PUBLICATIONS RELATING TO FORAGE CROPS

1. Weeks, Charles R. 1919. Growing Alfalfa in Western Kansas. Kans. Agr. Expt. Sta. Cir. 73. 10 pp.
2. Vinall, H. N. and Getty, R. E. 1920. Growing and Utilizing Sorghums for Forage. U.S. Dept. Agr. Farmers' Bul. 1158. 32 pp.
3. Vinall, H. N. and Getty, R. E. 1921. Sudan Grass and Related Plants. USDA Bul. 981. 86 pp.
4. Getty, R. E. 1921. Forage Crops in Western Kansas. Kans. Agr. Expt. Sta. Bul. 225. 54 pp.
5. Vinall, A. N., Getty, R. E., and Cron, A. B. 1924. Sorghum Experiments on the Great Plains. USDA Bul. 1260. 88 pp.
6. Savage, D. A. 1933. Buffalo Grass for Fairways in the Plains States. Bulletin U.S. Golf Assn. Grass Sec. 13:144-149.
7. Getty, R. E. 1934. Experiments with Forage Crops at the Fort Hays Branch Station, Hays, Kansas, 1913 to 1928. USDA Tech. Bul. 410. 92 pp.
8. Savage, D. A. 1934. Methods of Re-establishing Buffalo Grass on Cultivated Land in the Great Plains. USDA Cir. 328. 20 pp.
9. Savage, D. A. 1935. A Field Aspirator for Emasculating Sweet Clover Flowers. Jour. Amer. Soc. Agron. 27:774-775.
10. Savage, D. A. 1935. "They Came Through"—Survey Shows Where Drought Met Most Resistance. USDA Soil Conservation News Organ. 1(2):4-5.
11. Savage, D. A. and Jacobson, A. L. 1935. The Killing Effect of Heat and Drought on Buffalo Grass and Blue Grama at Hays, Kansas. Jour. Amer. Soc. Agron. 27:566-582.
12. Savage, D. A. 1937. Drought Survival of Native Grass Species in the Central and Southern Great Plains, 1935. USDA Bul. 549. 54 pp.
13. Savage, D. A. and Runyon, H. Everett. 1937. Natural Revegetation of Abandoned Farm Land in the Central and Southern Great Plains. Intern. Grassland Cong. Aberystwyth, Great Britain, Rpt. Sec. 1, Grassland Ecology, 178-182.
14. Wenger, Leon E. 1940. Inflorescence Variations in Buffalo Grass. Jour. Amer. Soc. Agron. 32:274-277.
15. Wenger, Leon E. 1941. Improvement of Buffalo Grass in Kansas. 32nd Bien. Rpt., Kans. State Board of Agr., pp. 211-224.
16. Wenger, Leon E. 1941. Soaking Buffalo Grass Seed to Improve Its Germination. Jour. Amer. Soc. Agron. 33:135-141.
17. Wenger, Leon. E. 1941. Re-establishing Native Grasses by the Hay Method. Kans. Agr. Expt. Sta. Cir. 208. 16 pp.
18. Wenger, Leon. E. 1943. Buffalo Grass. Kans. Agr. Expt. Sta. Bul. 321. 78 pp.
19. Meenen, F. E. and Timmons, F. L. 1949. Use of Herbicides in Production of Buffalo Grass Seed. Agron. Jour. 41:98-99.
20. Casady, Alfred J. and Anderson, Kling L. 1952. Hybridization, Cytological, and Inheritance Studies of a Sorghum Cross—Autotetraploid Sudan Grass x (Johnsongrass x 4 N Sudangrass). Agron. Jour. 44:189-194.
21. Harvey, T. L. and Hackerott, H. L. 1956. Apparent Resistance to the Spotted Alfalfa Aphid Selected from Seedlings of Susceptible Alfalfa Varieties. Jour. Econ. Ent. 49:289-291.
22. Harvey, T. L. and Hackerott, H. L. 1958. Spotted Alfalfa Aphid Reaction and Injury to Resistant and Susceptible Alfalfa Clones Reciprocally Grafted. Jour. Econ. Ent. 51:760-762.
23. Hackerott, H. L., Harvey, T. L., Sorensen, E. L., and Painter, R. H. 1958. Varietal Differences in Survival of Alfalfa Seedlings Infested with Spotted Alfalfa Aphids. Agron. Jour. 50:139-141.
24. Hackerott, H. L. and Harvey, T. L. 1959. Effect of Temperature on Spotted Alfalfa Aphid Reaction to Resistance in Alfalfa. Jour. Econ. Ent. 52:949-953.

