SUPPLEMENTING CATTLE FATTENING RATIONS WITH MINERALS

by

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INTRODUCTION

Purpose of Experiment

This experiment was conducted for the purpose of securing additional information relative to the possible advantage of adding calcium in the form of finely ground limestone to cattle fattening rations in which corn and cottonseed meal are used as the concentrate portion, and alfalfa or prairie hay, with and without silage, as the roughage portion of a cattle fattening ration.

This experiment was conducted by the writer at the Kansas Agricultural Experiment Station during the fall and winter of 1927 and 1928.

Acknowledgments

The writer is deeply indebted to his major instructor Dr. C. W. McCampbell for his advice and able assistance in preparing this thesis, and to Prof. B. M. Anderson for his helpful instruction in carrying out this feeding test.

Discussion

The cattle used in this test were high grade Hereford steer calves approximately six months of age. They were purchased from the Matador Land and Cattle Company, Matador, Texas.

The calves were divided into eight lots of ten head each. They were selected in a manner to insure as nearly as possible uniformity in size, weight, and general conformation in each lot. The calves were weighed individually for three consecutive days at the beginning and the end of the experiment, and the average of these three days' weights was taken as the initial and final weight, respectively. One weight was taken at the end of each thirty-day period.

Each steer had a neck strap with a brass numbered tag to serve as a means of identification.

The length of the feeding period was 180 days, beginning November 23, 1927 and ending May 22, 1928. They were fed twice daily, at 7:15 a.m. and 5:00 p.m.

All eight lots were hand fed the first 60 days. The non-silage group was fed all of the dry roughage it would consume in addition to the shelled corn and its allotted

amount of cottonseed meal. The silage group was fed a limited amount of dry roughage, consisting of alfalfa or prairie hay, once daily in addition to its corn and cottonseed meal and what cane silage it would clean up in addition. At the end of 60 days all eight lots were put on to self-feeders of shelled corn. It was necessary to grind the corn in the dry roughage group. These four lots where ground shelled corn was fed, the cottonseed meal was mixed with the ground corn. In lots two and four where ground limestone was fed, it was also mixed with the ground shelled corn and cottonseed meal. In the silage group, the ground limestone was mixed with the cottonseed meal in lots six and eight and hand fed just the same as the cottonseed meal in lots five and seven, twice daily on the silage.

At the end of 70 days the two silage lots receiving prairie hay (Lots 7 and 8) were cut from two pounds of prairie hay to one pound per head per day, as the calves would not consume the larger amount.

Water was supplied from the College system in two hundred gallon galvanized and concrete tanks exposed to the open, one to each lot. They were filled twice daily.

Method of Procedure

The feeds fed each lot were as follows:

Lot 1 -	Shelled corn	- Hand fed first 60 days
	Ground shelled corn	- Self fed last 120 days
	Cottonseed meal	- 1 pound per head per day
	Alfalfa hay	- Ad. lib.
Lot 2 -	Shelled corn	- Hand fed first 60 days
	Ground shelled corn	- Self fed last 120 days
	Cottonseed meal	- 1 pound per head per day
	Alfalfa hay	- Ad. lib.
	Ground limestone	- One-tenth pound per head per day
Lot 3 -	Shelled corn	- Hand fed first 60 days
	Ground shelled corn	- Self fed last 120 days
	Cottonseed meal	- 1 pound per head per day first 60 days
	Cottonseed meal	- 1 1/3 pound per head per day last 120 days
	Prairie hay	- Ad. lib.

Lot 4 -	Shelled corn	- Hand fed first 60 days
	Ground shelled corn	- Self fed last 120 days
	Cottonseed meal	- 1 pound per head per day first 60 days
	Cottonseed meal	- 1 1/3 pounds per head per day last 120 days
	Prairie hay	- Ad. lib.
	Ground limestone	- One-tenth pound per head per day
Lot 5 -	Shelled corn	- Hand fed first 60 days
	Shelled corn	- Self fed last 120 days
	Cottonseed meal	- 1 pound per head per day
	Alfalfa hay	- 2 pounds per head per day
	Cane silage	- Ad. lib.
Lot 6 -	Shelled corn	- Hand fed first 60 days
	Shelled corn	- Self fed last 120 days
	Cottonseed meal	- 1 pound per head per day
	Alfalfa hay	- 2 pounds per head per day
	Cane silage	- Ad. lib.
	Ground limestone	- One-tenth pound per head per day

Lot 7 -	Shelled corn	- Hand fed first 60 days
	Shelled corn	- Self fed last 120 days
	Cottonseed meal	- One pound per head per day first 60 days
	Cottonseed meal	- 1 1/3 pound per head per day last 120 days
	Cane silage	- Ad. lib.
	Prairie hay	- 2 pounds per head per day first 70 days
	Prairie hay	- 1 pound per head per day last 110 days
Lot 8 -	Shelled corn	- Hand fed first 60 days
	Shelled corn	- Self fed last 120 days
	Cottonseed meal	- 1 pound per head per day first 60 days
	Cottonseed meal	- 1 1/3 pound per head per day last 120 days
	Cane silage	- Ad. lib.
	Prairie hay	- 2 pounds per head per day first 60 days
	Prairie hay	- 1 pound per head per day last 120 days
	Ground limestone	- One-tenth pound per head per day

Discussion of Feeds Fed

Silage.- Silage is the product of finely cut plants which have been allowed to ferment in especially prepared places.

The crop most suited for making ensilage is corn, where it can be grown successfully, but of course there are limiting factors in corn production which in some localities prevents its being used. The grain sorghums and sorgo are the next best crops to use especially in the drier sections and on poorer lands. In Kansas the sorghums and sorgo are not used quite as much as corn. The counties where most of the silos are in use are those located in sections two and three, as indicated in Figure 1 (1). In these two sections corn yields better on the bottom lands and sorghums and sorgo yield best on upland soil, where the rainfall is limited and the land is less productive.

From a study of Figure 2 (2) of the eastern one-third of the state, this section produces a little more corn than sorghums and sorgo per acre. But with the large amount of these two crops grown it would indicate that this section takes advantage of the possibility of putting into

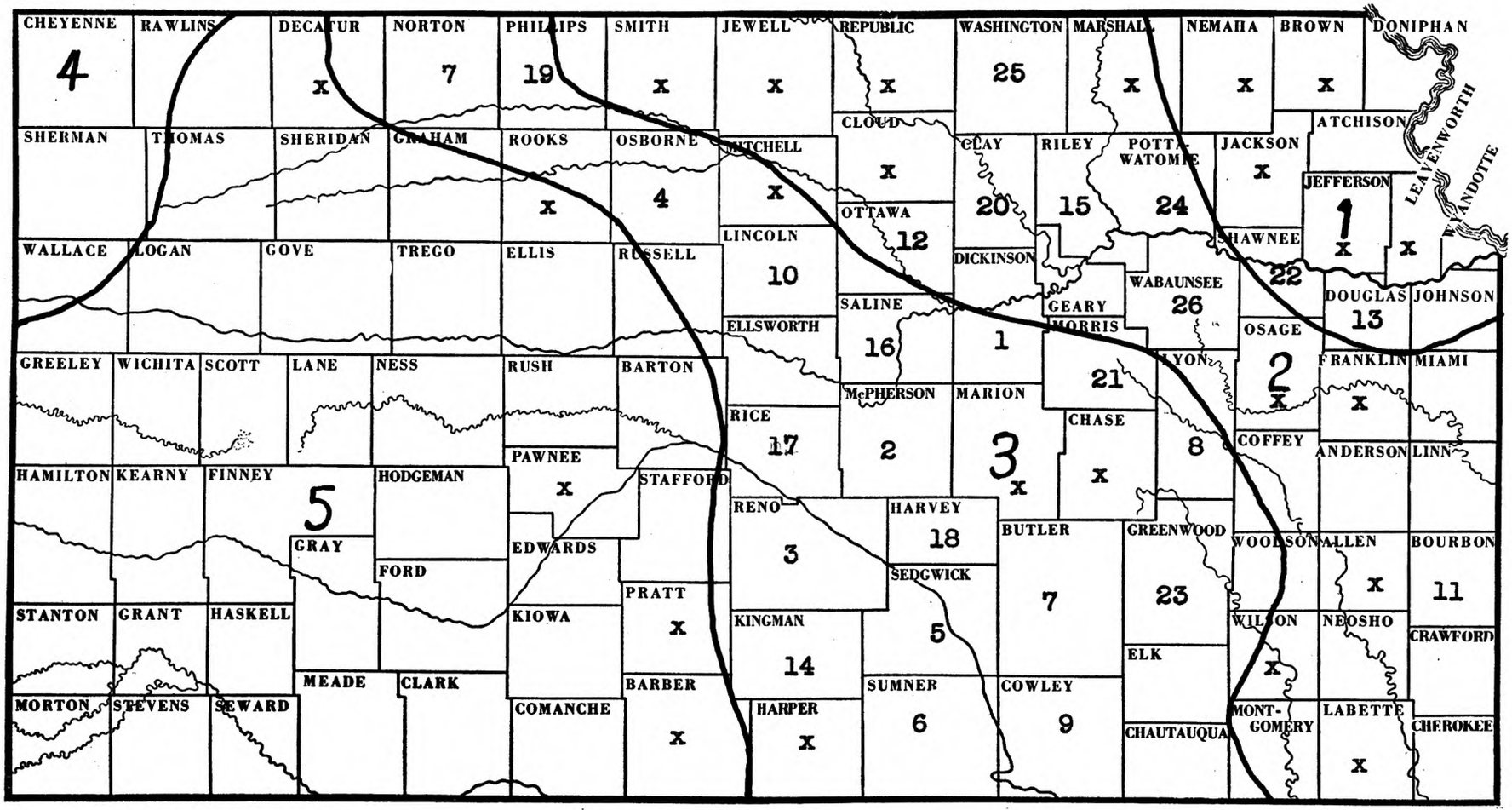


FIG. 1.
SILOS in Kansas - 1927- Total 13,034.
No. 1. = 492 silos in Kansas in 1927 (Dickinson County)
No. 26.= 203 " " " " "
x = 100 to 200 silos in 1927.

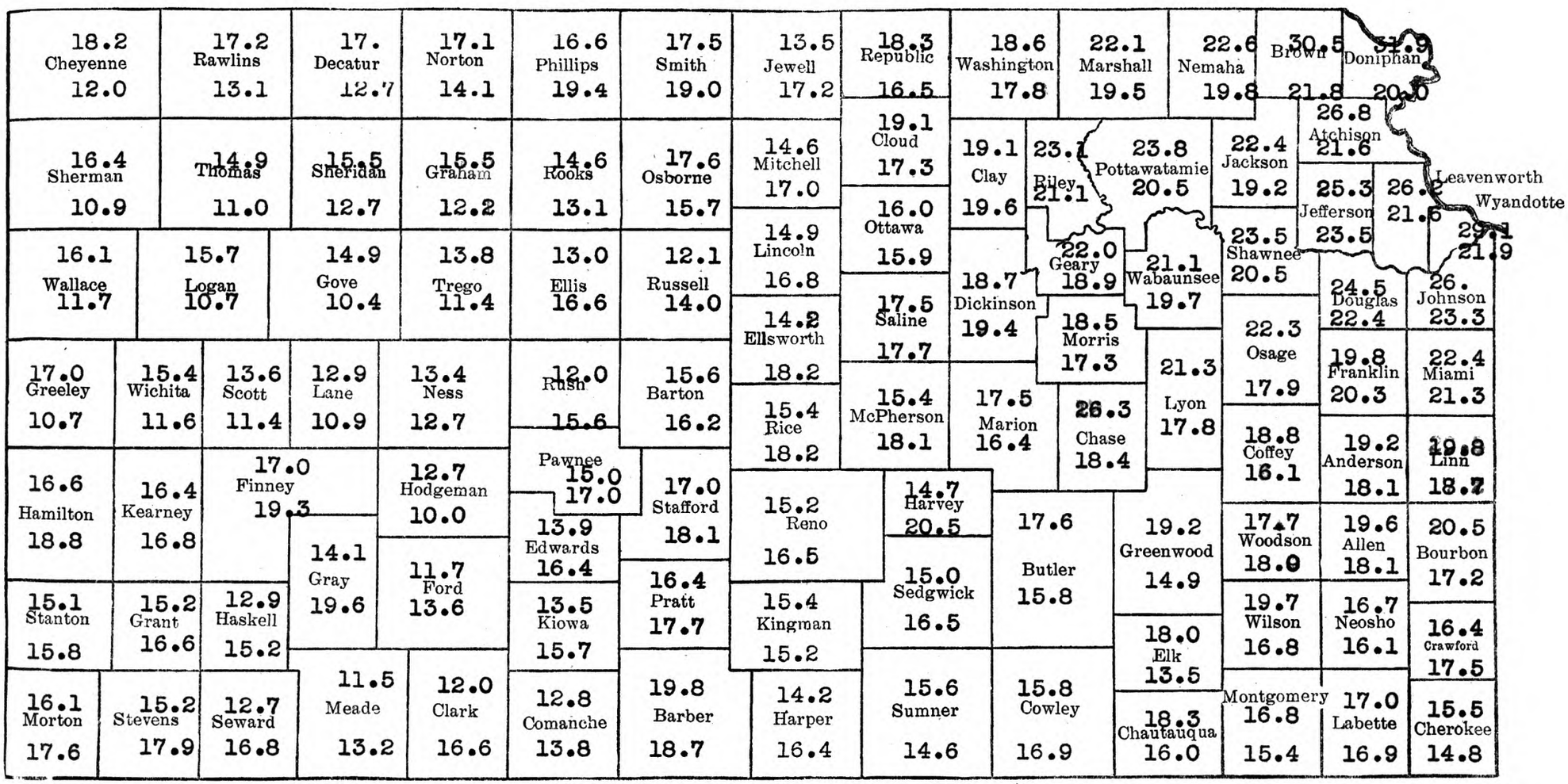


FIGURE 2. Showing the comparison of the average yields of corn and sorghum in each county in Kansas. Corn above; grain sorghums below.

the silo either corn, sorghum, or sorgo crops. This section has a large yield per acre of all three crops, ranging from fourteen to twenty-one bushels per acre. Corn yields a little higher per acre than does either sorgo or grain sorghums.

