Bulletin No. 371 - Fifty Years of Dry Land Research at the Nephi Field Station

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AGRICULTURAL EXPERIMENT STATION
UTAH STATE AGRICULTURAL COLLEGE
LOGAN, UTAH

PROFESSOR AARON F. BRACKEN (1890-1949), superintendent of the Nephi Dry Land Field Station for 31 years (1918-1949). During his period of leadership the experimental work at the Nephi Station set the pattern for dry farming practices in the Intermountain Area.

Professor Bracken attained a worldwide reputation as an authority on crop production in arid regions. His research covered almost the entire range of production problems with winter wheat. Among many other things he developed superior winter wheat varieties and he studied intensively the problems of nitrogen and organic matter depletion and maintenance in dry land soils.

In 1947 and 1948, Professor Bracken served as agricultural adviser to the Syrian government and was responsible for the introduction of superior cereal varieties into that country.

The authors: W. H. Bennett and D. R. McAllister are associate professors; D. W. Pittman, D. C. Tingey, and H. B. Peterson are professors, and I. G. Sampson is a former instructor in the Department of Agronomy.

Contents

Summary and Conclusions

THE Nephi Field Station is the oldest dry-land experimental farm in America still in operation. It was established in 1903 and dry land research has been conducted there ever since.

► Many of the practices of good husbandry now followed by dry farmers in the Intermountain Area originated at the Nephi Field Station.

► Experimental work at the Nephi Field Station has covered most of the problems of dry land agriculture. Investigations have included crop adaptation trials, cereal varietal testing, forage tests, grass seed production, tillage trials, fertility experiments, rotation studies, rate and date of seeding experiments, and a number of miscellaneous studies.

► When the Nephi Field Station was established dry farming in Utah was in its infancy, and little reliable information on dry farming practices was available. Since then dry farming has undergone considerable change and expansion, and it now represents an important phase of the agricultural economy of the state. In 1949, 33 percent of the total cropland of the state was dry farm land. Additional land has been cleared for dry farming since then.

► Dry farm land in Utah is used principally for the production of winter wheat. Consequently, expansion in dry farm acreage has expressed itself in an expansion in winter wheat acreage and production.

► The Nephi Field Station is located about 75 miles south of Salt Lake City, Utah, on an alluvial fan locally known as Levan Ridge. The topography is smooth with slopes of about two percent.

► Soils are reasonably uniform over a large portion of the farm and have been classified as Nephi silt loam and Nephi loam. The organic matter content of the surface soil ranges from 1.4 to 2.4 percent, the pH from 7.5 to 8.2, calcium carbonate from 3 to 13 percent, available phosphate from 5 to 23 parts per million[1], and available potassium from 70 to 187 parts per million.[1] The water table is deep.

► Average annual precipitation (1903 to 1953, inclusive), was 12.65 inches (August 1 to July 31 basis). The two extremes were 6.00 inches for the 1933-34 crop year and 19.08 inches for the 1913-14 crop year. May was the wettest month and June the driest. Spring precipitation had a significant effect on crop yields, as did total annual precipitation, and two years' precipitation. July through October rainfall and November through February precipitation were not significantly correlated with yields.

[1]Carbon dioxide soluble phosphate and potassium.

High yields of dry farm winter wheat were found to be directly associated with fall emergence. High spring rainfall cannot overcome the detrimental effects of poor fall emergence.

The average frost-free period was 110 days (28 year average).

April had the highest average wind velocity and October the lowest. The monthly variation was slight, however (range was from 3.05 miles per hour for October to 3.90 miles per hour for April).

Average total evaporation for April through October was 47.79 inches.

► Winter wheat proved to be the best adapted and most promising crop. Utah Kanred and Turkey 926 were the highest yielding varieties. However, they are both susceptible to smut. Cache, a variety with considerable smut resistance, yielded almost as well as Utah Kanred and Turkey 926. Wasatch was decidedly inferior in yield.

Winter wheat yielded nearly twice as much as the best spring wheat variety.

Results with barley and oats were not encouraging.

► Tall and pubescent wheatgrasses gave the highest yields of forage (hay stage). Alfalfa and an alfalfa-crested wheatgrass mixture produced high forage yields in some years but low yields in others. Rye gave good forage yields but is not recommended on winter wheat farms, because it is difficult to control and may become a weed pest. Intermediate, pubescent, tall, and crested wheatgrasses showed considerable promise for spring pasture. Good stands of small-seeded grasses and legumes were difficult to obtain in some years.

► Seed production studies have been made on tall, intermediate, pubescent, and crested wheatgrasses since 1948. A good stand of crested wheatgrass was more difficult to get than a good stand of the other species. However, after it was established, crested wheatgrass was a more consistent and dependable seed producer. Pubescent ranked next to crested in this respect. Tall wheatgrass gave the highest seed yields in years when precipitation was favorable, but was not able to produce a seed crop under dry conditions. Intermediate wheatgrass was not promising as a seed producer. In most cases row seedings gave higher seed yields than solid seedings. The 48-inch row spacing appeared to be superior to the 30-inch spacing for tall and intermediate wheatgrass. Crested and pubescent yielded about as well in 30-inch rows as in 48-inch rows, however. Nitrogen fertilizer stimulated vegetative growth but had little effect on seed yields. A residual effect from nitrogen applied in previous years was noted on vegetative growth. Results show that there are possibilities in growing wheatgrasses for seed on dry land. On the other hand there are hazards–seed prices are not stabilized, seed quality is frequently low, and yields may not be profitable if soil moisture is deficient.

► Varying fall plowing dates had no effect on wheat yield. There was no difference in the yields obtained from fall plowing and spring plowing when the spring plowing was done as early as possible or when delayed two weeks. Further delay in spring plowing reduced wheat yields drastically.

► Wheat yields were 8 percent higher when land was plowed 8 inches deep than when it was plowed 5 inches deep. There was little difference between the yields from 8-inch and 10-inch plowing. Subsoiling 15 and 18 inches deep did not increase yields. If maximum returns are to be obtained and if costs are to be kept down, plowing should not be shallower than 5 inches nor deeper than 8 inches—where conditions are similar to those at the Nephi Field Station.

► The moldboard plow gave significantly higher yields than the one-way disk and the disk harrow. However, the results probably reflect differences in depth of tillage as well as in type of implement. Relative crop yields are not fully adequate as a measure of the worth of a tillage implement. Erosion control and crop quality are also important. The goals of tillage can usually be attained better by using a number of implements rather than just one. Additional work is needed to evaluate the more recently developed tillage implements.

► Cultivation of fallow more than was necessary to control weeds did not increase yields.

► Peas plowed under when 6 and 12 inches high increased wheat yields slightly. When more mature than this peas reduced wheat yields. Wheat plowed under at similar stages of growth reduced wheat yields more than did peas. Evidence was found that the reduction in yield probably resulted from a temporary deficiency of nitrate nitrogen and that soil fertility of the green manured plots had actually been increased.

► Wheat yield and protein content were increased by nitrogen fertilization. Forty pounds nitrogen per acre showed more benefit than 20 pounds. The nitrate form of nitrogen was more effective than the ammonia form when comparable rates were used. No significant difference was found between fall and spring applications. Nitrogen fertilizer was not able to take the place of the fallow in 1952 trials. Results suggest it would be good procedure to wait until early spring before applying nitrogen fertilizer. If at that time there is evidence of poor fall emergence, winter injury, drought, or other unfavorable conditions, the fertilizer could be saved for a more propitious year. Evidence was found that small applications of nitrogen can counteract the reduction in yield often noted when a stubble mulch is used. Results from the use of urea spray were not encouraging. The same rates of nitrogen applied to the soil in early spring in the form of ammonium sulfate increased yield and protein content much more. If moisture is low response to nitrogen fertilizer may not be favorable.

► Manure increased the yield of winter wheat no matter what the rate or time of application used. Ten tons of manure applied every two years or every four years increased wheat yield approximately 20 percent over the unmanured. Where manure was applied only once (1915) a residual beneficial effect on yield was noted up to about the sixteenth year (1930). In the wetter years manure benefited wheat yields more than in drier years.

► Burning of straw increased wheat yield for many years then gradually decreased it. Over a period of 37 years burning increased yield about 2 percent as compared with plowing all the straw under. However, for the last 7 years of the period there was a 0.5 percent decrease in yield from burning. Plowing under straw probably lowered the content of available nitrogen in the soil and wheat growth was retarded. The loss of organic matter and nitrogen from burning the straw may now be depressing the yield more than enough to offset the greater availability of soil nitrates in the burned plots.

► The standard wheat-fallow cropping arrangement was compared with continuous cropping and with systems that permit one crop in two years and two crops in three years. Results suggest that where conditions are similar to those at the Nephi Field Station the alternate wheat-fallow cropping system will give greater net returns than the other systems mentioned.

► Twenty-seven rotations were evaluated. Wheat was common to all. Under no other rotation were wheat yields as high as they were under the alternate wheat-fallow cropping system. When row crops were substituted for fallow wheat yields were reduced 3½ bushels per acre. When alfalfa was included wheat yields were reduced 5½ bushels per acre. Nevertheless, it appears that alfalfa improved soil fertility; the yield reduction probably resulted from more complete and deeper drying of the soil by alfalfa. Except for alfalfa, the crop immediately preceding wheat was the one that had the predominant influence on the yield of wheat. Wheat was the only crop distinctly benefited by summer fallow.

► Yields gained consistently as seeding rate increased from 2 to around 6 pecks per acre. Above the latter rate yields remained about the same. Six pecks per acre gave the highest net yield. Seeding on October 1 gave the highest average yield. However, this was not greatly different from the average yields for September 15 and October 15 seedings.

► Over the period of a wheat-fallow cycle only 32 percent of the rainfall was stored as soil moisture. The other 68 percent was lost mostly by runoff and evaporation. Summer rainfall was ineffective in building up soil moisture reserves. Delay in spring plowing reduced the amount of soil moisture accumulated. Additional work is needed to determine how best to conserve moisture losses.

FIFTY YEARS OF DRY LAND RESEARCH AT THE NEPHI FIELD STATION

W. H. Bennett, D. W. Pittman, D. C. Tingey, D. R. McAllister, H. B. Peterson, I. G. Sampson

Introduction

History of the Station

THE Nephi Field Station is the oldest dry-land[2] experimental farm in America still in operation. It was established in 1903 by action of the Utah legislature and has been in continuous operation since. Five other arid experimental farms were established in Utah at the same time (Widtsoe and Merrill 1905) but they were all discontinued prior to 1920 (Harris *et al.* 1920).

The Nephi Field Station has had a most interesting history, and it is worthy of note that many of the men who were closely associated with it during its early history subsequently distinguished themselves as outstanding leaders. The station came into being largely as a result of the efforts of Dr. John A. Widtsoe, noted irrigation and dry farm authority of the west until his death in 1952. Under his leadership a systematic investigation was undertaken in 1901 to determine the possibilities of farming without irrigation in Utah. The experimental farm at Nephi was established largely as a result of that study. Dr. Widtsoe later became president of the Utah State Agricultural College, president of the University of Utah, and an apostle in the Latter-day Saints (Mormon) church.

From 1903 to June 30, 1907, the Station was operated by the Utah Agricultural Experiment Station. L. A. Merrill, agronomist of the Utah Station, directed the work until 1905. He was followed by W. M. Jardine, who continued as station agronomist until 1907. Some years later, Mr. Jardine served as secretary of agriculture in President Coolidge's cabinet, as United States minister to Egypt, as president of Kansas State College, and as president of Wichita University.

On July 1, 1907, a cooperative agreement for dry land research was entered into between the United States Department of Agriculture and the Utah Agricultural Experiment Station, and F. D. Farrell, who subsequently became president of Kansas State College, was appointed superintendent of the Nephi Station. He was succeeded in March 1910, by P. V. Cardon. Cardon served until 1913, and since then has won distinction as a national and interna-

[2]*Dry land* as referred to in this bulletin is that land which has an average annual precipitation of not more than 20 inches.

tional authority in the field of agriculture. He has been director of the Utah Agricultural Experiment Station, chief of the Forage Crops Division, and director of the Agricultural Research Administration, United States Department of Agriculture, and in December 1953, was elected director general, United Nations Food and Agriculture Organization.

A. D. Ellison followed Cardon as superintendent and in 1915, J. W. Jones succeeded Mr. Ellison. Jones was superintendent for nearly three years.

Aaron F. Bracken became superintendent in April 1918. He served until 1949. During this period, the pattern of dry farming practices in the Intermountain Area was pretty much set by the work done at the Nephi Dry Land Station.

In October 1920, the cooperative agreement between the United States Department of Agriculture and the Utah Agricultural Experiment Station was terminated. Since then the Nephi Experimental Farm has been operated solely by the Utah Station. From 1947 to the present the experiments have been in charge of various members of the agronomy staff. R. J. Evans directed the activities in 1947, W. H. Bennett in 1948, D. W. Thorne in 1949, while Professor Bracken was on leave of absence, DeVere R. McAllister supervised the work of the Station in 1950, and D. W. Pittman from 1951 to the present.

Other men who have been associated with the Nephi Farm at various times during its history—either planning the experiments and interpreting the results, or carrying out the work itself – include: F. S. Harris, George Stewart, Stephen R. Boswell, I. J. Jensen, James A. Eager, Wilson Foote, Merlin Boswell, Leo Bendixen, and Warren Bendixen.

Land furnished by County Commissioners

From 1903 to the present the land for the experimental work has been furnished by the Juab County commissioners. The original farm contained 40 acres of land, but in 1907 adjoining property was procured, and the size of the farm increased to 103 acres.

When the Nephi Field Station was established in 1903, dry farming in Utah was in its infancy. True, dry farming had been practiced to some extent since the days of early settlement. Parley P. Pratt reported that he grew good crops of wheat and rye without irrigation in 1848. Dry farming operations were carried out successfully at Bear River City in Box Elder County in 1863, on the Sand Ridge south of Ogden in 1865, in Cache Valley in 1871, and in Juab County in 1881. In 1881 the Broadhead family raised 15 bushels of wheat per acre on non-irrigated land at the mouth of Four Mile Creek. The eldest son, David, then filed on 160 acres with the stipulation that the land was arable. The claim was contested because all the water of the stream had been appropriated, and David Broadhead was charged with perjury and thrown into jail. Later he was acquitted upon proof that crops could be produced successfully without irrigation. Following this experience Mr. Broadhead named the land thus acquired "Perjury Farm" (Bracken 1940).

But, although some of the early attempts at arid farming in Utah were successful, there were many failures. Dry farming was uncertain because no one was familiar with methods of moisture conservation and with crops adapted to the conditions. By 1900 the Utah Agricultural Experiment Station was being contacted almost constantly for information on methods of raising dry-farm crops. But no reliable information was available; the only knowledge at hand was that based on the experience of a few successful dry farmers. It was this need for exact information on the possibilities and methods of dry farming that led to special investigations conducted by the Utah Agricultural Experiment Station, and to the establishment in 1903 of the six arid experimental farms previously referred to.

Dry farming grows up

Since 1903, dry farming has undergone considerable change and expansion and it now represents an important phase of the agricultural economy of the state. By 1929, there were 290,000 acres of cropland in Utah that were utilized for dry land crops, (Thomas *et al.* 1950) but according to Reuss and Blanch (1951) there were 576,300 acres of dry farm land in Utah in 1949. This represented 33 percent of the total cropland of the state. The breakdown by counties as reported by these authors, is given in table 1, appendix. It will be noted that some dry farm land was reported for every county except Piute. However, the major dry farm areas are found in northern and western Box Elder County, western Cache County, the Levan area of Juab County, Millard County, and in San Juan County.

Expansion in the dry land acreage of Utah has been especially pronounced since 1939. The tax assessment data reported by Reuss and Blanch (1951) indicate an increase from 1939 to 1949 of nearly 126,000 acres or 30 percent. Ninety-two percent of the increase occurred in 5 counties: Millard (41.6%), Box Elder (30.7%), San Juan (7.5%), and Washington (4.4%). Additional land has been cleared for dry farming since 1949, and in fig. 1, the approximate 1954 dry farm acreage[3], is compared with the dry farm acreage in 1934.

Dry farm land in Utah is used principally for the production of winter wheat. Consequently, the expansion in dry farm acreage has expressed itself in an expansion in winter wheat acreage and production (see table 2, appendix). In addition some 10,000 acres of newly cleared land have been shifted to the production of pinto beans in San Juan County.

Dry farming is not likely to undergo much further expansion in Utah within the foreseeable future because of the lack of land with the needed combination of good soil, adequate precipitation, and reasonably level topography (Thomas *et al.* 1950).

Throughout the entire period of growth and expansion, changes have taken place in dry farming methods and procedures. Operations have become highly mechanized, machinery greatly improved, and better cultural practices have been adopted. The experimental work carried out at the Nephi Station since 1903 has aided greatly in making these advancements possible, and has done much to improve, unify, and stabilize dry farming practices in Utah and in the West.

Location of Field Station

The Nephi Field Station is located in the Great Basin about 75 miles

[3]Courtesy John W. Metcalf, state soil scientist, U.S. Soil Conservation Service, Logan, Utah

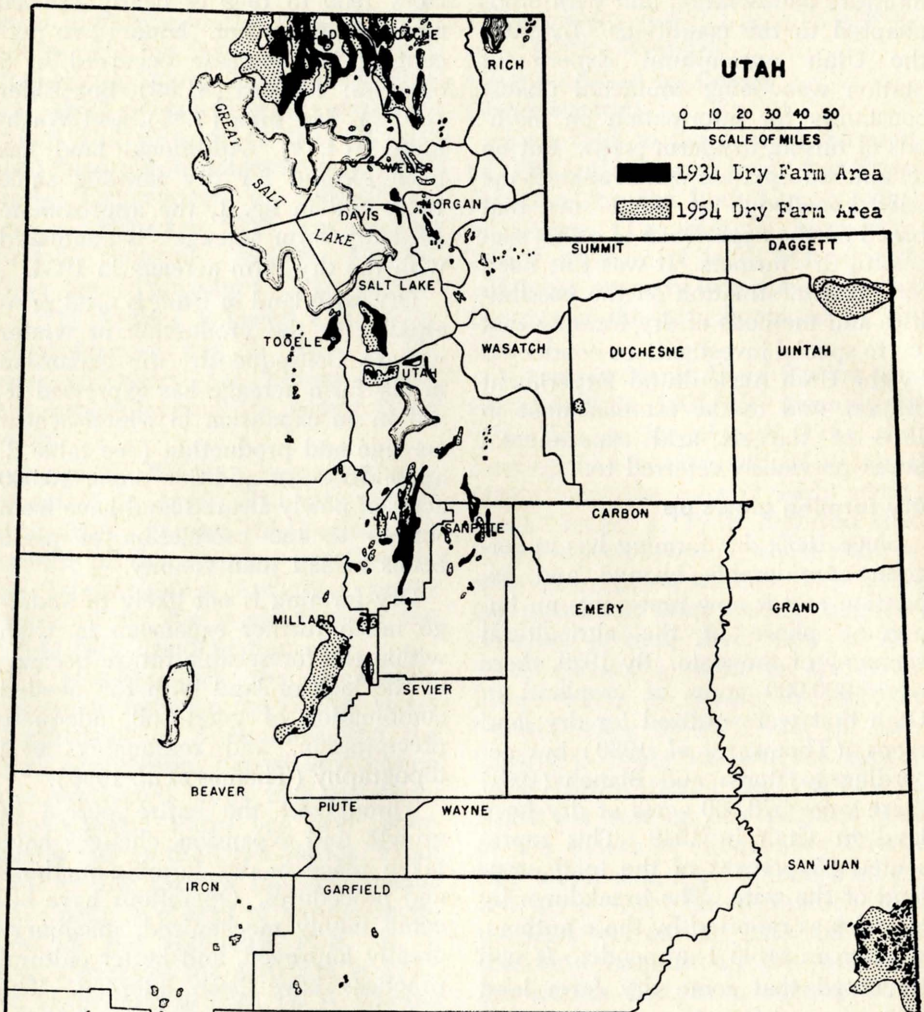

Fig. 1. Outline map of Utah showing expansion of dry farm acreage during the period 1934 to 1954

south of Salt Lake City, Utah (90 miles by present U. S. 91 highway). It is approximately 5 miles south-southwest of Nephi, in eastern Juab County at 39° 44′N. latitude and 111° 51′W. longitude. It is on the north slope of the Levan Ridge at an elevation of about 5,300 feet.