25. Ortman, E. E., Sorensen, E. L., Painter, R. H., Harvey, T. L., and Hackerott, H. L. 1960. Selection and Evaluation of Pea Aphid-resistant Alfalfa Plants. Jour. Econ. Ent. 53:881-887.
26. Harvey, T. L., Hackerott, H. L., Sorensen, E. L., Painter, R. H., Ortman, E. E., and Peters, D. C. 1960. The Development and Performance of Cody Alfalfa, a Spotted Alfalfa Aphid Resistant Variety. Kans. Agr. Expt. Sta. Tech. Bul. 114. 26 pp.
27. Sorensen, E. L., Painter, R. H., Ortman, E. E., Hackerott, H. L., and Harvey, T. L. 1961. Cody Alfalfa. Kans. Agr. Expt. Sta. Cir. 381. 10 pp.
28. Anonymous. 1952, 1953, 1954, 1955, and 1956. Fall Field Day Reports of Fort Hays Branch Station. Circulars 289, 302, 315, 330, and 345. Part of these reports concerned with investigations on sudangrass, sweetclover, tepary beans, safflower, cool-season perennial grasses, foxtail millets, and spotted alfalfa aphids.

SEED PRODUCTION AND DISTRIBUTION

Distribution of seed of improved varieties has been an important service of the Hays station. In the beginning, emphasis was not placed on the production of crops primarily for the production of seed for distribution; but good seed of the best known varieties was used for all field work, and a demand of farmers for this seed soon developed. The Station sold for seed 4,500 pounds of miscellaneous sorghums in 1904 and 152,700 pounds of winter wheat in 1908, principally of the Turkey variety. The wheat seed was released in lots of 2 to 15 bushels per farm and reached nearly all western Kansas counties. A total of 10,400 pounds of seed corn was sold the same year. In the spring of 1909 large quantities of seed corn and some spring wheat, barley, and oats were distributed. Pink kafir seed was sold for the first time this year, as was seed of dwarf yellow milo.

On June 13, 1909, a hailstorm destroyed the entire wheat crop so that no seed was available for distribution that year. Prof. A. M. Ten-Eyck in the 17th Biennial Report of the Station (June 1910) reported regarding the production and distribution of seed, "In fact nearly all the grain planted on the station farm is improved or pedigreed and is grown primarily for seed production. The best of the crop is reserved for seed, which is graded, sold and distributed among the farmers of Kansas and bordering states. 4,000 bushels of well-bred seed wheat and several thousand bushels of improved corn, kafir corn and small grains have been distributed from the Hays Branch Station during the last four years (1907-1910). The crops now growing or being harvested are largely from purebred seed, included in which are 300 acres of pure Kharkov wheat, all of the surplus of which will be offered for sale for seed and distribution to Kansas farmers." (37)

As sorghums became more important to western Kansas the demand for sorghum seed from the Station increased. Superintendent Helder in his report for 1914 says "An extensive work in growing sor-

Fig. 49.—A field of certified Dawn kafir. "The amount of seed that can be produced on the Station is the only limit to the amount that can be sold."

ghum seed for distribution has always been performed at the Station. The demand is extensive this winter from all parts of Kansas and from adjoining states. The supply will not prove adequate for the demand, but will be distributed as its possibilities permit. Four varieties of grain sorghum, and five varieties of cane seed are available from the 1914 crop." (38)

The four grain sorghums mentioned by Superintendent Helder were Dwarf Blackhull Kafir, Whitehull Kafir, Feterita, and Dwarf Yellow Milo. The sweet sorghum varieties were Red Amber, Black Amber, Freeds Sorgo, Western Orange, and Black Dwarf. In 1914, increase plots were planted to the five varieties of sweet sorghum. This seed was available for distribution in 1915.

The sorghums as a crop, both grain and forage, increased gradually in importance, in part due to the availability of pure improved seed

