "Farm Management Analysis of 107 Farms on Cumberland Plateau."

Inputs and costs involved in clearing land were studied for 97 farm tracts on the Cumberland Plateau, and reported in Monograph 177, "Labor, Materials, and Cost of Clearing Land on Cumberland Plateau." The average cost of clearing land to the stump stage was $24.41 per acre; of pulling stumps and following operations, $24.55 (Fig. 15). Labor alone averaged $14.28 per acre in the former case and $24.14 in the latter.

Value of salvaged timber products averaged $36.81 per acre. Thus the average income in excess of cost for farmers had they cleared only to the stump stage would have been $12.40 per acre. However, the total cost when stumps were removed was $12.15 per acre larger than the return from timber products removed. Farm-

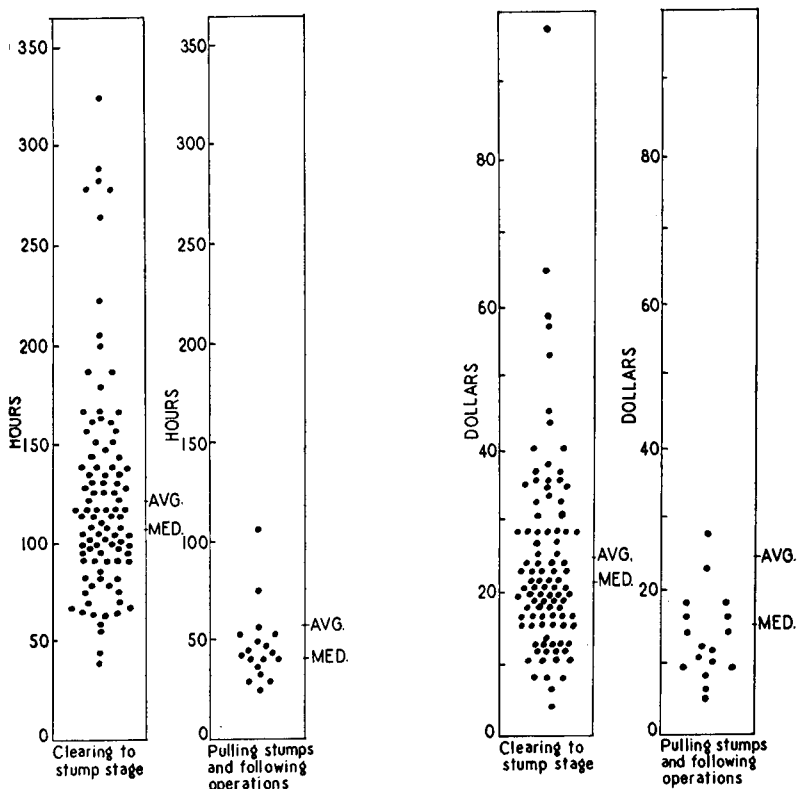


Fig. 15—Labor and cost of clearing land, per acre, sample farms, Cumberland Plateau.

ers estimated clearing and stumping to have increased land values $9.63 per acre, on an average. On this basis the net loss to farmers would have averaged $2.52 per acre.

Study of the snap bean enterprise, begun in type-of-farming area 14 in 1943, was continued and extended to area 12 in 1944. Field work has been completed, and analysis of the data is under way.

To determine if credit and credit facilities are sufficient to permit and encourage development of the Cumberland Plateau area, farmers and lending agencies of Cumberland, Fentress, Morgan, and Scott Counties were interviewed. First report of findings appeared in "Use and Need of Farm Credit on Cumberland Plateau," Monograph 178.

One-seventh of the farmers interviewed indicated the need for additional short-term credit, principally for crop production. These farmers sold from 2 to 4 times as much Irish potatoes, beans, and tomatoes as the average of all farmers interviewed.

Studies were continued of land classification as a factor in type of farming. A report was issued entitled "Quality of Land as a Factor in Farm Organization, Crop Yields, and Farm Income in Roane County, Tennessee," Monograph 172. Proportionately more double cropping was found on classes II and III uplands than on either of the poorer classes IV and V uplands or on river bottoms. Estimated normal corn yields averaged 31.9 bushels per acre on land class II, 24.6 bushels on class III, 22.8 bushels on class IV, and 16.4 bushels per acre on class V (Fig. 16). As soil slope increased, there was a decrease in corn yield per acre, even within the same soil series.

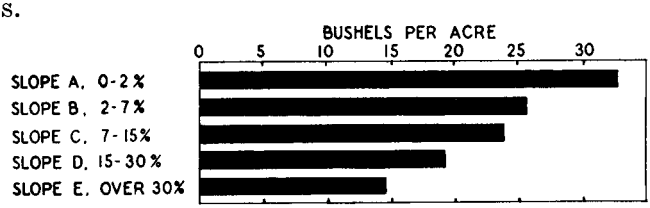


Fig. 16—Normal corn yields, by steepness of slope—93 upland farms, Roane County.

COOPERATIVE MARKETING

Studies in cooperative marketing were continued, including the marketing agencies involved in a given farm-market area. The role of both private and cooperative agencies must be considered before recommendations are made for changes in cooperative organizations. The study of possibilities of cooperation in the Knoxville milk shed, begun in 1943, was continued, and four reports were issued during the year, as follows: "Consumption of Dairy Products in Knoxville," Monograph 164; "Milk Delivery in Knoxville," Monograph 167; "Facilities and Agencies of Knoxville Milk Industry, 1943," Monograph 171; "Changes in Milk Collection Situation, Knoxville Milk Shed, 1943 and 1944," Monograph 174.

Dairy products and butter substitutes used by Knoxville families amounted to 21.5 percent of their weekly food bill. Average daily per-capita consumption of whole milk, March 1943, was .52 pint; of buttermilk, .18 pint. The amount of whole milk purchased by the low-income group was about one-half that purchased by the highest-income group; but the low-income families purchased over twice as much buttermilk.

In a sample residential area of the city, in which the milk-delivery situation for each family was recorded, 367 families were served by 21 retail trucks and 5 stores (Fig. 17). It was estimated that bottled-milk deliveries now requiring 14 distributors could be handled by one cooperative retail truck of average load, thus reducing truck costs by 70 percent and labor by 45 percent. Stores served 52.8 percent of the whole-milk customers, and 42.8 percent of buttermilk customers (Fig. 18).

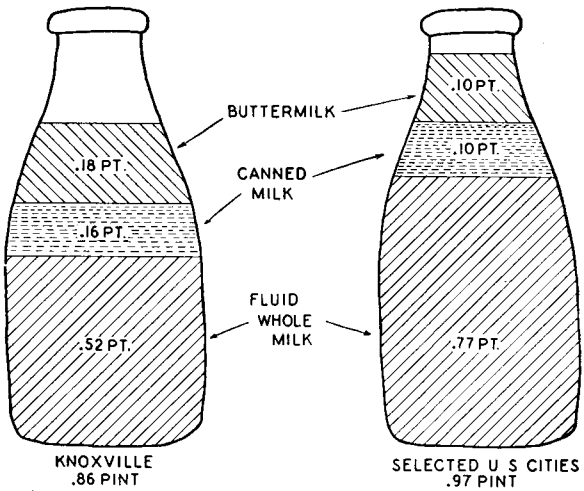


Fig. 17—Per-capita daily consumption of milk equivalent, Knoxville and United States.

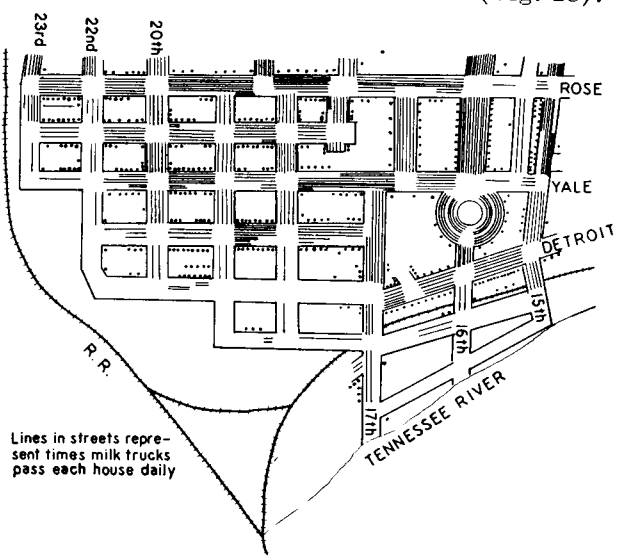


Fig. 18—Composite map of all milk-delivery routes in sample area, Knoxville, 1943.

Unusual factors entered the egg demand-and-supply situation in Tennessee during the year, causing abnormal price behavior. Monograph 175, "Producers' Prices for Eggs in Knoxville Trade Area," deals with price factors operating in the principal wholesale egg markets of East Tennessee, and with opportunities for improving the situation.

A progress report on changes in milk-collection economies in the Knoxville milk shed between 1943 and 1944 showed reduction in number of inefficient haulers in the area near Knoxville; but the decrease in number of nearby dairies necessitated more long-distance hauling to deliver the required amount of milk.

COTTON MARKETING

Cooperation was continued with the Cotton Division, Federal Agricultural Marketing Service. Cotton-improvement associations were set up in 26 Tennessee counties in 1944. In 6 of these counties, two groups were organized—one composed of farmers who planted largely the Deltapine variety, and another of farmers who planted Stoneville 2B. In 14 counties, educational meetings were held to acquaint farmers with the cotton-improvement work and the free-classing services. More than 21,000 cotton producers were members of organized cotton-improvement groups. These farmers submitted 120,000 samples for classing, compared with 79,000 in 1943. Members of the 32 cotton-improvment groups planted 420,845 acres of an improved variety of cotton in 1944, compared with 235,000 in 1943. The comparative percentages, by districts, of the cotton ginned that was classed in 1943 and 1944 were: District I, 18.5 in 1943 and 26.3 in 1944; District II, 16.4 and 24.1 respectively. In only 3 counties was there a decrease in 1944. In Henderson County the increase was from 0.7 percent in 1943 to 65.4 in 1944.

During September and October, sampling-agent agreements were secured from more than 200 agencies that indicated a willingness to act as sampling agent for cotton producers belonging to organized improvement groups. Supplies were delivered to these sampling agents throughout the ginning season. In many instances it was necessary to show the sample taker how to cut and prepare samples for shipment. Regulations were amended in late ginning season to require that sampling agents be bonded if the cotton was to be offered, and accepted, through the government purchase program. Only about 60 bonds were executed in Tennessee.