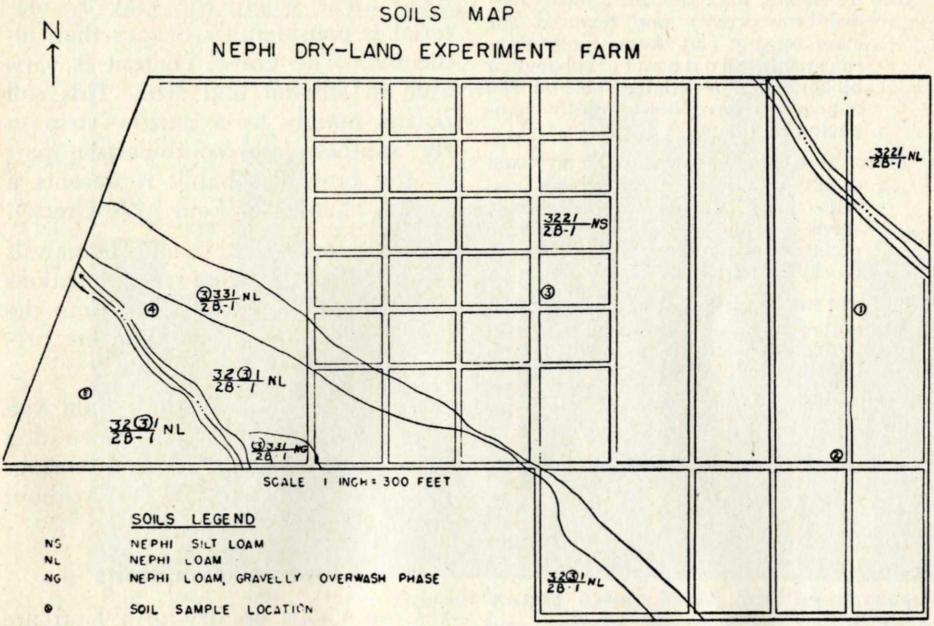

Fig. 2. Soils map of the Nephi Dry Land Experimental Farm prepared by L. Wilson

Slope and Topography

The station is located on an alluvial fan locally known as Levan Ridge. The topography is smooth with slopes of about 2 percent. The direction of slope is to the northwest. Two gullies cut across the farm; one in the northeastern corner is generally inactive and has not caused any material damage in recent years; the other is an active gully (Four Mile Creek) that cuts across the southwest corner.

Soils of Field Station

Previous publications on the Nephi Station (Harris *et al.* 1920, Bracken and Stewart 1930), have listed the soil as a clay loam, derived from the weathering of adjacent mountain ranges, reddish brown in color, and uniformly 10 feet or more in depth, with a nitrogen content of about 0.1 percent in the surface foot. A recent (1952) survey made by Wilson[4] has given a more refined picture of the soil conditions. This survey showed that the soils are reasonably uniform over a large portion of the farm. Only one soil series (designated as the Nephi series — a new series) was found, but two soil types (Nephi silt loam and Nephi loam) and one phase (Nephi loam, gravelly overwash phase) were noted. The distribution of these soils over the Station is shown in fig. 2. Following is a brief description of each type and phase:

Nephi silt loam

0 to 6 inches, dark reddish brown* (reddish-brown dry) silt loam, mildly calcareous; moderately alkaline; moderate to strong fine granular structure; friable; moderately permeable.

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[4]Wilson, Lemoyne. 1952 annual report on project 317. Utah Agr. Exp. Sta.

6 to 12 inches, dark reddish-brown (reddish-brown dry) fine textured silt loam or silty clay loam; moderately calcareous; moderate subangular blocky structure; friable. This horizon appears to have been slightly compacted by tillage.

12 to 33 inches, yellowish-red clay loam or silty clay loam. This horizon contains many calcium carbonate mottlings and an occasional soft lime nodule. It is massive to subangular blocky and friable.

33 to 54 inches, yellowish-red (both moist and dry) silty clay loam; massive; strongly calcareous with lime well disseminated.

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*Soil color and consistence are given for moist soil unless otherwise stated.

This soil is considered a normal zonal "Brown soil". The organic matter content of the surface soil ranges from 1.4 to 2.4 percent. Bracken and Greaves (1941) have shown significant losses of organic matter and nitrogen on dry farmed soils as compared with adjacent areas of virgin soils. In Juab valley a survey of 12 farms showed a nitrogen loss of 12.05 percent in the upper two feet of soil, approximately one-third of which could be accounted for by removal of the crops. For organic matter, the loss from cropped soil as compared to virgin amounted to 30 percent.

Nephi loam

Nephi loam is similar to Nephi silt loam, but has a loam surface texture and the substratem below 40 inches contains stratified gravelly material in some places. The loam type occurs in the northeast and in the southwest parts of the farm.

Nephi loam, gravelly overwash phase

This phase consists of an overwash of from 4 to 10 inches of gravelly loam material overlying the typical Nephi loam. There are probably local small areas where the gravelly material is considerably deeper than indicated. The gravel content is variable in amount and size. This soil occurs mainly as a narrow strip in the southern and southwestern part of the farm (probably represents a former channel of Four Mile Creek).

Soil samples for chemical analysis were collected from five locations over the farm at the same time the survey was made. The data are presented in table 3, appendix.

The water table at the Nephi Station is deep. Wells have been dug to a depth of 100 feet and borings made to a depth of 200 feet without striking water.[5]

Climatic Conditions

Crop yields on dry-farm land are influenced greatly by climatic factors. The most successful crop production requires that these factors be evaluated carefully and that practices be fitted to the climate.

Four climatic factors have been measured at the Nephi Station, namely, precipitation, temperature, evaporation, and wind velocity. In addition observations have been made on relative humidity and cloudiness—sufficient to indicate that the station has a relatively low humidity and a great deal of sunshine during the growing season.

Precipitation

Precipitation data were obtained at the station for the entire period 1903 to 1953, inclusive. These data are reported on a crop year (August 1 to July 31) basis in table 4, appendix.

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[5]Farrell, F. D. 1907 annual report on cooperative grain investigations at Nephi Substation. Utah Agr. Exp. Sta.

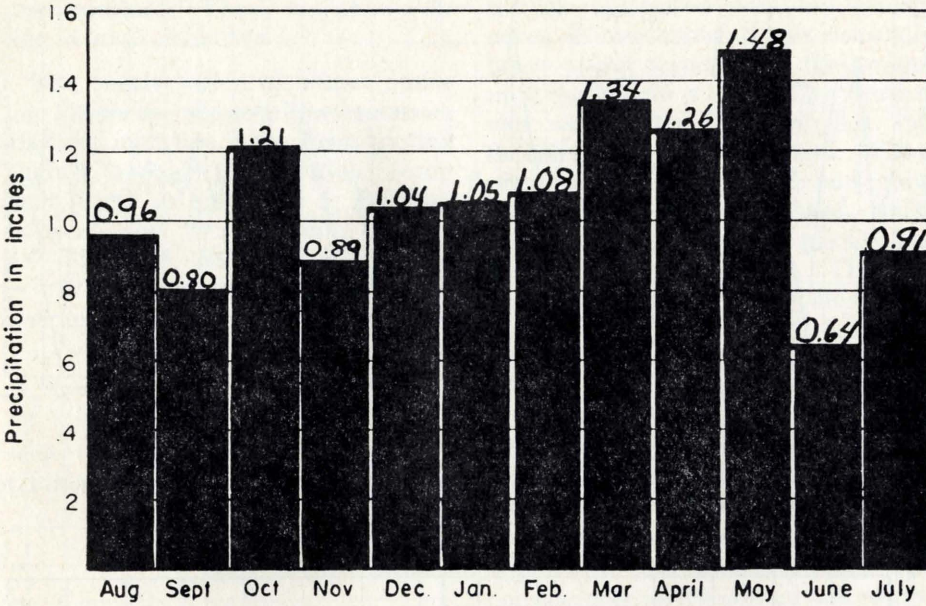


Fig. 3. Average monthly precipitation at the Nephi Station, 1903-1953, inclusive

The average annual precipitation for the fifty years was 12.65 inches. The two extremes were 6.00 inches for the 1933-34 crop year and 19.08 inches for the 1913-14 crop year. The fluctuations that have occurred between and within seasons should be noted because these, when examined along with data on other environmental factors and on crop yields, tend to emphasize that dry farm research must be long-time research and must take many factors into consideration to be most meaningful.

The average monthly precipitation is shown in fig. 3. May was the wettest month and June the driest. On the average, nearly a third (32.3%) of the annual precipitation came during the spring months, March to May, inclusive.

A number of workers have investigated the relation between wheat yields at the Nephi Station and precipitation. Greaves and Bracken (1946) reported that the seasonal distribution of rainfall is more important than the yearly total. Asfour (1950) and Zink (1940) found that the spring is the most important rainfall period. Peterson (1952), however, considered timeliness of storms, amount of precipitation during each storm, and amount of runoff to be of more importance than either total precipitation or seasonal distribution.

These workers had access to only part of the data now available. Some of them used precipitation data obtained at Levan rather than at the Nephi Station and the records show that precipitation over the years has been higher at Levan than at the Station. It is of some interest to know what the relations between yield and precipitation are when the data obtained at the Nephi Station itself over the entire 50 year period of its history

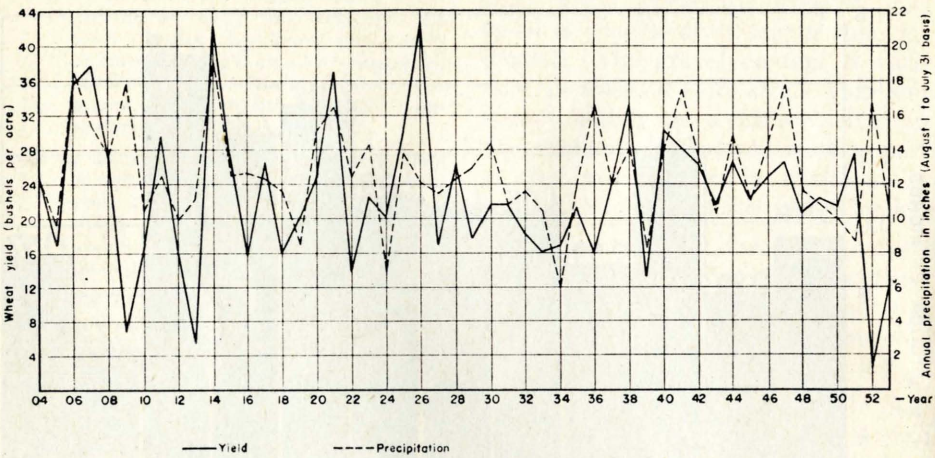


Fig. 4. Acre yield of wheat in relation to annual precipitation, crop year (August 1 to July 31) Nephi Station, 1904-1953, inclusive

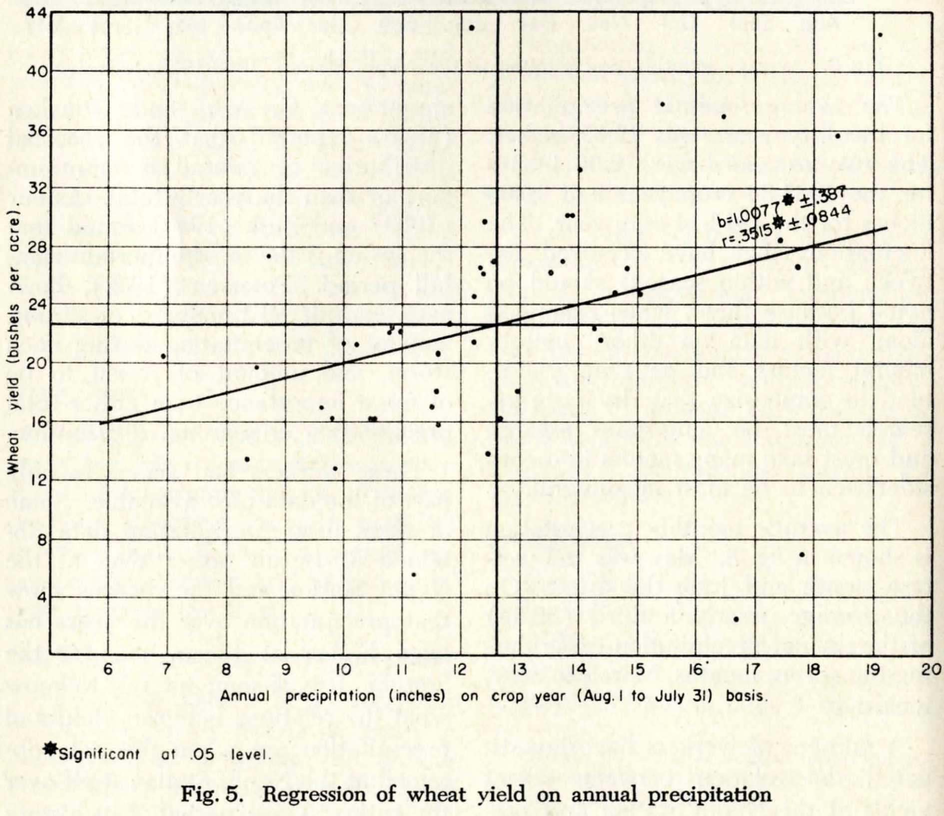


Fig. 5. Regression of wheat yield on annual precipitation

are examined. These are shown in figs. 4 to 9, inclusive.

The yearly yields of wheat under an alternate wheat-fallow rotation, 1904-53, inclusive, have been plotted against annual precipitation (crop year basis) in fig. 4 and 5. Relation between the two is quite evident (r=.3515* ± .0844 and b=1.0077* ± .387). However, there are some striking exceptions to the general be-

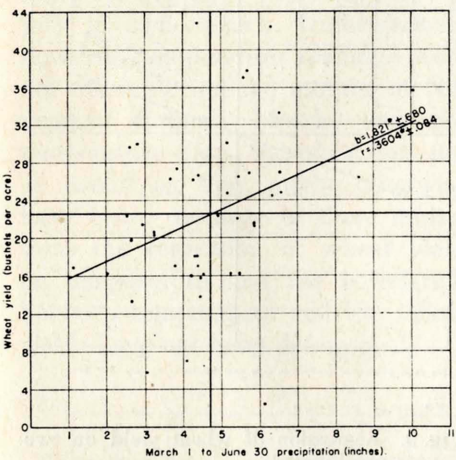
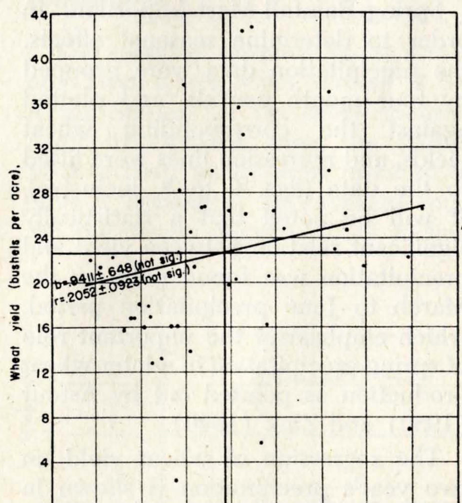


Fig. 6. Regression of wheat yield on March through June precipitation

havior. Two extreme exceptions show up for the years 1909 and 1952. Examination of the records discloses that environmental factors other than precipitation had pronounced effects on wheat yields in these two years. With respect to the latter, the months of June, July, August, and September in 1951 were exceptionally dry. Wheat emergence in the fall of 1951 was poor. In this connection it should be noted that Bracken and Cardon (1935) have presented evidence to show that high yields of dry-farm winter wheat in the Great Basin are directly associated with fall emergence. Winter snowfall was ususually heavy and it remained on the ground until the middle of April. The weather was warm after the snow left and the soil became unusually hard. Wheat plants did not stool well and grew poorly. On the other hand, early annual weeds, especially prickly lettuce, grew quite rapidly. The end result was that wheat yields were practically nil even though soil moisture content was more favorable than usual.

The 1909 wheat crop had an entirely different environment. Precipitation records (table 4, appendix) and the 1909 annual report on the Nephi Station show that rainfall in September and October 1908 was considerably above normal and storms delayed wheat planting until October 30 to November 2. The plants apparently did not become well enough established to withstand the winter



Not significant.

Fig. 7. Regression of wheat yield on July through October precipitation

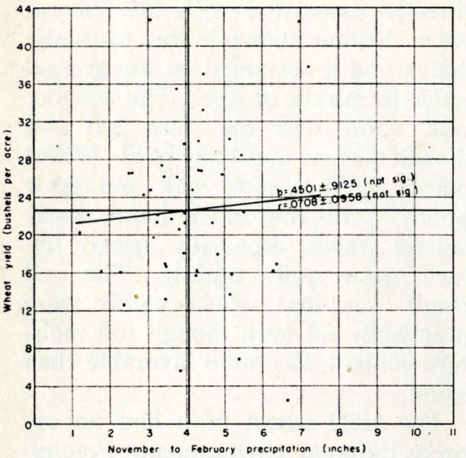


Fig. 8. Regression of wheat yield on November through February precipitation

conditions to which they were subjected because severe winter killing occurred.

Winter injury, loss of moisture through spring runoff, and severe spring crusting, were responsible for the low yields in 1913.

Spring Rainfall Most Important. In order to determine seasonal effects, the precipitation data were grouped by four month periods, and plotted against the corresponding wheat yields, and regression lines were fitted to the data (figs. 6 to 8, inclusive). It will be noted that a statistically significant relation between yield and precipitation was found only for the March to June precipitation period, which emphasizes the important role of spring precipitation in winter wheat production as pointed out by Asfour (1950) and Zink (1940).

The regression of wheat yield on two year's precipitation is shown in fig. 9. In this case the relation is highly significant.

It is evident from the above that at the Nephi Station both total amount and distribution of precipitation have had a pronounced effect on crop yields. The manner in which the precipitation falls and other environmental factors such as temperature, wind, evaporation, and soil conditions, have a bearing on the efficiency of rainfall in relation to yield. In some years these factors, singly or collectively, may have sufficient in-

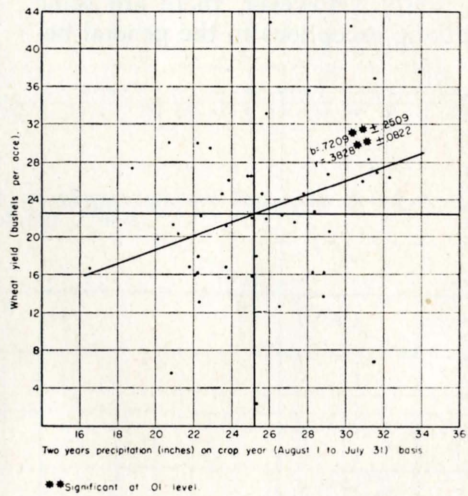


Fig. 9. Regression of wheat yield on two-year precipitation

fluence more than to offset the beneficial effects of favorable precipitation. One should not overlook the fact that yield is really an expression of the genetic makeup of the plants involved and the environmental complex as a whole.

Temperature

Temperature readings were taken at the Nephi Station over the 33 year period, 1909 to 1941, inclusive. In most years the readings were obtained for seven months (April through October). The data are reported in table 5 appendix, and the average monthly mean temperatures are shown graphically in fig. 10.

Mean temperatures give a fair measure of climate but maximum and minimum daily temperatures are sometimes more important in crop production because they represent the extremes to which plants are subjected. High summer temperatures at the Nephi Station have resulted in low crop yields when moisture was deficient, and low temperatures in winter and early spring, in combination with other factors, have caused winter injury in some years. Unfortunately, however, temperature readings were not taken during the months of November through March, and the temperature data, therefore, are not as useful as they might otherwise have been. Because of these limitations the regression of wheat yield on temperature and the correlation between temperature and the wheat yields have not been determined.

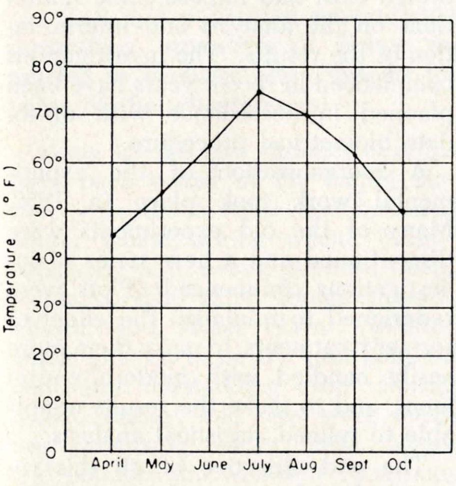


Fig. 10. Average monthly mean temperature, April to October, for the period 1908 to 1941, inclusive

The Nephi Station has an average frost-free period of 110 days, as shown in table 6, appendix.