The crop should be well ripened. In the case of corn, let it stand until the ear is well dented and the lower leaves on the stalk are dry, and in the case of sorghum or sorgo they should be cut and ensiled when the heads are mature.

If possible run the crop used through the cutter as quickly after cutting as possible. This maintains nearly all the moisture in the plant and less water is used, if water is used at all. It is best to cut the crop a little dry and add water as it is put in the silo than to put it in too green. A corn binder is the best suited to cut corn, sorgo, and grain sorghum crops for the silo. The cutter, the machine that cuts the crop for the silo, should cut the stalks in pieces varying from one-fourth to three-fourths of an inch in length. The finer the stalk is cut the easier it is to pack, and less danger from air pockets and spoiling, and consequently more silage in the silo.

To make silage it is necessary to exclude the air. To exclude the air the cut material must be of sufficient weight and fine enough to pack well. If the crop is dry it is more or less fluffy and does not pack well. Air pockets occur and this causes moldy silage. If the material is too dry water should be added as it goes into the silo. While silage that is too wet is not desirable it is hard to injure silage from adding water to it. More water should be added near the top of the silo than at the bottom.

There are two major changes that take place in a silo: (1) Physical changes. (2) Chemical changes. The chief physical changes are (1) Rise in temperature. (2) Change in color from green to brown. (3) Softening of the material caused by exudation of cell sap from cut tissues. (4) A reduction of the material to a homogeneous mass. (5) An acquisition of an acid taste and aromatic odor.

There seems to be a rather wide range in temperature for the best fermentation. An average for several tests made would range between 84°F. and 90°F. There is usually a steady rise in temperature for about the first fifteen days. One of the first evidences of silage fermentation is the production of heat and the evolution of carbon-dioxide.

Some chemical changes are fermentation caused by bacteria or enzymes, and ripening similar to cheese, which softens the fibers, makes the proteins more digestible and adds new and agreeable odors. This ripening process usually occupies three or four weeks. There are two types of ensilage, (1) Sweet silage, (2) Sour silage. Sweet silage is made where the temperature rises to around 90°F. and above, and sour silage (usually crops cut too green) is made when the temperature never gets above 80°F. Sweet silage is the best to feed stock as it has a more desirable taste and odor than does sour silage.

The cost of silage varies with the crop used, the tons raised per acre, and the cost of cutting, and the actual cost of machinery and labor involved in the operation of putting it in the silo. The biggest item in labor involved in growing the crop is harvesting it and putting it in the silo. There are other major items of expense such as land rental, manure, rental power for cutting, fuel for power to run cutter, and other numerous items that run the cost up to $20 to $25 per acre (3) and the cost per ton is around $3 to $5 per ton, according to the number of tons produced per acre. A large yield per acre will lower the cost per ton materially. At the station here the cost per ton is about $5.00.

The chemical analysis of silage varies depending on the maturity of the crop when it is put in the silo. The chemical analysis of the silage used in this test, which was made by the Chemistry Department at the Kansas State Agricultural College in 1928, is as follows:

Moisture	Protein	Fat	Fiber	Ash	N. F. E.	Acidity
74.73%	1.36%	.62%	6.33%	1.47%	12.91%	2.58%

The moisture and acidity vary more in different silos than any two factors. The moisture varies with the kind of crop used and the amount of moisture present in the crop used, and the amount of water used when the silage was put up.

The acidity varies according to the maturity of the crop that was used. The greener the crop the more acidity, and the riper the crop the less acidity.

Prairie Hay.-The hay from those grasses grown on the virgin soil that are cut and cured for the purpose of feeds are known as prairie hay. These grasses usually have a tall upright manner of growth, are light in color with a shallow root system and are low in protein and mineral matter, especially calcium. The feeding value of prairie hay is more variable than is alfalfa, owing to different kinds of grasses which go to make up the crop.

Prairie hay is produced very largely in the northern half of the Great Plains and the territory immediately adjacent on the east in Oklahoma, Kansas, Nebraska, Minnesota, North Dakota, and South Dakota.

In the eastern half of the prairie hay region the grasses are mostly bluestems (little and big) and blue-joint, with a lesser amount of Indian grass and switch grass. In the western part these grasses give way to western wheat grass, slender wheat grass, and side-oats grama with other species of grama entering into the production in favorable seasons.

The leading states in the production of wild or native hay in 1924, as reported by the U. S. Department of Agriculture Yearbook for 1924 are as follows: South Dakota first, Nebraska second, North Dakota third, Minnesota fourth, Kansas fifth, Oklahoma sixth, Iowa seventh, and Montana eighth.

Prairie hay in Kansas ranked seventh as a single crop in valuation in 1926, with a total valuation of over $6,000,000 from over 700,000 tons grown on 900,000 acres (4). The importance of prairie hay in Kansas agriculture is well recognized for it stands fifth in valuation as a single crop over a twenty-year period, 1906 to 1926.

The native grasses to be found in the eastern half of Kansas are mostly big and little bluestem. They are well adapted to conditions in this section of the state, where the soil is mostly clay or clay loam. The southeastern quarter of the state is the big producer of prairie hay. In fact it is about the only section of the state that does produce a surplus. In the other sections, most of the native hay is used at home. The western half of the state native grasses are grama, switch grass, Indian grass, and some Buffalo grass. The big and little bluestems require more rainfall than do most of the other grasses of Kansas and therefore are not well suited to the western half of the state where the rainfall is limited.

In the southeastern quarter of Kansas, where most of the surplus prairie hay is grown, the land is poor and not well adapted to growing some of the other crops, such as corn, wheat, and alfalfa. Woodson county, for example, produces more prairie hay than any county in the state with a total production of over forty-five thousand tons in 1926 (5). This is by far the largest yield of any of the crops in that county and represents over one-fourth of the total crop valuation in 1926.

Figure 3 shows the valuation of prairie hay for the leading prairie hay producing counties in Kansas in 1926, and Figure 4 shows the total production and valuation of this hay in Kansas for the last twenty years, from 1908 to 1927.

Most of the prairie hay in Kansas is harvested during August. The time of harvest depends to some extent upon weather conditions. If the rainfall has been abundant during May and June and the grass has made a good growth, cutting may begin to a limited extent in some localities before the middle of July in order to supply a demand for new hay. Frequently harvesting is hastened by extremely hot, dry weather which causes the blades to die and turn brown. Nearly all of the hay land in Kansas is cut over but once in a season, but it is not uncommon for fertile fields or low lying land upon which the coarser grasses are more abundant to be cut twice in a season. One cutting is made in July and the other in September. It is often necessary to make two cuttings from many lowland fields in order to prevent the hay from becoming coarse and unpalatable.

Practically all of the hay is cut by horse drawn mowers. The six-foot mower is probably the most popular, but they sometimes vary in length. Either a side delivery

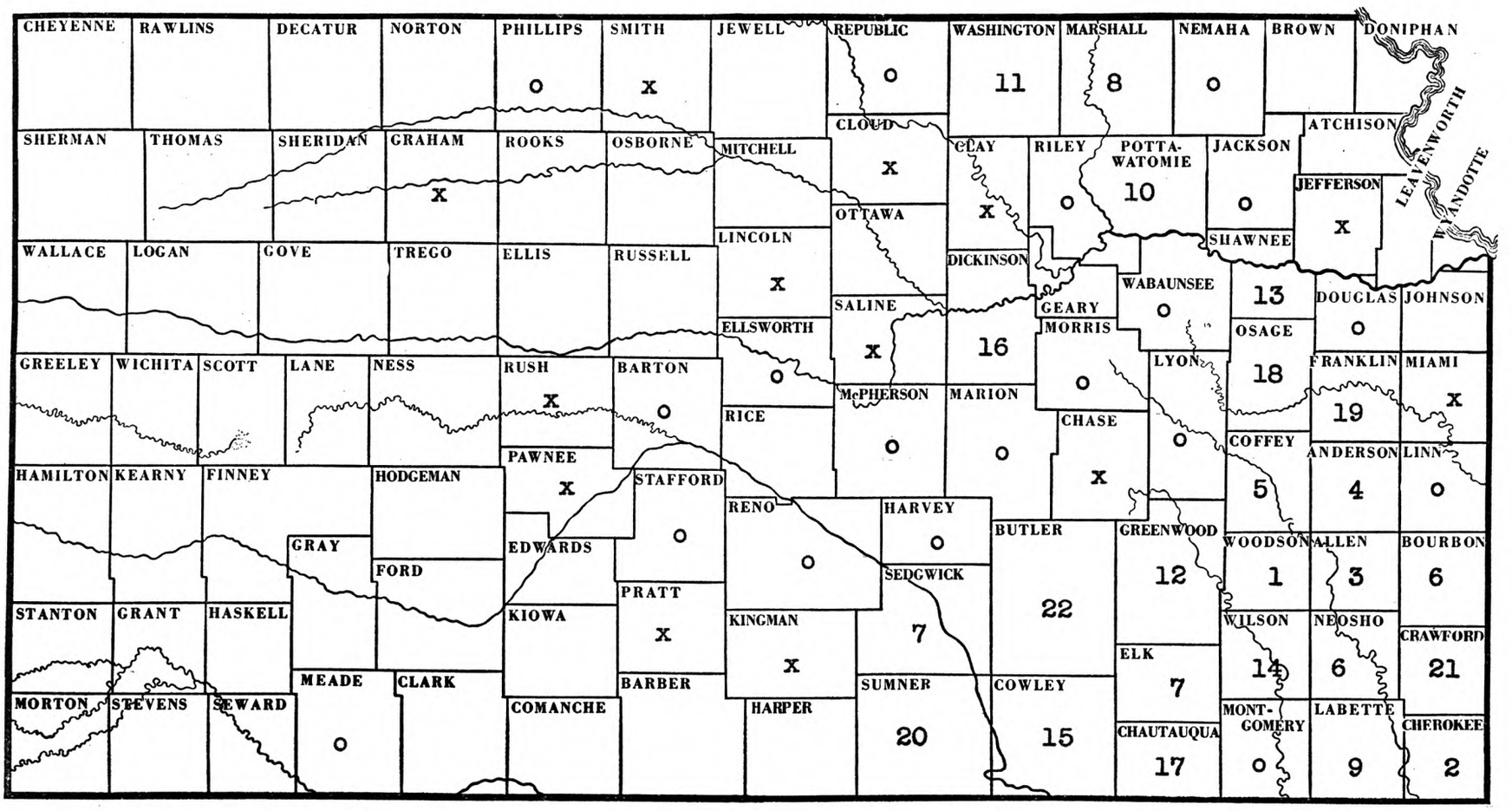


FIG. 3.

PRAIRIE HAY Valuation in Kansas 1926. Total valuation $6,163,682.00
Number 1 = $476,670.00 (leading county)
Number 22 = $101,302.00
o = $50,000 to $100,000.
x = $25,000 to $50,000.

Figure 4. Twenty Years of Kansas Agriculture - 1908 - 1927.

CORN	1908	1909	1910	1911	1912	1913
Bushels	150,640,516	147,000,000	152,810,000	105,047,000	156,499,000	18,420,000
Values	$82,642,000	$83,066,000	$76,402,000	$59,599,000	$83,483,000	$13,378,000

PRAIRIE HAY	1908	1909	1910	1911	1912	1913
Tons	1,145,000	1,497,000	1,589,000	1,146,000	861,000	1,061,000
Values	$5,495,000	$7,456,000	$11,860,000	$9,854,000	$6,583,000	$9,410,000

1914	1915	1916	1917	1918	1919	1920
87,338,000	142,653,000	62,127,000	106,166,000	44,539,000	63,083,000	132,786,000
$59,320,000	$73,547,000	$51,886,000	$120,540,000	$64,081,000	$82,845,000	$92,036,000

1914	1915	1916	1917	1918	1919	1920
492,000	1,659,000	1,211,000	1,031,000	694,000	1,106,000	1,088,000
$4,379,000	$8,440,000	$7,550,000	$14,782,000	$12,070,000	$15,742,000	$10,888,000

1921	1922	1923	1924	1925	1926	1927
96,484,000	95,311,000	125,680,000	131,007,000	104,860,000	58,380,000	176,712,000
$27,760,000	$51,648,000	$77,588,000	$106,311,000	$74,065,000	$41,010,000	$113,924,000

1921	1922	1923	1924	1925	1926	1927
1,039,000	957,000	1,019,000	1,035,000	787,000	636,000	1,137,000
$5,357,000	$5,841,000	$7,701,000	$6,946,000	$5,838,000	$6,163,000	$5,000,000

rake or sulky rake is used to rake the cut hay into windrows. In most sections of the state it is moved from the windrow to the stack or baler by means of a sweep rake. When it is stacked sometimes the overshot stacker is used. The hay is baled with a gasoline power presser. Usually, however, in some instances a one or two horse power press is used. Under favorable conditions the crop may be mowed in the evening and early morning and raked about noon and put into the stack or bale during the afternoon.