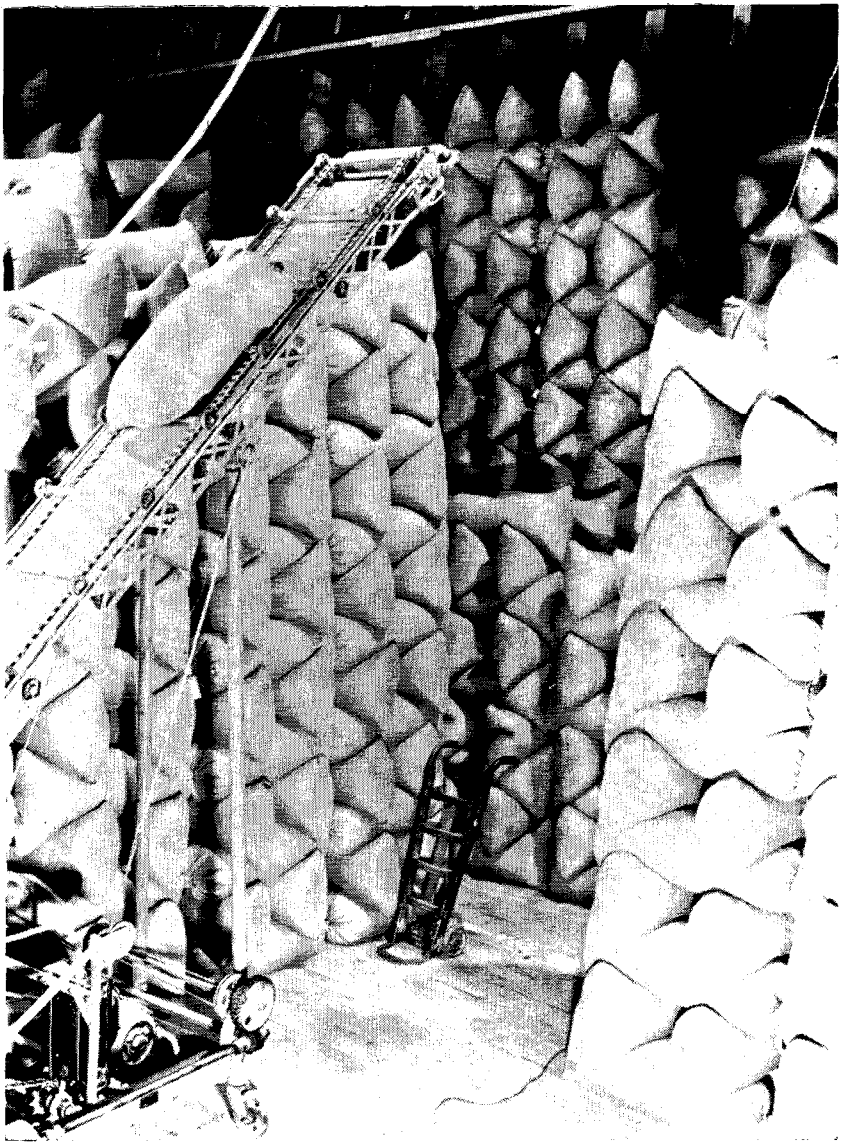

Fig. 50.—Certified seed stored over winter in the seedhouse. The seed was stored in bags piled to provide ventilation, which maintained high germination.

of the standard varieties from the Station. By 1925 the demand for pure certified sorghum seed became so great that the superintendent reported, "It seems as if the amount of seed that can be produced on the Station is the only limit to the amount that can be sold." (39)

Sorghum seed production at the Station reached a peak in 1925. The crop was produced under nearly ideal conditions. The seed produced was plump and bright, of high germination and excellent quality. Heads of seed had been hand selected the previous year and the fields had been carefully

rogued several times. The fields were widely separated from other sorghum varieties to prevent cross-pollination. Fields were at least 40 rods apart. Great care was exercised in harvesting, recleaning, grading, and storing the seed to maintain color, purity, and germination. Good cleaning facilities meticulously operated assisted in maintaining purity. Prompt harvesting and threshing with proper storage of seed in bags piled so as to provide ventilation insured high germination. The goal was 90 percent or higher germination. Pink Kafir, Dawn Kafir, Early Sumac, and Feterita were the principal varieties grown.

The sale of certified sorghum seed reached a maximum for the early years in the period 1925-1930. In 1925, 121,906 pounds were sold. The next year sales reached 244,659 pounds, and in 1930 they were 285,456 pounds. The sale of all kinds of certified seed of crop plants reached a maximum for the early years in 1930 with a total of 709,561 pounds. These sales consisted of 412,650 pounds of seed wheat and 285,456 pounds of sorghum seed. The seed went to 86 Kansas counties and 11 states.

Sudangrass was introduced from Africa by the U.S.D.A. in 1908. It was planted first at the Hays Station by R. E. Getty[11] in 1913, and recognized at once to be an excellent forage and pasture crop. In 1914, 23 acres were planted to sudangrass, which produced 100 tons of hay and 900 pounds of seed. The hay was used in a feeding experiment and proved highly palatable to livestock. The 900 pounds of seed were widely distributed in Kansas. The amount of seed was limited to four pounds to any one farmer. Instructions for growing the crop accompanied each shipment. The seed sold for $2 per pound. In 1915 larger lots of seed were sold to selected cooperators of the College and the Station, and seed produced by them was sold to other farmers.