Wind velocity

Mean wind velocities by months and years are reported in table 7, appendix. Here again, the readings were taken over the 33 year period, 1909 to 1941, inclusive, and in most years covered the seven months, April through October. Highest average wind velocities occur during April and the lowest in October (fig. 11). The monthly variation is slight, however. High velocities for short periods are not reflected in general averages, but are more important than mean velocities in their effects on plants. Damage from wind is rare at the station, however, although velocities up to 30 miles an hour have been measured for short periods.

Evaporation

The monthly evaporation as measured from a free water surface at the Nephi Station for the seven months, April to October, over the period 1908 to 1941, inclusive, is reported in table 8, appendix. The average total for the seven months, 47.79 inches,

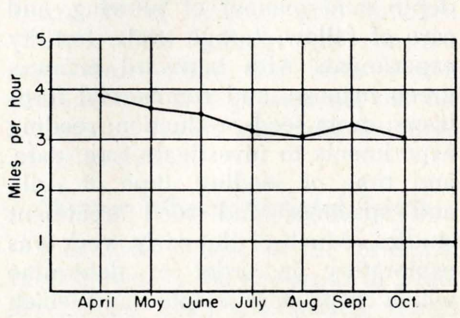


Fig. 11. Average wind velocity, April to October, for the period 1908 to 1941, inclusive

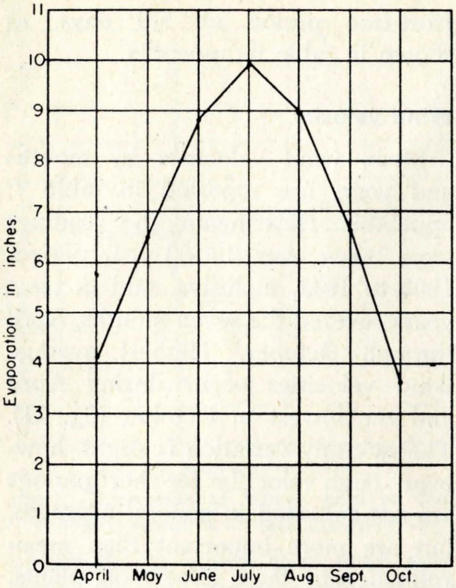


Fig. 12. Average monthly evaporation from free water surface, April to October, for the period 1908 to 1941, inclusive

is 3.78 times the total precipitation for the year.

The average evaporation by months is shown in fig. 12. It will be noted that the average evaporation-precipitation ratio for July is 10.9 to 1.0 whereas it is 3.3 to 1.0 for April and 3.0 to 1.0 for October. Evaporation is closely related to temperatures and wind velocity but temperature is the more important factor at the Nephi Station. Wind was not more prevalent during the months of high evaporation (fig. 11), but there is a close relation between evaporation and temperature as expected (fig. 10 and 12).

Nature of Research

THE work at the Nephi Field Station has covered most of the problems of dry land agriculture. Many different types and kinds of experiments have been carried out including crop varietal trials, mainly with winter wheat and other cereals; rotation tests; cropping experiments; tillage experiments, involving time, depth, and manner of plowing, and care of fallow; forage trials; fertility experiments with barnyard manure, green manure, and commercial fertilizers; grass seed production; seeding experiments to investigate rate, date, and time of seeding, type of drill, and spacings; and seed treatment studies. Much of the early work was exploratory in order to determine which crops were adapted and which practices had application. Some experiments are of long duration. Since they were planned at an early date certain weaknesses in experimental design exist and impose some limitations on the analysis and interpretation of the results. The investigations commenced in recent years have been planned in accordance with up-to-date biometrical procedure.

A reorganization of the experimental work took place in 1952. Many of the old experiments were discontinued and a new series of investigations commenced. Plots were redesigned to minimize the effect of former treatments, to make them more easily handled with modern equipment, and to make the results adaptable to refined statistical analysis.

The end objective of all this research has been to determine the principles and practices best suited to profitable dry land agriculture in Utah and other parts of the Great Basin.

Results of Experiments

MANY of the practices of good husbandry now followed by dry farmers in the Intermountain Area originated at the Nephi Station. This is evident to anyone who reviews the publications in which the experimental results have been reported and compares present day practices with the recommendations made therein.

There are many publications that deal with the results obtained at the Nephi Station. The most recent ones (Greaves and Bracken 1946, Bracken 1946) did not cover experimental results in detail, however, and the last publication that did was Utah Agricultural Experiment Station Bulletin 222, released in 1930.

The present publication is a summarization of the experimental data obtained over the entire 50 year period since the Nephi Field Station was established. Emphasis is given to the work done during the last 25 years.

Since there have been many different types and kinds of experiments conducted, it seems best to report the results, discussion, and conclusions for each phase separately.

Crop Testing

WINTER wheat appears to be the crop best suited for dry land areas similar to Nephi. Varieties presently known to be superior in yield under such conditions are Cache, Utah Kanred, and Turkey 926. Cache is recommended because it has resistance to smut. Baart is the most promising spring wheat variety but yields are approximately half those of fall-seeded varieties.

Tall and pubescent wheatgrasses, alfalfa, and sweet clover have been oustanding producers of forage under Nephi conditions. More work is needed to evaluate other species for forage and to investigate the feeding value of the wheatgrasses.

Many species and varieties of crops have been tested at the Nephi Station. Adaptation trials have included winter wheat, spring wheat, barley, oats, corn, peas, beans, potatoes, beets, sorghum, flax, rape, forage grasses, alfalfa, and sweet clover. Winter wheat proved to be the best adapted and most outstanding crop. Spring wheat, barley, and oats were much less promising. Corn, peas, beans, and potatoes did well only in seasons of higher than normal spring rainfall. Beets, sorghum, flax, and rape were unadapted and did poorly. Alfalfa, sweet clover, and certain forage grasses showed promise.

The results of the adaptation trials on most of these crops have been reported previously by Cardon (1914) Harris *et al.* (1920) and Bracken (1930). This bulletin will consider only those crops that have shown promise and will present all the experimental results obtained on these crops to date.

Winter Wheat Varietal Trials

Fall sown wheat is the principal crop grown on the dry lands in Utah. Ever since Utah was settled, wheat has been one of the most important crops in the state, and from all indications, it will continue to be so.

Winter wheat acreage in Utah during the past ten years has increased enormously (table 2, appendix). Wheat plays a vital role in the agricultural economy of the state because of the support it gives to the milling, baking, poultry, and general livestock industries, and to feed and processing plants.

Winter wheat variety trials have continued at the station from 1904 to the present. During this 50 year interval there was only one year that wheat failed to produce a crop.

Varieties being grown at the time the station was established were mostly soft kernel kinds. They were generally poor in baking quality particularly for bread making purposes. However, a variety known as Turkey was the first to be tested at the station. This was a hard red winter wheat of good milling and baking quality, particularly valuable for bread making purposes.

Data on the yields of winter wheat varieties that have been tested at the Nephi Station are presented in tables 1 to 5.

Because of the nature of the testing program it is seldom that many varieties continue in the tests for many years. As varieties prove to be low yielding or inferior in other ways they are dropped from the program. Turkey, Kofod, and Kharkof varieties were in the trials longer than any others. Turkey and Kofod were in the tests for 46 years. The average difference in the yield of these two varieties over this period was 1.9 ± .84 bushels. This is a difference of 9 percent in favor of Turkey (table 1).

Table 1. *Acre yield of fall sown wheat by 5 year intervals, and relative percentage of Turkey*

Variety	1904-1908	1909-1913	1914-1918	1919-1923	1924-1928	1929-1933	1934-1938	1939-1943	1943-1948	1949	Average*
					Acre yields						
					bushels						
Turkey	29.4	17.4	21.3	18.0	24.9	18.3	21.2	22.2	25.0	23.5	22.0
Kofod	23.3	9.1	22.5	19.1	24.7	17.1	21.2	18.7	24.1	24.4	20.1
Kharkof	26.2†	18.0	22.8	19.1	22.5	16.9	21.6	21.1	25.4	27.1	21.6
					Relative percentage of Turkey						
					percent						
Turkey	100	100	100	100	100	100	100	100	100	100	100
Kofod	79	52	106	106	99	93	100	84	96	104	91
Kharkof	89†	103	107	106	90	92	102	95	102	115	98

Turkey yielded higher than Kofod in 29 years out of the 46 and higher than Kharkof in 26 years out of 42 years.

*Turkey and Kofod just significant at 5 percent level.

†Only 1 year available.

Kofod, possibly because of winter killing, produced low yields between 1909 and 1913. In three of the years during this interval, Kofod was practically a failure. Except for this period there was no significant difference between Turkey and Kofod. During the 46 years Turkey varied in yield from 5.4 bushels in 1918 to 43 bushels in 1914. Kofod during the same interval, varied from .8 of a bushel in 1910 to 42.5 bushels in 1914. Kharkof has yielded about the same as Turkey. It was in the test for 42 years from 1908 to 1949. During this time it varied in yield from 7 bushels to 37.7 bushels per acre.

Additional varieties were added to the tests in 1909. Most of these were similar in type to Turkey. Average yields of these varieties over the 15 year period (1909 to 1923) and by five year intervals are shown in table 2, and are compared with the corresponding yields of Turkey. All the varieties except Kofod showed higher yields than Turkey. Except for Crimean the differences were not significant. The increase in the yield of Crimean over Turkey is largely a ıeflection of the 1916 yields. In that year for some reason Turkey yielded 10.3 bushels per acre and Crimean 23 bushels. This makes a difference of 12.7 bushels in one year, which would account for a considerable portion of the average differences for the 15 years. The yield of Kofod was 11 percent below that of Turkey. This resulted primarily from the low yield

Table 2. *Acre yields of fall sown wheat, and relative percentage of Turkey*

Variety	1909-1913	1914-1918	1919-1923	15 year average
		Yield		
		bushels		
Turkey	17.4	21.3	18.0	18.9
Kofod	9.1	22.5	19.1	16.9
Kharkof	18.0	22.8	19.1	20.0
Crimean	19.1	25.5	18.8	21.1
Bulgarian	17.4	24.7	18.5	20.2
Alberta Red	15.9	24.7	18.9	19.8
Armavir	17.8	23.1	20.3	20.4
Girka (winter)	18.2	20.7	20.6	19.8
		Relative percentage of Turkey		
		percent		
Turkey	100	100	100	100
Kofod	52	106	106	89
Kharkof	103	107	106	106
Crimean	110	120	104	112
Bulgarian	100	116	103	107
Alberta Red	91	116	105	105
Armavir	102	108	113	108
Girka (winter)	105	97	114	105

Table 3. *Acre yields of fall sown wheat and relative percentage of Utah Kanred*

Variety	1924-1928	1929-1933	1934-1938	1939-1943	1944-1948	25 yr. average
			Yield			
			bushels			
Utah Kanred	25.8	18.9	23.3	23.3	27.3	23.7
Turkey	24.9	18.3	21.2	22.2	25.0	22.3
Kharkof	22.5	16.9	21.6	21.1	25.4	21.5
Kofod	24.7	17.1	21.2	18.7	24.1	21.1
Sevier 59	29.2	17.5	24.6	21.6	26.9	24.0
Turkey 26	25.8	19.2	22.3	21.9	26.3	23.1
Turkey 926		20.1	22.4	23.8	27.4	23.4*
Montana 36		17.6	21.4	20.2	26.0	21.2*
Hays Kharkof #2			19.5	20.4	25.1	21.7†
TXK 237			23.2	21.2	25.7	23.4†
			Relative percentage of Utah Kanred			
			percent			
Utah Kanred	100	100	100	100	100	100
Turkey	97	97	91	95	92	94
Kofod	96	90	91	80	88	89
Kharkof	87	89	93	91	93	91
Sevier 59	113	93	106	93	99	101
Turkey 26	100	102	96	94	96	98
Turkey 926		106	96	102	100	101*
Montana 36		93	92	87	95	92*
Hays Kharkof #2			84	88	92	88†
TXK 237			100	91	94	95†

*Yields and percentage figures based on relative performance over 20 years rather than 25.

†Yields and percentage figures based on relative performance over 15 years rather than 25.

of Kofod during the 1909 to 1913 interval, as previously stated.

In 1924 a number of varieties were dropped from the testing program. One of these was Crimean, which had been the highest yielding variety up to that time. The reason why Crimean was dropped is not known. Other varieties were added. Most of them were similar to the Turkey type. The varietal yield data for 5 year intervals and for the 25 year period (1924-1948) are shown in table 3.

Utah Kanred and Turkey 926 high yielding

Utah Kanred was used in this test as the basis of comparison with other varieties in place of Turkey. Turkey, was, however, included in the test as the standard variety. It is obvious from the data that Utah Kanred yielded significantly higher than Turkey. It was higher in each of the 5 year intervals and averaged 6 percent higher for the 25 years. The difference was 1.4 ± .32 bushels. None of the other varieties used in the test appeared to be any higher yielding than Utah Kanred. Two strains, Turkey 26 and Turkey 926, were selections made from the Turkey variety by the late Professor A. F. Bracken, who was superintendent of the station for many years. Turkey 926 was released for commercial production, and is still being grown to a considerable extent in the Nephi area. From the data, it appears to be no better in yield than Utah Kanred.

Sevier 59, a selection out of Sevier, also appears to be as good in yield as Utah Kanred or Turkey 926. This is a hard white-kerneled variety generally low in quality. It is a variety of spring wheat and was considered to be non-winter-hardy. However, it never failed to produce a crop in the 25 years that it was tested at the Nephi Station. In the northern parts of the state Sevier 59 winter killed in some years.

Cache and Relief high yielding and smut resistant

Further adjustments were made in the testing program in 1937. Some of the older strains were eliminated and some new ones added. Among the new ones were two bunt-resistant selections developed by D. C. Tingey under the wheat breeding program at the Utah Agricultural Experiment Station at Logan. Data for the yield of these and other varieties are shown in table 4. Only one variety appeared to yield as high as Utah Kanred and that was Turkey 926. The two bunt-resistant varieties, Relief and Cache, were slightly lower in yield compared to Utah Kanred. However, during this 10 year period the average difference between Utah Kanred and Cache was 1.2 ± .93 bushels which is not enough to be significant.

It is interesting to note that during the first 5 year interval from 1937 to 1941, Utah Kanred gave a relatively higher yield over Relief and Cache than it did during the second interval from 1942 to 1946. Turkey 926 and Utah Kanred gave the same yield during this 10 year period. These trials were conducted under conditions where bunt, a common disease of wheat, was not a problem.

Table 4. *Acre yields of fall sown wheat and relative percentage of Utah Kanred*

		Yield			Relative percentage		
Variety	Source	1937-1941	1942-1946	10 yr. average	1937-1941	1942-1946	10 yr average
			bushels			*percent*	
Utah Kanred	Rod rows	30.2	25.2	27.7	100	100	100
Relief	" "	27.6	25.2	26.4	90	100	95
Cache	" "	28.3	24.7	26.5	94	98	96
Utah Kanred	Field plot	25.3	26.1	25.7	100	100	100
Sevier 59	" "	25.2	25.4	25.3	100	97	98
Turkey	" "	24.3	24.1	24.2	96	92	94
Turkey 26	" "	24.1	24.6	24.4	95	94	95
Turkey 926	" "	26.2	25.5	25.8	104	97	100
Hays Kharkof #2	" "	22.6	23.6	23.1	89	90	90
TXK 237	" "	24.8	23.7	24.2	98	91	94
Montana 36	" "	22.3	24.4	23.4	88	93	91
Kofod	" "	22.1	21.6	21.8	87	83	85
Kharkof	" "	23.1	23.7	23.4	91	91	91

Table 5. *Acre yields of fall sown wheat and relative percentage of Utah Kanred*

Variety	Yield			Relative percentage		
	1941-1945	1946-1953	13 yr. average	1941-1945	1946-1953	13 yr. average
	bushels			*percent*		
Utah Kanred	25.7	22.0	23.8	100	100	100
Cache	24.4	21.1	22.8	95	96	96
Wasatch	20.1	19.9	20.0	78	90	84

In no year was any bunt visible in any of the varieties.

Utah Kanred and Turkey 926 are both highly susceptible to all races of bunt including dwarf bunt, and there is considerable risk in growing either of these two varieties in the Nephi area because of this disease.

Wasatch smut resistant but low yielding

Wasatch, another bunt resistant variety developed at Logan, was added to the variety tests in 1941. Data for the 13 year period 1941 to 1953, are shown in table 5. Utah Kanred shows only a slight increase over Cache; and the difference is not significant. The 13 year average shows Wasatch down 3.8 ± 1.2 bushels. This difference is highly significant and indicates that Wasatch is a lower yielder than Utah Kanred or Cache. Wasatch is more resistant to dwarf bunt than Cache. However, because Wasatch yields less at the Nephi Station and also in the northern part of the state, Cache is preferred by most growers.

Spring Wheat Variety Yields Compared With Fall Sown Turkey

Spring wheat variety tests were started at about the same time as those on fall sown varieties. They

Table 6. *Acre yields of spring sown varieties of durum wheat compared with fall sown Turkey and relative percentage*

Variety	Yield				Relative percentage			
	1904-1910*	1910-1915*	1916-1919	14 yr. average	1904-1909*	1910-1915*	1916-1919	14 yr. average
	bushels				*percent*			
Mohamed Ben Bachir	10.8	9.4	9.2	9.8	100	100	100	100
Adjini	11.4	9.2	9.0	9.9	106	98	98	101
Turkey (winter)	25.1	26.1	11.6	21.6	232	278	126	220

*Data missing

Table 7. *Average acre yields of spring varieties of durum wheat compared with fall sown Turkey*

Variety	1914	1915	1916	1917	1918	1919	Avg.	Relative percentage
				bushels				*percent*
Mohamed Ben Bachir	18.5	14.2	14.2	8.6	12.2	1.7	11.6	100
Adjini	19.0	15.3	12.7	9.3	12.2	1.8	11.7	101
Kubanka	15.7	18.2	15.0	7.8	12.3	2.5	11.9	103
Velvet Don	17.2	12.8	14.6	8.7	11.8	2.5	11.3	97
Arnautka	15.0	14.2	14.0	8.6	11.5	2.3	10.9	94
Pelissier	12.7	17.0	9.3	10.6	11.0	1.8	10.4	90
Turkey (winter)	43.0	28.0	10.3	19.7	5.4	11.7	19.6	169

have not, however, been continued for as long a period of time. Data for the spring varieties in comparison with fall sown Turkey are shown in tables 6 to 9. The earlier tests involved varieties of durum wheat, two of which were tested from 1904 to 1919. Data for these are presented in table 6. Yields of fall sown Turkey, for the same intervals are included for comparison. There is no difference in the yields of the two spring sown varieties of durum for the 14 year period. It is obvious, however, that neither of the two durum varieties, spring sown, yielded half as well as did Turkey, fall sown.

Winter wheat yielded nearly twice as much as spring wheat

Some additional varieties were added to the yield trials beginning in 1914 and continuing to 1919. Of the new varieties added none seemed superior to the better yielding varieties used in the preceding tests. Compared with fall sown Turkey, the spring sown varieties yielded relatively higher than during the preceding period. Turkey yielded 169 percent of the standard durum variety (table 7).

In 1917 a number of varieties of common wheat were added to the spring sown variety tests. Data for the 19 year period (1917 to 1933) are shown in table 8. Baart was used as the standard, and when compared with the other spring sown varieties, gave a higher yield, with the exception of Chul. These spring sown varieties of common wheat give much lower yields than fall-sown Turkey. The yield of Turkey was 168 percent of that of the best spring sown variety.

A few additional varieties were added to the trials in 1921 and were continued to 1930. Averages for these varieties are shown in table 9. Again not one of the varieties appeared to be superior to Baart. Compared with the fall sown Turkey, however, the latter yielded 170 percent of the best spring sown variety.

Comparison of spring and fall sown varieties are of considerable interest. Farmers have often inquired about the possibilities of growing wheat on

Table 8. *Average acre yields of spring sown varieties of common wheat and relative percentage of Baart as compared to fall sown Turkey*

Variety	1917-1921	1922-1926	1927-1931	1932-1933	17-yr. average
	Yield				
	bushels	*bushels*	*bushels*	*bushels*	*bushels*
Baart	13.3	12.7	10.0	9.1	11.6
Marquis	9.8	10.0	8.0	6.0	8.9
Regenerated Defiance	8.6	10.0	6.5	6.7	8.2
Chul	15.1	10.5	9.8	8.2	11.4
Turkey (winter)	18.0	20.9	20.2	17.8	19.5
	Relative percentage				
	percent	*percent*	*percent*	*percent*	*percent*
Baart	100	100	100	100	100
Marquis	74	79	80	66	77
Regenerated Defiance	65	79	65	74	71
Chul	114	83	98	90	98
Turkey (winter)	135	165	202	196	168

dry land each year, the argument being that if the function of fallow is largely to allow nitrates to accumulate in the soil, these could be added in commercial fertilizers. It would then be possible to grow a crop each year rather than one in two years as is done at present with fall sown wheat.