The chemical analysis of prairie hay as made by the Chemistry Department of the Kansas State Agricultural College in 1927 is as follows:

Moisture	Protein	Fat	Crude Fiber	Ash	N.F.E.
12.50%	5.73%	3.24%	26.30%	6.35%	45.88%

The chemical analyses of the different grasses vary with the conditions under which they are grown, the section of the country, moisture, and condition of the soil. During the dry seasons it does not make such a rank growth and the fiber content is lower, which makes it a little more palatable, while in the wet seasons it makes a ranker growth which causes it to be high in fiber content and less palatable.

Alfalfa Hay.- Alfalfa hay is a bushy, perennial plant green in color with an upright manner of growth, very leafy, a deep root system, and high in protein, mineral matter, and some of the vitamins.

Alfalfa can now be grown to some extent in most all countries having temperate climate. It finds greatest favor in the United States, and is grown in almost every state in the Union, but by far the greatest acreage to be found is in the states west of the Mississippi. Figures 5 and 6 show the distribution of the plant in the United States (7) and the state of Kansas, together with the total production. In 1927 there were 923,056 acres of alfalfa in Kansas that produced 2,807,456 tons and was valued at $24,270,555 (8).

Kansas ranks second in number of acres devoted to alfalfa and in many respects alfalfa is the most important crop grown in Kansas. According to figures of the U. S. Department of Agriculture for 1926, Kansas ranks fifth in production. California is first in production and second in acreage. The ten leading states in alfalfa production are California, Nebraska, Colorado, Idaho, Kansas, Utah, Montana, Michigan, Wyoming, and Wisconsin in the order named (9).

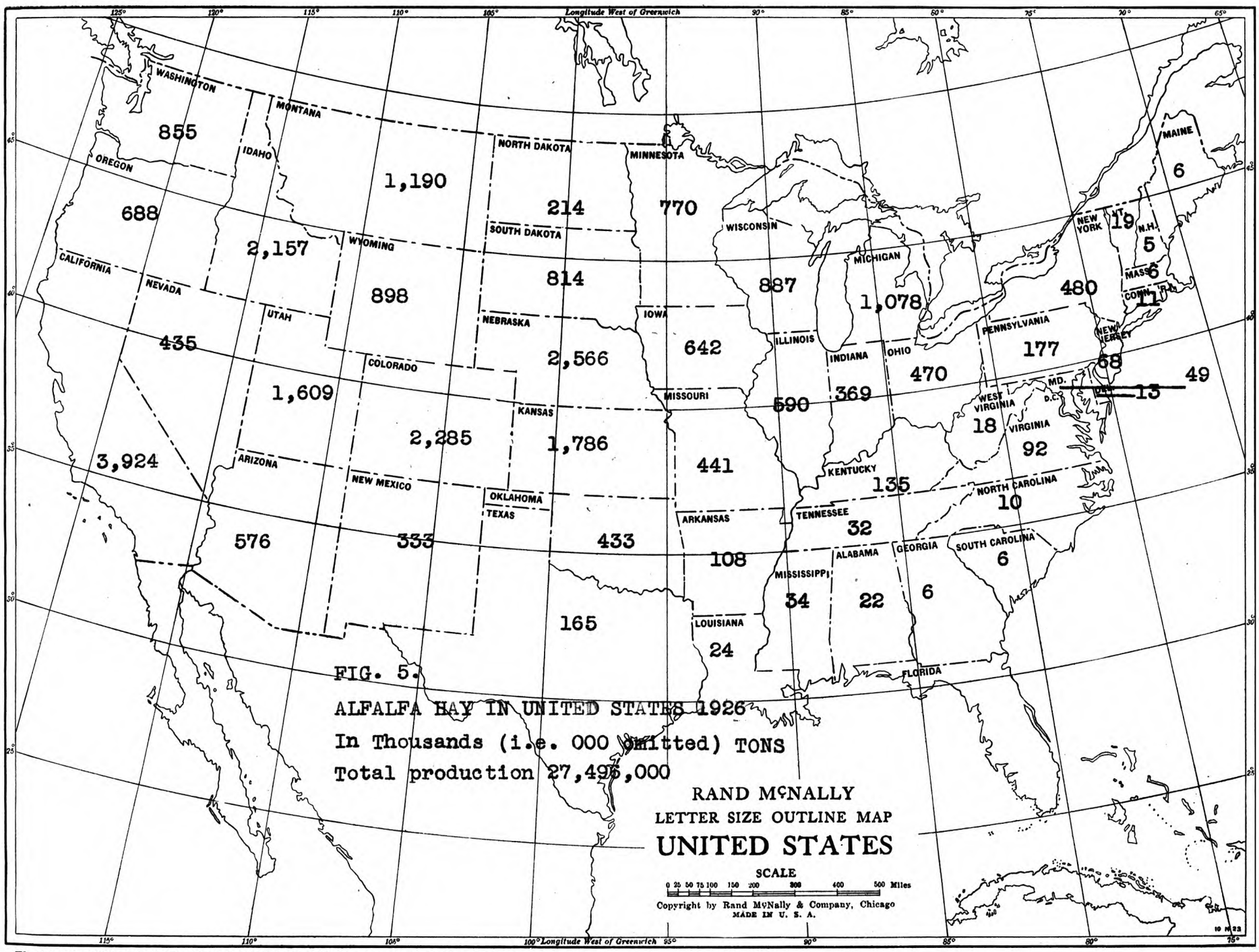


FIG. 5.

ALFALFA HAY IN UNITED STATES 1926

In Thousands (i.e. 000 omitted) TONS

Total production 27,495,000

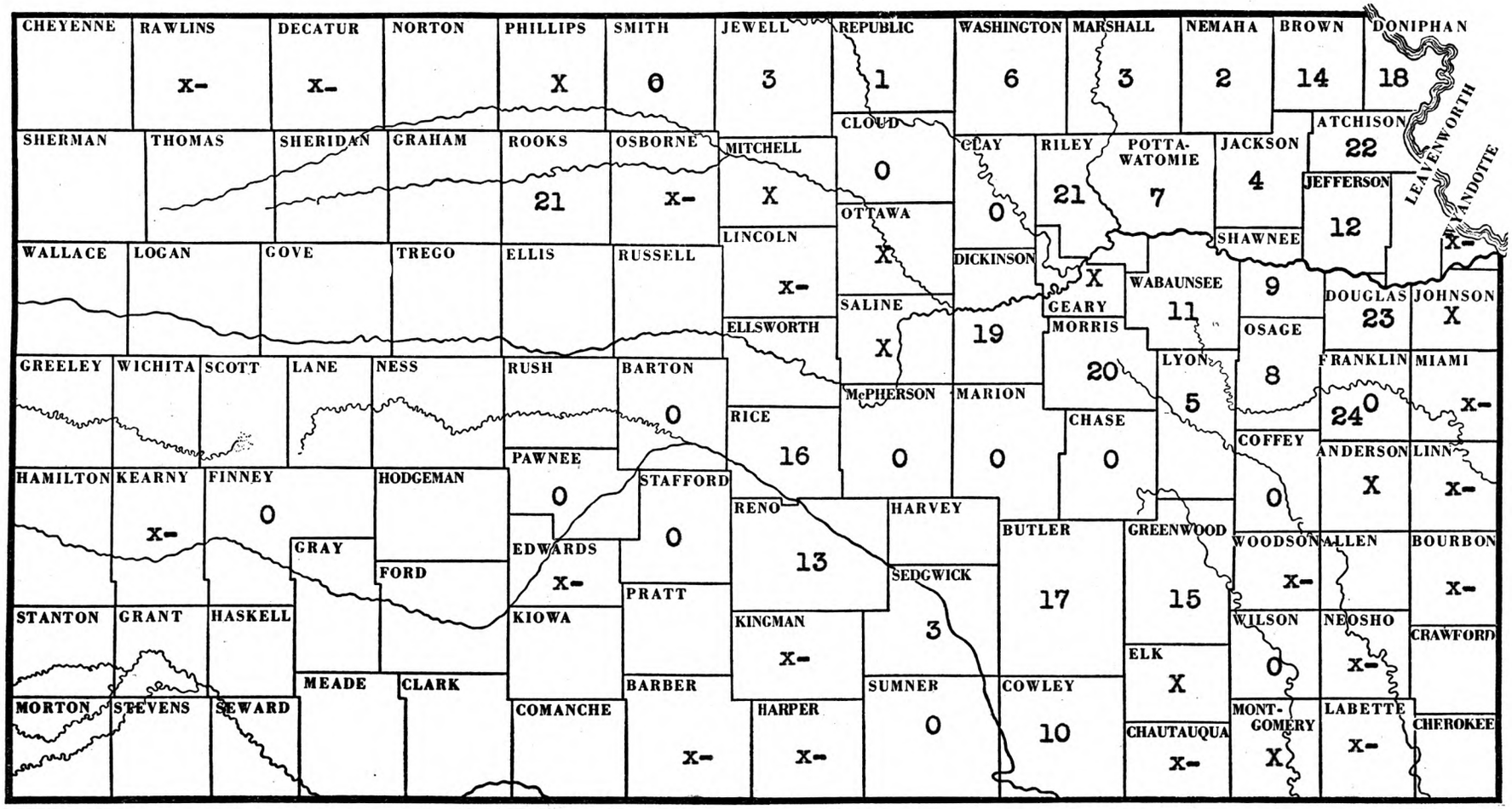


FIG. 6.

ALFALFA HAY Valuation in Kansas 1926- Total valuation - $26,230,757.00

Number 1. = $784,280.00

Number 24 = $410,000.00

0 = $300,000 to $410,000.

X = $200,000 to $300,000.

x = $100,000 to $200,000

In total valuation, wheat or corn greatly exceed alfalfa in Kansas, but there is no other crop that is so essential in relation to the livestock industry, so useful in rotation with other crops, or so valuable in proportion to the cost of production. Alfalfa will, in the future, as in the past, play an important part in any system of farming that may be considered permanent.

Alfalfa hay in Kansas is grown mostly in the northeastern and eastern sections of the state. Lyons and Nemaha have been the two leading counties in alfalfa production the last two years, 1926 and 1927. The southeast quarter ranks second, the western half's production being confined to the bottom lands and richer upland soil.

Although acreage of alfalfa in Kansas is relatively high, there has been a gradual decline since 1915, with the exception of one period, 1917-1920, when acreage in all crops was stimulated. In 1915 there were 1,360,000 acres as compared with about 890,000 in 1926. Figure 7 (10). This represents a decline of more than 465,000 acres or about one-third since 1915. The decrease has taken place largely during two periods, namely, from 1915 to 1917 and from 1920 to 1922. The first period of decline was possibly due to high grain prices during the world war, which induced many farmers to break up their alfalfa

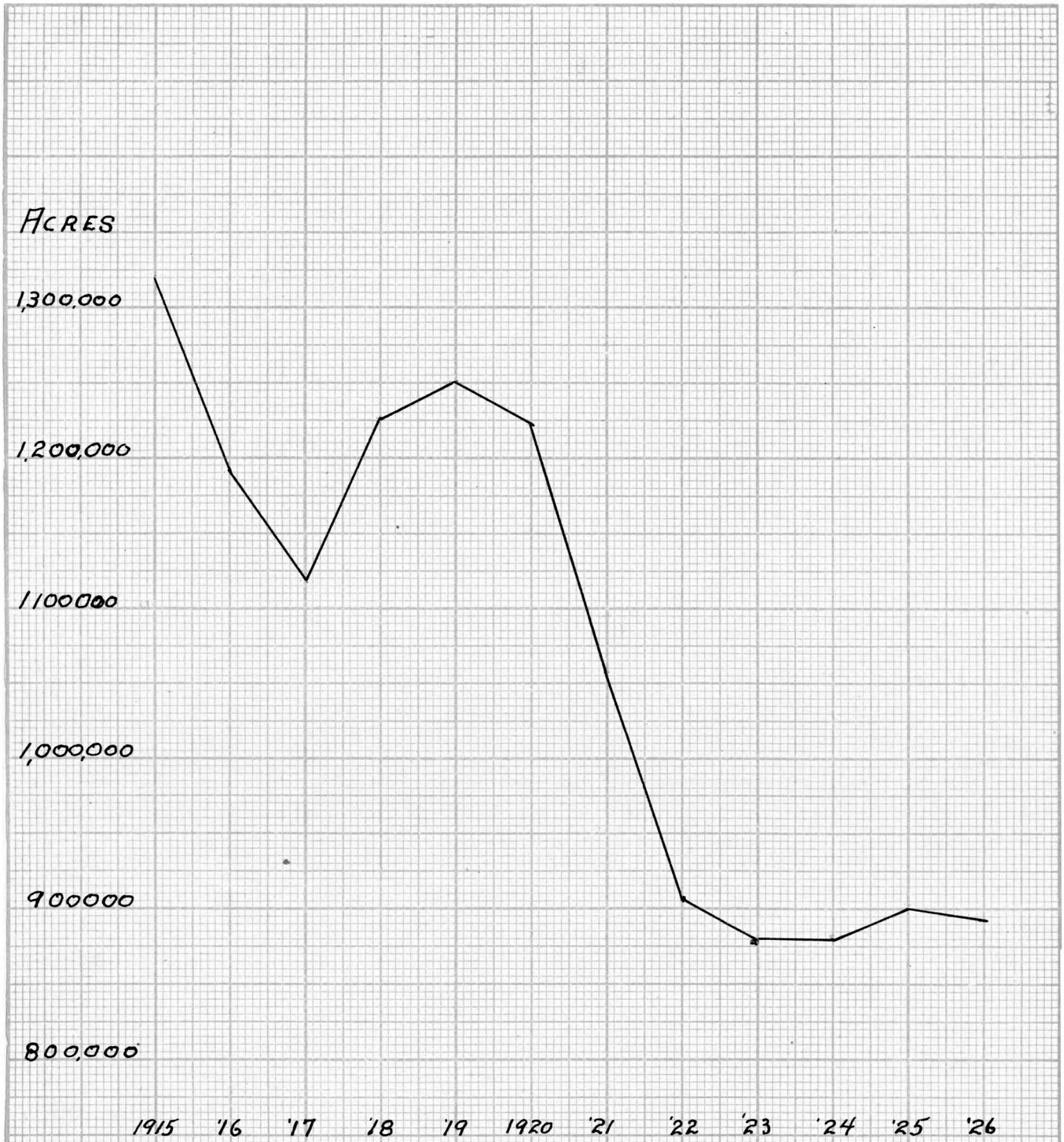


Figure 7. Graph - Showing the trend of alfalfa acreage in Kansas, 1915-1926.

land for grain crops. The decline during the second period is possibly due, in part at least, to insects, plant diseases, and unfavorable seasons. Other important factors are decreased fertility of the soil and winter killing.