Some supervision of the sampling of cotton seed was given at the several oil mills throughout the State. However, a large part of the seed had been sold when this work got under way.

Most of December was devoted to a study of the various ginning services offered to Tennessee farmers and the charges for each service. This was done in cooperation with the Cotton Marketing Studies Section, U. S. Department of Agriculture.

FOREST AND FARM ECONOMIC SURVEY

R. F. Kroodsma

The forest and farm economic survey has proceeded along the lines established in 1942. The survey consists of two phases: (1) the collection of economic data, with stress on farm woodlands and their place in the farm economy; and (2) a detailed examination of farm woodlands to determine species, soil, slope, growth, freedom from fire and grazing damage, and other factors.

Special attention is being given to the importance of wood products in the farm economy. For each farm visited, a detailed list is made of all wood products used or sold during the year; and a map is drawn showing (1) the amounts, types, locations, and ages of all woodlands, and (2) the locations and types of fences. In addition to the map, a list of all wooden structures on the farm is being compiled, by size, cubic-foot contents, and board feet of materials. At the conclusion of the project, the following statistics will have been compiled for farms of different sizes:

1. Number of fence posts required.
2. Annual requirements of fuel wood, fence posts, repair lumber, and other wood products.
3. Number of buildings per farm.
4. Board-feet capital of buildings.
5. Per-hour earnings for woods work.
6. Total drain in cubic feet of wood products.

The difference between total annual growth of farm woodlands as determined by the woodland inventory, and the drain caused by farm requirements, will indicate the possibilities of increased farm income from woodlands through cooperatives or otherwise.

During the past year, 54 new farm contacts were made in the 12th civil district, and woodland inventories were completed in the 9th, 24th, and 13th districts (Fig. 19). Inventories for the 12th district are practically current with the economic survey. A total of 3357 acres of woodland was inventoried during the year, 55 percent (1870 acres) of which was merchantable. The remainder contained less than 1000 board feet of lumber per acre.

Although no definite conclusions can be drawn from the surveys as completed to date, some trends are evident and some general statements can be made.

The following interesting and important facts have been brought out:

1. The woodland apparently is the most neglected part of the farm. This is due not so much to lack of interest as to lack of information and to the stressing of other farm enterprises.

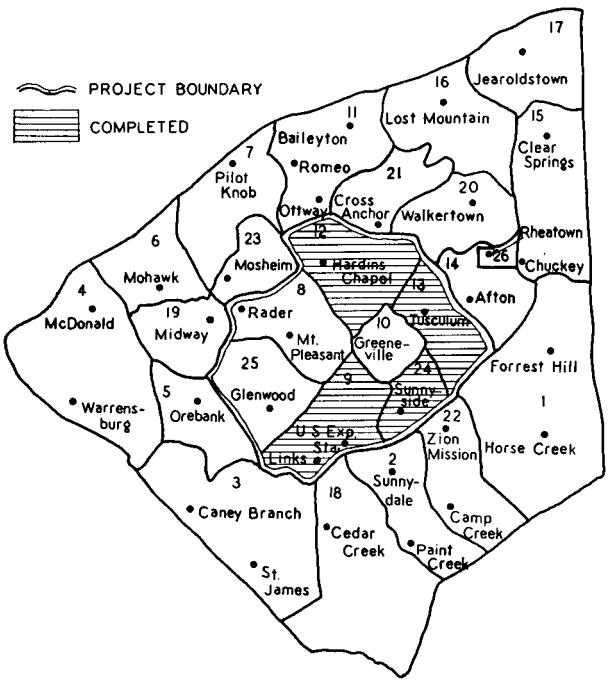


Fig. 19—Map of Greene County, Tennessee, showing location of forest and farm economic survey.

2. The majority of farm woodland owners have never sold any products from the farm woods. Much of the merchantable timber on farms is overmature and stagnating.

3. The greatest use made of the farm woods is for fuel, although many farmers have been forced to reduce their fuel-wood consumption in the past 5 years because of a shortage of help.

4. Of the farms in the 9th district, 48 percent have less than 5 acres of woodland per farm. Only 10 percent of all farm land in this district is in woods.

5. There is considerable misuse of products cut from the woods.

6. In the area already covered by the survey, over half of the farms have reduced their wood acreage in the past 5 years.

7. Most farm woodlands are grazed, but tracts injured by fires are the exception.

8. Most farmers are better equipped with tools for handling the woods than for other operations.

9. The survey to date indicates that farm papers and magazines are better than the radio as a medium for educating the farmer in regard to his woods.

10. A large percentage of farmers think that farm woodlands are taxed too high.

ENTOMOLOGY

S. Marcovitch and W. W. Stanley

SWEETPOTATO INSECTS

In 1942, the sweetpotatoes at the University Farm and in other parts of the State were seriously injured by holes and pits spread over their entire surface, as seen in figure 20. This injury was present also in 1943, but was not observed in 1944, a dry year.

Fig. 20—Sweetpotato injury in the field caused by larvae of the flea beetle, Systena elongata.

It appears that a wet season, such as 1942, favors the presence of the pest responsible for the damage. At first, the sweetpotato flea beetle was suspected of being the culprit, but rearing work failed to reveal any connection. Later it was found that another flea beetle, *Systena elongata,* was the cause of the injury. Very little is known of this pest, and much must be learned of its habits and life history before adequate control measures can be recommended.

BEAN BEETLE INVESTIGATIONS IN JOHNSON COUNTY

The bean beetle continues to be the limiting factor in the production of beans in Johnson County. This year, the Associate Entomologist has carried out investigations in that county on a much larger scale than in 1943. With the cooperation of the County Agent and the growers, practical field tests were made on 8 farms, embracing a total of about 70 acres.

The principal insecticides used were .75-percent rotenone and cryolite, both being effective materials when properly applied. Early in the season, when showery weather prevailed, the rotenone was somewhat the more effective. Later the corn earworm made its appearance in some fields. For this pest, cryolite is the more effective. It is estimated that about 100 tons of rotenone dusts and 53 tons of 60-percent cryolite dusts were used, the total retail value being about $42,000.

The practice of growing two crops of beans is mainly responsible for the enormous number of beetles in Johnson County. Where the first crop is not destroyed after picking, the situation becomes aggravated. The only way to control this pest is by the destruction of the vines soon after picking and a vigorous campaign of dusting. Community clubs might take on the project of bean beetle control, since it is a community problem.

It is planned during the coming season to try out new insecticides, such as Sabadilla and DDT, not only for the bean beetle but also for the bean leafhopper, which at times assumes considerable importance.

INSECTICIDAL PROPERTIES OF SOME COAL-TAR PRODUCTS

In the investigation of certain coal-tar products, it was observed that cresylic acid possessed good knockdown properties. Few insecticides have sufficiently quick action to stop the insects from crawling soon after they are hit. Pyrethrum has excellent knockdown, affecting the nervous system and producing paralysis. Phenol and its derivatives affect the nerve ends, and thus quickly produce paralysis.

In this study, the German roach and the common *Culex* mosquito were used as test animals. On roaches the materials were applied in the dust form, being mixed with an inert absorbent, such as "Diluex." This is a grade of fuller's earth; it has excellent absorbent properties, and is capable of taking up from 10 to 30 percent liquid and yet remaining a relatively dry dust. These dusts were forced, by means of a foot pump, into a celluloid cylindrical tower and allowed to settle for 5 minutes on the roaches. Usually a charge of 500 milligrams was employed. It produced a deposit of about .8 milligram per square centimeter. A typical dust consisted of—

	Percent
Cresylic acid	3
Methyl napthalene	3
Kerosene	24
Diluex	70

The commercial "cresylic" acids are so designated for convenience, but actually they consist of mixtures of phenols, cresols, xylenols, and alkyls, and are fractionated according to boiling points as they come off the stills.

In order of toxicity, as dusts, they were as follows: (1) Phenols, (2) cresols, (3) xylenols. The peak of toxicity was reached with a commercial cresylic acid, X-1 grade, from the Koppers Company, having a boiling range of 210-217° C. A 3-percent dust, as designated in the table above, killed 91 percent of the roaches in 24 hours, and also had good knockdown.

This X-1 cresylic acid contains about 30 percent meta para cresol, the remainder of the contents being mostly xylenols. A petroleum cresylic acid from the Shell Oil Company, with a boiling range of 225° to 250° C., showed poor toxicity at the 3-percent level.

The tar oils with boiling ranges of 230° to 360° C. generally were much lower in toxicity than the tar acids when tested as dusts on roaches.

In another series of tests, mosquito larvae were employed. Cresylic acid is used to some extent as a larvicide in mosquito control, especially where a quick kill is required. The materials tested are shown in table 39.

Table 39—*Toxicity tests of coal-tar acids and oils.*

Material	Source and boiling range	Dose	Dead in—		
			1 hour	2 hours	3 hours
			Percent	Percent	Percent
Phenol	U. S. P. 186° C.	1-5,000	0	0	0
Cresol	" 202° C.	1-5,000	0	0	0
Cresylic acid	Koppers 210-217° C.	1-5,000	0	30	90
" "	" 220-225° C.	1-5,000	0	50	90
" "	" 220-240° C.	1-5,000	0	50	50
" "	Shell 200° C.	1-5,000	50	50	50
" "	" 225° C.	1-5,000	90	100	.....
Tar oil	Reilly 225-360° C.	1-5,000	100	.....	.....
Culicide (B)	Socony 150-250° C.	1-5,000	100	.....	.....

It is interesting that the same materials show a different order of toxicity when another test animal is employed, or when a different formulation of the same material is used. Among the tar acids the petroleum cresylic acid showed greater toxicity than the coal-tar cresylics. Tar oil was even more toxic than the tar acids when used in a concentration of 1 part to 5000 parts of water. Culicide (B), a by-product in petroleum cracking, showed good toxicity, killing the mosquito larvae in less than one hour.

NEW INSECT PESTS ENTER TENNESSEE

The European corn borer (*Pyrausta nubilalis*), introduced into the United States in 1909, has finally found its way into Tennessee and is now present in Sumner, Montgomery, and Robertson Counties.

The Japanese beetle (*Popillia japonica*), first observed in New Jersey, in 1916, has appeared at Bristol and Mountain City.

Comstock's mealybug (*Pseudococcus comstocki*), has been found in Swann's apple orchard at Dandridge. Injury is due primarily to the fungous growth on the honeydew produced by the mealybugs.