To grow a crop each year on dry land in Utah would require spring planting, because not enough moisture comes in the fall to permit the preparation of a seedbed. Data are not available on the yields of wheat under such a cropping system. However, if one assumes the yields under such a system to be equivalent to what was obtained in the variety tests on spring wheat sown on fallow, which is unlikely, it is possible to make a comparison. The 17 year

Table 9. *Acre yields of spring sown varieties of common wheat and relative percentage of Baart as compared with fall sown Turkey*

Variety	1921-1925	1926-1930	10 yr. average	1921-1925	1926-1930	10 yr. average
		bushels			*percent*	
Baart	15.8	9.6	12.7	100	100	100
Chul	14.4	9.3	11.8	91	96	93
Hard Federation	11.5	9.1	10.3	73	95	81
Marquis	12.9	7.2	10.1	82	75	80
Regenerated Defiance	11.4	7.3	9.3	72	76	73
Kota	13.8	9.0	11.4	87	94	90
Turkey (winter)	20.8	22.4	21.6	132	233	170

average for the highest yielding spring wheat variety was 11.6 bushels. In two years this would be equal to 23.2 bushels compared with a yield of 19.5 bushels in a fall sown wheat fallow system. This is a difference of only 3.6 bushels. The added expense for fertilizer and its application, plus the land preparation, seeding, and harvesting necessary for the additional crop would make annual cropping an unprofitable practice in the Nephi area.

Barley Varietal Trials

Two series of variety tests were conducted on barley; one fall sown and the other spring sown. The former was done from 1914 to 1927, and the latter from 1904 to 1910 and from 1915 to 1919. The results were reported by Harris *et al.* (1920) and Bracken and Stewart (1930). Spring barley showed little promise; the best variety had an average yield of less than 18 bushels per acre. Winter barley yielded nearly twice as much as spring barley when winter injury was not a problem. However, all barley varieties lack winter hardiness and winter-kill in severe seasons—thus the usefulness of this crop is limited.

Oat Variety Testing

Oat varieties were tested at the Nephi Station from 1904 to 1926. Yields of all varieties were low—not high enough to justify growing oats on dry land under conditions similar to those at the Nephi Station.

Forage Tests

Early forage crop trials, begun at the Nephi Field Station in 1904, were exploratory and included a large number of grasses, legumes, and miscellaneous plants.

Difficult to get good stands

The work done prior to 1920 was reported by Cardon (1914) and Harris *et al.* (1920). Difficulty was frequently experienced in getting good stands of the small seeded grasses and legumes. Fall seeding was found to be hazardous for alfalfa and sweet clover and was satisfactory for grasses. Alfalfa was the most promising forage legume in these early tests. After stands were established alfalfa produced a good first cutting in most years, with yields frequently in excess of 1½ tons dry forage per acre. Sweet clover also did fairly well after stands were established; yields were frequently in excess of one ton dry forage per acre and occasionally in excess of two.

Smooth bromegrass was the most promising grass in the early trials. However, it became sod bound with age and then produced poorly. Tall oatgrass showed some promise. The cereals such as wheat, barley, rye, emmer, and mixtures of these produced in excess of one ton of dry forage per acre.

More intensive forage crop testing was commenced in 1934. Different forage crops were seeded in one-tenth acre plots in an experiment that provided for three replications of each crop. Some species were planted in the fall of 1934 and others came into the test still later. Differences in age of stand are, therefore, a complicating factor in this experiment and these differences should be kept in mind in interpreting the results.

Comparative yield data for the period, 1936 to 1943, inclusive, and the statistical analysis of the data are

Table 10. *Forage yields obtained at Nephi Station, 1944-1953 inclusive, by years and for the period (average of 3 replications)*

Species or mixture	Acre yield (dry weight basis) 1944	1945	1946	1947	1948	1949	6 year average	
				tons				
Common rye	1.95	0.50	0.43	0.53	0.48	0.98	0.81	
Michel's rye	1.91	0.86	0.48	0.76	0.47	0.99	0.91	
Crested wheatgrass	0.66	0.41	0.17	0.16	0.08	0.67	0.36	
Smooth bromegrass	0.46	0.27	0.12	0.15	0.15	0.24	0.23	
Tall wheatgrass	1.65	1.09	0.59	1.44	0.61	0.93	1.05	
Alfalfa	2.08	0.72	0.16	1.25	0.07	0.85	0.85	
Alfalfa and crested wheatgrass	1.91	0.79	0.37	1.05	0.16	0.84	0.85	
Western wheatgrass	0.91	0.80	0.34	0.27	0.31	0.51	0.52	
Pubescent wheatgrass	1.52	1.14	0.61	1.09	0.52	1.16	1.00	
"F" for species or mixture	24.88**	19.44**	16.17**	20.75**	15.85**	15.19**	43.70**	
L. S. D. .05	0.37	0.20	0.14	0.32	0.16	0.21	0.13	
L. S. D. .01	0.51	0.27	0.19	0.44	0.22	0.30	0.18	
C. V.	14.74	15.73	22.05	24.8	28.19	15.51	25.59	C.V. for error (a)
							18.27	C.V. for error (b)
							19.63	gen. C.V.

Combined analysis of variance for 1944-1949 data

Source	D.F.	S.S.	M.S.	F.
Species	8	12.2009	1.5251	43.70**
Reps	2	0.0088	0.0044	
Error (a)	16	0.5590	0.0349	
Years	5	22.3256	4.4651	25.23**
Years X species	40	8.4321	0.2108	11.91**
Years X reps	10	0.1070	0.0107	0.60
Error (b)	80	1.4135	0.0177	
Total	161			

**Significant at .01 level.

shown in table 9, appendix. It will be noted that a highly significant difference among species was found for all years except 1942[6]. Sweet clover yields were outstanding but it was in the test for only two out of the eight years. Crested wheatgrass, rye, and alfalfa were the next highest yielding species. It should be noted that rye was cut at two different stages to determine how late it could be cut and still make sufficient recovery to reseed and thus perpetuate itself from year to year. The relative yields obtained are, therefore, a reflection of recovery as well as stage of maturity. This is quite a different situation from what would prevail if the rye were seeded every year.

Tall wheatgrass (*Agropyron elongatum*), pubescent (stiff-hair) wheatgrass (*Agropyron trichophorum*), and Michel's rye were introduced into the experiment in 1943. The yield data obtained during the subsequent six year period, 1944 to 1953 inclusive, are shown in table 10. Here again it should be remembered that differences in age of stand are a complicating factor. The statistical analysis of the data is given at the bottom of table 10.

Tall and pubescent wheatgrass gave highest yields of forage

A highly significant difference in the forage yields of the species was found for the entire period of this test. Tall wheatgrass produced the highest yield of forage with pubescent wheatgrass a close second. There is no significant difference statistically between the yields of these two species, however, based on the average results over the six year period. Alfalfa alone and the alfalfa plus crested wheatgrass mixture were high yielding in some years but gave low yields in other years. Smooth bromegrass, western wheatgrass, and crested wheatgrass were relatively low yielding. There was no significant difference between the yields of common rye and Michel's rye. Rye is practically a sure crop to grow for forage on dry land but its use on such should be discouraged because it is a menace to successful winter wheat production. In this connection it should be noted that as early as 1906 the Utah Agricultural Experiment Station had this to say about rye, "we do not recommend that rye be grown on a farm in connection with winter wheat as it spreads very easily soon becoming a pest that is very hard to get rid of" (Jardine 1906). The experience that dry farmers in Juab valley have had with rye since that time

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[6]"F" for species or mixture is a statistic calculated to show whether there are significant differences among the species or mixtures. The asterisks (*) indicate the level of significance. If there is no asterisk then F is not significant. If there is one asterisk F is significant at the .05 level and if there are two asterisks then F is significant at the .01 level. When the F value is not significant the accepted interpretation is that there are *no* significant differences among the yields of the species or mixtures. Small differences in yield may occur through chance variations in fertility, moisture, and other characteristics of the individual plots. The actual differences required to be considered significant are indicated by L.S.D. (least significant difference) values. Two probability levels (or odds) of the L.S.D. are given when the F for varieties is significant. When two varieties differ by as much as the amount of the L.S.D. at the .05 level, it may be stated that under the conditions of the experiment the odds are 19 to 1 that one species or mixture is really better yielding than the other. Odds of 99 to 1 are indicated by the .01 L.S.D. values. This explanation applies to all tables in this bulletin where "F" values are shown.

"C.V." (coefficient of variation) is a measure of relative variation — it expresses the standard deviation in percentage of the mean.

speaks emphatically of the wisdom in that early admonition.

The statistical analysis of the yield data shows a highly significant difference among years, which means that forage yields on dry land will be much higher in some years than in others. This variation in yield from year to year is believed to result primarily from differences in the amount of available soil moisture. However, other factors of the environment, such as insects and diseases, may also influence the results. The analysis also shows a highly significant years x species interaction which means that the species responded differently in different years, or, in other words, the highest yielding species in one year may not be the highest in another year when conditions are different.

Valuable for pasture

In these experiments the forage was harvested at the hay stage. However, some of the grasses showed considerable promise for spring pasture. This was especially true of pubescent wheatgrass, crested wheatgrass, tall wheatgrass, and smooth brome which grew well in early spring. Intermediate wheatgrass was not included in the forage experiment but was in seed plots nearby. It made excellent early spring growth and appeared to be outstanding for pasture. The ability of intermediate, pubescent, and tall wheatgrasses to furnish green feed after crested wheatgrass is mature, is a definite advantage for later pasture.

Trials have been conducted with other forage crops at the Nephi Station, but the results have not been encouraging (Cardon 1914). Vetch, sorghum, and soybeans have done poorly. Field peas have done well when they could be planted early enough to take advantage of the cool spring weather. When this could be done yields as high as 1200 pounds of vines and 1800 pounds of seed per acre were obtained. This early planting, however, is usually not possible because the heavy soil conditions prevent early working of the soil. Peas have done poorly in hot, dry weather. From time to time since 1904, fair yields of corn fodder have been produced in favorable years, but the crop has been practically a failure in unfavorable years.

Grass Seed Production

GROWING grasses for seed on dry land has possibilties—but there are hazards, also. With perennial grasses there is less frequent expense for seed and land preparation than with wheat. Grasses aid greatly in soil conservation. But it is sometimes difficult to get good stands. Seed yield and quality are frequently low, and grass seed prices are not stabilized.

Crested wheatgrass appears to be a more dependable seed producer than tall, intermediate, and pubescent wheatgrasses under Nephi dry land conditions. Row seedings are best, but additional work is needed to determine the best spacing for the various grasses. Seeding should be done in the fall or very early spring and should be shallow (not over 1 inch deep). Harvesting must be timely and done with care to avoid loss from shattering. Additional work is needed to determine why the effect of nitrogen fertilizer

on grass seed yields is erratic and unpredictable; also to determine why seed yields of some species (e.g. intermediate wheatgrass) drop off drastically with increase in age of stand.

Grass seed production is a subject of some interest to dry farmers. Especially is this true if there are wheat acreage restrictions. When this is the case the need for a cash crop substiute to take the place of wheat is keenly felt. Unfortunately, there are not many substitutes for wheat on dry land. The investigations that have been made on grass seed production should, therefore, be of interest.

The possibility of growing grass for seed production on dry land was considered at the Nephi Station as early as 1906. In that year smooth bromegrass produced 465 pounds of seed per acre. In 1909, however, its seed yield was only 25 pounds per acre. No further attention was given to grass seed production until 1937. In that year Walker and Bracken (1938) obtained 390 pounds of seed per acre from smooth bromegrass and 313 pounds from crested wheatgrass. The following year these grasses yielded 283 and 591 pounds of seed per acre, respectively. In 1940 the acre yields were 145 pounds for smooth brome and 279 pounds for crested wheatgrass.

These tests were hardly more than field observations. It was not until 1948 that grass seed production experiments actually began. Since then investigations have been carried out on crested, tall, intermediate, and pubescent (stiff-hair) wheatgrasses, to determine their seed production possibilities and limitations on dry farm land. The effects of different spacings, nitrogen fertilizer, soil moisture, clipping, and age of stand have been studied in a confounded factorial experiment involving the four species, 3 spacings, 3 nitrogen levels and 4 replications.

It is not intended that this publication present and discuss the detailed results obtained in this experiment. This will be left for a later publication. The present bulletin will merely call attention to some of the more important findings to date. Four years' data are summarized in table 11. It will be noted that yield fluctuations from year to year have been great. This, and the fact that in some species fluctuations were more pronounced than in others, suggests that grass seed production studies on dry land should be of long duration.

Crested wheatgrass the most dependable seed producer

Tall wheatgrass was the highest yielding species in years when precipitation and soil moisture were favorable. It was not able to produce a seed crop under dry conditions, however.

Intermediate wheatgrass behaved similarly to tall wheatgrass, but at a lower level throughout. This specie does not look promising for seed production under conditions such as prevail at Nephi. It does look good for early spring grazing, however.

More difficulty was experienced in getting satisfactory stands of crested wheatgrass than of the other species in this experiment. However, after it was well established crested wheatgrass was a more consistent and dependable seed producer than the others. Furthermore, it was more

Table 11. *Comparative seed yields of four wheatgrass species for three different spacings over all nitrogen levels, Nephi,* 1950 *to* 1953, *inclusive*

Species	Yield per acre (clean seed)			
	1950	1951	1952	1953
		pounds		
Crested wheatgrass (standard)				
solid seeded	12.8	29.9	67.9	48.1
30 inch rows	62.4	20.9	74.5	64.9
48 inch rows	55.4	29.2	62.6	63.9
Tall wheatgrass (A-1876)				
Solid seeded	48.7	3.6	175.1	3.0
30 inch rows	90.0	3.6	188.8	2.1
48 inch rows	134.6	7.4	194.4	8.5
Intermediate wheatgrass (Ut. 109)				
solid seeded	38.0	2.9	45.4	1.8
30 inch rows	58.5	3.0	37.4	1.9
48 inch rows	74.6	5.5	37.7	3.4
Pubescent wheatgrass (A-1488)				
solid seeded	108.3	11.6	81.5	9.1
30 inch rows	132.8	16.2	69.9	13.7
48 inch rows	119.6	19.1	55.7	24.7

Average of 4 replications

capable of producing a seed crop under adverse conditions.

Pubescent wheatgrass was better able to produce seed under dry, adverse soil moisture conditions than tall or intermediate wheatgrasses. However, it was much inferior to crested wheatgrass in this respect.

Row seedings gave best seed yields

In most cases row seedings gave higher seed yields than solid seedings. The 48 inch row spacing was the superior one for tall and intermediate but in some years the 30 inch spacing gave higher yields for crested and pubescent.

Nitrogen fertilizer at the rates and in the manner applied, had little effect on seed yields. However, nitrogen stimulated vegetative growth early in the season, but later on burning was most severe where vegetative growth was heaviest. A residual effect on vegetation from nitrogen fertilizer applied in previous years was noted. This effect can be seen in fig. 13 and shows up to better advantage in the cover picture of the bulletin (lower left corner).

Under Nephi conditions the species reached the mature seed stage in the following order: crested, pubescent, intermediate, and tall.

Pubescent wheatgrass was a more vigorous sod-former than intermediate wheatgrass.

From the results to date it can be concluded that the growing of wheatgrass for seed production at the Nephi Station has shown some possibilities. The cash value of the seed produced, based on average yields for the four years and May 1953 prices, ranged from a low of $12.65 (intermediate wheatgrass—solid seeded) to a high of $69.72 (pubescent wheatgrass – 30 inch rows). The picture changes, of

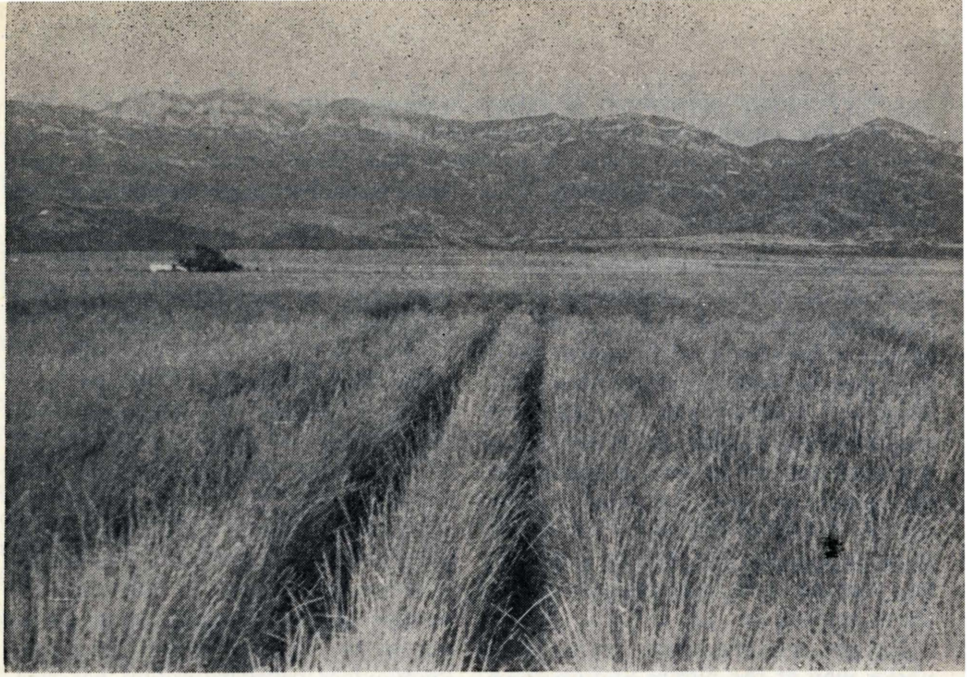

Fig. 13. Grass seed production plots at the Nephi Station. Dark areas show residual effect of nitrogen applied in previous years (Picture taken July 12, 1952)

course, as seed prices change. Since these grasses are perennials there is less frequent expense for seed and land preparation, than there is with wheat. Furthermore, grasses aid greatly in soil conservation.

On the other hand the experimental results have demonstrated that there are hazards in growing wheatgrasses for seed production on dry farm land. It is sometimes difficult to get satisfactory stands. This is especially true of crested wheatgrass. Crested wheatgrass is a fairly consistent and dependable seed producer. The other species, especially tall and intermediate fall down in this respect. They give fair to good seed yields in favorable years but the yields are extremely poor under adverse conditions. Seed quality is frequently low on dry land and last but not least it should be mentioned that seed prices are not stabilized.

Experimental results and observations to date suggest that late fall seeding of grasses is preferable to spring seeding under the conditions that prevail at the Nephi Station because with fall seeding there is lower seedling mortality during the hot, dry summer period.

Tillage Investigations

LONG - TIME tillage experiments at the Nephi Station show that:

- **fallow land need not be plowed deeper than 8 inches**
- **plowing should be done in the fall or early spring**
- **subsoiling 15 and 18 inches deep did not increase wheat yields**

► **frequent cultivation of fallow is unnecessary**

► **the moldboard plow gave slightly higher yields than the one-way disk and disk harrow. There is evidence that these results apply to most dry farms in the Intermountain Area. More modern tillage implements are now being evaluated.**

Success in dry land farming is dependent upon many factors. A most important one is efficient and timely tillage. The choice of tillage method may greatly influence the cost of production. Furthermore, if the best possible crop yields in a particular environment are to be obtained, tillage practices must be fitted to the climate and to the soil. Therefore, it is important that tillage practices be studied and appropriate procedures arrived at.

Tillage investigations have been under way at the Nephi Station since 1904. In that year a depth of plowing and subsoiling experiment was commenced; this was continued until 1950. Other tillage experiments, some of which were factorial, came later to investigate time and depth of plowing, frequency and manner of cultivation of fallow, and type of plow or tillage implement.

The principles of dry land soil management have not changed during the history of these investigations. However, our understanding of these principles and our knowledge of soil—water—plant relations and the purposes and methods of tillage have changed greatly. To illustrate, early thinking on the value of a dust mulch is no longer tenable. It was once thought that the soil should be worked frequently with a harrow or drag in order to provide a dust mulch which was supposed to hold near the surface water brought from lower depths by capillary action. It is now known that capillary action has relatively little influence on the movement of soil moisture available to crops in dry farming (Conlon 1952).