Pink kafir, the first grain sorghum developed at the Station, was produced during the period 1907-1910. It proved to be an exceptionally good variety for central and western Kansas, in yield of both grain and forage. It had a wide distribution and was considered by growers as one of the most valuable sorghum crops. Some seed of the variety was sold to farmers in 1909. Two fields on the Station were planted to Pink kafir in 1915. They produced a good crop of forage as well as grain. Pink kafir was the most dependable grain sorghum for western Kansas before the combine types of grain sorghums were developed. Seed sales of the variety reached a maximum in 1926 when 122,056 pounds were sold. The sales during the eight-year period 1922-1929 were 359,061 pounds. As late as 1942, 81,172 pounds of Pink kafir seed were sold, but after that time Pink kafir for grain

11. Mr. Getty was a scientific employee of the U.S.D.A. stationed at the Hays Station.

was replaced rapidly by the combine sorghums.

Atlas Sorgo, a cross between sourless sorgo and Blackhull kafir made by I. N. Farr of Stockton and purified by the Kansas stations at Manhattan and Hays, became a popular variety because of its white seed, high yield, quality, and strength of stalk. It was grown first for seed distribution in 1927. Over 12,000 pounds of seed were produced in 1928 and 11,918 pounds were distributed in 1929.

Wheatland, the first combine-type grain sorghum, was distributed by the Station for seed in 1931. Since the crop was new and popular, it was considered advisable to obtain as wide a distribution as possible. Sales were limited to 120 pounds to a grower, the quantity needed to plant 40 acres. A total of 8,216 pounds was sold to 82 growers in 35 counties, principally in western Kansas.

Early Kalo and Pink Kafir were planted first at the Station in 1938, but the grain was not sufficiently pure to be distributed as seed. The first distribution of pure seed was in 1940 when 5,940 pounds of Early Kalo were sold.

Cody. During World War II when the country was cut off from supplies of glutinous starch made from cassava, a tropical plant, acute shortages of this type of starch developed. This type of starch was needed for adhesives and for the manufacture of tapioca. Cody sorghum, developed at the Hays station, contained a waxy endosperm from which this type of starch could be produced. From only a few seeds, Cody was increased by growing a second crop during the winter in the greenhouse and as a winter crop in southern California, Arizona, and Texas. Cody grain was produced for the General Foods Corporation both by the Station and by farmers to whom Cody seed had been supplied. In 1945 the Station sold 35,760 pounds of Cody seed. There was no demand for the crop after the close of the war, when supplies of glutinous starch from the tropics became available again.

Norkan, an early white-seeded sorghum produced at the Hays station from a cross made between Atlas and Early Sumac, was released first and sold for planting in 1941. A total of 12,010 pounds of seed was distributed, of which 9,892 went to Kansas farmers and 2,128 were sold outside the state.

Ellis, another variety produced at the Hays station, was first released for planting in 1948. The variety is a cross between Atlas and Leoti Red. It has white seed and a sweet stalk. It is valued for its palatability and earliness, maturing about the same time as Early Sumac. The first seed of the variety, 15,397 pounds, was sold in 1948.

FEDERAL SEED STOCKS COMMITTEE

The serious drouth in 1934 caused an acute shortage of sorghum seed for planting in

western Kansas in 1935. To aid farmers in securing seed, the U.S.D.A. set up in the Plains states Federal Seed Stocks Committees. One of these committees was at the Hays station. The superintendent and the cerealist were made collaborators of the department to purchase and distribute seed. High - quality Dawn Kafir seed was shipped from Texas. Some good Wheatland was obtained near Lakin and Sublette, and Dwarf Yellow Milo obtained near Elkhart. This seed, produced under irrigation, was distributed by the committee throughout the drylands of western Kansas. The drouth was severe again in 1936. This year was the first in over 15 that the Station sorghum crop failed completely to produce seed. A small quantity of Atlas seed, produced on bottomland that had been flooded, was sold at 15 cents a pound.

SEED WHEAT DISTRIBUTION

Seed wheat distribution by the Station was made extensively in 1910 when 6,400 bushels of Kharkov seed were sold. This variety had been introduced recently into the United States by the U.S.D.A. It went to all parts of Kansas and many other states.

Kanred wheat, released for distribution to farmers in 1918, was the only variety grown and distributed by the Hays station between 1919 and 1932. In 1925, 233,250 pounds of Kanred seed wheat were sold and in 1930 the sales increased to 412,650 pounds. In 1931, due to drouth, the wheat seed was shriveled and sales of