The two varieties best adapted to Kansas conditions are Kansas Common and Grimm. Grimm is a Minnesota variety and is known for its winter hardiness. It is not as well adapted to Kansas conditions as Kansas Common. Grimm variety of seed is much higher in price.

The alfalfa plant is very sensitive to acid soils. The nitrogen fixing bacteria which develop in the nodules of the roots of these plants require a neutral or slightly alkaline medium in which to grow and develop. Acid soils not only retard the growth and work of these bacteria but actually destroy most of them. To correct this condition it is necessary to apply lime. A deficient supply of lime is indicated by a short root stem and yellowish-green leaves. The plants have small weak crowns and low yielding capacity. The result is the stand becomes very thin and the alfalfa plants being replaced by weeds and grass.

The value of lime to soil is well illustrated by a test made in Allen County, Kansas (11) in which lime was applied from 1915 to 1923 to a plot and compared with

the no-lime plot. The limed plot yielded three times as much per acre over the eight-year period.

The rate of application of lime varies with fineness of the limestone and acidity of the soil, but usually about one to three tons per acre in eastern Kansas is applied. Figure 8 shows the sections in the state that need lime.

The quantity and yield of alfalfa hay depends very materially upon the time the crop is cut and the way it is cured. In making alfalfa hay it is especially important to guard against loss of leaves, which are the most valuable portion of the crop. Widstoe at the Utah Station shows that while leaves and flowers of alfalfa cut early in bloom make up 43 per cent of the hay, they contain two-thirds of all the crude protein and early three-fourths of all the fat (12). The leaves contain twice as much protein and less than half the crude fiber as the stems. They also contain more ash (minerals), more nitrogen free extract, and more ether extract (fat) than stems (13). The relative value of different cuttings of hay will depend on the climatic conditions. The second and later cuttings which are usually finer stemmed and more leafy than the first cutting, are better except for horses.

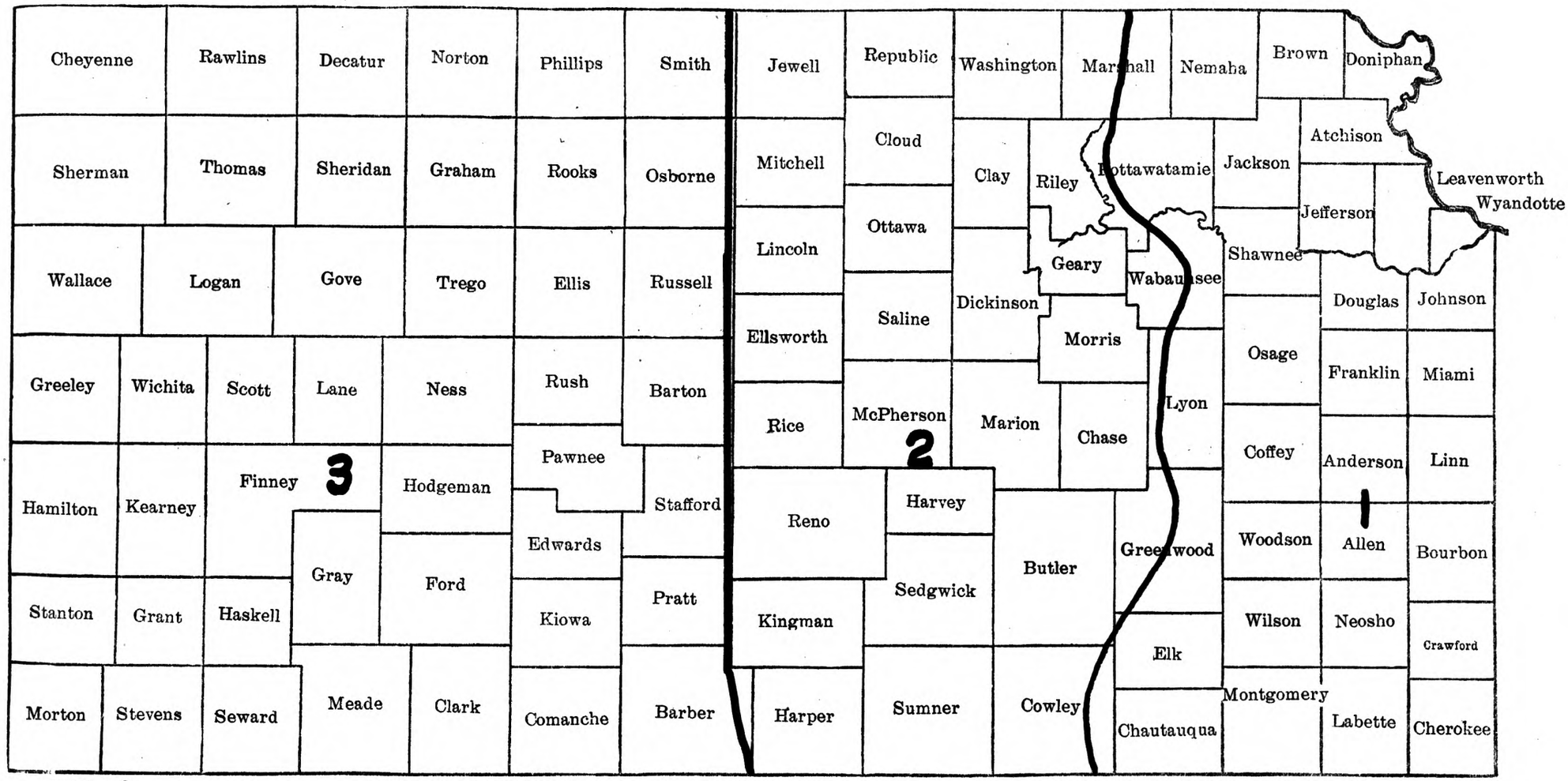


FIG. 8.

MAP OF KANSAS SHOWING WHERE LIME IS NEEDED FOR ALFALFA.

1- Section of state in which most upland soils need lime.

2- Section of state in which upland soils that have been heavily farmed for long time may need lime.

3- Section of state in which soils do not need lime at the present time.

The old rule to begin cutting when the field is about one-tenth in bloom is reasonably safe. Avoid too frequent or too long intervals in cutting as both injure the stand and value of the hay crop. Too frequent cutting injures the stand and too great loss in quality results from delayed cutting.

The most important point in curing alfalfa is to retain as many leaves as possible. If possible, alfalfa should be cut, cured, and stacked or put under shelter without being rained on.

It is a good plan to cut in the morning, rake in windrows with a side delivery rake as soon as the leaves on top of the swath become dry and turn the windrows with the rake. The next morning stack or bale as soon as the hay is sufficiently dried.

The chemical analysis of alfalfa hay varies with the time of harvest, weather conditions, soil conditions, and method of curing.

The chemical analysis of alfalfa hay as made by the Chemistry Department of the Kansas State Agricultural College in 1927 is as follows:

Moisture	Protein	Fat	Crude Fiber	Ash	N. F. E.
12.70%	12.68%	1.48%	30.18%	8.70%	34.76%

The federal grades of alfalfa are as follows (14):

U. S. Grade	Leafiness % of leaves	% Green color	Maximum of foreign material
No. I	40%	60 % or more	5%
No. II	25%	35 % or more	10%
No. III	Less than 25%	Less than 35%	15%

Corn.- Corn, Zea Mays, is a large, rank growing plant belonging to the genus Zea of the grass family. It has no close relatives either among cultivated or wild grasses, and it is therefore quite different from the other familiar cereals as to the structure and arrangements of its parts and in many other respects. On account of its sensitiveness to frost, corn cannot be planted so that it will make part of its growth in the fall, live over the winter like wheat or rye, and complete its growth and produce seed the following spring and summer. It is therefore called a spring annual.

Roots are separated into three groups, namely, temporary, permanent feeding roots, and the brace roots. The temporary roots only last a few days, and are replaced by the permanent roots that form near the surface of the ground, regardless of the depth of planting. These roots grow out laterally for some distance before turning downward. The depth to which they will penetrate depends upon

the position of the water table and upon the texture of the soil. In loose, fertile soils they have gone as far as five or six feet. The brace roots spring from the first, second, third and sometimes from the fourth node above the ground. Their function is to brace the plant especially when it bends over from rain or wind.

The stem or culm. The stem is filled with pith. The lower internodes are round, but near the top of the plant where the leaf sheath fastens, the internode is slightly flattened or grooved. When the ear is formed the flattened part of the internode is much more pronounced to make room for the growing ear. The stalks vary greatly in height. Even in the same field we find it growing in the fertile spots much ranker and larger than it does in the less fertile spots. The growth is likewise influenced by the amount of rainfall, sunshine, and length of the growing season. Different varieties of corn grow taller than others even when grown side by side and under similar conditions. The average height is from five to fifteen feet although smaller types such as pop corn and sweet corn grow from four to ten feet, while some types reach around twenty to twenty-five feet in height.

The leaves. Since corn is a large rank growing plant, it needs great expanse of leaf surface to afford room for the combining of the necessary amount of elements of the plant food required for its growth. Therefore, the leaves of the corn plant are much broader and longer than those of the smaller cereals. The width of leaves vary in size with the different types and varieties. Continual selection of seed corn from wide leaf varieties has produced a very large leaf for use in the silo. The number of leaves per growing plant varies from ten to twenty. A leaf grows from each node of the stalk, but the lower leaves seldom grow to maturity since many are broken off during cultivation and they wither and die. At maturity about twenty per cent of the plant is leaf in weight. The loss in weight at maturity is due to loss of lower leaves and transfer of food to the developing ear. The flowers of the plant are cross-pollinated and wind-pollinated.

The ear is carried on a short shank or branch growing from a node between the leaf sheath and the culm. The shank is made up of several short internodes from each of which grows a husk, and these, overlapping, form the covering of the ear. The top ear is the first and usually the only one to develop. Some varieties in the south

produce two or more ears per stalk. In the north most of the varieties produce only one ear, but under very favorable conditions two ears are commonly found. There is a great variation in number of rows of grain and size of the ear. Varying from one inch in pop corn to sixteen inches in large varieties of dent corn. The number of rows vary from eight in flint to as many as twenty-four in dent corn.