HOME ECONOMICS

Florence L. MacLeod and Mary L. Dodds

RETENTION OF ASCORBIC ACID IN FOODS

The project on the ascorbic acid stability in food served to army units stationed at the University of Tennessee was initiated in 1943, but the greater part of the work was done during the first half of 1944. Data were published in mimeographed form in Oc-

tober, 1944, as "Progress Notes." The Institutional Management Department of the School of Home Economics, which operates the institutional kitchens of the University, cooperated in the study. The foods investigated were limited to those which should contribute appreciable amounts of the vitamin to the diet because of the original content or the quantity eaten. Eleven commodities, some of them consisting of the same vegetable prepared in different ways, were analyzed for ascorbic acid and dry weight before and after cooking and through the serving period. Of eight commodities, 10 samples were taken before preparation and 10 after; of the other 3 commodities, 5 samplings replaced the 10. Each sampling was replicated 6 times.

The results of the experiment, although furnishing calculated average retention values, served to emphasize sharply the limitation of such data. Factors which cause irregularity in results are of two kinds: first, the innate variability of physiological material which is always present; second, the manipulations of the material from storage to serving. Because of moisture and seasoning changes in processing, percentage retention under the conditions of this study appears to be an invalid criterion, giving no means of comparison either on the wet or the dry basis. An effort was made to approximate a correction. This showed retentions to be higher than those calculated. Figures are given in the "Progress Notes" mentioned above.

In a study of this kind the fixing of controllable variables defeats to a degree the original purpose of observing actual institutional methods and of determining the losses in such preparation. The extensive data collected in the course of the work showed very definite trends, which, if better understood, might help to bridge the gap between results of work rigidly controlled and results under institutional procedures. With this possibility in view, cabbage and spinach were chosen and the effects of added seasonings, especially fat, were followed by the sampling of the same batch throughout the periods of cooking and serving. The samples were analyzed for dry weight and ascorbic acid. For cabbage, 3 samples were taken raw, 3 after cooking but before any additions were made, 3 after salt addition, and 3 after fat addition. This last sampling extended through the serving period. Spinach was similarly sampled in the cafeteria, and the work was paralleled by laboratory scale studies. Gross alterations in dry weight could be attributed to definite procedures in preparation. The data have provided a means of observing some of the changes occurring throughout the large-scale preparation and, to a degree, a quantitative measure of the changes. In this series of experiments both the Loeffler and Ponting indophenal methods for ascorbic acid and the Roe 2, 4-dinitrophenylhydrazine method for total ascorbic acid (ascorbic and dehydroascorbic acid) were used. While the values differed little for these vegetables, the Roe method seems worth while, since with it all antiscorbutic material is accounted for.

HUMAN EXPERIMENTS

Two papers dealing with experiments on the ascorbic acid metabolism of women were published in the *Journal of Nutrition* in 1944. Work was continued in the summer. Statements in the literature have indicated that human ascorbic acid studies made in the summer months have shown irregularities. It is stated also that the loss of ascorbic acid in perspiration is a factor to be considered in industrial plants and in desert fighting. Data on actual loss of ascorbic acid in sweat have not indicated large losses, but the vitamin possibly could be destroyed in coming through the sweat glands and therefore not be found on analysis. The findings in this laboratory of a weight requirement of approximately 1 mg./kg. of body weight for a normally active woman suggested the possibility of investigating an alteration of this relationship due to summer heat. Accordingly, 7 women were studied for their requirements for 4 weeks, June 19 to July 16, 1944. The mean average temperature range per day was from 78.5 to 90.8° F. The outcome of this work was inconclusive and suggested that either the experimental period was too short for adjustments to be made for pre-experimental differences in the subjects, or the summer temperatures did alter the metabolism of ascorbic acid. The first possibility is the more likely in the light of the accumulated data of this laboratory.

HORTICULTURE

EXPERIMENTS AT KNOXVILLE STATION

Brooks D. Drain, A. B. Strand, Donald S. Burgis, and Joan K. Wiley

A shortage of help, both skilled and unskilled, necessitated further curtailment in the work of the Horticultural Department at Knoxville. Only a small amount of hybridizing was done on any project. Progenies and materials already under test were taken care of.

PEARS

A group of Station workers from adjacent states went over the pear-breeding project at both Knoxville and Clarksville in early October. Seven selections having superior plant and fruit characters had been isolated and propagated, and were furnished to our guests for trial at their home stations. Ten other selections were furnished, upon request, to neighboring stations for trial and for use in breeding work.

Low temperatures killed many pear blossoms in April, but a small crop of fruit was produced and fruit notes were taken. A few successful crosses were made and hybrid seed saved. A small population of hybrid seedlings were grown from seed and transferred to the field. Several thousand fire blight inoculations were made in pear trees growing in nursery rows. The dry weather of July and early August interfered with the development of blight

from these inoculations, but several hundred blight-susceptible seedlings were isolated and destroyed. A large number of more-or-less fire blight-resistant seedlings were propagated on *Pyrus calleryana* stock.

SMALL FRUITS

Strawberries.—Irrigation was used on one half of a strawberry range that fruited for the second season. The test was started in 1942 and was laid out with a guard strip between the irrigated and nonirrigated plots. Small differences in yields were noted during both seasons. It was concluded that applications of water did not pay under conditions of this trial.

The more recently developed varieties of strawberry were grown in comparison with the older sorts. Table 40 presents yield data on 6 of these varieties. The differences among the 3 new varieties—Tennessee Shipper, Tennessee Supreme, and Tennessee Beauty—are small. These varieties gave much larger yields than Aroma, Premier, and Blakemore.

Table 40—*Yields*[1] *of strawberry varieties, second season,* 1944.

Variety	Number of plots	Irrigated		Not irrigated	
		Average yield per plot	Yield per acre	Average yield per plot	Yield per acre
		Pounds	Crates	Pounds	Crates
Blakemore	17	15.22	180.2	15.13	179.1
Tennessee Shipper	4	15.41	182.5	18.82	222.8
Premier	1	10.53	124.6	11.83	140.0
Tennessee Supreme	4	17.27	204.5	16.08	190.4
Aroma	1	[2]3.65	[2]43.2	[2]5.09	[2]60.2
Tennessee Beauty	4	[2]15.02	[2]177.9	[2]18.59	[2]220.1

[1]A small amount of cold injury in April.

[2]Picking discontinued May 31.

Neighboring states, as well as Tennessee, increased their plantings of the 3 varieties developed by this Department.

Raspberries.—A number of successful black raspberry crosses were made; the hybrid seed were stratified and later planted.

A large population of red raspberries were fruited and fruit notes taken. Some superior selections were isolated and propagated for further trial. The older selection range was moved and discard material destroyed.

More extensive plantings of the 2 new red raspberry varieties developed by this Department were made by farmers. The Tennessee Autumn variety is finding a place in the home food supply.

Blackberries.—*Rubus macrocarpus*, giant blackberry of Columbia, has been grown for 2 years at Knoxville, but the plants have neither blossomed nor fruited. A number of successful crosses were made with such varieties as Eldorado, Himalaya, Ancient Briton, Florida Marvel, Evergreen, and native blackberry. The hybrid seed was stratified in cold storage and later planted.

VEGETABLES

Beans.—A crop of beans in the urd-garden bean project was grown in the greenhouse. Mr. A. B. Strand, who kept the records on this project, was transferred to field-plot work in the Douglas Dam area and took his breeding material with him. A fresh supply of urd beans was secured from Dr. J. W. Morse of the U.S.D.A. and the bean work transferred to the West Tennessee Station, at Jackson.

Sweetpotatoes.—The transfer of Mr. Strand interfered with the work on the sweetpotato project. A part of the material was taken to the plots near Dandridge, but one set of plots was maintained at Knoxville. Unit No. 1 Porto Rico, La. No. 9, Bunch Porto Rico, Nancy Gold, Porto Morado, and Nancy Hall were grown at Knoxville.

Turnips.—The soil was so hard and dry in late July that the entire area for fall-crop turnips was watered before plowing. One half of the range received a heavy watering (41 cu. ft.) when the seed was sown. The other half was not irrigated. There were 3 planting dates. Yields of greens and turnips from the irrigated plots were much higher in the first planting, slightly higher in the second, and somewhat lower in the third. This indicated that late rains were sufficient for turnips this season.

Garden Peas.—A good crop of peas was produced on the Station plots. The earlier plantings yielded nearly 2 tons per acre of peas in the pod. April 15 planting was not worth picking. Wando, a new variety from the Vegetable Breeding Laboratory, led in production in the earlier planting. Trial plantings of this new variety were made by Victory Gardeners and many favorable reports were received.

Tomatoes.—Sioux gave an excellent yield among the determinate varieties of tomatoes. The quality was good. Victor made a poor showing in this group. Marglobe led in production. Pan America gave a good yield, but the fruit varied greatly. Several varieties from the breeding work of the Plant Pathology Department segregated so much that they will require further selecting. Richmeat is an interesting variety for home gardens, but the fruit is rough.

MISCELLANEOUS

Pyrethrum.—Work on high-testing clonal strains of pyrethrum was discontinued. Crowns of the different strains were grown and the seedling population discarded. A shipment of the more valuable strains was sent to an experiment station in Ecuador.

Fruits and Vegetables for Processing.—Plantings were managed so that fairly large samples of fruits and vegetables would be available for food processing, such as frozen pack, dehydration, and canning. Sweet corn, crowder peas, and midsummer crops were in-

jured severely by drouth. Further details are given in the report of the General Chemistry Department.

Flowers and Shrubs.—Very few new ornamental plants have been received during the past 3 years. Promising kinds and selections were propagated and distributed through various clubs and organizations. This makes possible widespread trial over Tennessee.

EXPERIMENTS AT WEST TENNESSEE STATION

Jackson

J. P. Overcash and Brooks D. Drain

SMALL FRUITS

Strawberry Breeding and Inheritance Studies.—A heavy frost at blossoming time killed many blossoms and small fruits and greatly reduced the yields of all varieties and selections that were in bloom. For this reason fruit notes were not made for the seedlings from crosses in 1942, but plants were transferred to another field to be fruited in 1945. Because of the severe late frost it was impossible to judge the value of many selections from previous years, and all selections that were not fruited in rows in 1943 were placed in the new planting to be fruited again in 1945.

Raspberries.—The yields from a red raspberry variety trial which was set in March 1943 are given in table 41. There were 3 randomized plots of each variety or selection.

Table 41—*Yields per acre of several raspberry varieties and selections,* 1944.