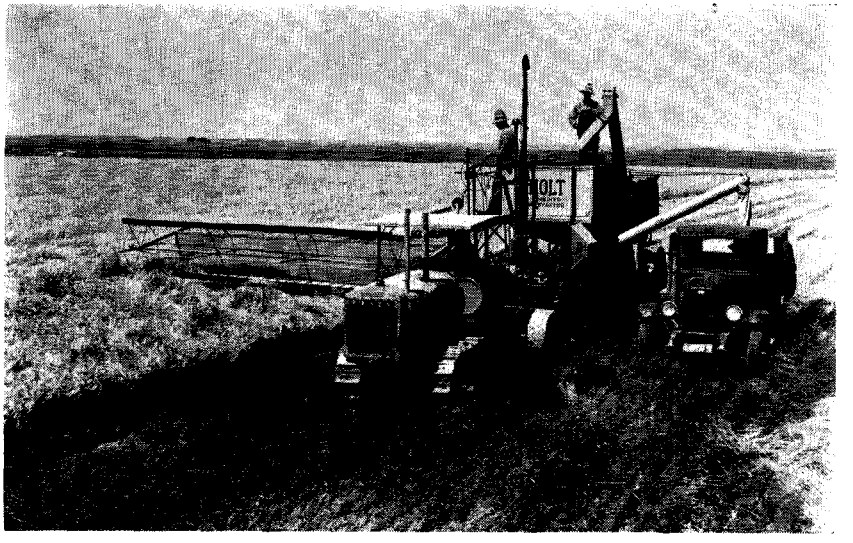

Fig. 51.—Combining Kanred wheat, which was the only variety grown and distributed by the Station between 1919 and 1932. Over 400,000 pounds of Kanred were sold in 1930.

Kanred dropped to 167,032 pounds. Most of the seed sold that year had been produced in 1930.

Tenmarq wheat, a new variety produced by the College, was planted first at the Station in the fall of 1932. The season of 1933 was very dry. The Tenmarq field produced only 15 bushels per acre of shriveled grain, with a total yield of 1,600 bushels. Only a small quantity of this grain was sufficiently plump to be suitable for seed. This seed was used to plant a 120-acre field in the fall of 1933. The rest of the good seed was sold to farmers, each sale being limited to 20 bushels. In 1939 a carload of Tenmarq seed was shipped for distribution to farmers in Texas. Tenmarq continued to be distributed until 1945.

Comanche, released by the College, had superior milling and baking quality and was planted first at the Station in 1943. The variety lodged badly at the Station in both 1944 and 1945. Due to this weakness, little Comanche seed was distributed.

Kiowa wheat, a cross between Chiefkan and Oro and Tenmarq, produced cooperatively by the Manhattan and Hays stations and the U.S. D.A., was released for distribution in 1950. A total of 1,700 bushels of Kiowa was sold for seed that year. Kiowa outyielded Comanche two to three bushels per acre and had a stiffer straw than Comanche or Tenmarq.

Bison, a bearded hard red winter wheat recommended for the western three-fifths of Kansas, was selected from a cross of Chiefkan x Oro x Tenmarq made at the College in 1938. The first generation was grown at the College in 1939. Later generations were grown at Hays where A. F. Swanson made the final selection resulting in Bison wheat in 1943. The variety is closely related to Kiowa. It possesses superior characteristics of high yield, good test weight, resistance to stinking smut (bunt), tolerance to wheat streak mosaic, stiff straw, and good milling and baking qualities. Bison was first released from the Station in 1956. Over 15,000 bushels of seed of the variety were distributed.

DISTRIBUTION OF SEED OF OTHER CROP PLANTS

Seed of crop plants other than wheat and sorghum has been grown and distributed by the Station. As has been stated, fairly large quantities of seed corn and some Stavropol and six-rowed barley were distributed in the early years. Burt, considered to be the best variety of oats in early years, was sold to farmers in small quantities. Barley was the best of the spring grains. Flynn barley, a smooth-awn variety, proved well adapted to western Kansas conditions. It was produced in limited quantities beginning in 1935. Only 2,018 pounds were released that year, but 10,444 pounds were sold in 1937. Osage oats, a variety produced

by the College, were grown first at the Station in 1946, with 28,126 pounds of seed being distributed that year.

Alfalfa. Alfalfa was one of the first crops planted on the Station. It was grown primarily for hay, but under favorable conditions seed crops were produced. A total of 35,172 pounds of seed of Kansas Common alfalfa was distributed in 1937. Buffalo alfalfa, a wilt-resistant strain selected from Kansas Common, was released first in 1944. The highest production and sale of this variety was in 1947 when 14,113 pounds were sold. This seed was in demand and had a wide distribution. A new strain of alfalfa resistant to both bacterial wilt and spotted alfalfa aphids was developed and released in 1959 under the name of Cody. Over 6,000 pounds of foundation Cody seed have been released during the last three years (1959-1961) and there are presently growing at the Station about 100 acres of Cody eligible for the production of foundation seed.