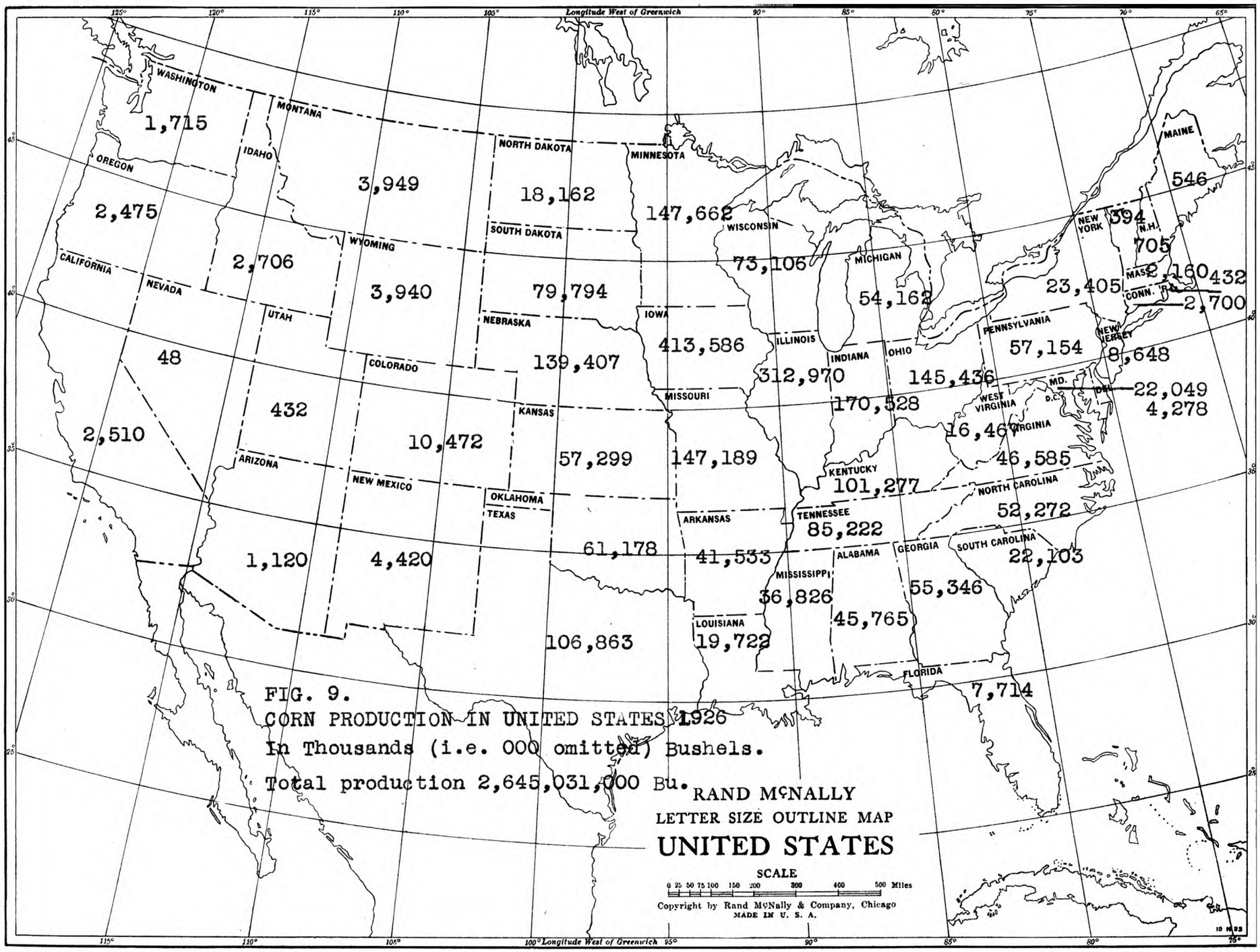
The kernel develops in three stages. First, the milk stage, at the time when it contains a milky fluid which is sweet in taste due to the presence of sugar that is later changed to starch. Second, with the ripening of the plant to the "dough" stage. Third, at maturity to a firm, dry state.

Corn is a heat loving plant and will not thrive in regions having cool nights during the growing season.

Corn can be successfully grown in every state of the Union though it flourishes best in the great region between the Appalachian and the Rocky Mountain Plateau. It requires more thorough tillage and makes most of its growth during late summer and early fall. This requirement of thorough tillage brings many advantages to the soil not forced upon it in growing the other cereals. In

numbers of bushels produced and total valuation, corn far exceeds any other crop grown in the United States. In 1926 there were 2,645,031,000 bushels produced, valued at about $1,655,000,000. Figures 9 and 10 show the distribution of the plant in the United States (14) and the state of Kansas respectively (15). In Kansas, production is more or less confined, as far as big producing counties are concerned, to northeast and east central portions. The three leading counties in 1926 were Nemaha, Brown, and Doniphan. (Figure 10). The varieties best adapted to the various sections of the state are shown in Figure 11. Figure 12 shows the average yield per acre of corn in Kansas for the period 1915-1926. The low yield in the periods 1916-1918 and 1924-1926 was possibly due to unfavorable weather conditions. A study of Figure 4 shows the acreage and valuation for the twenty-year period 1906-1926.

The low rainfall and the hot, dry winds, especially during the latter part of the growing season, are limiting factors in the production of corn in the central and western parts of the state. Corn requires a better soil for its growth than do any of the other cereal crops. It is also more likely to be injured by unfavorable climatic conditions. It grows best on deep, fertile soils in warm,



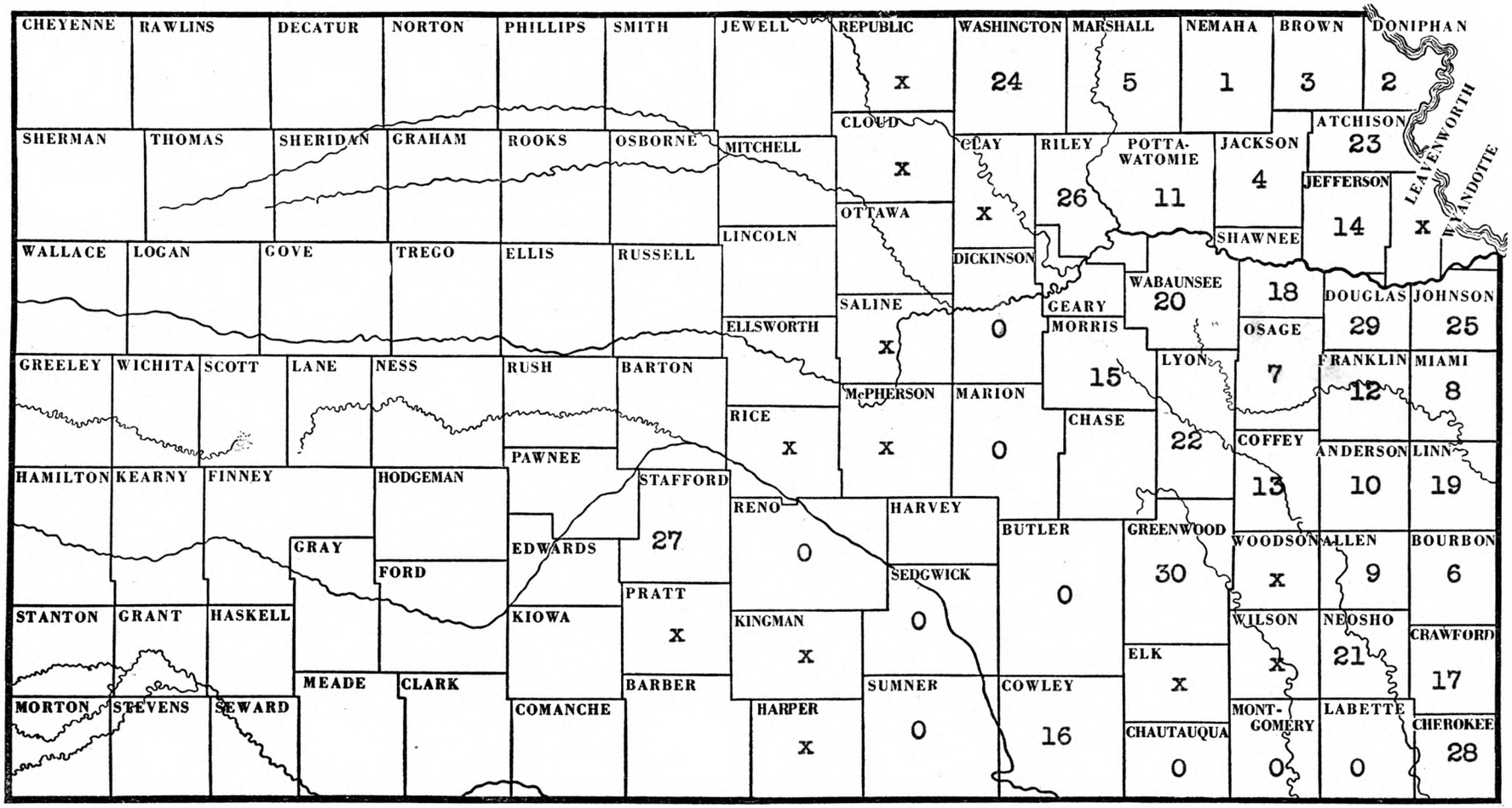


FIG. 10.
CORN - Valuation in 1926 - Total valuation $41,010,514.00
No. 1. = $1,677,508.00 (Nemaha County).
No. 30.= $ 617,497.00
0 = Over $500,000 to $800,000 Valuation.
x = $200,000 to $500,000 .

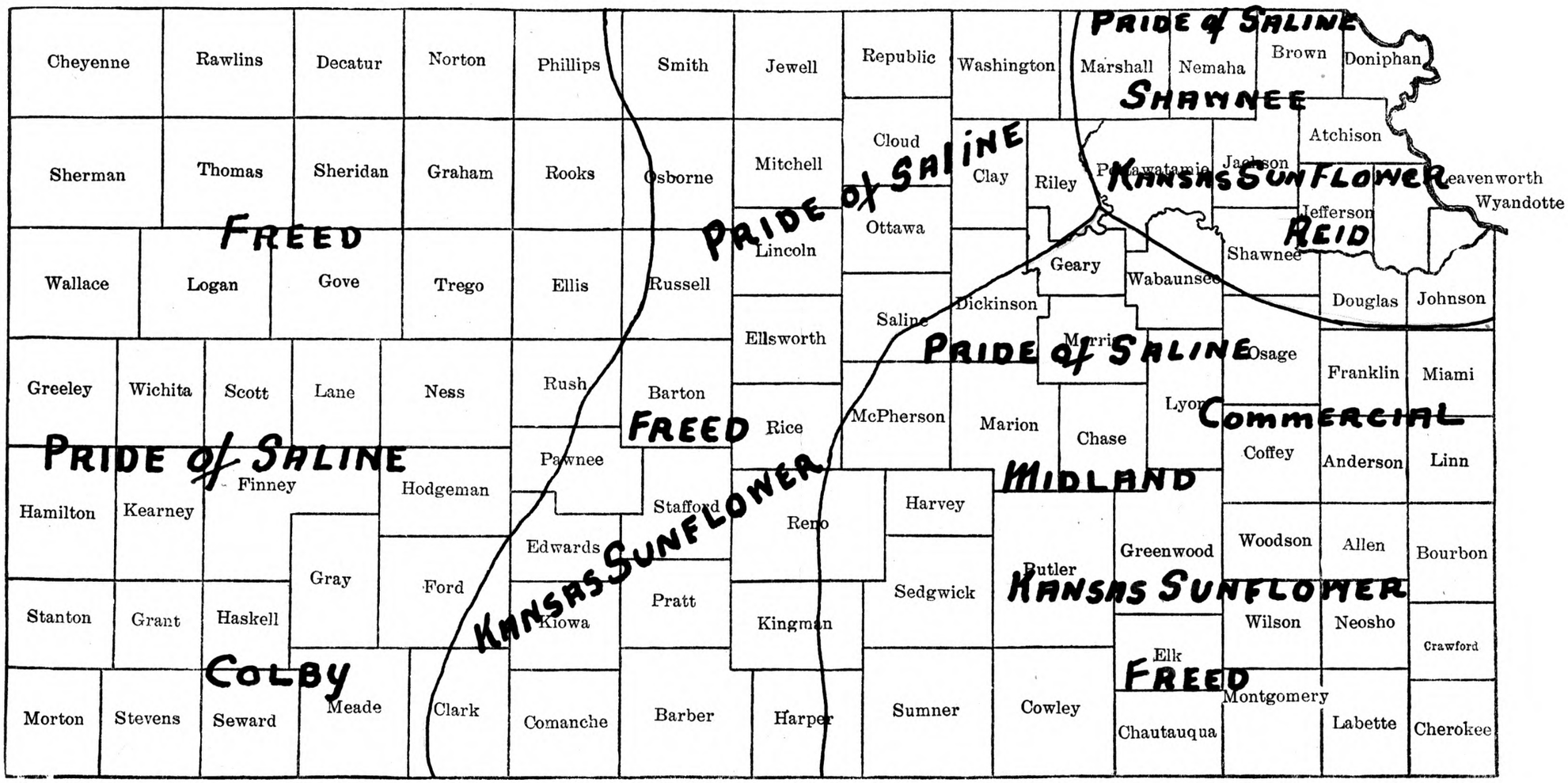


FIG. 11.
STANDARD VARIETIES OF CORN FOR KANSAS AND AREAS TO WHICH THEY ARE ADAPTED.