Variety or selection	Early yield May 22-June 11	Total yield May 22-June 29
	Pints	Pints
Indian Summer	466	[1]1160
Tennessee Luscious	525	2151
Latham	816	2650
Tennessee W 211	1399	4283
Marcy	460	1192
Tennessee X 228	492	1529
Sunrise	629	2780
Tennessee X 333	486	1866
St. Regis	901	[1]2326
Tennessee X 344	778	2009
Tennessee Autumn	642	2307
Tennessee Y 839	1134	[1]3201
Taylor	745	2482

[1]Summer crop only; does not include the fall crop.

VEGETABLES

Cabbage Varieties.—A variety trial involving 8 varieties with 6 randomized plots of each variety gave the following yields, calculated in tons per acre: Succession, 8.25; Henderson's Premier, 7.24; Golden Acre, 6.80; Marion Market, 6.62; Earlykrop, 6.51; Charleston Wakefield, 5.99; Copenhagen Market, 5.83; Early Jersey Wakefield, 5.24. The average weights in pounds per head were: Succession, 2.94; Marion Market, 2.10; Henderson's Premier, 2.04; Golden Acre,

1.98; Earlykrop, 1.96; Copenhagen Market, 1.96; Charleston Wakefield, 1.90; Early Jersey Wakefield, 1.50.

Straw-Hay Test with Cabbage and Tomatoes.—In 1941, an experiment was started in which alfalfa hay and oat straw at the rate of 2.5 tons per acre were plowed under, both separately and together, several months before tomatoes were set in the field. In

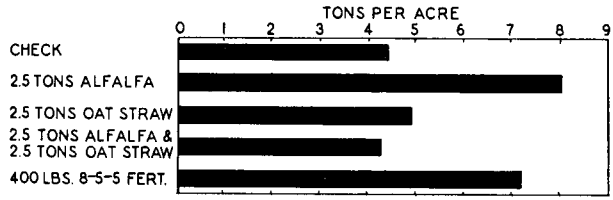


Fig. 21—Effects of plowing under alfalfa hay and oat straw, and a combination of the two, on the yield of Copenhagen Market cabbage at the West Tennessee Station, Jackson, 1944.

1941, 1942, and 1943 these treatments were found to produce marked effects on the yield of tomatoes. In 1944 these plots were set with Copenhagen Market cabbage plants. Pronounced effects were noted on the cabbage yields (see Fig. 21).

Sweetpotato Varieties.—Two sweetpotato variety trials were conducted during 1944. They were set on the same range, on the same day, with the same spacing in the rows. One trial was dug in August and sold on the green market, while the other was dug in October for storage. There were 4 randomized plots of each variety. Each plot had 2 guard rows. Results are shown in table 42.

Table 42—*Calculated yields per acre of U. S. No. 1 sweetpotatoes.*

Variety	Dug August 28, 1944	Dug October 13, 1944
	Bushels	Bushels
Nancy Gold	88	312
Nancy Hall	54	342
Vine Porto Rico	52	236

SWEET CORN VARIETIES

Twelve varieties of sweet corn were tested, with results shown in table 43.

Table 43—*Yields and weights of ears of several varieties of sweet corn.*

Variety	Ears per acre		Average weight in husk
	Dozen	Pounds	Pounds
Allegheny	677	3880	.478
Bantam Evergreen	343	2290	.556
Cream-O-Gold	907	3940	.362
Golden Cross Bantam	567	2880	.425
Golden Hickory Sweet	510	3300	.539
Golden Hybrid 2439	510	3460	.565
Ioana	653	4370	.557
Lincoln	647	4370	.587
Pontiac	717	6040	.702
Silver Cross Bantam	470	2860	.507
Tennessee Hybrid	460	3220	.583
Top Flight Bantam	640	4580	.596

MISCELLANEOUS

Garden Sage Trials.—The spacing test with garden sage indicated that under the soil and climatic conditions involved the most growth per unit length of row occurred where the plants were spaced 18 inches apart, rather than 24 or 36 inches. The results for two years are shown in table 44.

Table 44—*Effects of various spacings of garden sage plants on the yield of air-cured leaves and stems when the rows were three feet apart.*

Spacing in rows	1943		1944	
	Plot yield	Yield per acre (calculated)	Plot yield	Yield per acre (calculated)
Inches	Pounds	Pounds	Pounds	Pounds
18	13.99	758	44.77	3868
24	10.89	590	37.16	3011
36	7.72	418	26.56	2295

An application of oat-straw mulch around garden sage plants resulted in a more vigorous growth. Check plots yielded at the rate of 2105 pounds of air-cured leaves and stems, while the mulched plots yielded at the rate of 2744 pounds per acre. Fifteen garden sage selections were tested for yield and local adaptation. Several of these show considerable promise as very productive strains. The color of blossoms varies from white to dark purple. Some of the selections produce seed profusely, while others produce almost no blossom or seed.

Gladiolus Varieties.—Fifteen varieties of gladioli were grown and the dates of blossoming, length of spikes, color and corm production were recorded. They were then graded. The best varieties were marked with 4 asterisks (****), and the poorest were marked with 1 asterisk (*), the others being intermediate: ****Bit O'Heaven, Firefly, Golden Cup, Peggy Lou, Tweedledee, Vee Cream; ***Camellia, Paradise, Sandra; **Blue Danube, Carol Jean; *Jalna, Mary Jane, Milford, Rewi Fallu. The largest corms were produced by Bit O'Heaven, Golden Cup, Peggy Lou, Paradise, Tweedledee, and Vee Cream.

PEAR ORCHARD AT MERICOURT STATION
Clarksville

Brooks D. Drain and Donald S. Burgis

The pear orchard at the Mericourt Station received very little care during the past season, the limited amount of help available being largely occupied on the new station at Springfield. About 130 selections blossomed; part of them were killed by cold; insects and diseases destroyed part of the fruit, and a part became overripe on the trees. Few notes of value were secured. Very little fire blight developed in this orchard.

The trees are heavily budded for the coming season. Many scions of the best varieties were cut for propagation and further trial.

PLANT PATHOLOGY

C. D. Sherbakoff

INTRODUCTION

The plant Pathology Department confined its studies during the year mainly to the breeding of disease-resistant lines of cotton, red clover, strawberry, tobacco, tomato, watermelon, and wheat. These studies were in pursuance of projects previously organized. Considerable time, however, was devoted to disease problems not covered by the projects but of immediate and sometimes urgent importance to the farmers. Some attention was given to identification of diseases of interest to other workers in the Station and Extension Service and to farmers.

Mr. James M. Epps was in immediate charge of all work in West Tennessee. Mr. Dennis H. Latham had the oversight of tobacco-disease studies in Middle Tennessee, and also assisted in the work on tomato and strawberry diseases.

BEAN DISEASES

Under the stimulus of wartime prices and heavy demand for snap beans, the culture of this crop in East Tennessee, especially in Johnson County, developed to a considerable extent. The climate and soil appeared to be very favorable to the crop. Since the importance of the control of Mexican bean beetle was early recognized, the assistance of Mr. W. W. Stanley, Associate Entomologist, was made available to the growers. From the beginning he found not only insect injury, but in many instances severe damage by certain diseases, besides some inperfections in the beans themselves. Of these abnormalities, the so-called flat pod appeared to be the most important.

Following is a brief account of the diseases that were found to be of special importance in snap bean culture in the Johnson County area during the 1944 season. All of these diseases are discussed and illustrated in Bulletin 186.

Anthracnose.—Locally the disease is often called "nail-head rust." It produces roundish to oval, slightly sunken spots on the pods and on the stems. During moist weather the spots are pink. This is due to the development of numerous minute masses of the spores of the fungus that causes the disease. It causes dark discoloration of the veins on the underside of leaves.

The disease and the method for its control have been known for a long time. Control consists primarily in the use of western-grown seed. The reason for the success of this method is simple and obvious. The disease-causing fungus survives from season to season almost entirely on the infected seed; and since slightly infected seed show no discoloration or other sign of infection, it cannot be separated from disease-free seed by any practical means. In

the dry climate of the West there is not enough moisture on the plants to put the sticky spores in a condition to spread the disease. Hence, even if the disease is present in a field, it will not affect even the pods on the diseased plants. Moreover, if there were an occasional season in the West with enough moisture for the spread of the disease, there would be no disease to spread, because locally grown seed, anthracnose free, would have been used. It is a mystery, therefore, why some fields in the Johnson County area planted with seed claimed to be western-grown were severely affected with anthracnose. Pathologists with considerable experience along this line, who were consulted by Mr. Stanley and the writer, are confident that western-grown bean seed should give a crop free from anthracnose in the East, regardless of the weather, unless it followed another bean crop in the same season. The writer concurs in this opinion.

Greasy Pod.—Mr. Stanley found that in some fields there was a very high percentage of abnormally dark green pods, with a greasy-looking surface, and of more-or-less conspicuous bumpy shape. Usually such pods were produced on plants with puckered leaves of uneven green color. Considering all these symptoms, it may be assumed, until proved otherwise, that the trouble is of a virus nature closely approaching that of the common bean mosaic. The difference may be due to a different virus or to a peculiar reaction of the particular variety of bean, Tendergreen. It has been reliably reported that the common bean mosiac is about 50 percent transmitted through the seed. Hence, greasy pod, if it is similarly transmitted, should be controlled in seed-producing fields.

Pod Rots.—There are two very common and in some cases very destructive bean pod rots, each caused by a specific fungus inhabiting the soil. One of the rots, which may be called white mold pod rot, is caused by the fungus *Pythium* and is favored by wet and relatively cool weather. The affected pods show soft, watery rot, usually covered with a conspicuous white mold. While the trouble sometimes causes noticeable damage in the field, it is most damaging in storage and shipping, since a half dozen infected pods in a hamper may readily spoil the entire lot in a few days at room temperature. The fungus is extremely sensitive to copper toxicity, and hence should be readily controlled by treatment of the soil surface under the plants, when the pods begin to develop, with any form of copper. Unfortunately, dusts and sprays with copper compounds caused more or less injury to bean plants, and hence some experiments with this method of control of pod rots are needed.

Brown rot of bean pods is caused by another fungus, *Rhizoctonia*, which usually shows on the pods touching soil. It is the same fungus that causes damping off of young plants. Since the fungus spreads most readily over a soil surface packed by rains, it can be kept fairly well in check by shallow cultivation close to the plants after every good rain, as long as the vine growth permits.