Buffalograss. The native grasses proved to be best for re-establishment of grass on the Great Plains following the dust storms of the 1930's. A high-yielding strain of buffalograss called Hays Buffalo was released in 1943. A large quantity of Hays Buffalo as well as Common Buffalograss seed was distributed. This seed contributed greatly to the re-establishment of grass on the Plains and resulted in the stabilization of much of the blow lands of western Kansas. In addition to buffalograss, the seed of sideoats grama, blue grama, and western wheatgrass was grown and distributed.

The most certified seed distributed in any one year by the Station was in 1951 when a total of 1,197,367 pounds of seed was sold, 783,940 pounds of sorghum, 340,310 pounds of wheat, 66,628 pounds of oats, 374 pounds of alfalfa, and 115 pounds of buffalograss.

DRYLAND AGRICULTURE

The Division of Dryland Agriculture of the U.S.D.A. in the early part of the twentieth century established in the Great Plains area a number of experimental stations to study crop adaptation, the effect of different cultural methods, cropping systems, and fertilizer practices upon crop production, and the adaptation of various practices to farming in this area. These stations provided reliable information about crops that could be grown and successful methods of farming in a new region. One of these stations was started cooperatively at the Hays Station, in 1906, with the arrival of L. E. Hazen, an employee of the Department of Agriculture. Mr. Hazen was followed in 1909 by A. L. Hallsted who served as project leader until 1945, a period of 36 years. Mr. Hallsted's long period of service and devotion to the work contributed greatly to the success of the project. The Office of Dryland Agriculture paid the salary of the project leader and the Sta-

tion furnished the land, equipment, and most of the labor.

The work as a cooperative project terminated in 1958.

The experimental work consisted of a study of cropping systems, tillage practices, and cultural methods for dryland farming. The first experimental plots were laid out for the 1906 crop year on what was essentially virgin land, the sod having been broken less than five years. Thirteen acres were devoted to experimental plots the first year, but the area in plots was later increased to about 60 acres. The plots were 2 x 8 rods, divided by 40-inch alleys, and the ends separated by 20-foot roadways. Standard recommended varieties of each crop were grown. The same variety was planted on all plots of a given crop in any one year. Improved varieties were substituted whenever seed became available.

Cropping Systems. The work embraced over 50 cropping systems with winter wheat, spring wheat, grain sorghums (kafir, milo, etc.), barley, oats, corn, sorgo, sudan, alfalfa, and bromegrass. Most of the systems were in use during most of the years of the dryland studies.

Summer fallowing, a common practice in the dry areas of the western states, was introduced into many cropping systems. Several crops were grown both continuously and in alternate fallow-crop systems over a long period. Moisture stored in the soil during the fallow period in addition to the rainfall during a cropping season usually insured increased crop yields.

Winter wheat, the major crop in central and western Kansas, was grown after fallow in 10 cropping systems, after wheat in 8 systems, after green manure in 4, after barley in 4, and after both sorghum and corn in 3. Kafir was included in 15 cropping systems, barley in 21, oats in

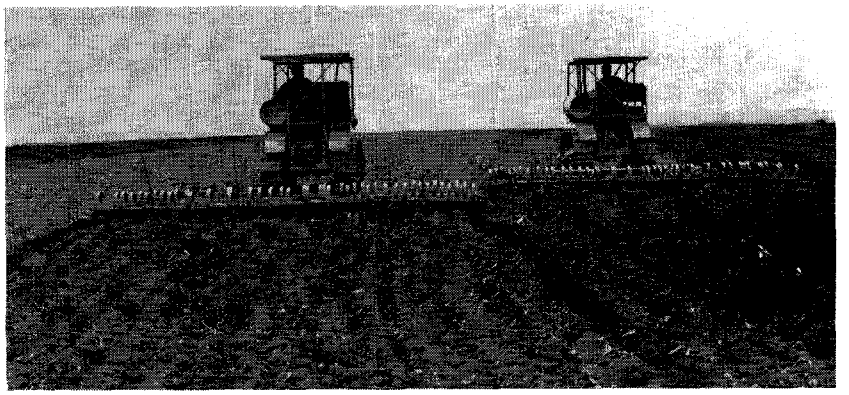

Fig. 52.—Summer fallowing with spring tooth harrow. Summer fallowing, a common practice in the dry areas of the western states, was introduced into many cropping systems.

Fig. 53.—Double disking wheat stubble immediately after harvest. Results at the Station showed that initial tillage should begin as soon after harvest as possible when the land was to be reseeded to winter wheat.

16, corn in 11, and spring wheat in 7.