All of the tillage tests at the Nephi Station were carried out on land that was cropped and fallowed in alternate years, but the experiments were so arranged that yield results were obtained every year. Unless otherwise stated, the depth of plowing was about 8 inches in all tests and the

Table 12. *Winter wheat yields following various depths of fall plowing,* 1910 *to* 1949, *inclusive, reported as averages for specified periods*

	Treatment				
	Fall plowed			Subsoiled in fall	
Period	5 inches deep	8 inches deep	10 inches deep	15 inches deep	18 inches deep
			bushels per acre		
1910-1914	21.7	22.5	21.8	21.7	20.5
1916-1919	19.8	20.6	21.7	21.7	19.8
1920-1924	23.4	27.5	22.5	25.5	26.2
1925-1929	25.3	29.0	28.9	27.0	28.2
1930-1934	18.1	19.7	18.5	18.8	17.1
1935-1939	21.1	21.9	21.9	20.6	19.7
1940-1944	26.5	26.6	27.5	27.0	27.3
1945-1949	22.3	24.2	25.1	25.0	24.7
39 year average	22.3	24.2	24.1	23.4	23.0

plots were 1/10 acre in size (36 feet x 121 feet).

Depth of Plowing and Subsoiling

The purpose of the depth of plowing and subsoiling experiment which began in 1904 was to determine the effects of various depths of fall plowing and subsoiling on crop yields. The results prior to 1910 were considered to be preliminary and were not reported. However, comparative yield data were obtained for the period, 1910 to 1949, inclusive. These data are shown by 5-year intervals in table 12 and in complete detail in table 10, appendix.

Eight inch plowing better than five

Yields for the 8 inch plowing depth were higher than those for the 5 inch depth in 30 of the 39 years, and averaged about 8 percent higher over the 1910-1949 period. The difference was 1.87 ± .69 bushels which is significant statistically.

There was practically no difference between the yields obtained for the 8 and 10 inch depths of plowing.

Subsoiling did not increase yields

Fall plowing to a depth of 8 inches gave significantly higher yields than subsoiling 18 inches deep. The difference was 1.35 ± .54 bushels.

No significant difference was found between 8 inch fall plowing and 15 inch subsoiling (.8706 ± .709).

From the results of this experiment it can be concluded that subsoiling does not result in an increase in wheat yields under dry land conditions such as exist at the Nephi Station, and that where fall plowing is done it should be deeper than 5 inches but need not be deeper than 8 inches.

Double plowing not necessary

In 1916 an investigation was started to determine whether or not it was advantageous to plow in both the fall and spring and if so which depth combinations would give the best results. The data from this experiment for the period, 1916-1949, inclusive, are reported as 5-year averages in table 13, and in more detail in table 10, appendix. Plowing 8 inches deep in the fall followed by plowing 3 inches deep in the spring gave significantly higher yields than plowing 3 inches in the fall and 8 inches in the spring or 8 inches in the fall and 8 inches in the spring. However, the yields obtained when land was double

Table 13. *Winter wheat yields following fall and spring plowing at various depths,* 1916 *to* 1949, *inclusive, reported as averages for specified periods*

Period	Treatment		
	Plowed 8 inches fall, 3 inches spring	Plowed 3 inches fall, 8 inches spring	Plowed 8 inches fall, 8 inches spring
		bushels per acre	
1916-1919	19.5	18.1	18.8
1920-1924	25.9	23.3	22.8
1925-1929	26.6	25.8	24.5
1930-1934	18.4	18.2	16.3
1935-1939	21.0	20.1	19.7
1940-1944	27.9	26.6	23.5
1945-1949	24.6	19.7	20.4
34 year avg.	23.5	21.8	20.9

Table 14. *Winter wheat yields on fall and spring plowed land treated in various ways,* 1916-1949, *inclusive, reported as averages for specified periods*

Treatment	Average yield 1916-1919	1920-1924	1925-1929	1930-1934	1935-1939	1940-1944	1945-1949	34 yr. average
	bushels per acre							
Fall plowed, ordinary cult. of fallow*	20.6	27.5	29.0	19.7	21.9	26.6	24.2	24.3
Spring plowed, ordinary cult. of fallow*	22.1	25.0	27.6	21.1	23.3	26.8	23.5	24.2
Fall plowed, no cult. weeds hoed	21.0	25.5	25.6	17.3	20.3	27.3	24.4	23.1
Spring plowed, no cult. weeds hoed	21.2	25.8	27.5	20.2	22.6	29.3	23.3	24.3
Fall plowed, cult. frequently†	19.7	24.7	26.5	17.3	21.8	27.8	22.9	23.0
Spring plowed, cult. frequently†	19.4	24.6	27.8	19.6	22.5	26.6	22.7	23.4
Spring plowed after fall disking	17.3	24.5	24.6	19.2	21.4	26.0	22.1	22.3
Fall plowed after fall disking	19.2	25.9	27.7	17.9	20.8	26.5	22.7	23.1
Fall and spring plowed, cult. frequently†	21.3	26.2	27.9	19.5	20.7	25.5	23.7	23.6

*Under ordinary cultivation fall plowed land was harrowed in the spring as soon as possible, followed by one or two weedings as necessary, followed by a leveling and another harrowing. Spring plowed land was harrowed twice and leveled with one weeding required only in occasional years.

†Under frequent cultivation land was worked every two weeks during the fallow period (received about eight cultivation treatments.)

plowed were lower than where it was plowed but once in the fall to a depth of 8 or 10 inches.

The obvious conclusion from these data is that where conditions are similar to what they are at Nephi a single plowing in the fall to a depth of 8 inches is preferable to plowing in both the fall and the spring.

Time of Plowing

Several time of plowing tests have been conducted. Two of them were factorial in nature and considered treatment of fallow as well as time of plowing. The effects of plowing at various times in the fall, in the spring, and from double plowing have been measured.

The data from one of these experiments are reported in table 14 and table 11, appendix. It will be noted that the yields on fall and spring plowed land were similar. The small differences in their mean yields over the 34 year period are not significant statistically. Double plowing did not increase yields significantly over single plowing.

Results from another time of plowing test are reported in table 15. Two dates of fall plowing and five dates of spring plowing were compared in this experiment.

Table 15. *Winter wheat yields on land plowed at various dates in the fall and in the spring. Nephi Station* 1932-1936 *inclusive*

Treatment	1932	1933	1934	1935	1936	5 year average
			bushels per acre			
Fall plowed early	19.3	11.8	14.1	15.2	17.7	15.6
Fall plowed late	19.4	10.3	13.8	15.2	18.4	15.4
Spring plowed early	19.9	9.8	16.6	16.1	18.1	16.1
Spring plowed 2 weeks later	19.2	8.7	16.6	16.4	20.3	16.3
Spring plowed 4 weeks later	18.2	8.0	14.1	15.7	17.8	14.8
Spring plowed 6 weeks later	15.6	4.0	10.8	13.6	16.4	12.1
Spring plowed 8 weeks later	14.6	3.2	6.9	12.6	15.0	10.5
"F" for treatments	26.78**	12.80**	23.52**	3.06*	6.07**	65.95**
L. S. D. .05	1.25	2.78	2.18	2.43	2.07	0.85
L. S. D. .01	1:75	3.90	3.05		2.91	1.19
C. V.	3.89	19.81	9.21	9.09	6.59	7.40 C.V. for error (a) 8.88 C.V. for error (b) 8.66 gen. C.V.

Average of 3 replications

Combined analysis of data for 1932-1936, inclusive

Source	D.F.	S.S.	M.S.	F.
Treatments	6	447.9425	74.6571	65.95**
Reps	2	113.5555	56.7777	50.16**
Error (a)	12	13.5845	1.1320	
Years	4	1399.4253	349.8563	214.48**
Years x treatments	24	114.0807	4.7534	2.91**
Years x reps	8	47.5959	5.9495	3.65**
Error	48	78.2981	1.6312	
Total	104	2214.4825		

*Significant at .05 level.
**Significant at .01 level.

Plow in fall or early spring

The statistical analysis of the data shows no significant difference between the fall plowed early and fall plowed late treatments. Yield differences between fall plowing and spring plowing were not significant when the spring plowing was done as early in the spring as the plow would scour or up to 2 weeks later. However, if spring plowing were delayed more than 2 weeks yields were noticeably reduced. The reductions were highly significant when spring plowing was delayed 6 and 8 weeks.

There was a highly significant years x treatments interaction. This means that the relation among the treatments varied somewhat from year to year. To illustrate, delaying spring plowing reduced yields much more (proportionately) in 1933 than in 1936.

Twelve years' data from a similar but more comprehensive experiment are reported in table 16, and in table 12, appendix.

In this experiment the fall plowing was done about October 10. Early spring plowing was done just as soon in the spring as the plow would scour (April 27 in 1940, but June 1, 1939). The other spring plowing treatments were at 2 week intervals thereafter.

Plantings were made at random in 1/7 acre plots (28 feet by 222 feet).

The statistical analysis shows a highly significant difference among the treatments. This is undoubtedly a reflection of the drastic yield reduction that occurred when spring plowing was delayed unduly. Reduction in yield began to be significant when spring plowing was delayed 4 weeks beyond the early plowing date. Differences were highly significant,

Table 16. *Winter wheat yields as influenced by time of plowing and frequency of tillage, 1939 to 1950, inclusive, reported as averages for specified periods*

Treatment	Average 1939-1942	Average 1943-1946	Average 1947-1950	12 year average
		bushels		
Fall plowed—no tillage*	25.1	23.9	28.0	25.7
Fall plowed—med. tillage†	23.5	23.6	26.8	24.7
Fall plowed—freq. tillage‡	23.2	23.6	25.9	24.3
Spring plowed early—no tillage*	24.4	23.2	26.2	24.6
Spring plowed early—med. tillage†	24.0	24.1	24.8	24.3
Spring plowed early—freq. tillage‡	23.6	24.0	24.3	24.0
Spring plowed 2 weeks late—no tillage*	21.7	24.6	25.5	24.0
Spring plowed 2 weeks late—med. tillage†	23.4	24.7	27.3	25.1
Spring plowed 2 weeks late—freq. tillage‡	21.1	23.1	24.4	22.9
Spring plowed 4 weeks late—no tillage*	17.7	20.8	24.6	21.1
Spring plowed 4 weeks late—med. tillage†	20.8	21.7	26.1	22.9
Spring plowed 4 weeks late—freq. tillage‡	19.7	21.0	24.8	21.8
Spring plowed 6 weeks late—no tillage*	15.3	15.2	19.7	16.7
Spring plowed 6 weeks late—med. tillage†	15.0	15.5	24.4	18.3
Spring plowed 6 weeks late—freq. tillage‡	15.5	16.7	18.4	16.9

*No tillage — no tillage of fallow but weeds pulled

†Medium tillage — fallow, machine weeded when necessary and harrowed three times

‡Frequent tillage — fallow, machine weeded when necessary and harrowed every two to three weeks from plowing time until seeded.

"F" for treatments		8.14**
L. S. D.	.05	3.00
L. S. D.	.01	4.05
C. V.		27.64 for error (a)
		14.33 for error (b)
		15.87 generalized

**Significant at .01 level

however, between the 6 weeks late spring plowed and all the other treatments. On the other hand, no significant difference was found between spring plowed early and spring plowed 2 weeks late. The same relation was found between the fall plowed and spring plowed early or spring plowed 2 weeks late treatments.

Seasonal differences are reflected in the highly significant years x treatment interaction, which means that the relative treatment behavior varied from year to year. To illustrate, the yields for the 6 weeks late spring plowed treatment in 1939 and 1942 were much lower in proportion to the yields of the other treatments than was the case in 1949 and 1950.

These results are in agreement with those obtained in the other time of plowing tests. The evidence is sufficient to warrant the conclusion that plowing or working of land to be fallowed should be done either in the fall or in early spring. If a farmer has a large acreage of land to prepare for fallow it would be advantageous to prepare some in the fall and the balance in early spring rather than extending the spring preparation period unduly.

The length of the period over which spring plowing can be done without having yields measurably decreased varies with the season. Ordinarily, spring plowing should not be delayed more than 2 or 3 weeks after the time when plowing can first be done in the spring. However, the safe period is longer if spring comes early than it is if spring comes late. Additional delay in spring plowing when one is already late drastically reduces yields.

Frequency of Cultivation

At one time it was thought that frequent cultivation of summer fallow was necessary for profitable dry farm yields. Experiments at the Nephi Station have shown that this is not so. One of these experiments was of 34 years' duration (1916-1949, inclusive). Three levels of cultivation frequency were investigated in this experiment. They were: ordinary cultivation of fallow, frequent cultivation of fallow, and no tillage but weeds hoed (see bottom of table 14 for explanation). The treatments were applied to fall plowed land, spring plowed land, and to land plowed in both fall and spring. The value of fall disking was also appraised in this experiment.

Frequent cultivation of fallow not necessary

Frequent cultivation of fallow gave lower average yields than ordinary cultivation or no cultivation—weeds hoed. This was true for both fall and spring plowed land. The differences were not statistically significant, however.

Spring plowing followed by ordinary cultivation of fallow gave a significantly higher average yield than spring plowing after fall disking. The mean difference was $1.97 \pm .84$.

Fall plowing after fall disking gave higher yields than spring plowing after fall disking. The difference was not significant statistically, however.

These results were obtained in an early-designed experiment in which the treatments were not replicated. In 1938, however, a more elaborate test was commenced to evaluate the effects of cultivation frequencies with more precision. This was set up as a

Table 17. *Comparative winter wheat yields resulting from the use of the moldboard plow, one-way disk and disk harrow,* 1930-1949, *inclusive, reported as averages by five-year periods*

	Treatment		
Period	Moldboard plow	One-way disk	Disk harrow
		bushels per acre	
1930-1934	19.0	18.5	17.8
1935-1939	20.5	21.7	21.3
1940-1944	24.3	22.3	19.5
1945-1949	20.8	20.1	18.8
20 year average	21.1	20.6	19.3

factorial experiment to include 5 different times of plowing and 3 intensities of fallow cultivation. Three replications of the treatments were provided.

The experimental results appear in table 16 and in table 12, appendix.

Treatments differed in a highly significant manner. It should be noted, however, that this is attributable mainly to the time of plowing factor rather than to cultivation frequency. When the L.S.D. figures are applied to the yield data it will be seen that there is no significant difference between the no tillage, medium tillage, or frequent tillage treatments on land otherwise treated alike.

The results from the two experiments on cultivation frequency are in agreement. They suggest that it is not good practice for dry farmers to work fallow land more frequently than is necessary to control weeds.

Type of Plow or Tillage Implement

An experiment to compare the moldboard plow, one-way disk, and disk harrow was started in 1930. Relative wheat yields were used as the basis for comparison. Twenty-one years' data were obtained (table 17 and table 13, appendix). Although the yield differences obtained were not large the statistical analysis shows them to be highly significant. The moldboard plow gave significantly higher yields than the one-way. The latter had an even greater advantage over the disk harrow. There was a highly significant difference among years, as might be expected. The interaction, years x treatments was also highly significant. This is evident even from an examination of the data given in table 13, appendix. It will be seen that the disk harrow gave the highest yields in 1935 and 1939. Both the one-way and the disk harrow gave higher yields than the moldboard in 1933. Over the 21 year period, however, the moldboard plow gave significantly higher yields.

These results undoubtedly reflect the effects of differences in depth of tillage as well as type of implement. The nature of the experiment was such that it is not possible to determine how much yields were influenced by the one factor and how much by the other. This should be kept in mind in interpreting the data.

In evaluating these results, it should be remembered that relative crop yields are not thoroughly reliable or adequate as a measure of the worth of a tillage implement. Other things are important also. If one implement favors erosion more than another, the detrimental effects may not be immediately expressed in reduced yield.

Quality may be affected before yield is or to a greater extent.

New research to evaluate the more modern tillage implements was commenced at the Nephi Station in 1952. It will be necessary to carry on the experiments for a number of years before the data will be ready for release.

Tillage on dry farms between harvest time and seeding time should accomplish three objectives: First, it should control weeds and thus save soil moisture. Second, it should provide a good seedbed well supplied with moisture by the time of planting. Third, it should retain some crop residue on the surface to help control erosion. These goals can usually be attained better by using a number of implements rather than just one. The choice of implement should be made on the basis of how well it accomplishes these objectives and on its cost of operation.

Spring Harrowing of Winter Wheat

Field tests to determine the effect of spring harrowing on the yield of winter wheat were carried on from 1909-1915 and from 1923 to 1929 (Stephens *et al.* 1932). The plots that were harrowed yielded less than those not harrowed.

Fertility Experiments

AT THE Nephi Station:

- **most green manure treatments reduced wheat yields**
- **nitrogen fertilizer increased both wheat yield and protein content when moisture and other environmental factors were favorable**
- **urea spray was less effective than ammonium sulfate**
- **farm manure increased the yield of winter wheat**
- **burning the stubble increased wheat yield 2 percent over a 37 year period, but for the last 7 years of the period there was a 0.5 percent decrease in yield from burning.**

Dry land soils formed under arid conditions are naturally low in organic matter and nitrogen. Furthermore, the alternate wheat-fallow cropping system has reduced the organic matter and nitrogen content of these soils to even lower levels (Bracken and Larsen 1947). The consequent inability to produce good yields of high protein wheat consistently is of concern to farmers, processors, and research workers. Two questions arise —why not use a green manure crop, preferably a nitrogen-fixing legume, to build up soil fertility, and why not apply nitrogen fertilizers to improve wheat yield and quality? Both of these questions have received attention at the Nephi Station.

Green Manure

The value of green manure was investigated over the 36 year period, 1915 to 1951, inclusive. The experiments involved two green manure crops, field peas and wheat. Each was grown separately and was plowed under at four stages of growth – 6 inches high, 12 inches high, bloom stage, and near maturity (peas in pod stage and wheat in "milk" stage). Wheat alternating with fallow without green manure was used as a control for comparison. There were two

Table 18. *Average yield of wheat under different green manuring treatments at Nephi Station and yield of subsequent crop after fallowing without green manure*

Green manure plowed under	Peas as green manure: While green manured 1916-1951	Peas as green manure: After bare fallow 1953	Wheat as green manure: While green manured 1916-1951	Wheat as green manure: After bare fallow 1953
	bushels per acre			
6 inches high	23.1	17.8	20.1	16.6
12 inches high	23.2	17.3	17.6	16.7
In bloom	21.0	18.0	14.5	18.4
Nearly mature	21.5	18.2	12.9	8.7
No green manure	22.7	12.8	22.7	12.8

plots of each treatment each year. The same plots received the same treatment year after year.

The average yield of wheat for each treatment over the 36 years is given in table 18. The green manure experiment was discontinued in 1951. However, all the plots that had been in the experiment were fallowed in 1952 and were cropped to wheat in 1953. The purpose of this was to measure possible residual effects of the treatments.

Most green manure treatments reduced wheat yields

The results show that of the treatments used only peas plowed under when 6 inches high and when 12 inches high gave higher yields of wheat than did the control plots with no green manure. However, the increase in yield resulting from these treatments was no more than one-half bushel of wheat per acre. All the other green manuring treatments reduced the yield of wheat. The reduction in wheat yield was much greater with wheat as the green manure than with peas. The more nearly mature the plants were allowed to become before being plowed under the greater the reduction. The slight increase in yield obtained by plowing under peas when 6 to 12 inches high was not nearly sufficient to pay for the extra expense.

From the wheat yields obtained on the plots in 1953 it would appear that the fertility of the green manured plots has actually been increased to a considerable extent over the control (except on plots where wheat had been plowed under at the nearly mature stage). Peas were more effective in increasing the soil fertility than wheat and (with the exception noted before) the larger the green manure crop was allowed to become the greater was the increase in fertility. (1953 was a rather low-yielding year as a whole and so the yields are all lower than the average of the preceding 36 years.)

In interpreting these results certain points should be kept in mind. A green manure crop both in growing and in decomposing uses soil moisture that might otherwise be stored for use of the next wheat crop. Also, when plant growth is plowed under, the soil may dry out more rapidly than it otherwise would. Another point besides loss of moisture is that the decomposition of fresh plant material temporarily robs the soil of nitrate nitrogen. The accumulation of nitrate nitrogen is one reason for the summer fallow. There is not sufficient time between plowing under of the green manure and the drilling of the wheat to allow for complete decomposition of the green manure and subsequent rebuilding of the soil nitrate. New seedings of fall wheat may suffer, therefore, because of an insufficient supply of nitrate nitrogen.

In moist soil a small application of nitrogen fertilizer at the time plant material is plowed under may counteract nitrate reduction during decomposition. A deficiency of soil moisture on dry land is an entirely different matter, however. One may be able to do little about overcoming the detrimental effects of such deficiency. The results at Nephi and elsewhere suggest that if there is plenty of soil moisture a green manure crop might be used to advantage. However, if moisture is too limited difficulties will be experienced.