Root Rots.—There are several different fungi responsible for root rot of beans; and since they are favored by different conditions, it is difficult to devise means of control for all of them. It seems that on the whole the root rots are less damaging in well-fertilized land properly prepared about two weeks in advance of planting time, and that beans should not be planted when the soil is still too cold for good germination. Some bean root rot becomes more serious with repetition of the bean crop on the same piece of ground. Therefore, proper crop rotation is necessary, with beans grown not oftener than once in 4 years. Often when root rot begins to show in a field, it can be checked by the plowing of dirt toward the plants, thus giving them a chance to develop new roots above the injured ones.

COTTON

A number of selections of the more promising wilt-resistant segregates from crosses between wilt-resistant cottons, including Sea Island, and several of the best available upland varieties had been made at Knoxville and Jackson. The selections were based primarily on lint percentage and staple length, strength, and fineness. Dr. Hertel's Laboratory made determinations of the staple characters of a large number of the selections. Wilt resistance of most of the selections was determined during the wintertime in the greenhouse, by means of inoculations of the selections with liquid cultures of the fungus causing wilt. A number of the selections appeared to be good enough to justify their increase next season, at least sufficiently for yield test in 1946.

RED CLOVER

A number of red clover lines, inbred since 1936 and selected continuously for resistance to southern anthracnose and powdery mildew, and for uniformity in plant appearance and seed color, have been obtained. Preliminary tests of these clovers in comparison with the common Tennessee "Resistant" clovers, at Jackson and Knoxville, definitely indicate that the lines tested gave uniformly poorer stands and less vigorous plants. Though some data from Jackson indicate that late in the season these new lines caught up with the others, there seems to be no doubt that the inbreeding resulted in reduced vigor. Testing of definite mixtures between the newly developed clovers, therefore, should be next on the program in red clover improvement.

STRAWBERRIES

Because of the labor shortage and transportation difficulties, the field tests with strawberries at Portland were discontinued. Consequently, evaluation of the different black root-tolerant hybrids was carried out at Knoxville and Springfield. One of the promising strawberries at Knoxville, No. 48-18, has been planted this spring also near Dandridge and Dayton, in cooperation with A. B. Strand

and T. R. Gilmore, for comparison with other standard varieties now grown in the State. This strawberry and three others of the most promising varieties, at present are being tested at Knoxville and Springfield, in comparison with four varieties now considered best for Tennessee.

TOMATOES

Field and greenhouse tests of a few promising leaf spot-tolerant breeding lines were obtained from the U. S. Vegetable Breeding Laboratory at Charleston, S. C., and from the Pennsylvania Experiment Station. Neither of the tomatoes showed distinct tolerance to the common leaf spot here, caused by the fungus *Alternaria.*

Hybrids of *Lycopersicum esculentum* x *L. hirsutum* so far have shown susceptibility to the leaf spot referred to. All of the hybrids were sterile, while some backcrosses were found to be fertile.

The tests for resistance to *Fusarium* wilt were carried at Jackson and at Knoxville, in the field and in the greenhouse—in the latter case under artificial inoculation. Some of the tomatoes, including Pan America and the selected segregates from the hybrids obtained from the Missouri Experiment Station a number of years ago, showed complete resistance to the wilt, and some also proved to be high-yielding and of good fruit type. In general, it may be considered now that the *Fusarium* wilt is no longer a menace to tomato culture.

TOBACCO

Tobacco studies have been conducted exclusively at Springfield and have consisted mainly in the breeding of mosaic-resistant dark varieties. A large number of different lines of the hybrids obtained by crossing the resistant varieties on the more popular susceptible dark tobaccos, obtained from Dr. E. E. Clayton, of the U. S. Department of Agriculture, were grown on a scale sufficient for evaluation of yield and quality, expressed finally in money value. The data were obtained in cooperation with the local marketing agencies and classifiers. The records formed the basis for further improvement of the tobaccos by selections from the present lines and by backcrossing the more promising of these to the best susceptible dark tobaccos.

A number of mosaic-resistant tobaccos approaching Medole in commercial value have been developed. Improvement of these tobaccos will be necessary, however, before they can be released to the growers to replace the varieties now grown.

WATERMELON

Breeding for resistance to *Fusarium* wilt—the most destructive disease of watermelon in Tennessee and many other states—has been continued. Most of the work is being carried on by Mr. Epps at Jackson with segregates of hybrids originally developed by the late Dr. L. E. Miles, then plant pathologist of the Mississippi Sta-

tion and with Epps's own crosses made between the various wilt-resistant watermelons and some of the best commercial susceptible varieties. A number of the resistant segregates were also back-crossed on the commercial varieties. The tests were conducted in fields where all susceptible watermelons died early in the season. The selections were also tested for wilt resistance in the greenhouse under conditions of artificial inoculation with the fungus causing wilt. Some of the selections were grown at Knoxville, some on the Cotton Farm near Knoxville, and some near Decherd; and in no case did wilt appear. Some of the lines still show variations in appearance, and most of them have somewhat pale-red flesh color, thus showing need for further improvement. All of them have a high sugar content.

WHEAT

All the work with wheat was carried at Knoxville and on the Blount County farm. Two promising new wheats resistant to rusts are being grown on 1/10 acre each to provide seed for uniform variety tests by the Agronomy Department. Thirty-eight other promising rust-resistant selections are grown on 1/40 acre each to provide enough wheat for the quality test. Four hundred and seventy-eight progenies of last year's head-row selections are grown in double rod rows, in triplicate; 294 head rows selected from the more promising new wheats and 268 F_1 plants of 48 different back-crosses of 8 rust-resistant segregates on 6 high-quality, high-yield soft winter wheats, are being grown at Knoxville.

LIBRARY

Sarah C. Currell

Interest in agricultural research has been indicated by an increase in the number of volumes added to the Experiment Station and College libraries, resulting in a livelier circulation of literature among the readers. This year, 222 volumes were added to the Station collection and 566 to the College, a total of 788 volumes, including purchases and gifts. This figure brings the total number of books on the shelves to 21,037.

The collection of periodicals has shown a steady growth. Last year the number received by the Station and College, through subscription, exchange, and gift, was 307. This year the number increased to 325.

A large bulletin collection is indispensable to an agricultural library. Bulletins are received from the United States Department of Agriculture and state experiment stations and extension divisions, and, in times of peace, from many foreign countries. On account of war conditions, this last source has furnished a greatly diminished supply. Some bulletins are bound and cataloged, while others are circulated as individual copies. The number of bulletins added to the collection this year is 1,034.

There was an increase of 50 in number of volumes sent to the bindery. This was due largely to foreign periodicals which had been reinstated. During the year, 162 volumes were bound, at a cost of $237.00. These have all been cataloged.

The late Dean Jacob's collection of agricultural books and pamphlets was donated to the library.

The inter-library loan service is still used extensively by the Station staff. It affords them access to rare and valuable material not found in their own library.

The slogan of the library is Service. Special attention is given to the staff members of the Station and substations, the faculty and students of the College of Agriculture and the Junior College at Martin, the Agricultural Extension Service, the Tennessee Valley Authority, and any research workers seeking assistance.

MIDDLE TENNESSEE EXPERIMENT STATION

Columbia

L. R. Neel, Superintendent

RAINFALL

Although total rainfall for the year 1944 was far above normal, 61.86 inches, the season was one of the poorest on record for corn, hay, and early pasture. More hay was imported into Middle Tennessee than ever before, and the corn crop was very short. The year was characterized by periods of heavy rainfall, followed by periods of drouth.

Early in the season, during the 86-day period from February 1 to April 26, inclusive, the rainfall was 22.11 inches. This was followed by a 100-day period, April 27 through August 4, when the total rainfall was only 5.84 inches. At that time the corn crop and early hay crops were being made, and pastures needed much more moisture than they got. Then, from August 5 through September 29, 56 days, there was a fall of 18.67 inches of rain. A 45-day period followed when there was just .48 inch; and the year ended with 7.27 inches in the last 12 days.

In a fertilizer test on medium soil that would produce about 30 bushels of corn per acre in a good season without fertilizer, the check plot gave a yield of 12.46 bushels; the plot with 75 pounds per acre of nitrate of soda gave 13 bushels; 150 pounds of nitrate of soda, 12.13 bushels; 37.5 pounds of ammonium nitrate, 13.85 bushels; 75 pounds of ammonium nitrate, 10.10 bushels—results attributable to a very unfavorable season.

SMALL GRAINS

Exemplifying the value of reasonable diversification, the small grains gave normal returns in a poor corn, hay, and pasture season (table 45).

Table 45—*Yields per acre of small grains following applications of nitrate of soda in varying amounts.*

Crop	No nitrate	50 lbs. nitrate	100 lbs. nitrate	150 lbs. nitrate	200 lbs. nitrate
	Bushels	Bushels	Bushels	Bushels	Bushels
Barley	28.4	40.0	40.6	48.7	51.2
Winter oats	34.6	50.6	61.8	65.6	79.6
Balbo rye	19.5	25.1	28.3	31.8	35.8
Wheat	17.5	28.0	26.7	27.5	30.0

VARIETY TRIALS

Wheat.—Yields per acre: Carala, 25.4 bu.; Tennessee Bluestem No. 2, 24.6 bu.; Tennessee Fulcaster No. 612, 21.9 bu.; Red Rock, 20.7 bu.; Leap's Prolific, 20.0 bu.; Thorne, 19.3 bu.

Winter Oats.—Yields per acre: Forkedeer, 57.4 bu.; Stanton Strain, No. 2, 51.5 bu.; 090 X Bond 140-17-63-75-243, 50.98 bu.; Lee, 49.9 bu.; Fulwin, 48.3 bu.; Tennex, 47.3 bu.; 090 X Victoria 139-13-102-248, 43.4 bu.; Fulgrain Strain No. 6, 38.2 bu.

Spring Oats.—Yields per acre: Kanota, 53.5 bu.; Columbia, 48.91 bu.; Brunker, 44.97 bu.; Vicland, 40.92 bu.; Forkedeer, 14.97 bu.; Tennex, 13.21 bu.; Fulwin, 11.97 bu.

Barley.—Yields per acre: Jackson No. 1, 42.7 bu.; Tennessee Bearded No. 52, 42.6 bu.; Jackson, 40.1 bu.; Kentucky No. 1, 39.8 bu.; Tennessee Hooded No. 6, 35.5 bu.; Missouri Beardless, 26.4 bu.

DATE- AND RATE-OF-SEEDING TRIALS

Small Grain.—Results of date-of-seeding tests with barley and oats are shown in table 46.