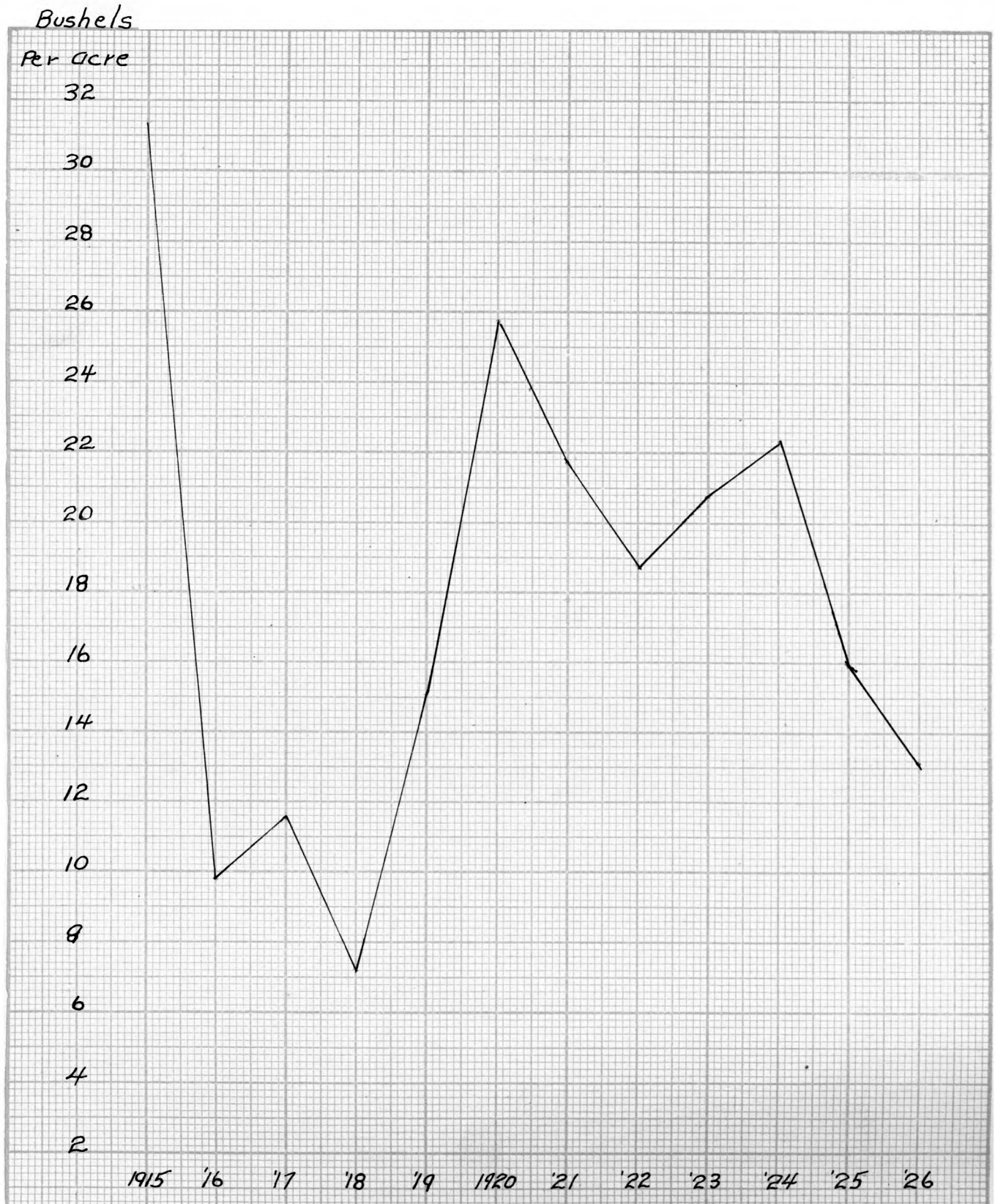


FIG. 12.

AVERAGE YIELD PER ACRE OF CORN IN KANSAS: 1915 to 1926.

moist climates, with frequent showers and plenty of sunshine. It is especially liable to injure by drowth and hot winds when it is in the silking and tasseling stages and when the ears are forming. It is usually an unprofitable crop on poor lands. In those sections of the state where midsummer drowths, hot winds, and poor soils are found, other crops such as the grain sorghums and sargos can frequently be substituted to advantage.

The general methods of harvesting corn are: (1) Cutting and shocking for rough feed. (2) Cutting for silage. (3) Husking the grain from the standing stalks. The third method is most extensively employed. The value of stover is receiving greater recognition however, and the practice of saving it for feed is becoming more general.

Corn should be cut for fodder when the bottom leaves become dry, which under ordinary conditions, is shortly after the ears become well glazed. It possesses its maximum feeding value at this time. If cut too soon it will be more subject to damage from weather and fungus growths and will yield less than if cut at the right time. If the cutting is delayed the stover deteriorates rapidly in quality. When corn is produced for feeding cattle, the greatest returns can be obtained by using it as silage. It should be cut when the ears become well glazed. The

value of the silo for saving immature corn was well shown in 1913 when corn that had dried up and was harvested in the usual manner rotted in the shock and was practically worthless, while the same kind of corn placed in the silo made good feed.

Corn may be fed in any of the following forms: (1) Stover, (with the ears on). (2) Fodder, (with the ears off). (3) Ears, (with or without the shuck on); (a) whole ears, (b) broken ears. (4) Corn-and-cob meal (where the cob and grain are ground together). (5) Corn silage, (with or without the ears on). (6) Hogged down, (where hogs are permitted to run in the field and eat the ears off the stalk). (7) Shelled corn, (either dry or soaked). (8) Ground shelled corn, (chops). (9) Corn soilage, (fed in the green stage). (10) Ground corn by-products: corn bran, corn feed-meal, corn germ meal, corn gluten feed, corn meal, corn oil cake meal.

The accompanying table shows the grades of corn in this state. This table indicates that moisture content is the big determining factor in the grades of corn although foreign material and heat damage and other damages are limiting factors also. A high moisture content will have the biggest effect on the weight, which is lowered with a high moisture content. Most of the corn sent to market in

this state would come under grades 2 and 3, some in the lower grades, but very little in grade 1. During very wet periods at the end of the growing season, the corn is always lowered in grade on account of the high moisture content. This naturally lowers the price and feeding value of the grain.

The farmer can increase the grade of his corn some by proper cultivation to rid the crop of all the foreign material possible and by watching his corn after it has been put into the bind to see that it does not heat and damage. This can be done by giving it good ventilation and airing it a little when it does start to heat.

The chemical analysis of corn varies with the different grades of corn. The weather conditions, whether it is wet or dry, the soil upon which it is grown, the variety of corn planted, and method of handling in the binds, all affect the chemical analysis materially. When the season is late and the corn gets frosted on before maturity, the feeding value is materially affected, and thus the chemical analysis is somewhat affected, unless it is fed at once to hogs or cattle, before it gets moldy.

The chemical analysis of shelled corn as analyzed by the Chemistry Department at the Kansas State Agricultural College in 1926, is as follows:

Moisture	Protein	Fat	Crude Fiber	Ash	N. F. E.
12.48%	9.44%	4.11%	2.02%	1.68%	70.27%

Grade No.	Minimum test weight per bushel Pounds	Maximum Limits of: Moisture percent	Foreign material and cracked corn Percent	Damaged Corn: Total percent	Damaged Corn: Heat damage Percent
1	55	14.0	2	2	0.0
2	53	15.5	3	4	.1
3	51	17.5	4	6	.3
4	49	19.5	5	8	.5
5	47	21.5	6	10	1.0
6	44	23.0	7	15	3.0

Classes - White - Yellow - Mixed
98% 95%

(19)

Cottonseed Meal.- To the Chinese probably belongs the credit for making the first use of cottonseed oil, for their records show that in the Seventeenth Century in China cottonseeds were sometimes ground and fed to oxen and that an oil suitable for illumination was obtained. In America the first mention of cottonseed oil is found in the records of Doctor Otto of Bethlehem, Pennsylvania, dated 1768. In England in 1783 a prize was posted by the

Society for the Encouragement of Arts, Manufacturing, and Commerce for a practical method for extracting oil from cottonseed. On March 2, 1799 a United States patent was issued to C. Whiting covering a process for extracting cottonseed oil.

The industry has grown since 1900 from 2,479,000 tons of cottonseed crushed, with a valuation of 70 million dollars, produced by 357 mills located in various cities in the south, to a total of 4,605,000 tons of cottonseed crushed, valued at $240,855,000 by 530 mills in 1925 (6).

After cottonseed has been cleaned and more or less of the short lint covering the seeds removed by machinery, the leathery hulls of the cottonseed are cut by machines, called hullers, so the kernels may drop out. The kernels are separated from the hulls by screens and are then crushed, heated, placed between cloths, and subjected to hydraulic pressure to remove the oil. The residue is a hard, yellowish, board-like cake about one-half inch thick, 14 inches wide, and 32 inches long. For the trade in the eastern and central states the cake is generally ground to a fine meal. For the western trade it is often broken into pieces of pea or nut size for cattle and coarsely ground for sheep, while the export cake is commonly left whole. For feeding out of doors broken cake is preferable

to meal, as it is not scattered by the wind. Unadulterated cottonseed meal of good quality should have light yellow color and a sharp, nutty odor. A dark or dull color may be due to age, adulteration with hulls, overheating during the cooking process, or fermentation, all of which injure its quality.

Cottonseed meal is one of the richest of all feeds in protein and carries over 8 per cent fat. The protein and fiber content vary considerably depending chiefly on how thoroughly the hulls are removed from the meal. The value of fresh and wholesome meal depends on the percentage of protein it contains.

The state governments require that a tag be placed on every sack of cottonseed meal telling the protein content, together with a complete analysis of the meal.

Owing to its wide variation in composition, cottonseed meal should be purchased on a guarantee basis whenever possible. During recent years, as the millers have found, they can sell the lower grades of meal for nearly as high a price per ton as meal high in protein, many have removed the hulls less thoroughly from the kernels, thereby producing meal lower in protein and higher in crude fiber than previously. Northern farmers will usually find it most economical to purchase high-grade meal.

The grades of cottonseed meal and their protein contents are:

Superior	43% Protein
Choice	41% "
Prime	38.6% "
Sound	36% "
Cottonseed feed (Cottonseed meal plus hulls)	36% "
Cold pressed cake	25% "

The chemical analysis of the cottonseed meal used in this experiment as analyzed by the Chemistry Department at the Kansas State Agricultural College in 1927 is as follows:

Moisture	Protein	Fat	Crude Fiber	Ash	N. F. E.
8.0%	41.69%	8.08%	11.03%	5.41%	25.79%

Ground limestone.- The ground limestone used in this test is from the Carthage Crushed Rock Company of Carthage, Missouri. A brief description of the method of preparing this rock for commercial use is as follows: The Carthage limestone formation is a uniform body of stone and unusually solid in formation and this solidity eliminates to a great extent any possibility of foreign matter or dirt getting into the finished product. Tests from the quarry show a calcium carbonate content of from 98.25% to

as high as 99½%. In preparing the raw material for grinding, every piece is hand picked and all operations are by hand so that it eliminates dirt and other matter which might naturally accrue through the use of steam shovels or other means of gathering up the rock.

The limestone used in this test, as analyzed by the Chemistry Department of the Kansas State Agricultural College, shows a calcium content of 39.22% = 98.04% calcium carbonate.

DISCUSSION OF EXPERIMENT

Results of Test

The results of this test in considerable detail are shown in Tables I and II. It will be noted that Table I represents the dry roughage group and Table II the dry roughage plus silage group.

The results from the standpoint of margin per steer, secured from adding ground limestone in this test may be summarized as follows:

(1) Adding ground limestone to an alfalfa hay, corn, cottonseed meal ration did not increase the margin per steer.

Table I. The relative value of adding ground limestone to alfalfa hay and to prairie hay when fed to fattening calves.

November 23, 1927 to May 21, 1928 - 180 days

Lot number	1	2	3	4
Ration Fed	Ground corn C.S.M. Alfalfa hay	Ground corn C.S.M. Alfalfa hay Ground lime-stone	Ground corn C.S.M. Prairie hay	Ground corn C.S.M. Prairie hay Ground lime-stone
Number of steers in lot	9	10	10	10
Number of days on test	180	180	180	180
	Pounds	Pounds	Pounds	Pounds
Initial weight per steer	377.96	375.50	370.33	370.50
Final weight per steer	821.11	814.67	757.83	776.33
Total gain per steer	443.15	439.17	387.50	405.83
Daily gain per steer	2.46	2.44	2.15	2.25
Average daily ration:				
Ground corn	9.74	9.60	9.83	10.09
Cottonseed meal	1.12	1.11	1.36	1.40
Alfalfa hay	6.03	5.84	....	....
Prairie hay	....	....	4.43	5.03
Ground limestone	....	.11	....	.12
Feed required for 100 pounds gain:				
Ground corn	395.78	393.51	456.50	447.50
Cottonseed meal	45.60	45.43	63.27	61.92
Alfalfa hay	245.12	239.41	....	....
Prairie hay	....	....	205.63	223.01
Ground limestone	....	4.57	....	5.16
Cost of 100 pounds gain	$ 9.31	$ 9.29	$ 9.91	$ 9.88
Initial cost per steer @ $11 per cwt.	41.58	41.31	40.74	40.76
Feed cost per steer	41.26	40.80	38.40	40.10
Steer cost plus feed cost	82.84	82.11	79.14	80.86
Value per head at home	108.80	105.91	94.73	98.98
Margin per head	25.96	23.80	15.59	18.12
Necessary value per cwt. at feed lot to break even	10.09	10.08	10.44	10.42
Value per cwt. at feed lot K.C. price minus $.50 per cwt.	13.25	13.00	12.50	12.75
Margin per cwt.	3.16	2.92	2.06	2.33

FEED PRICES: Ground corn $.90 per bushel; cottonseed meal $50 per ton; alfalfa hay $15 per ton; prairie hay $10 per ton; ground limestone $20 per ton.

Table II. The value of adding ground limestone to alfalfa hay and silage, and to prairie hay and silage when fed to fattening calves.