Yield data from more than 30 cropping systems indicate that average wheat yields are not greatly different when the crop of the previous year or the land use has been the same. An exception shows a lower average yield from continuous wheat as compared to wheat after wheat in systems including fallow. Weed control has been a problem with continuous cropping with small grain. Green manuring crops in the rotation were of no benefit for winter wheat production. Any value they might have had was offset by their use of soil moisture which could have been utilized better by the main crop. As much wheat was produced by fallowing one year in four as with continuous cropping to to wheat. Fallowing lends stability to production because of higher yields and fewer crop failures.

Yields of milo after fallow were nearly twice those obtained with continuous cropping. The percentage increase was greater than for any other crop. Sorghum crops apparently make more effective use of stored soil moisture. Milo averaged about twice the production of corn.

Barley was the highest-yielding spring grain, exceeding oats or spring wheat. Spring wheat produced about half as much as winter wheat. Neither corn nor spring wheat compared favorably with sorghum or winter wheat.

Tillage Experiments. Tillage studies included time and method of preparing seedbeds for winter wheat, comparison of listing and plowing, frequency of plowing, and tillage methods for summer crops. Seedbed preparation studies for more than 50 years show that the initial tillage should begin as soon after harvest as possible when land is to be re-

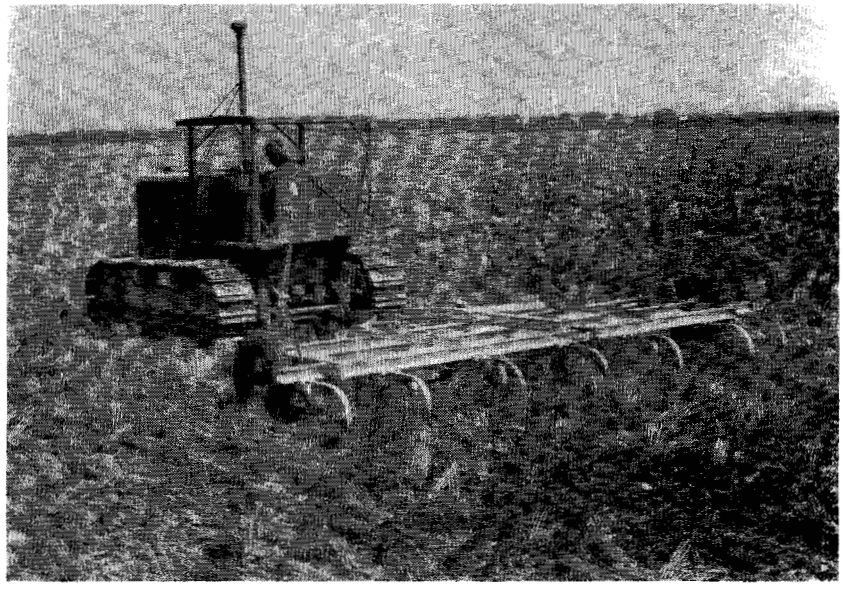

Fig. 54.—Preparing seedbed for wheat with duckfoot cultivator. Shallow cultivation such as could be done with subsurface equipment proved as satisfactory for wheat production as deeper tillage with a moldboard plow or lister.

seeded to winter wheat. Early plowing consistently gave higher yields than late plowing, by some 5 bushels per acre. Yield from early listing was 2 bushels greater than for early plowing for the 51 years. Increased moisture storage in listed plots apparently accounted for the higher yield. Shallow cultivation, such as can be done with a one-way disc plow and subsurface tillage equipment, was as satisfactory for wheat production as deeper tillage with a moldboard plow or lister. Subsurface tillage leaves the crop residues on the surface and provides protection against soil blowing. These residues also increase the infiltration rate of moisture. Fall tillage was superior to spring tillage for preparing the seedbed for spring crops.

Cultural Practices. Cultural practices studied included subsoiling in deep tillage, burning stubble, barnyard manure for winter wheat and for sorghum, crop response to commercial fertilizer, crop spacing, and contour tillage. Average yields of several crops grown continuously, or of those grown the second year after fallow, were increased substantially by subsoiling. The method is expensive and the need for frequent subsoiling is questionable. Plowing 14 inches deep had no effect on the yield of wheat after fallow.

A 10-year experiment to de-

termine the effect of stubble burning on subsequent wheat yields with different tillage methods was started in 1945. Winter wheat was grown continuously; stubble was burned in July after harvest. Burning did not affect average yields. However, burning is a poor practice because it increases the wind erosion hazard.

The effect of barnyard manure in a three-year rotation of fallow - wheat - kafir was studied from 1914 to 1957. Straw at the rate of 2 1/2 tons and manure at the rates of 3 and 6 tons per acre were applied in the spring on the growing wheat crop, and spring manure applications of 3, 6, 9, and 12 tons per acre made on plots planted to sorghum. All treated plots received manure and straw every third year. Yields obtained for 44 years indicated that manure and straw had little or no effect during this period on yield of either wheat or kafir. Straw and the heaviest manure applications tended to depress straw yields slightly. Kafir grain yields were not affected significantly but kafir forage yields were increased slightly by manuring.