Table 46—*Date-of-seeding tests with small grains—yields per acre.*

Date of seeding	Barley		Oats	
	Bushels	Pounds	Bushels	Pounds
September 1	45.0	2160	84.3	2696
September 15	42.5	2040	63.7	2038
October 1	42.5	2040	61.8	1978
October 15	37.5	1800	56.2	1798
November 1	30.0	1440	52.5	1680
November 15	22.5	1080	43.1	1379
December 1	17.5	840	41.2	1318

Barley.—Yields per acre in rate-of-seeding tests were as follows: 2 pks. seeded, yield 35 bu.; 3 pks., 37 bu.; 4 pks., 42 bu.; 5 pks., 45 bu.; 6 pks., 46 bu.; 7 pks., 47.2 bu.; 8 pks., 47.5 bu.

Of course variety trials and dates and rates of seeding for a single year may be of little value, but when continued over a period of 10 or more years they become of real worth.

SORGHUMS

VARIETIES AND RATES OF PLANTING

Sorghum made a good yield of silage in spite of the drouth. Yields reported in table 47 were made on medium land without stable manure, but with a light application of ammonium nitrate. Results of rate-of-planting tests are given in table 48.

Table 47—*Results with crops grown for silage.*

Crop	Lodged at harvesting time	Date ready for silage	Yield per acre
	Percent		Tons
Neal Paymaster corn	None	Sept. 26	4.46
Huffman corn	None	Sept. 26	6.22
Texas Seeded Ribbon sorghum	75	Oct. 6	13.50
Hodo sorghum	75	Oct. 16	16.74
Sugar Drip sorghum	15	Oct. 6	12.60
Silver Top sorghum	10	Sept. 28	11.25
Colliers sorghum	10	Oct. 16	14.40
Iceberg sorghum	5	Sept. 28	13.50
Red X M	5	Oct. 1	10.44

Table 48—*Rate-of-planting tests with silage crops.*

Crop	Rate of planting per acre	Yield per acre
		Tons
Redtop sorghum	2.5 lbs. seed	9.62
Texas Seeded Ribbon sorghum	2.5 lbs. seed	14.37
Hodo sorghum	2.5 lbs. seed	17.25
Neal Paymaster corn	4000 stalks	2.80
Huffman corn	3200 stalks	4.20
Redtop sorghum	5 lbs. seed	13.00
Texas Seeded Ribbon sorghum	5 lbs. seed	15.00
Hodo sorghum	5 lbs. seed	18.75
Neal Paymaster corn	6000 stalks	4.55
Huffman corn	4800 stalks	7.05
Redtop sorghum	7.5 lbs. seed	11.25
Texas Seeded Ribbon sorghum	7.5 lbs. seed	13.00
Hodo sorghum	7.5 lbs. seed	15.75
Neal Paymaster corn	12,000 stalks	4.62
Huffman corn	9600 stalks	7.55

GRAIN SORGHUMS

For the first time, grain sorghums were grown at the Middle Tennessee Experiment Station in comparison with Neal Paymaster corn (table 49). It was a good year for the sorghums, as the early drouth held the yield of corn down much below average while the sorghum that waited for rain may have produced an average yield or even better. Four of the so-called combine sorghums were grown. These were Caprock, Plainsman, Bonita, and Westland. Four taller grain sorghums that have been used for grain and forage in the West were Club, Hegari, Black Hull Kaffir, and Early Kalo. One sweet sorghum, Sorgo, was grown for grain production.

Table 49—*Grain sorghums—yields per acre, in comparison with those of Neal Paymaster corn.*

Variety	Height of stalk	2½ pounds seed	5 pounds seed
	Inches	Bushels[1]	Bushels
Caprock	30	32.5	39.1
Plainsman	30	29.7	42.8
Bonita	36	20.8	28.0
Westland	30	15.9	27.0
Club	42	31.0	35.5
Hegari	38	23.5	34.0
Black Hull Kaffir	50	21.5	24.5
Early Kalo	38	19.5	28.0
Atlas Sorgo	60	20.0	22.0
Neal Paymaster corn	....	24.8	29.4

[1]50 pounds per bushel.

Sorghum was planted May 30. All of the grain sorghums were cut and cured in shocks and threshed October 20. Atlas Sorgo was not threshed until November 11.

About a half acre of Plainsman sorghum was sown for combining, half in narrow rows for cultivation and half with grain drill at a heavier rate. This was harvested very successfully with a combine after frost in November. Seed was dry enough to store for a while in bags and then for dumping in bin. Yield was 32 bushels per acre.

RATE-OF-LIMING TEST

Eight years ago, lime was used at various rates to determine the effects on different farm crops. At first, 8 legumes were grown—alfalfa, sweet clover, black medic, red clover, alsike clover, hop clover, crimson clover, and Korean lespedeza. All of these benefited from moderate liming except hop clover and crimson clover, which were not affected. None of the legumes benefited to any extent from extra-heavy liming except black medic; and crimson clover was seriously injured by an excess of 4 tons of lime per acre. Other crops that were grown on the land later were corn, Texas Seeded Ribbon sorghum, and soybeans. Growth, development, and yield of corn were adversely affected by heavy applications of lime. In 1943, the yield of corn where 10 tons of lime had been used was 2.5 bushels, against 29 bushels where 2 tons had been used. Growth of sorghum was retarded by heavy applications of lime, and final yield reduced several tons per acre, but not to the extent that the yield of corn was affected. The yield of soybeans seemed to be reduced by heavy applications of lime, but not as much as the yield of corn.

In the spring of 1944, Columbia oats was sown on the rate-of-liming plots. Yields were very moderate on all plots; but the plot that received 8 tons of lime 8 years ago produced 13.7 bushels per acre, against 26.8 bushels on the plot that received 2.5 tons.

BITTERWEED ERADICATION EXPERIMENT

Bitterweed studies began at the Middle Tennessee Experiment Station more than a dozen years ago. At that time it was discovered that the weed will mature seed as soon as the flower opens, that the seed is not scattered to a serious extent by wind, and that the plant could not be maintained under ordinary plot conditions. This last fact led to a line of treatment for eradication of the plant from a pasture. Bitterweed-infested land on a private farm was used for some eradication tests. It was found that the weed practically disappeared from infested pasture land if stock was kept off it from March to October.

Starting in the fall of 1940, a large hay-frame load of bitterweed per acre was spread on six ½-acre pasture lots that had been pastured close. As the sod was good, the stand secured the next year was not satisfactory. More bitterweed was spread on the land

in the fall of 1941; the land was disked, and cattle were fed on the lots in the fall. This greatly improved the stand by 1942, but it was not until the summer of 1943 that the stand was pronounced satisfactory—and to get this result the land was again disked and used as feed lots in the fall of 1942.

Eradication plans were started in the fall of 1943. The method of handling the 6 plots was as follows: All stock was to be kept off plot 1 through 1944; plot 2 was to be pastured all through the year whenever the stock could get anything to eat there, and some feeding was to be done on it in the fall; plot 3 was to be rested October 15 to April 15 and pastured during the summer season whenever there was anything to eat; plot 4 was to be pastured October 15 to April 15 and rested through the summer season; plot 5 was to be rested October 15 to July 15 and pastured for 3 months; plot 6 was to be used as a meadow, orchard grass and Korean lespedeza being sown on the land after disking in early fall. As a result of this treatment practically all of the bitterweed disappeared from plot 1; plot 2 retained its full stand of the weed; plots 3 and 4 were greatly reduced in stands, but still retained too much; bitterweed disappeared in plot 5 to the point at which hand-pulling would not be impossible; and while it was greatly reduced in the meadow, another year apparently would be required to produce effective results. By 1945 conclusive results should be secured.

PASTURE TESTS

Dairy Grazing Experiment.—Dairy cows that receive a moderate grain ration—the same amount per cow for each kind of pasture—were pastured on a good bluegrass pasture and a very good alfalfa and orchard grass pasture from April 2 through October. Another group of cows was pastured on Sudan grass June 15 to September 28. Results are shown in table 50.

Table 50—*Comparison of bluegrass, orchard grass-alfalfa, and Sudan grass pastures for dairy cows.*

Item	Bluegrass Apr. 2-Oct. 31	Orchard grass-alfalfa Apr. 2-Oct. 31	Sudan grass June 15-Sept. 28
Grazing period (days)	185	185	105
Grazing per acre (days)	133	150	153
Milk produced per acre (lbs.)	2483	2739	2847
Butterfat per acre (lbs.)	125	141	159
Gain in body weight (lbs.)	35	56	104

Comparison of Summer Grazing Crops.—Tift Sudan grass, common Sudan grass, pearl millet, and soybeans were tried as summer pasture crops (table 51). Since it was the more practical proce-

Table 51—*Comparison of Sudan grasses, millet, and soybeans as summer pasture crops for yearling steers.*

Pasture	Pasture yield for yearling steers per acre	Gain per acre	Average daily gain
	Days	Pounds	Pounds
Tift Sudan grass	208	460	2.21
Common Sudan grass	228	270	1.18
Pearl millet	172	460	2.67
Soybeans	120	280	2.33

dure, beef calves were used in this test. It is believed, however, that the data can very well be applied to dairy cattle.

Button Clover for Winter and Spring Grazing.—During the last few years button clover has been grown on the Station farm under several conditions (see Fig. 22). The crop appears promising for

Fig. 22—A volunteer crop of button clover in corn being turned under for corn in April at the Middle Tennessee Station.
One seed crop turned under has now volunteered under these conditions for three years.

Tennessee. One of its good features is that it will volunteer from year to year once a crop is allowed to seed. It seems to do best on prepared land. It does not furnish as much early spring grazing as crimson clover, but will furnish considerable grazing after crimson clover is mature. The seed are difficult to harvest, and various methods of seed harvesting are being studied.

WEST TENNESSEE EXPERIMENT STATION

Jackson

Ben P. Hazlewood, Superintendent

LAND PURCHASES

Another 20 acres of land was added to the West Tennessee Station early in the year 1944, the purchase to be financed out of income from the area. It is a very desirable tract, being bounded on the north, west, and south by original Station property and on the east by the Gulf, Mobile and Ohio Railroad.

The acquisition of land for the much needed enlargement of the Station was begun in 1941. Up to the present time, 35 purchases have been made, embracing a total of 448 acres. These tracts are

located on all sides of the original Station. Besides providing increased acreage, well adapted to experimental purposes, they have greatly improved boundaries and highway frontage. The original purchase, in 1908, consisted of 189 acres. A few years later, 25 more acres were bought. The total now is 662 acres.

The new land makes available for Station work six additional soil types that are prevalent in West Tennessee: Beechy, Dyer, Falaya, Ina, Waverly, and Memphis.