November 23, 1927 to May 21, 1928 - 180 days

Lot number	5	6	7	8
Ration fed	Shelled corn, C.S.M., Cane silage, Alfalfa hay	Shelled corn, C.S.M., Cane silage, Alfalfa hay, Ground limestone	Shelled corn, C.S.M., Cane silage, Prairie hay	Shelled corn, C.S.M., Cane silage, Prairie hay, Ground limestone
Number of steers in lot	10	10	10	10
Number of days on test	180	180	180	180
	Pounds	Pounds	Pounds	Pounds
Initial weight per steer	371.00	371.33	374.00	372.83
Final weight per steer	787.83	819.00	747.00	809.33
Total gain per steer	416.83	447.67	373.00	436.50
Daily gain per steer	2.32	2.49	2.07	2.43
Average daily ration:				
Shelled corn	9.77	9.51	9.65	9.85
Cottonseed meal	1.00	1.00	1.16	1.16
Cane silage	9.71	10.05	8.91	10.14
Alfalfa hay	2.01	2.00	....	....
Prairie hay	....	....	1.36	1.41
Ground limestone	....	.10	....	.10
Feed required for 100 pounds gain:				
Shelled corn	422.04	382.45	465.66	406.21
Cottonseed meal	43.18	40.21	55.78	47.66
Cane silage	419.49	404.15	430.03	418.18
Alfalfa hay	86.85	80.42	....	....
Prairie hay	....	....	65.42	58.19
Ground limestone	....	4.02	....	4.12
Cost of 100 pounds gain	$ 9.11	$ 8.40	$ 9.78	$ 8.66
Initial cost per steer @ $11 per cwt.	40.81	40.85	41.14	41.01
Feed cost per steer	37.97	37.60	36.48	37.80
Steer cost plus feed cost	78.78	78.45	77.62	78.81
Value per head at home	100.45	106.47	93.38	105.21
Margin per head	21.67	28.02	15.76	26.40
Necessary value per cwt. at feed lot to break even	10.00	9.58	10.39	9.74
Value per cwt. at feed lot K.C. price minus $.50 per cwt.	12.75	13.00	12.50	13.00
Margin per cwt.	2.75	3.42	2.11	3.26

FEED PRICES: Shelled corn $.84 per bushel; alfalfa hay $15 per ton; prairie hay $10 per ton; cottonseed meal $50 per ton; cane silage $5 per ton; ground limestone $20 per ton.

(2) Adding ground limestone to a prairie hay, corn, cottonseed meal ration increased the margin per steer $2.53.

(3) Adding ground limestone to an alfalfa hay, corn, cottonseed meal, silage ration increased the margin per steer $6.35.

(4) Adding ground limestone to a prairie hay, corn, cottonseed meal, silage ration increased the margin per steer $10.64.

(5) Adding ground limestone to a calf fattening ration, the roughage portion of which was prairie hay alone, increased the margin per steer $4.69 more than when ground limestone was added to a calf fattening ration the roughage portion of which was alfalfa hay.

(6) Adding ground limestone to a calf fattening ration, the roughage portion of which was prairie hay and silage, increased the margin per steer $4.29 per head more than when ground limestone was added to a calf fattening ration, the roughage portion of which was alfalfa hay and silage.

(7) For two years previous to 1927-1928, tests were made at the Kansas Agricultural Experiment Station, relative to the value of adding calcium, either in the

form of calcium carbonate or ground limestone, to a ration consisting of corn, cottonseed meal, alfalfa or prairie hay and silage. The results of these three tests are summarized as follows:

	1	2	3
Ration fed	Corn C.S.M. Alfalfa hay Silage	Corn C.S.M. Prairie hay Silage	Corn C.S.M. Prairie hay Silage Calcium Carbonate
Average daily gain per head	2.37	2.12	2.40
Average selling price per cwt.	$10.83	$10.33	$10.75
Average profit per head	$12.90	$ 6.00	$13.59

In 1926 straight calcium carbonate was used. In 1927 and 1928 finely ground limestone testing approximately 99% calcium carbonate was used.

(8) In addition to the results secured relative to the addition of ground limestone, attention should be directed to results indicating the relative value of prairie and alfalfa hay which may be summarized as follows:

(a) The ration in which alfalfa hay alone was used as roughage portion of the ration produced .31 of a pound per steer greater daily gain, a selling price of $.75 per

cwt. greater and a margin of $10.37 per steer greater than a ration similar in every respect except that prairie hay alone instead of alfalfa hay alone was used as the roughage portion of the ration.

(b) A ration in which alfalfa hay and silage were used as the roughage portion of the ration, produced .25 of a pound per steer greater daily gain, a selling price of $.25 per cwt. greater and a margin of $5.91 per steer greater than a ration similar in every respect except that prairie hay and silage instead of alfalfa hay and silage were used as the roughage portion of the ration.

Tables of Results

Table III shows the average daily feed consumed per steer by thirty-day periods.

Table IV shows the average daily gain per steer by thirty-day periods.

Table V shows the average cost of 100 pounds of gain by thirty-day periods.

Tables VI and VII are graphs showing the average cost of 100 pounds of gain by thirty-day periods, for the dry roughage and silage groups.

Tables VIII and IX are graphs showing daily gain per steer by thirty-day periods for dry roughage and silage groups.

Similar Investigations at Other Stations

Investigations made by several different experiment stations have demonstrated the fact that alfalfa and similar hays are decidedly superior to prairie and similar hays, either as a part of, or the whole of the roughage portion of cattle fattening rations. A few stations have attempted to prove the feeding value of prairie and similar hays by increasing the protein allowance. This however, has not resulted in as good results as those secured from the use of alfalfa hay and a smaller amount of protein supplemental feeds. No station had attempted to improve the feeding quality of prairie hay by the addition of minerals rich in calcium until 1925, when the Kansas Agricultural Experiment Station started the series of tests in an attempt to improve the feeding value of prairie hay by adding calcium and protein in amounts that the prairie hay plus the calcium and protein would equal the calcium and protein content of alfalfa hay. Tests conducted by the Kansas Agricultural Experiment Station

Table III. Average daily feed by periods.

Group I - Dry Roughage Group

Lot No.		30 days	60 days	90 days	120 days	150 days	180 days	Average
1	Corn	3.82	6.95	9.37	12.74	12.87	12.74	9.74
	Cottonseed Meal	1.00	1.00	.90	1.27	1.29	1.27	1.12
	Alfalfa Hay	8.03	7.46	4.65	5.59	5.30	5.19	6.03
2	Corn	3.82	6.95	9.46	11.50	12.50	13.38	9.60
	Cottonseed Meal	1.00	1.00	.91	1.15	1.25	1.34	1.11
	Alfalfa Hay	8.49	7.44	4.65	5.03	4.78	4.65	5.84
	Ground Limestone	.10	.10	.09	.12	.13	.13	.11
3	Corn	3.82	6.95	10.25	12.84	13.31	11.79	9.83
	Cottonseed Meal	1.00	1.00	1.24	1.67	1.73	1.50	1.36
	Prairie Hay	7.76	6.03	2.63	3.19	3.50	3.47	4.43
4	Corn	3.82	6.95	10.30	13.09	13.28	13.10	10.09
	Cottonseed Meal	1.00	1.00	1.25	1.70	1.73	1.70	1.40
	Prairie Hay	7.33	6.17	3.30	3.92	4.58	4.88	5.03
	Ground Limestone	.10	.10	.10	.13	.13	.13	.12

Group II - Silage Group

5	Corn	3.82	6.95	9.71	12.62	12.14	13.40	9.77
	Cottonseed Meal	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Cane Silage	12.63	13.47	6.10	7.98	9.42	8.68	9.71
	Alfalfa Hay	2.07	2.00	2.00	2.00	2.00	2.00	2.01
6	Corn	3.82	6.95	9.66	11.50	12.07	13.07	9.51
	Cottonseed Meal	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Cane Silage	12.13	13.65	6.10	7.98	10.14	10.30	10.05
	Alfalfa Hay	2.00	2.00	2.00	2.00	2.00	2.00	2.00
	Ground Limestone	.10	.10	.10	.10	.10	.10	.10

7	Corn	3.82	6.95	9.36	11.30	12.69	13.77	9.65
	Cottonseed Meal	1.00	1.00	1.24	1.30	1.10	1.30	1.16
	Cane Silage	12.63	13.90	4.95	6.60	6.70	8.68	8.91
	Prairie Hay	2.07	1.77	1.37	1.60	1.00	1.00	1.36
8	Corn	3.82	6.95	10.03	12.14	12.64	13.53	9.85
	Cottonseed Meal	1.00	1.00	1.24	1.30	1.10	1.30	1.16
	Cane Silage	12.63	14.07	5.72	7.98	10.14	10.30	10.14
	Prairie Hay	2.07	1.90	1.50	1.00	1.00	1.00	1.41
	Ground Limestone	.10	.10	.10	.10	.10	.10	.10

Table IV. Average daily gain per steer by periods.

Lot Number	30 days	60 days	90 days	120 days	150 days	180 days	Average
1	2.14	2.18	2.02	2.91	2.76	2.37	2.46
2	2.05	2.32	2.32	2.33	3.03	2.59	2.44
3	1.86	1.68	1.95	2.83	2.50	2.09	2.15
4	1.62	1.80	2.45	2.82	2.77	2.08	2.25
5	2.42	2.03	2.15	3.10	2.48	1.69	2.32
6	2.39	2.15	2.23	3.03	2.62	2.50	2.49
7	2.03	1.87	1.37	2.53	2.47	2.17	2.07
8	2.11	2.12	2.20	3.42	2.63	2.08	2.43

Table V. Average cost of daily gains by 30 day periods.

Lot Number	30 days	60 days	90 days	120 days	150 days	180 days	Average
1	6.60	8.31	9.77	9.09	9.45	11.03	9.31
2	7.15	7.80	8.58	10.29	8.44	10.43	9.29
3	6.48	9.46	10.12	8.83	10.39	11.07	9.91
4	7.28	8.92	8.29	9.20	9.61	12.71	9.88
5	5.31	8.75	9.32	8.03	11.43	15.55	9.11
6	5.35	8.32	9.00	7.69	9.45	10.51	8.40
7	6.09	9.21	13.90	8.95	9.69	12.08	9.78
8	5.90	8.22	9.44	7.02	9.43	12.83	8.66

Table VI. Graph - showing average cost of 100 pounds gain by thirty-day periods (dry roughage group).

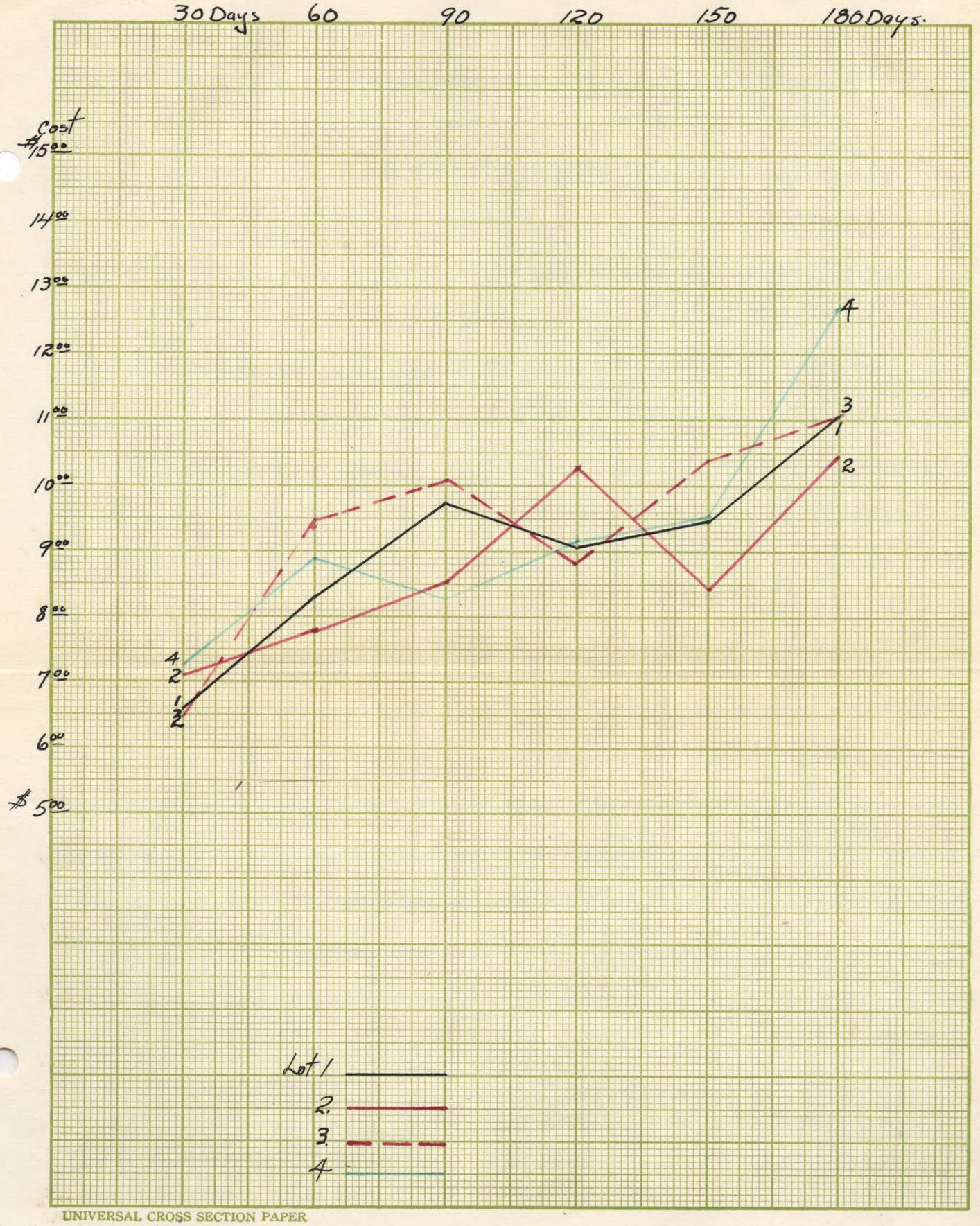


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Table VII. Graph - showing average cost of 100 pounds gain by thirty-day periods (silage group).