Commercial Fertilizers

Experiments to determine the effect of commercial fertilizers on the yield and quality of winter wheat were conducted from 1943 to 1953, inclusive. The investigations included both nitrogen and phosphate fertilizers. The land on which the tests were run had received no previous fertilizer treatments during the 40 years it had been under cultivation. Alternate wheat and fallow was the cropping system used in these experiments except where otherwise noted. All fertilizers were broadcast except the fall application in 1945, which was drilled. Wheat yield data were taken over the period 1945-1953, inclusive. Data on protein content were obtained from 1943 through 1948.

Results of these experiments up to and including 1950 have already been published (Peterson 1952). Experimental results since 1950 are reported

Table 19. *The influence of commercial fertilizers on the yield of winter wheat at the Nephi Station,* 1945-1951, *inclusive*

Fertilizer treatment			Acre yield							
Kind of fertilizer	Fertilizer per acre	Nitrogen per acre	1945	1946	1947	1948	1949	1950	1951	Average
	pounds		*bushels*							
			Fall application							
No fertilizer			22.3	11.7	35.3	28.0	17.4	28.8	16.1	22.8
Sodium nitrate	125	20	28.3	21.2	36.3	30.3	22.5	32.4	20.5	27.4
Sodium nitrate	250	40	29.7	24.0	46.8	33.0	24.4	37.2	18.9	30.6
Ammonium sulfate	100	20	25.3	17.0	36.8	31.0	19.7	32.0	16.9	25.5
Ammonium sulfate	200	40	28.0	19.3	39.3	30.3	21.7	34.0	17.4	27.1
Ammonium sulfate	300	60	—	—	41.6	34.0	26.7	34.8	18.1	
11-48-0	100	11 (+48 of P_2O_5)	25.7	13.7	35.1	29.3	20.1	30.0	18.3	24.6
16-20-0	125	20 (+25 of P_2O_5)	29.5	15.7	36.1	29.0	21.7	35.6	18.6	26.6
Superphosphate	100	(43 of P_2O_5)	23.0	18.0	—	—	—	—	—	
			Spring application							
Sodium nitrate	125	20	23.8	18.3	42.7	30.7	23.6	32.8	21.2	27.6
Sodium nitrate	250	40	29.5	24.5	43.1	30.3	22.8	35.6	19.1	29.3
Ammonium sulfate	100	20	24.8	15.3	43.0	29.0	20.9	30.0	16.8	25.7
Ammonium sulfate	200	40	25.0	17.3	43.0	27.6	22.9	31.6	17.7	26.3

Table 20. *Effect of nitrogen fertilizer on protein content of winter wheat at Nephi Station, 1943-48, inclusive*

Treatment	Protein						
	1943	1944	1945	1946	1947	1948	Average
				percent			
No nitrogen (control)	11.09	9.62	9.99	8.57	8.11	10.42	9.63
40 lbs. nitrogen per acre—*fall**							
Sodium nitrate		12.78	10.96	9.58	10.12	12.72	11.23
Increase from fert.		3.16	0.97	1.01	2.01	2.30	1.89
Ammonium sulfate		10.30	10.85	8.93	9.60	11.48	10.23
Increase from fert.		0.68	0.86	0.36	1.49	1.06	0.89
40 lbs. nitrogen per acre—*spring*†							
Sodium nitrate	14.94	12.16	12.22	9.95	11.15	11.65	12.01
Increase from fert.	3.85	2.54	2.23	1.38	3.04	1.23	2.37
Ammonium sulfate	12.39	10.17	10.83	8.66	10.16	11.15	10.56
Increase from fert.	1.30	0.55	0.84	0.09	2.05	0.73	0.92
20 lbs. nitrogen per acre—*fall**							
Sodium nitrate		11.65	10.83	9.33	9.35	11.32	10.49
Increase from fert.		2.03	0.84	0.76	1.24	0.90	1.15
Ammonium sulfate		9.90	10.39	8.59	8.81	10.85	9.70
Increase from fert.		0.28	0.40	0.02	0.70	0.43	0.36
20 lbs. nitrogen per acre—*spring*†							
Sodium nitrate	13.06	10.88	9.88	8.70	9.26	10.52	10.38
Increase from fert.	1.97	1.26	0.11	0.14	1.15	0.10	0.75
Ammonium sulfate	11.07	10.00	10.05	8.64	9.35	11.43	10.09
Increase from fert.	0.02	0.38	0.06	0.07	1.24	1.01	0.45

*Fall applications were made about seeding time.

†Spring applications were made in early spring as soon as it was dry enough to get on the land.

here. Summaries of the data obtained before 1950 will also be included in order to make the picture complete.

The yield data by years for the period 1945-1951, inclusive, are reported in table 19 (the 1952 and 1953 results will be considered separately for reasons that will be apparent later). The superphosphate treatment was in the test for only 2 years and the heaviest rate of nitrogen (60 pounds per acre) for 5 years. The other treatments were tested over a longer period of time.

The effect of nitrogen fertilizers on the protein content of winter wheat is shown in table 20.

Nitrogen increased wheat yield and protein content

From the aforementioned results it is evident that yield and protein increases were obtained from the use of nitrogen fertilizer. The 40-pound applications were more effective in increasing yield and protein content than were 20-pound applications. The nitrate form of nitrogen was more effective than the ammonia form when comparable rates were used. Forty pounds of nitrogen applied in nitrate form gave as high a yield as 60 pounds of nitrogen applied in ammonia form. No significant difference was found between fall and spring applications.

Table 21. *Effect of commercial fertilizer on winter wheat yields at Nephi Station in 1952*

Treatments	Rate per acre: Fertilizer	Rate per acre: Nitrogen	Yield: Wheat after wheat	Yield: Wheat after fallow
	pounds	*pounds*	*bu.*	*bu.*
No fertilizer			3.0	7.5
Sodium nitrate	125	20	3.3	8.0
Sodium nitrate	250	40	3.2	7.4
Ammonium sulfate	100	20	2.7	7.3
Ammonium sulfate	200	40	3.0	7.5
11-48-0	100	11 (+48 of P_2O_5)	3.5	8.3
16-20-0	125	20 (+25 of P_2O_5)	5.2	8.3
Average for season for nitrogen alone treatments (lines 2 to 5)			3.1	7.6
Average for nitrate treatments			3.3	7.7
Average for sulfate treatments			2.9	7.4

Peterson (1952) reported that no benefit was shown from phosphate alone or in combination with nitrogen on the soils at Nephi. However, examination of the data leads one to believe that further testing of such fertilizers should be made.

The 1952 results are reported separtely (table 21) because 1952 was an unusual year. A prolonged heavy covering of snow so injured the wheat plants that all yields were exceptionally low. Also, in 1952, the experiment was carried out on wheat after wheat as well as on wheat after fallow. This was done to help answer the question, "Can nitrogen fertilizer replace the summer-fallow on dry land?" In this unusual year the fertilizer treatments, with the possible exception of 16-20-0, had little effect on the yield of wheat. This was true no matter whether the wheat followed wheat or fallow. However, the fact that wheat after fallow yielded more than twice as much as wheat after wheat, whether fertilized or not, is an indication that the effect of the fallow was not duplicated by the fertilizer. Since there was an abundance of both moisture and nitrogen (especially on the fertilized plots), it seems that the beneficial effect of fallow cannot be explained entirely on the basis of moisture and nitrogen.

Since the 1952 results show that nitrogen fertilizer was of little value when wheat yield was limited more by some other factor or factors than by fertility, and since in most years spring and fall applications gave nearly equal results, it would seem to be good procedure to wait until early spring to apply the fertilizer. If there were poor stands, poor fall emergence, winter killing, drought, or other unfavorable conditions, the fertilizer could be saved for a more propitious year. On the other hand, fertilizer applied after spring rains are over might be of little value.

Fertilizer tests in 1953 show beneficial effect of nitrogen

In 1953 the fertilizer tests were simplified for greater ease of operation with large machinery. The yields (table 22) indicate a good response to nitrogen fertilizer up to 50 pounds of nitrogen per acre. How-

Table 22. *Effect of different sources and amounts of nitrogen fertilizer on yield of winter wheat after fallow at Nephi in 1953*

Kind of fertilizer	Rates of nitrogen—pounds per acre: None	25	50	Average
		bushels per acre		
Ammonium sulfate	18.0	20.4	22.7	20.4
Ammonium nitrate	18.0	21.0	22.3	20.4
Average	18.0	20.7	22.5	

L.S.D. at .05 level = 1.5 bu.
(5 replications)

ever, no significant difference was found between ammonium nitrate and ammonium sulfate when the same amount of nitrogen was applied in each.

Fertilizer needs may vary with tillage

The new cultural tests at the Nephi Station (started in 1952) include different methods of initial tillage of stubble – both with and without application of a small amount of nitrogen fertilizer at the time of first breaking the stubble. The purpose of this is to determine whether small quantities of nitrogen fertilizer can counteract the reduction in yield often obtained when a "stubble mulch" is used to check erosion. The 1953 results (table 23) include only initial tillage of the stubble in the spring of the fallow year. Differential fall treatments were commenced in the fall of 1952 and the effects will be first expressed in the 1954 yields.

The 1953 results show that the plow gave the highest yield. In this case, wheat yield was not increased by nitrogen fertilizer. The one-way and the disk harrow gave slightly lower yields. Here again yields were not increased by nitrogen fertilizer.

The tillage methods which may be considered more distinctly "stubble mulch" (using narrow cultivator shovels 10 inches deep at 1 foot intervals, a deep chisel 18 inches deep at 30 inch intervals, and a broad "subtiller" blade 10 inches deep) gave distinctly lower yields of wheat than the plow, one-way or disk harrow. With the stubble mulch treatments, however, yields were brought up to about the level of the one-way and the disk harrow by the addition of 20 pounds of nitrogen per acre. Leaving the stubble undecomposed till mid-

Table 23. *Influence of nitrogen fertilizer and tillage method on winter wheat yields at the Nephi Station in* 1953 *on land under alternate wheat-fallow system*

Tillage method	No nitrogen	20 lbs. nitrogen per acre
	bushels grain per acre	
Plow	17.0	16.7
One-way (wheatland plow)	14.4	15.6
Disk harrow	15.1	14.3
Chisel 10″ deep 12″ apart	13.4	16.0
Chisel 18″ deep 30″ apart	10.6	15.0
Subtiller (blade) 10″ deep	11.9	13.6

L.S.D. at .05 level = 2.0 bushels
(12 replications).

Table 24. *Effect of urea spray applied at two different dates on the yield of winter wheat compared with equivalent amounts of ammonium sulfate applied to the soil, Nephi Station,* 1951

Kind of fertilizer	Time of application	Pounds nitrogen applied per acre				
		None	12½	25	50	Average
		Yield				
		bushels per acre				
Ammonium sulfate	April 7 (to soil)	1.47	16.0	17.7	17.1	16.4
Urea (NuGreen) spray	May 26 (5 leaf)	13.2	13.6	13.9	14.8	13.9
Urea (NuGreen) spray	June 19 (bloom)	13.6	11.7	13.9	13.1	13.1
Average		13.8	13.8	15.2	15.0	

L.S.D. at .05 = 2.1 bushels

summer, when it was cultivated in, probably lowered the nitrate content of the soil, which retarded the wheat. Nitrogen fertilizer corrected this condition.

Peterson (1952) reported that rainfall influences the results of fertilizer experiments. He noted a fair correlation between spring rainfall and response to nitrogen fertilizer.

Should fertilizer be sprayed on growing wheat?

Experiments in Kansas, Washington, and other places have shown that spraying nitrogen fertilizer on wheat plants might at times be feasible. Urea has been the most frequently used spray fertilizer because with urea there is less danger of injury to the plants. Airplane applications have been made where the wheat was so large that it would be seriously injured by the wheels of ground applicators.

An experiment was conducted at the Nephi Station in 1951 to determine whether the spray method of applying fertilizer had promise under Nephi conditions. Different rates of urea spray were applied to growing wheat plants at two different stages. Equal amounts of nitrogen, in the form of ammonium sulfate, were applied to the soil in the spring of the crop year for comparison. The results (tables 24 and 25) suggest that the wheat plants were able to utilize nitrogen fertilizer sprayed on the leaves, but less effectively than when applied to the soil earlier. This was

Table 25. *Effect of urea spray applied at two different dates on the protein content of winter wheat compared with equivalent amounts of ammonium sulfate applied to the soil, Nephi Station,* 1951

Kind of fertilizer	Time of application	Pounds nitrogen applied per acre				
		None	12½	25	50	Average
		percent protein				
Ammonium sulfate	April 7 (to soil)	8.56	8.36	9.20	9.68	8.95
Urea (NuGreen) spray	May 26 (5 leaf)	8.26	8.59	8.46	8.45	8.44
Urea (NuGreen) spray	June 19 (bloom)	8.23	8.36	8.70	8.68	8.49
Average		8.35	8.44	8.79	8.94	

Treatment differences not significant statistically for the 0, 12½ and 25 pound rates of nitrogen nor for the overall analysis. However, there is a significant difference between the 3 treatments at the 50 pound rate of nitrogen in favor of the soil application. (L.S.D. at the .05 level for the 50 pound rate = 0.96).

true for both yield and protein content. The early application of urea was slightly beneficial to yield, but the later application was not. With one exception the differences noted were not significant statistically, however. Applying urea at the two higher rates when wheat plants were in bloom, increased protein content more than when the same rates of urea were applied when the wheat plants were in the 5-leaf stage. However, when the same rates of nitrogen were applied to the soil early (April 7) in the form of ammonium sulfate, protein content was increased much more.

These results are not encouraging for the use of urea spray under Nephi conditions especially when the relative cost of the fertilizers is considered.

A similar experiment to evaluate urea spray was carried out in 1952. Results were inconclusive, however, because of winter injury to the wheat crop.

Farm Manure

Experiments to determine the effect of barnyard manure on winter wheat yields were conducted from 1915 to 1949, inclusive. The tests were carried out on land cropped under the standard wheat-fallow system. Rotted manure from neighboring barn lots was applied in the spring of the fallow year and then plowed under. Thirteen different treatments were used and each was applied to duplicate one-twentieth acre plots.

The treatments can be grouped into three categories: (1) various amounts

Table 26. *Winter wheat yields on plots manured in various ways, Nephi Station* 1915-1949, *inclusive, by 4 year intervals*

Treatment	Average per acre yield									35 year average
	1915-18	1919-22	1923-26	1927-30	1931-34	1935-38	1939-42	1943-46	1947-49	
					bushels					
a	17.2	22.7	27.9	21.1	20.1	23.9	23.6	24.8	24.2	22.8
b	17.2	23.3	28.9	22.1	19.8	25.2	23.4	25.7	22.9	23.2
c	16.7	23.3	30.7	24.3	21.3	24.9	26.3	28.6	27.6	24.8
d	18.2	26.3	32.6	26.3	21.4	26.5	28.1	30.6	30.2	26.6
e	20.0	28.5	37.0	26.5	21.8	25.8	28.2	29.4	33.1	27.7
f	17.3	23.8	29.2	23.1	21.7	25.3	25.9	27.9	27.2	24.6
g	18.8	24.8	30.8	25.3	21.7	25.7	28.1	29.1	28.9	25.9
h	19.3	27.1	33.3	26.6	22.7	26.0	28.9	32.0	31.9	27.4
i	18.6	24.1	28.9	21.9	20.6	24.8	21.9	24.6	23.7	23.3
j	19.5	24.3	30.4	21.6	20.0	24.1	23.5	24.2	23.3	23.5
k	18.9	23.8	29.9	22.3	19.0	23.7	23.8	25.2	24.3	23.4
l	20.7	24.6	30.2	23.6	19.9	23.8	25.0	26.2	24.2	24.2
m	19.9	25.7	30.4	23.8	19.8	24.5	24.5	25.7	26.9	24.4

Key to treatments:
a — no manure
b — 1 ton manure per acre every 2 years
c — 2½ tons manure per acre every 2 years
d — 5 tons manure per acre every 2 years
e — 10 tons manure per acre every 2 years
f — 2½ tons manure per acre every 4 years
g — 5 tons manure per acre every 4 years
h — 10 tons manure per acre every 4 years
i — 2½ tons manure per acre in 1915 — none subsequently
j — 5 tons manure per acre in 1915 — none subsequently
k — 10 tons manure per acre in 1915 — none subsequently
l — 15 tons manure per acre in 1915 — none subsequently
m — 20 tons manure per acre in 1915 — none subsequently

of manure applied each alternate year, (2) different quantities of manure applied every four years, and (3) manure applied in certain definite amounts in 1915, with no later applications.

The results are summarized in table 26, and are reported in detail in table 14, appendix.

Barnyard manure increased wheat yield

The results show that barnyard manure increased the yield of winter wheat, no matter what the rate or time of application. Where the manure was applied every two years the yield of wheat was increased slightly but consistently for each increased amount of manure applied. This was also true where the manure was applied every four years. Where the rates were the same applying manure every four years gave yields almost as high as applying it every two years. For example, 10 tons manure applied every two years increased wheat yield 21 percent over the check (no manure), as compared with a 20 percent increase where 10 tons manure were applied every four years.

Where manure was applied in 1915 only, the 2½, 5, and 10 ton rates gave about the same average yields for the 35 year period. The 15 and 20 ton rates had a more beneficial effect on yield.

Five tons manure every four years increased yield more than did 2½ tons every two years. Likewise, 10 tons manure every four years increased yield more than did 5 tons every two years.

Inspection of the data shows that where manure was applied only once (1915) it continued to increase wheat yield up to about the sixteenth year (1930). Thereafter, there was no noticeable benefit.

To determine if manure was more effective in the wetter years than in the drier years a correlation was run between precipitation by crop years and the average yearly increases in yield from manure treatments b, c, d, and e, over treatment "a" (correlation coefficient "r" was equal to $+0.522^{**} \pm .140$. This value of "r" is significant at the 1 percent level and it can be concluded that in the wetter years manure was more effective in benefiting wheat yields than in the drier years.

Burning Straw vs. Other Stubble Disposal

Burning the straw as contrasted with plowing it under or cutting with a binder and hauling most of if off to a thresher, was under test at the Nephi Station on the same plots from 1915 to 1953. The results are summarized in table 27, and are shown in detail in table 15, appendix.

Burning the straw increased wheat yield for many years then gradually decreased it. On the whole, as an average of the 37 years, burning the straw on the plots increased the yield of wheat by about 2 percent as compared with plowing all the straw under. The difference is statistically significant. However, when the results are summarized by 10-year intervals it may be observed that the stimulation by burning has been steadily decreasing from nearly 4 percent increase in the first decade to a one-half percent decrease in the last 7 years.

Table 27. *Long time effect of burning or removing straw for many years (wheat fallow system) as shown by average yields of wheat for successive 10 year periods, Nephi Station, 1916-1953, inclusive*

	Treatment		
	Straw returned	Binder cut straw removed	Straw burned
		bushels per acre	
1916-1925			
Yield	23.1	22.6	24.0
Gain or loss		−.5 (−2.2%)	+.9 (+3.9%)
1926-1935			
Yield	21.9	21.0	22.6
Gain or loss		−.9 (−4.1%)	+.7 (+3.2%)
1936-1945			
Yield	23.6	23.7	23.9
Gain or loss		+.1 (+.4%)	+.3 (+1.3%)
1946-1953			
Yield	20.9	21.2	20.8
Gain or loss		+.3 (+1.4%)	−.1 (−.5%)
Average 1916-1953 (37 years)			
Yield	22.5	22.2	23.1
Gain or loss		−.3 (−1.3%)	+.5 (+2.2%)

"F" for treatments = 4.9**
L.S.D. .05 = 0.5 bushels

**Significant at .01 level.

At the same time, cutting with a binder and hauling most of the straw away from the plots lowered the yield of wheat by more than 1 percent. This difference is not statistically significant and is not consistent with time.

These results may be interpreted in different ways. It may be assumed that the stimulating effect of burning the straw (or the depressing effect of plowing under all the straw) was owing to the often observed effect that fresh straw mixed with soil lowers the content of avaliable nitrate nitrogen in the soil (presumably by retarding the action of nitrate-forming bacteria which differ from most soil bacteria in this respect.) At the same time the gradual loss of total nitrogen in the soil by burning the straw may have ultimately depressed the yield more than enough to offset the increased availability of what nitrogen there was. These two effects may have operated in such a manner as to produce erratic results where only part of the straw was hauled away.