There has been much favorable comment concerning the improved appearance of the Station as a result of these recent additions.

WEATHER

Weather conditions this year were favorable for excellent crop production. The rainfall was well distributed and slightly above normal. Both maximum and minimum temperatures were moderate.

DAIRY CATTLE GRAZING

Cows fed only pasture, hay, and silage produced 78 percent as much as cows given the same roughage with full grain feeding. The variations in production were about the same for the two groups of cattle for the different seasons of the year. Cows fed only roughage ration for as long as 7 continuous lactations produced and reproduced normally. The roughage feeding consisted of alfalfa hay, corn and sorghum silage, and all-year pasture. The all-year pasture was furnished during the summer months by a permanent sod of clovers and grasses supplemented with Sudan grass, and during the winter months by early-August-seeded crimson clover.

FIELD CROPS

Rotations.—The extensive rotation work was continued. The most outstanding responses from the various treatments were from lime, legumes, manure, and potash. The turning under of Korean lespedeza, in a 1-year rotation of barley and lespedeza, has given a marked increase in the yield of barley where lime was applied. These experimental rotations have been conducted for 36 years, and will be continued. They have given valuable data and have proved very interesting for observation from year to year.

Dates of Planting.—Experiments on this project are conducted with the major field crops. A summary of tests with corn for the past 12 years emphasizes the value of early planting for highest yield.

Table 52 gives the yields of Jellicorse corn from plantings made from early April until early June, at average intervals of about two weeks.

Table 52—*Results of date-of-planting tests with Jellicorse corn.*

Average date of planting	Apr. 4	Apr. 16	Apr. 29	May 12	May 25	June 6
Average yield per acre	Bushels 41	Bushels 36	Bushels 35	Bushels 33	Bushels 32	Bushels 27

Varieties.—The regular introduction of new varieties of field crops requires continuous testing of the major crops to determine the relative importance of the introductions. A recent summary of the corn variety test shows the comparative value of some of the best corn hybrids and a standard open-pollinated variety.

Table 53 shows the yields of 3 Tennessee hybrids, Nos. 10, 14, and 15, and Jellicorse.

Table 53—*Comparative yields of three Tennessee corn hybrids and Jellicorse.*

Variety	Yields						
	1940	1941	1942	1943	1944	5-yr. Av.	4-yr. Av.
	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels	Bushels
Jellicorse	90	47	67	46	49	60	52
Tenn. Hybrid No. 10	91	46	74	51	44	61	54
Tenn. Hybrid No. 14	....	52	76	51	48	....	54
Tenn. Hybrid No. 15	94	46	68	50	51	62	54

Rates of Planting.—In the growing of field crops, the rate of planting has an important bearing on yields. The subject has been given considerable attention by this Station.

Table 54 gives the yields of Jellicorse corn, grown on "rich" land at 4 rates of planting, from 1921 to 1944, inclusive.

Table 54—*Average yields per acre of Jellicorse corn grown on "rich" land at four rates of planting.*

Rate of planting—stalks	Yield		
	Ears	Grain	Stover
Number:	Number	Bushels	Tons
4238	7323	56	1.81
5313	7735	60	1.99
6515	8420	64	2.20
7645	8355	60	2.21

The area on which this corn was grown had an annual application of 10 tons of farm manure per acre. The corn was fertilized with 100 pounds of nitrate of soda per acre when about one foot high.

Table 55—*Average yields of corn under continuous fertilization for* 31 *years,* 1914-1944.

Treatment	Yield
	Bushels
No fertilizer	24
No fertilizer, peas planted at last cultivation	27
5 tons farm manure	43
5 tons farm manure, peas planted at last cultivation	47
5 tons farm manure 200 lbs. 16% phosphate 50 lbs. muriate of potash 100 lbs. nitrate of soda	52
5 tons farm manure 200 lbs. 16% phosphate 50 lbs. muriate of potash 150 lbs. nitrate of soda	53

Fertilizer Tests.—A considerable part of the field-crops work consists of fertilizer tests. Several of these tests have been conducted over long periods of time. Table 55 gives the results from continuous fertilization of corn for 31 years.

OTHER PROJECTS

For work at the West Tennessee Station not reported above, reference is made to the reports of the departments in charge, as follows:

Livestock: ANIMAL HUSBANDRY.

Cotton, Soybeans, Small Grains: AGRONOMY—CROP IMPROVEMENT.

Plant Diseases: PLANT PATHOLOGY.

TOBACCO EXPERIMENT STATION[5]

Greeneville

J. L. Vandiver, Assistant Agronomist

WEATHER CONDITIONS

The very severe drouth at the Tobacco Station affected the results of many of the tests in such a way that they are worthless. Throughout most of the State late summer rains came in time to produce satisfactory tobacco yields, but these rains did not fall in the vicinity of Greeneville.

IRRIGATION

Since burley tobacco may be injured by too much water as often as by drouth, it has not been thought wise to recommend irrigation generally for tobacco without further trials. When it became obvious that very little tobacco was going to be produced this year, irrigation tests were made on small plots where other tests were not being conducted. They were carried out in two fields and were replicated three times in each field. In one field the results were: 1317 pounds per acre, valued at $674.00, for the irrigated plots; and 887 pounds, valued at $323.63, for the plots that were not irrigated. The soil was better in the other field where the test was conducted, and a still greater increase resulted from irrigation.

It looked as if seed production would be very light on the breeding plots. They were therefore irrigated, while on all other plots irrigation was used only at transplanting time to assist in getting a stand. The plots too far away from water to be irrigated had a very poor stand.

FERTILIZER TESTS

Fertilizer studies on both Shackleton and Nolichucky types of soil were so severely affected by the drouth that the results are of no value. The rotation tests also were ruined.

[5]All of the tobacco work is in cooperation with U. S. Department of Agriculture.

HEIGHT-OF-TOPPING TEST

The topping test was badly injured by the drouth, but a fair yield was made and the results are of value. These tests have been conducted for a number of years. The medium, or standard, topping (at about 18 leaves) proved to be best. The plots that were not topped were the poorest.

USE OF SOD CROPS IN LIVESTOCK PRODUCTION

The cow-calf herd of 40 cows was reduced considerably this year because of Bang's disease. The herd had been tested and certified for several years, and it is not known where the infection came from. The drouth was so severe that the remaining herd was too large for the permanent grazing area, and the cattle were allowed to graze on the alfalfa fields. Only the first cutting of alfalfa was used for hay except on a limited area where normal crops were grown by the aid of irrigation.

MOW HAY DRIER

Hay-curing equipment was installed in one of the barns during the summer and was used with satisfactory results in the curing of alfalfa hay in early fall.

LEGUME SILAGE

Liquid phosphoric acid was not available in the fall of 1943, so that none was used as a preservative for legume silage. The feeding tests this year consisted of sericea without a preservative; sericea with molasses; a 50-50 mixture of alfalfa and sericea; corn-and-sorghum silage with and without a light grain feed; alfalfa with molasses and without any preservative; and a 50-50 mixture of alfalfa and sericea with molasses as a preservative. None of the pens of calves made gains on sericea silage except where it was put into the silo with alfalfa. All of the groups receiving alfalfa silage made satisfactory gains. The calves that were fed corn-and-sorghum silage alone lost weight, but those receiving a very light grain feed in addition to the corn-and-sorghum mixture made gains.

VALUE OF GRAIN WHEN FED TO STEERS BEING FINISHED ON GRASS

Ten steers averaging between 800 and 900 pounds were used to test the value of grain for steers being finished on grass. The animals were divided into groups of 5. They were put on a permanent pasture consisting of bluegrass, hop clover, and white clover about the 20th of April. One group was fed a grain mixture consisting of crushed corn, barley, and cottonseed meal. They were fed once a day and given all that they would clean up in about 2 hours. During the 118-day feeding period they consumed an average of $28.40 worth of grain feed. At the end of the feeding period the grain-fed cattle showed a return of less than $3.00 per head for the grain when compared with the 5 steers that received no grain.

HIGHLAND RIM EXPERIMENT STATION

Springfield

Frank S. Chance, Assistant Director

The original tract of land to be developed into an experiment station for the study of agricultural problems peculiar to the Highland Rim section of the State was purchased in 1943. A few acres were used for tobacco variety studies that year, but complete possession was not secured until January, 1944. During this year a portion of the Mericourt tract at Clarksville was sold and an additional tract of 136 acres adjacent to the Highland Rim Station was purchased. The remainder of the Mericourt tract is being operated from the Springfield headquarters.

Buildings on the farms that were purchased for the Highland Rim Station consist of 5 tenant houses, 5 tobacco barns, 2 livestock barns, and some small outbuildings. Only two of the tenant houses are good enough to repair for permanent use, but the others are being utilized temporarily. All of the tobacco barns are in fair or good condition; one livestock barn is in good condition, but the other is of little value. Fencing on both farms is poor and inadequate, except a small amount of new fence on the recent purchase.

The Robertson County Road Commission helped by grading and repairing about three-fourths of a mile of road through the Station property, but the roads are in need of much more repair.

Some tests were made on a number of varieties of dark-fired tobacco, burley tobacco, sweetpotatoes, tomatoes, strawberries, and wheat, and a small series of plots were devoted to sweetpotato fertilizer requirements where the crop is grown on Dixon silt loam soil.

PLATEAU EXPERIMENT STATION

Crossville

Frank S. Chance, Assistant Director

Land for the Plateau Station was purchased in 1943. Much time and labor are required to put it in shape for extensive experimental work. Three wells have been drilled and water has been installed in the two houses repaired for permanent use. A 30 x 30-foot farm shop was partly built and work started on a potato green-sprouting room and an implement shed.

The Cumberland County Road Commission gave valuable assistance in grading the road from the state highway to the building area near the railroad crossing, and the Station spread enough rock on it to make an all-weather road.

About 35 acres were reshrubbed in the field on the left of the road leading into the Station property and in the field along the railroad on the east side. Part of the rock were removed from the fields to get them ready for seeding to grass in 1945.

A 3-acre tract of woodland was cleared on the north side of the railroad. A portion of this tract was seeded in oats and crimson clover in preparation for some future potato work where isolation is necessary. The remainder of it was used for fertilizer and grass tests.

Potato breeding work in cooperation with the U. S. Department of Agriculture was continued. A number of the new seedlings were planted for increase and some of the older varieties were tested for yield and quality. Fertilizer and spraying tests were conducted, but the results may not be of much value because of a drouth during the critical period for potatoes.

In cooperation with men from the University, variety tests were made on corn, soybeans, small grains, and flax, and fertilizer tests on lespedeza.