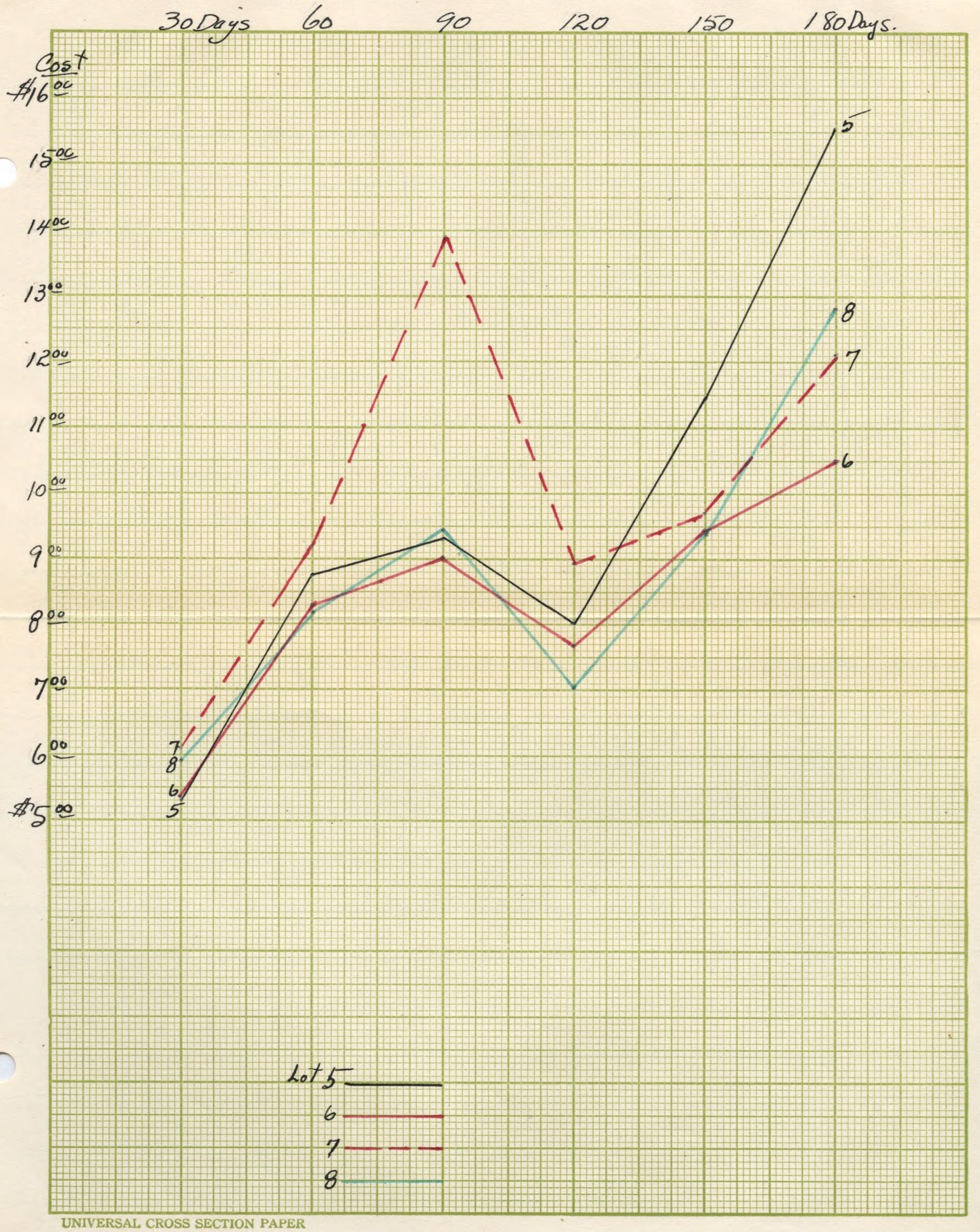

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Table VIII. Graph - showing average daily gain per steer by thirty-day periods (dry roughage group)

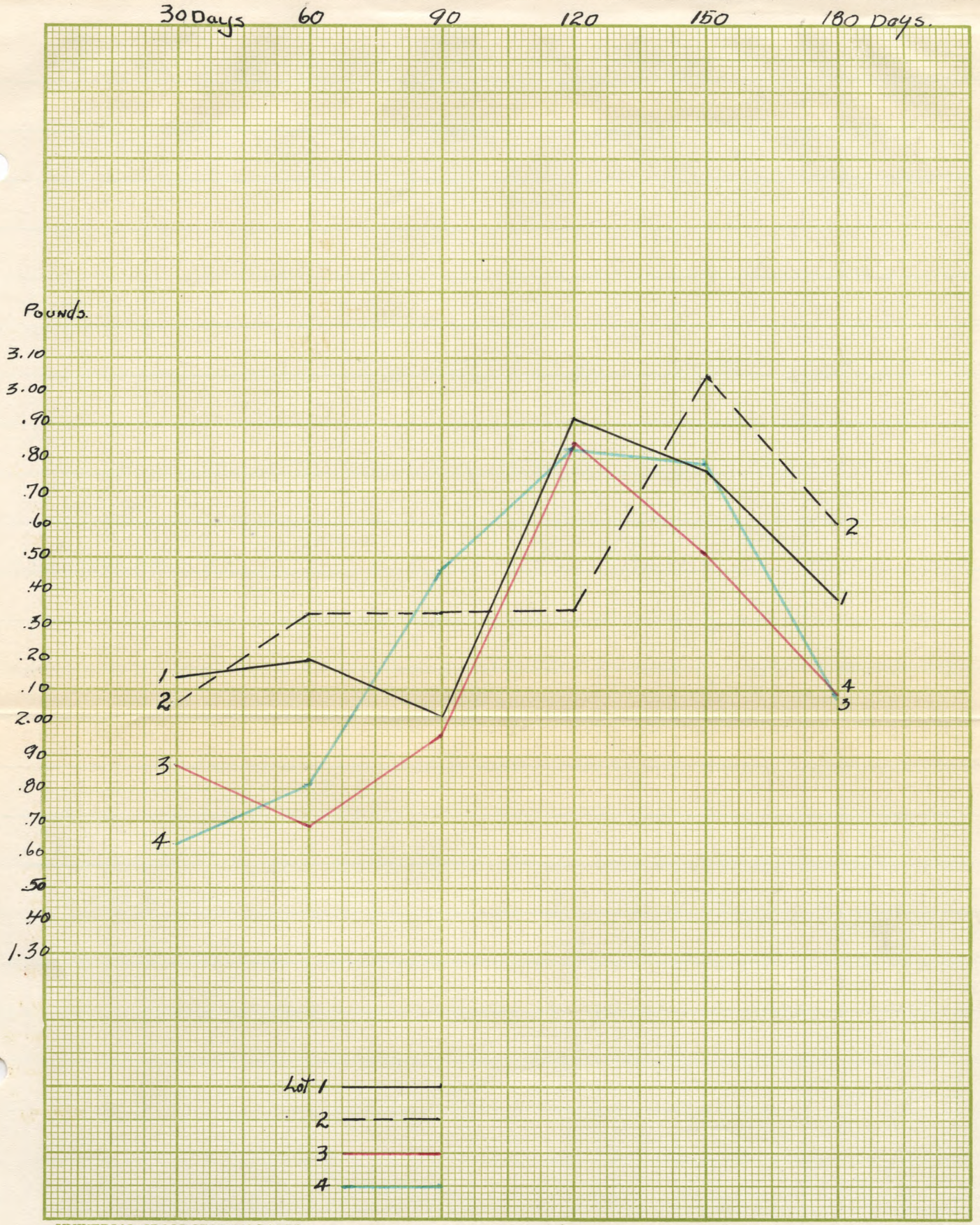

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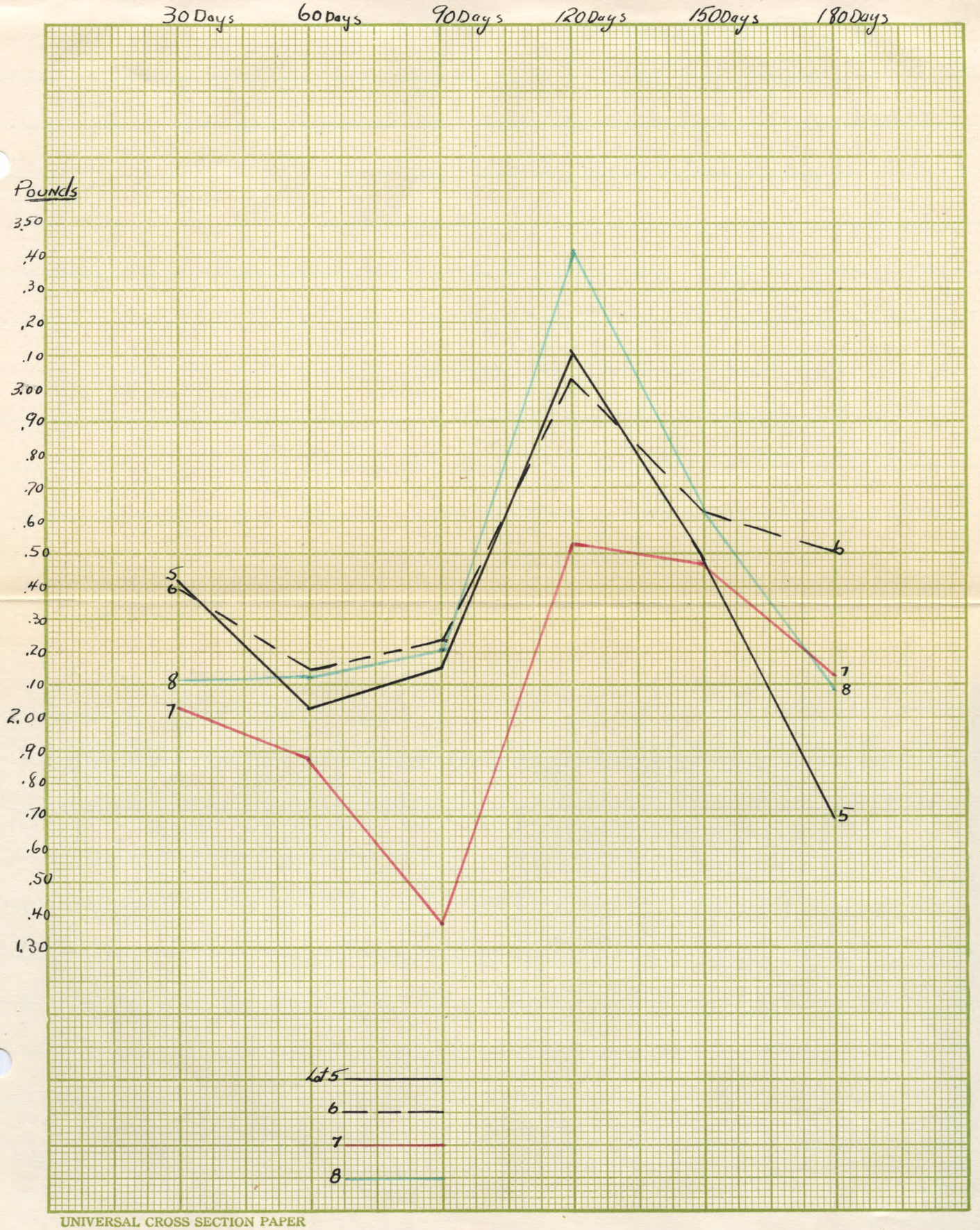
Table IX. Graph - showing average daily gains per steer by thirty-day periods (silage group).



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involved the use of calcium in the form of pure calcium carbonate, ground limestone, bone meal, and acid phosphate. Calcium carbonate and ground limestone proved to be the most satisfactory forms of calcium to use. Since ground limestone, of a high calcium carbonate content, proved to be practically as satisfactory as pure calcium carbonate and was much cheaper, it has been used as a source of calcium in the more recent tests conducted by this station.

Oklahoma Agricultural Experiment Station.- The Oklahoma Agricultural Experiment Station conducted a test during the winter of 1927-1928 in which a ration consisting of ground corn, cottonseed meal, and prairie hay plus ground limestone, was compared with a ration consisting of ground corn, cottonseed meal, and alfalfa hay. The gains were almost identically the same in each case, the selling price was the same per pound and the profit was $6.11 per head more where the prairie hay plus ground limestone was fed in place of alfalfa hay.(17).

Illinois Agricultural Experiment Station.- During the winter of 1927-1928 the Illinois Agricultural Experiment Station conducted a test in which the basal ration consisted of ear corn, silage, and cottonseed meal. One lot received two pounds of alfalfa hay in addition to the

basal ration, another lot one-tenth of a pound of deodorized bone meal in addition to the basal ration, and the third lot received both alfalfa hay and bone meal. During the first 126 days the lot which received alfalfa hay in addition to the basal ration and no bone meal, made an average daily gain of 2.28 pounds; the lot which received the bone meal in addition to the basal ration and no alfalfa hay made an average daily gain of 2.1 pounds; and the lot which received both alfalfa hay and bone meal made an average daily gain of 2.14 pounds per steer.

This indicates that even so small an amount as one-tenth of a pound of bone meal per head daily slows up the gains on these calves (18).

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