An experiment with commercial fertilizer began in 1920 with continuous winter wheat. Fertilizers that were predominantly phosphatic showed no response for the 27-year period. Another experiment was initiated in 1950 to study the effect of both nitrogen and phosphorus on winter wheat grown continuously or grown the second year after fallow. Significant and profitable yields were obtained four of nine years with 30 pounds of nitrogen per acre, but there was no re-

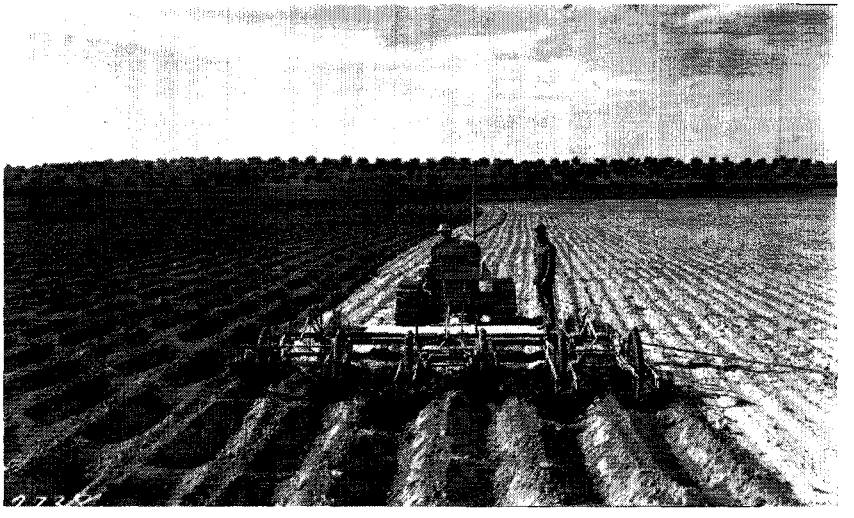

Fig. 55.—Basin listing on contour for wheat. The effect of planting on contour was studied over a period of 10 years, and increases in yield of 10 to 20 percent were obtained.

sponse in yield for five years, 1953 to 1957. Dr. R. E. Luebs reported, "The data indicate three factors largely determine response to nitrogen. They are (1) surface soil moisture at planting, (2) subsoil moisture at planting, and (3) spring rainfall. All these were above average in the four years yield increases were obtained with nitrogen fertilizer. The opposite was generally true the five years when no response was obtained." (40)

Corn and kafir were planted in rows 40 inches and 80 inches apart to compare the yields of both the row crops and the wheat crops that followed in a 2-year rotation. In this 24-year study (1924-1948), corn yields were reduced 5.4 bushels and kafir yields 4.9 bushels per acre when planted in the wider rows, but the yield of wheat that followed was increased 1.5 bushels following corn and 2.9 bushels following kafir.

Planting on the contour of crops in a rotation of wheat-milo-barley, on land with a 2 to 3 percent slope, was studied for 10 years—1948 to 1957. The soil was moderate or low in permeability. A one-way disc plow or disc harrow was used for the initial seedbed tillage operations the first 6 years. The last 4 years subsurface tillage methods were used. The same tillage operations were performed on both the contour and noncontour plots. Average increases of 10 to 20 percent were obtained from contour tillage for first-year wheat, second-year wheat, milo, and barley respectively. Moisture stored in the contour plots averaged an additional 2.9 inches.

The half century of investigational work in dryland farming indicates that the successful dryland farmer in this area, insofar as possible, must follow a flexible system in his cropping sequences, tillage methods, and cultural practices and choose them to fit the weather and soil conditions, taking into consideration the preceding crops, surface residues, weed populations, soil moisture, and soil tilth.

PROJECT LEADERS IN DRYLAND AGRICULTURE

Name	Year appointed	Year terminated
Hazen, L. E.	1907	1908
Hallsted, A. L.	1909	1945
Erhart, Andrew B.	1946	1948
Brown, Paul L.	1949	1956
Luebs, R. E.	1956	1959

PUBLICATIONS RELATING TO DRYLAND AGRICULTURE

1. Call, L. E. and Hallsted, A. L. 1915. The Relationship of Moisture to Yield of Winter Wheat in Western Kansas. Kans. Agr. Expt. Sta. Bul. 206.
2. Chilcott, E. C. and Cole, John S. 1918. Subsoiling, Deep Tillage and Soil Density in the Great Plains. Jour. of Agri. Research. 14:481-521.