Livestock work at Crossville is covered in the Animal Husbandry section of this report.

TRUCK-CROP INVESTIGATIONS IN THE DOUGLAS RESERVOIR AREA

A. B. Strand

The Tennessee Experiment Station, in cooperation with the TVA, started the Douglas Truck-Crop project in behalf of the vegetable industry that was disturbed by the loss of bottom land in the areas above the Douglas and other dams in East Tennessee.

Most truck crops in this section have been grown on bottom land. It is the aim of the present study to determine whether they can be grown profitably on uplands. The problem is being attacked through studies of adapted varieties, fertilizer requirements, management, and irrigation.

Early in the spring of 1944, a committee of local farmers and agricultural workers made a survey of the Douglas Lake area for the purpose of selecting a suitable site for these tests. A small tract of land was chosen a mile and a half south of Dandridge, on the highway to Sevierville. The farm is almost surrounded by the lake. Its proximity to an abundance of water for irrigation studies was a big factor in its selection.

SOIL TYPE AND CONDITION

The soil is an old terrace containing some smooth cobblestones. It is classed, generally, as Holston fine sandy loam and Nolichucky fine sandy loam. There is also in the area some Monongahela fine sandy loam. These soils all have a pale yellowish-gray surface and might be thought of as one and the same type by the casual observer. Tests made in the soils laboratory of the Experiment Station showed that they are very low in phosphate, potash, and organic matter, but are fairly well supplied with calcium.

TESTS WITH VEGETABLES

Bush Beans.—The severity of the 1944 drouth is indicated by the low yield of bush beans on the nonirrigated soil (see table 56). Regardless of fertilizer application, there was no significant difference in the crop. All beans harvested from the nonirrigated plots were classed as Grade B and valued at 85 cents per bushel. Those harvested from the irrigated plots were grade A beans and valued at $1.30 per bushel. The results obtained on the irrigated plots show that when either nitrogen, potash, or phosphate is left out of the fertilizer mixture the yield is materially reduced. Nitrogen appeared to be the most effective element in the mixture.

Table 56—*Bush-bean fertilization and irrigation tests.*

Plot No.	Fertilizer		Yields per acre	
	Formula	Application per acre	Irrigated	Non-irrigated
		Pounds	Bushels	Bushels
1	0-10- 5	600	198	38
2	5-10- 5	600	310	34
3	10-10- 5	600	292	43
4	5- 0- 5	600	224	38
5	.....	.....	172	34
6	5- 5- 5	600	277	36
7	5-10- 0	600	210	34
8	5-10-10	600	296	32

Tomatoes.—A series of plots similar to those used in the bean test were planted to tomatoes. The results indicated that nitrogen was of little value in the fertilizer mixture and that there is a great need for both phosphate and potash in a tomato fertilizer on that type of soil. Irrigation did not prove to be of much value to the tomato crop. It was not continued throughout the growing season, however, because of the excessive amount of fruit rot on the irrigated area.

In addition to the bean and tomato studies, variety-adaptation, fertilizer, and irrigation tests were made on other vegetable crops.

All of the crops responded liberally to irrigation, except tomatoes, and they showed some response.

CHANGES IN STAFF

Appointments

A. H. Chambers, Assistant Agricultural Economist, January 1.
J. A. Ewing, Assistant Superintendent, Middle Tenn. Exp. Sta., September 15.
Mary K. Good, Assistant General Chemist, January 3.
Ruth M. Marston, Assistant General Chemist, April 1.
Joan K. Wiley, Assistant Horticulturist, April 1.

Resignations

George W. Bible, Assistant Animal Husbandman, July 31.
D. S. Burgis, Assistant Horticulturist, June 30.
Ruth M. Marston, Assistant General Chemist, June 30.
Jesse E. Parker, Poultry Husbandman, April 30.

PUBLICATIONS, 1944

BULLETINS

No.	Title	Authors	Date	Pages
187	The Improved Castor-Bean Sheller	H. A. Arnold M. A. Sharp	January	9
188	Pastures for Growing Pullets	Jesse E. Parker B. J. McSpadden	January	12
189	Sweetpotato Culture	Brooks D. Drain C. D. Sherbakoff C. A. Mooers Ben P. Hazlewood	February	22
190	Electric Light Bulbs as a Source of Heat for Hotbeds	George E. Zerfoss A. B. Strand	February	12
191	Depth and Method of Soil Preparation and Cultivation for Corn and Cotton	C. A. Mooers	May	11
192	The Cumberland Plateau in Tennessee	F. N. Masters C. E. Allred	September	30
193	Milk Goats in Tennessee	S. A. Hinton J. J. Bird	October	11

CIRCULAR

87	The Tennessee Liquid Fertilizer Distributor	M. A. Sharp	February	8

MONOGRAPHS

(Mimeographed)

163	Production Capacity of Farms of Different Size Groups, Jefferson County, Tennessee	W. P. Ranney	January	61
164	Consumption of Dairy Products in Knoxville	B. H. Luebke W. S. Rowan C. C. Mantle	January	38
165	Farm Management Analysis of 107 Farms on the Cumberland Plateau	E. J. Lebrun	February	34

No.	Title	Authors	Date	Pages
166	Population Situation and Trends in Tennessee as a Whole	F. N. Masters C. E. Allred	March	47
167	Milk Delivery in Knoxville	B. H. Luebke C. C. Mantle W. S. Rowan	March	38
168	Possibilities of Sweet Potato Production in West Tennessee	S. W. Atkins C. C. Mantle	May	56
169	Association of Crops with Soils and Other Factors, Jefferson County, Tennessee	H. J. Bonser	May	77
171	Facilities and Agencies of Knoxville Milk Industry, 1943	B. H. Luebke C. C. Mantle W. S. Rowan	June	43
172	Quality of Land as a Factor in Farm Organization, Crop Yields, and Farm Income in Roane County, Tennessee	H. J. Bonser L. G. Kerby A. K. Schmidt	June	45
173	Farm Size in Relation to Land Use, Yields, Volume, Value of Production, and Total Nutrients, Overton County, Tennessee	H. J. Bonser	July	58
174	Changes in Milk Collection Situation, Knoxville Milk Shed, 1943 and 1944	B. H. Luebke C. C. Mantle	August	29
175	Producers' Prices for Eggs in Knoxville Trade Area	B. H. Luebke Margaret Guilford	September	40
176	Former Use of Land Now in Douglas Reservoir	H. J. Bonser	October	43
177	Labor, Materials, and Cost of Clearing Land on Cumberland Plateau	H. J. Bonser C. E. Allred C. C. Mantle	November	43
178	Use and Need of Farm Credit on Cumberland Plateau	B. H. Leubke A. H. Chambers C. E. Allred	December	45
179	How the Plateau Is Farmed on Sand Mountain, Alabama	F. N. Masters C. E. Allred	December	40

ARTICLES AND PAPERS

AGRONOMY

Title	Authors	Publication	Pages
Length, Fineness, and Strength of Cotton Lint as Related to Heredity and Environment	N. I. Hancock	Jour. Am. Soc. Agron., Vol. 36: 530-536. 1944	7
Maize Hybrids Susceptible to Earworm	F. D. Richey	Jour. Heredity, Vol. XXXV: 327-328. 1944	2

CHEMISTRY

An Innovation in Technic of Citrate Digestions	W. H. MacIntire H. L. Marshall T. A. Meyer	Jour. A.O.A.C. 27: 272-283. 1944	11
Fused Tricalcium Phosphate: Relation of Degree of Defluorination to Fertilizer Value of Quenched Fusions of Rock Phosphate	W. H. MacIntire S. H. Winterberg B. W. Hatcher George Palmer	Soil Scence 57: 425-442. 1944	17
Industrial Precipitated Tricalcium Phosphates Variance in Chemical, Structural, and Fertilizer Properties	W. H. MacIntire S. H. Winterberg H. L. Marshall George Palmer B. W. Hatcher	Ind. Eng. Chem. 36: 547-552. 1944	5
Factors that Influence the P_2O_5 Transitions that Occur in the Ammoniation of Superphosphate	W. H. MacIntire H. L. Marshall R. C. Shank	Jour. A.O.A.C. 27: 413-425. 1944	13
Report on Soils and Liming Materials	W. H. MacIntire	Jour. A.O.A.C. 27: 531. 1944	1
Report on Liming Materials —Neutralizing Value of Calcium Silicate Slag	W. M. Shaw	Jour. A.O.A.C. 27: 532. 1944	1

DAIRYING

Development and Use of the Barn Haydrier	C. E. Wylie John A. Schaller	Jour. Dairy Sci., Vol. XXVII: 654. 1944	1

ECONOMICS

Agriculture After the War	Willard P. Ranney	Homefront Planning for Postwar Period, Chap. III, Univ. of Tenn. Record, Extension Series, Vol. XX: No. 2, p. 26. 1944	10

Title	Authors	Publication	Pages
A Postwar Population Policy for the Southeast	Howard J. Bonser	Social Forces, Vol. 23: 38-41. 1944	4
ENGINEERING			
A New Liquid Fertilizer Distributor. Plywood Silos	M. A. Sharp	Agr. Engr., Vol. 25: 58. 1944	1
A New Irrigation Sprinkler	M. A. Sharp	Agr. Engr., Vol. 25: 252. 1944	1
Tests of Plywood Panels	M. A. Sharp	Agr. Engr., Vol. 25: 350.	1
HORTICULTURE			
Studies on Clonal Strains of Pyrethrum	Brooks D. Drain W. A. Simanton A. C. Miller	Proc. Am. Soc. Hort. Sci., Vol. 44: 521-524. 1944	4
Breeding Plants for Adaptation, Freedom from Insect Injury, and Disease Resistance	Brooks D. Drain	Proc. Am. Soc. Hort. Sci., Vol. 45: 225-228. 1944	4
NUTRITION			
Blood Plasma Ascorbic Acid Values Resulting from Normally Encountered Intakes of this Vitamin and Indicated Human Requirements	Mary L. Dodds Florence L. MacLeod	Jour. Nutrition, Vol. 27: 77-87. 1944	12
A Survey of the Ascorbic Acid Status of College Students	Mary L. Dodds Florence L. MacLeod	Jour. Nutrition, Vol. 27: 315-318. 1944	4
PLANT PATHOLOGY			
Use of Liquid Culture of Fusarium for Field Inoculation of Cotton	C. D. Sherbakoff Paul R. Miller D. M. Simpson	Phytopathology, Vol. XXXIV: 254-256. 1944	3