Another theory might be that the stimulation by burning on the plots was partially caused by destruction of mites or other inconspicuous pests or diseases such as might live over in plant residues. This effect also would be gradually overshadowed by the reduction in the total nitrogen in the soil.

Whatever the explanation it seems that the increased yield brought about by burning the straw on the plots did not persist more than 30 years.

During this time it seems to have masked a definite reduction in fertility.

It should be remembered that under the conditions at the Nephi Station the weight of the straw is usually about equal to the weight of the grain. Under other conditions, where the weight of the straw is often much more than the weight of the grain, different results might be expected.

Cropping Experiments

WHAT happens to winter wheat yields when the customary wheat-fallow rotation commonly practiced in the Great Basin is not followed is shown in table 28.

The same yield was obtained (20.7 bushels per acre) the first year after fallow whether the cropping system involved 1 crop in 2 years or 2 crops in 3 years. The second crop in a 2 crops in 3 years system dropped in yield to near that of continuous cropping, plowed.

The low average yields for 1 crop in 2 years, disked; and continuous cropping, disked, point out the need for deeper stirring of the land than was possible with the horse-drawn disk-harrow used throughout most of this trial.

The low average yields for the 'no-tillage' systems with and without fallow point out the need for tillage to control weed growth.

These experimental results suggest that under conditions such as exist at the Nephi Station the alternate wheat-fallow system will give greater net returns than the other cropping systems—provided the land is tilled sufficiently to control weeds. Such a system permits moisture and nitrate accumulation and the preparation of an adequate seedbed.

Yields were higher when wheat followed two years of fallow than when it followed one year of fallow. However, the 2.7 bushels per acre increase was not sufficient to compensate for the loss of a year and for the extra fallow expense.

Table 28. *Average acre yields of winter wheat produced from various cropping systems at the Nephi Station over the* 36 *year period from* 1915 *to* 1950, *inclusive*

Method of cropping	Average yield	Lowest yield	Year	Highest yield	Year
			bushels		
1 crop in 3 years, plowed	23.4	10.1	1915	40.6	1921
1 crop in 2 years, plowed	20.7	8.1	1915	37.9	1938
2 crops in 3 years, (1st crop)	20.7	8.5	1915	35.2	1926
2 crops in 3 years, (2nd crop)	10.4	1.6	1939	22.9	1923
Continuous cropping, plowed	9.3	2.7	1939	18.7	1921
1 crop in 2 years, disked	9.2	2.1	1919	30.7	1938
Continuous cropping, disked	6.9	1.6	1945	16.3	1925
1 crop in 2 years, no tillage	6.7	0.7	1931	16.4	1925
Continuous cropping, no tillage	5.8	1.1	1931	16.8	1921

Rotations

THE alternate wheat-fallow rotation has given most satisfactory wheat yields under Nephi dry land conditions. Wheatgrasses have shown promise but additional research is needed before definite recommendations can be made. Alfalfa has reduced wheat yields but has built up soil fertility. Where precipitation is more favorable than at Nephi rotations consisting of wheat, alfalfa, and/or grasses, and fallow may be preferable to alternate wheat and fallow.

Since the early days of the Nephi Station, efforts have been made to find a crop rotation which would be superior to the standard alternate wheat-fallow cropping system. To date these efforts seem to have been unsuccessful but the search still continues.

The disadvantages of the present standard (wheat-fallow) system are: (1) There is only one crop in two years; (2) The soil is unduly exposed to erosion and blowing during the fallow period; (3) The soil is gradually losing its nitrogen and organic matter under this system (Bracken and Larsen 1947). Loss of nitrogen and organic matter occurs under this cropping system because of rapid oxidation during the fallow year and because of a lack of legumes and sod-forming crops. As yet the wheat yield data on the farm seem to show no consistent reduction because of this lowering of the nitrogen and organic matter content of the soil (table 16, appendix). These results are in harmony with the results obtained on dry land in western Canada over a 40 year period (Hill 1954). However, improved varieties and cultural methods may have compensated for a real reduction in fertility.

Some of the advantages that might be expected to accrue from crop rotation are: (1) a profitable crop from the land nearly every year; (2) much less erosion and blowing of the soil; (3) maintenance of soil fertility, especially nitrogen and organic matter; (4) easier control of pests and diseases; (5) better seasonal distribution of labor and (6) more certainty of income with a diversity of crops. Recent governmental restrictions on wheat acreage are making it almost imperative to find substitute crops.

The principal difficulties encountered in the search for a satisfactory rotation have been: (1) no crop has yet been found which will consistently do as well as winter wheat after fallow; (2) when pasture crops are introduced, fencing is usually required with attendant extra expense and problems; (3) alfalfa—the most promising legume tried so far – exhausts soil moisture reserves to a considerable depth. As a result alfalfa yields drop off progressively. Furthermore, the yields of crops grown subsequently are adversely affected. An unusually wet year or one or two years of fallow may be needed to recoup soil moisture after alfalfa.

Rotation studies at the Nephi Station to date have centered principally on trying to find a satisfactory annual row crop to replace the summer fallow and on trying to grow alfalfa in regular rotation.

Twenty-seven Rotations Have Been Tried

The oldest rotation at the station, except for the continuous wheat and alternate wheat-fallow tests, was started in 1908.

This was a six-year rotation involving winter wheat alternating successively with the row crops, corn, field peas (in rows), and potatoes. Enough plots were used to make it possible for each crop and each sequence to be represented every year.

In 1918 three two-year rotations were added, namely: winter wheat alternating with corn; winter wheat alternating with peas, and winter wheat alternating with potatoes.

Twenty-one additional rotations were started in 1915. Two of them included alfalfa in combination with grain crops and row crops. The balance involved various combinations of grain crops, row crops, and fallow. Wheat, oats, and barley were the grain crops that were used and corn, peas (in rows), and potatoes were the row crops. The experiments included two-year, three-year, four-year, six-year, and eight-year rotations. In the two-year rotations each row crop alternated with fallow. There were two types of three-year rotations. One type involved two years of grain (various combinations) followed by a row crop. The other type consisted of wheat followed by a row crop, followed by fallow. The four-year rotation consisted of wheat, corn, wheat, and fallow. The fallow land was treated in three different ways. In one case peas were plowed under as a green manure. In another rye was seeded early and then plowed under at an early stage. The third treatment consisted of plowing and clean cultivating the fallow in the usual manner. Two different six-year rotations were employed. One consisted of wheat, corn, oats, peas, barley, and fallow in that sequence. The other consisted of wheat followed by alfalfa (3 years) followed by oats and then corn. The eight-year rotation included wheat, potatoes, barley, alfalfa (4 years), and corn in that order.

In these rotations the peas, corn, and potatoes were all planted in rows. The barley used was winter barley but the oats were spring oats.

Results of Rotation Experiments

The results of the rotation experiments are shown in detail in tables 16 and 17, appendix, and are summarized in tables 29 to 32.

From table 29 it will be noted that two sets of yield data were obtained for peas, namely: bushels of threshed, dry peas per acre and tons of dry forage per acre. Corn yields were taken only as tons of dry fodder per acre — ear corn yields were usually negligible. Alfalfa yields represent only second, third, and fourth year alfalfa (averaged together). First year alfalfa yields were low.

The average crop yields obtained in the rotation experiments over the 18 year period, 1916-1933, and over the 34 year period, 1916-1949, inclusive, are shown in table 29. To show the extreme variations that occurred from year to year, the highest and lowest individual plot yields for each treatment are given. With some crops the average yield was fair, but such average was based pretty much on a few good years and in many years the crop was a complete failure.

There was only one wheat/fallow rotation included in these experi-

Table 29. *Average and extreme yields of crops under various rotations at the Nephi Field Station*

11 rotations—34 yr. avg. (1916-49)

Plots per yr.	Crop	Following after	Avg. yield	Extreme yield range: High	Extreme yield range: Low
			Grain or seed		
			bushels per acre		
1	wheat	fallow	23.4	38.2	6.5
20	wheat	fallow	23.0	52.7	6.5
6	wheat	row crops	19.9	40.0	2.3
2	wheat	peas	19.7	35.8	5.5
2	wheat	corn	19.7	40.0	2.3
2	wheat	potatoes	20.4	39.7	5.0
1	wheat	alfalfa	13.5	33.3	0.0
1	wheat	wheat-cont.	9.0	20.4	2.0
2	peas	grain	3.4	7.5	0.0
2	potatoes	grain	20.7	95.5	0.0
1	peas	fallow	3.2	7.0	0.0
1	potatoes	fallow	12.9	40.0	0.0
1	oats	alfalfa	12.8	41.8	0.0
			Dry forage		
			tons per acre		
2	peas	grain	0.49	1.58	0.00
2	corn	grain	0.60	3.14	0.00
1	peas	fallow	0.46	1.08	0.00
1	corn	fallow	0.60	3.14	0.00
1	corn	alfalfa	0.50	3.24	0.00
2	alfalfa	grain	0.77	1.73	0.17

27 rotations—18 yr. avg. (1916-33)

Plots per yr.	Crops	Following after	Avg. yield	Extreme yield range: High	Extreme yield range: Low
			Grain or seed		
			bushels per acre		
1	wheat	fallow	22.7	38.2	6.5
20	wheat	fallow	22.7	52.7	6.5
18	wheat	row crops	18.7	36.7	2.3
5	wheat	peas	18.5	33.2	3.5
8	wheat	corn	18.5	36.7	2.3
5	wheat	potatoes	19.4	36.4	5.0
2	wheat	alfalfa	9.9	36.9	0.0
1	wheat	wheat-cont.	9.2	20.4	2.0
3	wheat	wheat-2nd yr.	9.3	36.4	2.2
7	peas	grain	3.5	7.8	0.0
7	potatoes	grain	24.3	95.5	0.0
1	peas	fallow	3.5	7.0	0.0
1	potatoes	fallow	18.2	40.0	0.0
1	oats	alfalfa	8.7	21.7	0.0
1	potatoes	alfalfa	21.2	43.7	0.0
1	barley	alfalfa	15.4	47.9	3.3
3	oats	wheat	9.0	30.3	0.0
2	oats	corn	9.4	25.0	0.0
3	barley	wheat	10.7	33.5	0.0
2	barley	peas	15.8	33.9	3.3
			Dry forage		
			tons per acre		
7	peas	grain	0.47	1.18	0.00
10	corn	grain	0.65	2.26	0.00
1	peas	fallow	0.48	1.08	0.00
1	corn	fallow	0.37	0.96	0.00
2	corn	alfalfa	0.41	0.45	0.31
2	alfalfa	grain	0.77	1.80	0.02

ments. However, the control plots for many of the other rotations were treated similarly to the wheat/fallow rotation plots. Twenty such plots were averaged together to get the figure for "wheat after fallow – 20 plots per year".

Wheat was the only crop common to all the rotations and the other crops were to be judged partly by their effect on the yield of wheat. An inspection of the first 9 lines of table 29 shows that the other crops, or treatments, fall into 4 groups in relation to their effect on the yield of wheat.

Alternate fallow/wheat rotation gave the highest yield of wheat

Alternate fallow / wheat rotation gave the highest yield of wheat of any of the cropping systems with an average of 23.4 bushels per acre (34 yr. avg.). This includes the highest individual plot yield of 52.7 bushels per acre in 1926. It also includes one plot yield as low as 6.5 bushels per acre in 1931. All the other rotations had still lower minima, however. The alternate wheat-fallow rotation still represents the standard cropping system on Levan Ridge.

Row crops in place of fallow reduced wheat yield

When any one of the 3 row-crops—peas, corn, or potatoes – was substituted for fallow in alternation with wheat the average yield of wheat was reduced to about 19.9 bushels per acre (34 yr. avg.). This is roughly about 85 percent of the yield obtained under the wheat/fallow rotation. The use of these row crops instead of fallow cost about 3½ bushels of wheat per acre. The yield of the row crops was not sufficient to compensate for this reduction and it is open to question whether the reduction in erosion was sufficient to justify such a practice for that reason alone. It should be noted, however, that where peas alternated with wheat the nitrogen content of the soil was increased slightly (Greaves and Bracken 1946).

Alfalfa reduced yield

When alfalfa was introduced into the rotation (extending it to 6 or 8 years with only one crop of wheat) the yield of wheat was reduced to 14.5 bushels per acre or about 62 percent of the wheat yield obtained under the alternate wheat/fallow system. This is a loss of nearly 9 bushels of wheat per acre. If 3½ bushels of this loss may be attributed to the use of row crops instead of fallow in these rotations there still remains a loss of 5½ bushels of wheat per acre chargeable to the use of alfalfa in the rotation. This is discouraging since other experiments (Walker and Bracken 1938) at Nephi have shown that the growth of alfalfa in rotation actually builds up the soil nitrogen

Table 30. *Average yields of wheat in* 3 *year rotations with fallow, barley or oats, and row crops for the* 18 *year period,* 1916-1933

Crop before wheat	Crop after wheat: Potatoes	Corn	Peas	Average
	bushels per acre			
Fallow	24.0	23.9	23.3	23.7
Barley	19.5	19.6	19.3	19.5
Oats	19.4	19.1	17.7	18.7
Average	21.0	20.9	20.1	

Table 31. *Average yield of wheat in 3 year rotations of wheat, wheat, row crop, (18 year averages) 1916-1933, inclusive*

Crop before wheat	1st year wheat	2nd year wheat	Average
		bushels per acre	
Peas	17.9	9.2	13.6
Corn	18.0	9.2	13.6
Potatoes	19.3	9.6	14.5
Average	18.4	9.3	

which has been depleted by the use of the alternate fallow/wheat system for about 50 years.

Alfalfa increased ultimate soil fertility

As a matter of fact the yield of wheat in 1952 on these former alfalfa rotation plots—after the rotation had been discontinued and the land all summer fallowed in 1951 – was distinctly higher than the wheat yield obtained in 1952 on the long time alternate wheat/fallow plots. Unfortunately 1952 was a year of crop failure, caused by smothering under prolonged winter snows. Nevertheless the yield of wheat on the former alfalfa rotation plots averaged 8.0 bushels per acre as against 2.9 bushels for the former alternate wheat/fallow plots and 3.3 bushels per acre for former wheat/alternate row crop plots.

The actual reduction in yield of wheat that occurred on the plots in rotation with alfalfa can probably be attributed to more complete and deeper drying of the soil by the alfalfa. Given time to recuperate its moisture (1951 was a year of heavy precipitation) the soil seems to be really improved by the alfalfa. Except in unusually wet years, however, perhaps two years of fallow may be needed to restore the soil moisture.

Table 32. *Average yield of wheat in 4 year rotations of wheat, corn, wheat, fallow (bare fallow, pea fallow, rye fallow) (18 year averages),* 1916-1933, *inclusive*

	Wheat after fallow	Wheat after corn
	bushels per acre	
Bare fallow	22.2	18.1
Pea fallow	16.8	17.4
Rye fallow	17.3	18.1

Continuous wheat yielded less than 40 percent as much as the alternate wheat/fallow rotation

The lowest average yield of wheat —about 9.0 bushels per acre—was produced by the continuous wheat plots. This is less than 40 percent of the yield obtained under the alternate fallow/wheat rotation and so represents actually less wheat per year for the two crops in two years than was produced by the alternate wheat/fallow procedure. This seems to be an adequate explanation for the continuation of the alternate fallow/wheat system in Nephi-Levan area.

The yield of wheat in 3-year, 4-year, and 6-year rotations with fallow, barley or oats and row crops was comparable to the yield following these crops in shorter rotations. The results are summarized in tables 30, 31, and 32. Wheat after fallow gave best results. Wheat after barley or oats was comparable to wheat after row crops. The different row crops used in the rotations made little difference in the yield of wheat.

Results from another series of 3-year rotations with two years of wheat followed by a row-crop for one year are shown in table 31. The yield of first year wheat following a row crop was comparable to that of wheat in the wheat/row crop alternation while the yield of the second year wheat was practically the same as that of wheat on continuous wheat plots. There was no appreciable difference in the effect of the different row crops on the yield of wheat.

Results obtained in the 4-year rotation are reported in table 32. It will be noted that the yield of wheat after bare fallow was comparable with that of all wheat after fallow and the yield of wheat after corn was comparable with the yield of all wheat after row crops. The use of peas or rye as a green manure reduced the yield of wheat somewhat. This agrees with the results obtained in the regular green manure tests.

In the 6-year rotation the average yield of wheat, 19.7 bushels per acre, was not quite up to that obtained on most of the wheat after row crop plots. Apparently, one year of fallow in six was not sufficient to obtain the full beneficial effect of fallow on wheat. The yield of the other crops was comparable to that in other rotations.

A general conclusion that can be drawn from a study of the wheat yields obtained in these rotation experiments is that, except for alfalfa, it was the crop immediately preceding the wheat that had the predominant influence on the yield of wheat. The effect of the other crops was not noticeable. In the case of alfalfa, left on the land for 3 or 4 years, the immediate depressing effect on wheat yield persisted for at least 2 or 3 years. Presumably the depressing effect will last until the soil has replenished its moisture supply after which there will be a stimulating effect, at least in wet years, because of increased soil nitrogen and organic matter.

Summer fallow had little effect on yield of peas and corn

The use of summer fallow had little noticeable effect on the yield of peas and of corn (table 29) but produced a rather consistent reduction in the yield of potatoes. The depressing effect of fallow on potato yields is rather difficult to explain. It seems that of all the crops tried at the Nephi Station wheat is the only one distinctly benefited by the summer fallow. Prescott (1934) has reported that the use of the bare fallow in Australia gives a still greater increase in the yield of irrigated wheat than of dry land wheat. At the Rothamsted Experiment Station in England (Hall 1905), in a humid climate, the yield of wheat after fallow (17.1 bushels per acre) was considerably higher than that of wheat grown continuously (12.7 bushels per acre). It seems that wheat is a crop that is especially responsive to the summer fallow.

Table 33. *Average yields of winter wheat in a seeding rate-and-date experiment at the Nephi Station* 1921-1933, *inclusive*

Rate of seeding	Date of seeding: Aug. 1	Aug. 15	Sept. 1	Sept. 15	Oct. 1	Oct. 15	Nov. 1	13 year average	Net on average†
				bushels per acre					
2 pecks	18.3	17.3	17.6	16.6	19.2	19.8	17.4	18.0	17.50
3 pecks	20.0	19.8	19.0	19.1	20.3	20.4	20.1	19.8	19.05
4 pecks	22.3	20.8	19.9	21.3	21.8	20.8	21.0	21.1	20.10
5 pecks	20.4	21.7	20.3	21.6	23.3	21.9	21.1	21.5	20.25
6 pecks	21.6	22.0	20.6	22.8	22.8	21.7	22.3	22.0	20.50
7 pecks	21.9	20.5	20.4	23.5	23.0	22.5	22.5	22.0	20.25
8 pecks	21.8	20.4	21.2	23.2	23.0	22.3	22.6	22.1	20.10
Average	20.9	20.4	19.9	21.2	21.9	21.3	21.0	20.9	
F. (rates)	1.88	4.72**	2.96*	11.89**	7.37**	2.78*	10.77**	27.20**	
F. (years)	65.99**	134.22**	110.02**	85.25**	116.65**	99.46**	129.12**	535.04**	
L. S. D. .05	2.94	1.98	1.99	2.06	1.64	1.71	1.56	2.57	
L. S. D. .01	3.90	2.63	2.64	2.74	2.18	2.27	2.07	3.41	
C. V. (%)	17.98	12.43	12.78	12.44	9.57	10.27	9.52	13.71	
F. (dates)								2.24*	

*Significant at .05 level

**Significant at .01 level

†Figures reported in this column were arrived at by subtracting the seed planted (bushels per acre) from the yield obtained (bushels per acre).

Seeding Experiments

EXPERIMENTS show that dry farmers in the Intermountain Area should sow winter wheat at the rate of approximately 90 pounds per acre. Where conditions are similar to what they are at Nephi seeding should be done about October 1 in rows spaced 7 inches apart.

Rate and Date of Seeding

Rate of seeding experiments on winter wheat were conducted at the Nephi Station from 1904 to 1933. However, data were not reported for the years 1904-1909, 1912, and 1918 because results were incomplete. The experiments conducted prior to 1921 did not consider planting date.

The rate of seeding results for the years 1910 to 1919 inclusive, excluding 1912 and 1918, were reported by Harris *et al.* (1920). Turkey (C. I. 2998) was planted throughout the experiment while Kofod (C. I. No. 2997) was planted from 1915 on. From 1910 to 1916 the seeding rates were 2, 3, 4, 5, and 6 pecks per acre. Beginning with 1917 the 7 and 8 peck rates were also used. Results of these early experiments indicated that yields increased with seeding rate until 5 or 6 pecks per acre were reached. Yields tended to remain about the same with seeding rates heavier than 6 pecks per acre. Largely as a result of this work the rate of seeding winter wheat on dry land became well standardized at 5 to 6 pecks per acre on clay loams, with less on the lighter soils (Bracken and Stewart 1930).

Beginning in 1921 and continuing through 1933 a rate-and-date-of seeding experiment was conducted. In this experiment winter wheat was sown at 7 different rates on 7 different dates. The rates were 2, 3, 4, 5, 6, 7, and 8 pecks per acre. The dates were August 1 and 15, September 1 and 15, October 1 and 15, and November 1. Plots were one-twentieth acre in size.

Results obtained for the years 1921 to 1929 were reported by Bracken and Stewart (1930) and by Stephens *et al.* (1932). This present bulletin presents the average yields of winter wheat obtained with the various rates and dates over the entire 13 year period of the test (table 33).

The data show that yields gained consistently as seeding rate increased from 2 to around 6 pecks per acre. Above the latter rate yields held about the same indicating that an excess of seed was being sown.

Yields differed significantly for different rates at each date except August 1. Yields for the different years differed drastically as emphasized by the high F values for years. Yields differed significantly for different seeding dates, the highest yield being for wheat seeded October 1.

Spacing and Cultivation Test

A spacing and cultivation experiment on winter wheat was conducted from 1923 to 1933. Row widths of 7, 14, 21, and 28 inches were compared and the effects of cultivation on growing wheat determined. Plots were one-twentieth acre in size. One-half of each plot was cultivated when the wheat was about 4 inches high and the other half left uncultivated. Per acre seeding rates were evidently held constant.

Table 34. *Average yields of Kanred winter wheat in a spacing-cultivation experiment at the Nephi Station* 1923-1933, *inclusive*

	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932	1933	11 yr. average
Spacings uncultivated						*bushels per acre*						
7 inches	27.5	23.1	40.1	37.0	18.9	32.9	21.2	22.2	12.7	15.4	25.4	25.1
14 inches	24.6	22.2	34.3	38.7	17.5	30.2	21.0	20.5	13.7	19.0	26.9	24.4
21 inches	21.8	23.8	31.1	36.8	20.2	30.0	20.3	22.4	13.8	15.0	26.7	23.8
28 inches		22.1	31.8	31.1	16.0	30.7	24.5	15.1	14.4	17.7	26.7	23.0
Average (uncultivated)	24.6	22.8	34.3	35.9	18.1	31.0	21.8	20.1	13.7	16.8	26.4	24.1
Spacings cultivated												
7 inches	22.1	21.7	35.9	38.7	19.5	37.5	18.3	17.5	15.3	21.9	26.0	24.9
14 inches	20.8	19.0	29.9	35.3	17.2	33.5	17.4	15.4	16.0	16.4	24.2	22.3
21 inches	19.7	22.2	27.5	34.3	18.0	32.5	21.9	14.5	16.2	16.0	24.2	22.5
28 inches		21.9	24.3	34.1	16.5	28.3	20.7	9.7	13.0	15.4	22.4	20.6
Average (cultivated)	20.9	21.2	29.4	35.6	17.8	33.0	19.6	14.3	15.1	17.4	24.2	22.6
Average (overall)	22.8	22.0	31.9	35.7	18.0	32.0	20.7	17.2	14.4	17.1	25.3	23.3
F value treatments			10.82**	3.57		7.36**	0.55	17.32**	0.95	0.92	0.67	3.48
L. S. D. .05			5.03	(not		3.49	(not	3.52	(not	(not	(not	(not
L. S. D. .01			7.44	sig)		5.17	sig)	5.22	sig)	sig)	sig)	sig)
C. V. (%)			6.68	5.36		4.62	20.24	8.62	13.38	20.35	10.52	11.99

**Significant at .01 level

Bracken and Stewart (1930) reported the results of this test for the period 1923-1929, inclusive. This current report includes the results through 1933, the final year of the experiment.

Yield data are reported in table 34. The data could not be analyzed statistically for the years 1923, 1924, and 1927, because of unavailability of individual plot yields from the two replications involved.

Only in three years (1925, 1928, and 1930) did the treatment yields differ significantly from the mean. On the other hand yields decreased with increase in row width and cultivation with the best average yield obtained on the 7 inch uncultivated plots.

Type of Drill

The furrow drill was compared with the ordinary drill in an experiment conducted at the station from 1923 to 1929, inclusive. No advantage was found for the furrow drill except in years of low precipitation (Bracken and Stewart 1930).

Soil Moisture Studies

SOIL moisture studies were superimposed on many of the tests conducted at the Nephi Station. It was found that over the period of a wheat-fallow cycle only 32 percent of the rainfall was stored as soil moisture (Bracken and Cardon 1935). The other 68 percent was lost mostly by runoff and evaporation, with a small amount penetrating down below the reach of plant roots. Summer rainfall was ineffective in building up soil moisture reserves. Time of spring plowing had a marked influence on the amount of soil moisture accumulated. The latter decreased with lateness of spring plowing in about the same ratio that wheat yields decreased. Depth of plowing, frequent cultivation of fallow, and no tillage of fallow had practically no influence on the amount of moisture stored provided weeds were controlled.

Additional work needs to be done on soil moisture to determine how best to conserve the 68 percent moisture now lost by runoff and evaporation. Also, more work should be done on prediction of yields from available soil nitrogen and soil moisture at various times of the year.

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Appendix

Table 1. *Estimated acreage of dry farm cropland in Utah by counties.* 1949*

County	Acres	County	Acres	County	Acres
Beaver	400	Iron	3,200	Sevier	100
Box Elder	190,800	Juab	57,000	Summitt	1,700
Cache	78,200	Kane	5,500	Tooele	16,800
Carbon	300	Millard	77,700	Uintah	10,000
Daggett	100	Morgan	3,400	Utah	22,500
Davis	5,200	Piute	0	Wasatch	200
Duchesne	11,300	Rich	2,000	Washington	10,100
Emery	1,300	Salt Lake	25,500	Wayne	1,100
Garfield	400	San Juan	31,300	Weber	4,300
Grand	500	Sanpete	15,400		
				Total	576,300

*Based on dry-farm land assessed for taxes in 1949 plus dry-farm acres among Indian lands, vacant lands, state institutions and tax-exempt properties, as reported by Lawrence A. Reuss and George T. Blanch, in *Utah's land resources.* Utah Agr. Exp. Sta. Spec. Rep. 4. 1951.

Table 2. *Acreage harvested, total production, and average yield per acre of winter wheat in Utah,* 1908-1953, *inclusive**

Year	Acreage harvested‡	Total production	Average yield per acre	Year	Acreage harvested‡	Total production	Average yield per acre
	1000 *acres*	1000 *bushels*	*bushels*		1000 *acres*	1000 *bushels*	*bushels*
1908†	50	1,150	23.0	1931	217	3,038	14.0
1909	120	2,388	19.9	1932	189	3,213	17.0
1910	133	2,194	16.5	1933	180	2,340	13.0
1911	150	3,000	20.0	1934	138	1,932	14.0
1912	160	3,040	19.0	1935	159	3,180	20.0
1913	180	3,150	17.5	1936	172	2,408	14.0
1914	225	5,175	23.0	1937	188	3,008	16.0
1915	245	5,145	21.0	1938	213	4,686	22.0
1916	250	4,500	18.0	1939	157	2,638	16.8
1917	160	2,960	18.5	1940	180	3,420	19.0
1918	160	2,720	17.0	1941	198	4,653	23.5
1919	150	1,905	12.7	1942	167	3,090	18.5
1920	146	2,321	15.9	1943	158	3,239	20.5
1921	150	2,985	19.9	1944	235	5,076	21.6
1922	159	2,067	13.0	1945	221	4,972	22.5
1923	148	2,945	19.9	1946	239	4,780	20.0
1924	140	1,862	13.3	1947	256	5,632	22.0
1925	146	3,212	22.0	1948	332	6,308	19.0
1926	150	3,150	21.0	1949	355	6,922	19.5
1927	158	3,002	19.0	1950	326	4,798	16.0
1928	177	3,717	21.0	1951	323	5,814	18.0
1929	185	2,960	16.0	1952	339	4,746	14.0
1930	207	4,554	22.0	1953§	342	5,814	17.0

*Source: 1909-1953, incl. U. S. Agricultural Marketing Service, Office of Agricultural Statistician, Salt Lake City, Utah

1908 — U. S. Department of Agriculture Yearbook. 1908. p. 610

†No data on winter wheat acreage available prior to 1908.

‡Approximately 9/10 of the acreage reported is on dry farm land and 1/10 on irrigated land.

§1953 figures are preliminary.

Table 3. *Soil analysis data obtained on soils of the Nephi Farm by Wilson in 1952*

Sample No.	Depth	pH paste	Organic matter	$CaCO_3$ (lime)	Avail. PO_4*	Avail. K*	Mech. composition sand	silt	clay
	inches		*percent*	*percent*	*ppm*	*ppm*	*percent*		
1	0-6	8.1	1.6	6	6	106	14	58	28
1	6-12	8.0	1.4	13			15	48	37
1	12-20	8.2	1.5	17			16	42	42
1	20-40	8.1	1.1	18			10	47	43
1	40-52	8.2	.6	16			46	31	23
1	52-60	8.4	.5	29			23	48	29
2	0-6	8.0	1.5	4	6	107	21	55	24
2	6-14	8.1	1.5	11			14	50	36
2	14-20	8.2	1.1	16					
2	20-40	8.1	1.0	18					
2	40-60	8.2	.7	19					
3	0-6	7.5	2.4	3	23	187	25	51	24
3	6-16	7.8	1.3	7			20	47	33
3	16-20	8.1	1.2	18					
3	20-40	8.1	1.2	16					
3	40-60	8.3	1.0	25					
4	0-6	8.0	1.4		8	90	46	39	15
4	6-24	8.2	.9				32	41	27
4	24-40	8.0	1.1				32	40	28
5	0-6	7.6	2.0		5	70	25	48	27
5	6-12	7.9	1.3				16	41	43
5	12-18	8.0	1.2						
5	18-40	8.0	.8						
5	40-56	8.0	1.0						

*Carbon dioxide soluble phosphate and potassium.

Table 4. *Monthly, average monthly, yearly, and average yearly precipitation on crop year basis* (*Aug.* 1 *to July* 31) *Nephi Dry-Land Experimental Farm,* 1903-1953, *inclusive**

Crop year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Total
1903-04	0.15	0.92	1.56	0.24	0.52	0.68	1.44	2.41	0.80	3.10	0.02	0.36	12.20
1904-05	0.17	0.20	1.05	0.00	0.97	0.28	2.22	1.57	1.22	1.39	0.21	0.31	9.59
1905-06	0.60	3.17	0.08	1.01	0.57	1.48	0.68	3.83	2.87	2.92	0.43	0.80	18.44
1906-07	1.57	0.61	T	1.47	1.82	1.90	2.01	1.42	0.93	1.76	1.58	0.32	15.39
1907-08	1.46	0.74	0.84	0.50	1.97	0.81	1.11	1.12	0.29	3.64	0.67	0.52	13.67
1908-09	3.41	2.28	1.73	0.46	0.62	2.57	1.70	1.03	2.21	0.68	0.17	0.95	17.81
1909-10	2.84	0.68	0.32	1.53	1.51	0.61	0.61	0.81	0.46	0.72	0.03	0.38	10.50
1910-11	0.10	2.37	1.57	0.58	0.84	1.92	0.61	1.05	0.56	0.24	0.76	1.77	12.37
1911-12	0.28	1.07	0.75	0.44	0.66	0.39	0.29	2.80	1.47	1.05	0.17	0.48	9.85
1912-13	0.62	0.47	3.07	1.52	0.27	0.59	1.45	0.78	0.86	0.30	1.08	0.16	11.17
1913-14	1.68	1.12	1.30	1.81	1.21	2.94	1.00	0.43	3.20	0.71	1.94	1.74	19.08
1914-15	0.29	0.04	1.35	0.15	0.65	1.27	2.25	0.98	1.29	3.21	1.04	0.02	12.54
1915-16	0.21	1.37	0.49	0.90	0.60	1.95	1.75	2.96	0.28	0.96	0.00	1.14	12.61
1916-17	0.78	0.50	2.54	0.20	1.26	0.24	0.90	0.33	1.63	3.28	0.21	0.44	12.31
1917-18	0.29	0.81	0.07	1.06	0.50	1.95	0.72	1.04	0.89	0.96	1.54	1.77	11.60
1918-19	0.06	1.16	0.96	1.62	0.82	T	0.67	0.95	0.75	0.95	0.00	0.54	8.48
1919-20	0.75	2.39	1.47	0.69	0.40	0.73	1.21	2.34	2.38	1.21	0.63	0.81	15.01
1920-21	2.14	0.59	2.64	0.89	0.71	1.57	1.27	0.71	2.25	2.41	0.24	1.03	16.45
1921-22	0.75	0.56	0.75	0.32	1.88	1.77	1.18	1.59	1.40	0.88	0.55	0.82	12.45
1922-23	2.05	0.19	0.48	1.14	1.85	1.69	0.82	0.75	1.32	1.33	0.66	1.96	14.24
1923-24	0.60	0.61	0.94	0.15	0.53	0.39	0.10	1.28	0.06	1.84	0.05	0.37	6.92
1924-25	1.05	0.88	1.29	0.68	1.63	0.54	1.48	1.31	1.61	0.60	1.72	1.03	13.82
1925-26	1.18	0.74	1.54	0.46	0.85	0.45	1.26	0.75	1.78	1.65	0.18	1.31	12.15
1926-27	0.48	0.42	0.00	2.17	1.22	0.97	1.99	1.44	1.37	0.52	0.44	0.48	11.50
1927-28	0.48	1.52	1.84	1.54	0.82	0.41	0.68	1.56	0.77	1.52	0.41	0.79	12.34
1928-29	0.20	0.16	0.84	1.64	0.59	0.79	0.91	1.44	1.22	0.85	0.85	3.46	12.95
1929-30	1.80	0.85	0.81	0.26	0.45	1.77	1.12	2.22	0.88	2.58	0.17	1.44	14.35
1930-31	2.44	2.61	1.41	0.72	0.18	0.14	0.40	0.81	0.96	0.74	0.03	0.32	10.76

Table 4. *Monthly, average monthly, yearly, and average yearly precipitation on crop year basis (Aug. 1 to July 31) Nephi Dry-Land Experimental Farm, 1903-1953, inclusive*—(Cont'd)*

Crop year	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May	June	July	Total
1931-32	1.08	0.29	0.47	1.17	1.01	1.14	1.50	1.90	0.80	0.52	1.09	0.59	11.56
1932-33	1.14	0.03	1.05	0.26	0.75	1.10	0.15	1.07	1.21	2.79	0.17	0.80	10.52
1933-34	0.55	0.19	0.28	0.30	0.72	0.80	1.60	0.22	0.26	0.14	0.62	0.32	6.00
1934-35	0.11	0.14	0.53	2.45	1.14	0.56	0.53	1.34	1.98	2.54	0.00	0.87	12.19
1935-36	1.48	0.26	0.05	0.43	1.15	1.49	3.21	1.21	0.86	0.56	1.88	4.05	16.63
1936-37	0.75	0.30	1.20	0.55	1.14	1.45	0.85	1.55	0.77	1.37	0.05	1.80	11.78
1937-38	0.59	0.86	1.01	0.32	1.51	0.84	1.74	2.06	1.29	2.94	0.22	0.62	14.00
1938-39	0.28	0.27	1.30	1.12	0.61	1.14	0.56	0.53	0.52	0.81	0.78	0.42	8.34
1939-40	0.61	2.61	2.56	0.10	0.21	2.10	2.71	1.35	1.31	T	0.15	0.16	13.87
1940-41	0.19	1.10	1.37	0.84	1.07	1.93	1.62	2.22	2.41	1.17	2.17	1.35	17.44
1941-42	1.39	0.87	2.90	0.65	1.97	0.24	0.93	0.99	0.90	1.70	0.09	0.88	13.51
1942-43	0.39	0.32	0.93	1.35	0.51	0.46	0.90	0.66	0.45	3.20	0.69	0.35	10.21
1943-44	1.35	0.18	2.10	0.31	0.49	1.42	0.33	2.23	3.22	1.36	1.81	0.00	14.80
1944-45	0.12	0.30	0.36	1.09	0.39	0.29	1.47	2.14	0.98	0.77	1.51	1.54	10.96
1945-46	2.53	0.82	1.64	1.07	1.94	1.03†	0.10	0.80	1.51	2.83	0.00	0.34	14.61
1946-47	2.27	0.08†	5.52	2.45†	1.70†	0.27	0.52	0.45	1.78	0.87	1.29	0.46	17.66
1947-48	1.60	0.95	1.80	1.20	1.85	0.15	0.60	1.35	0.68	0.15	1.05	0.20	11.58
1948-49	0.63	0.02	0.53	0.66	1.94	1.31	0.06	0.99	0.67	2.77	0.49	0.75	10.82
1949-50	0.28	0.82	1.30	0.50	1.42	1.33	0.68	0.59	1.36	0.72	0.25	0.79	10.04
1950-51	0.45	0.31	0.43	1.24	0.97	0.43	0.71	0.49	2.29	0.94	0.11	0.31	8.68
1951-52	0.81	0.12	1.55	1.42	3.01	1.35	0.87	2.53	0.87	1.37	1.45	1.32	16.67
1952-53	0.76	0.17	0.00	0.69	0.56	0.75	0.36	0.79	1.25	2.55	0.12	1.84	9.84
Totals	47.79	40.04	60.57	44.32	51.96	52.38	53.83	67.17	63.08	74.07	31.77	45.28	632.26
Average	0.96	0.80	1.21	0.89	1.04	1.05	1.08	1.34	1.26	1.48	0.64	0.91	12.65

**Source*: Weather data collected at Nephi Dry Farm Station except entries marked with †, which were taken from weather records of Levan Station.

†From weather records of Levan Station reported in Climatological data—Utah, 1946.

T = Trace.

Table 5. *Summary of mean, maximum, and minimum temperatures (°F) by months from April to October for the years* 1909 *to* 1941, *inclusive, at the Nephi Station**

Year	April			May			June			July			August			September			October		
	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.
1909	44	76	12	52	83	21	66	94	33	71	99	41	72	95	46	60	85	27	50	79	12
1910	50	85	18	57	92	28	67	97	40	73	101	41	71	96	32	64	92	33	46	78	23
1911	44	74	13	54	85	22	64	94	35	70	95	36	70	96	41	61	91	29	45	75	16
1912	41	68	20	52	88	25	62	90	27	70	95	41	70	95	42	54	84	25	44	78	8
1913	48	76	23	57	62	22	63	92	43	70	96	43	72	93	47	59	87	28	46	74	15
1914	47	74	28	59	85	27	62	94	31	70	93	45	72	96	45	62	91	31	51	75	28
1915	52	78	29	51	82	16	60	91	28	70	95	45	71	97	43	58	87	28	52	81	21
1916	48	80	23	51	81	20	62	94	30	71	96	37	67	93	38	61	89	25	46	71	22
1917	42	74	13	48	81	28	61	94	27	72	100	38	69	96	42	63	91	29	50	84	10
1918	43	73	14	55	81	29	68	101	31	71	98	48	69	97	36	61	91	32	52	90	21
1919	44	†	†	53	†	†	63	†	†	77	101	43	73	100	46	71	90	28	41	72	14
1920	40	76	9	49	82	26	62	90	21	73	100	43	69	96	38	60	88	26	46	86	13
1921	41	70	20	52	77	30	64	96	30	71	98	29	60	95	48	71	86	30	54	84	21
1922	37	69	14	52	85	24	67	99	35	73	103	46	73	96	49	65	91	34	54	84	26
1923	43	71	21	53	83	25	57	95	24	71	99	48	67	91	45	59	91	26	46	74	19
1924	44	75	18	56	85	23	66	95	33	73	98	49	70	97	37	64	94	33	49	80	26
1925	47	79	26	57	87	31	59	94	32	72	104	42	68	92	43	59	87	28	47	81	22
1926	45	69	24	55	88	26	66	100	36	68	100	40	66	98	40	59	88	16	52	83	26
1927	42	79	14	52	89	23	63	97	38	71	100	39	65	94	42	61	90	33	50	82	17
1928	43	83	14	58	90	21	61	98	28	72	102	38	69	99	40	62	94	25	50	81	20
1929	43	74	11	53	84	22	62	97	26	72	98	42	71	95	49	58	87	32	47	82	17
1930	52	81	25	51	85	25	66	94	31	73	98	49	69	92	47	59	88	30	45	75	17
1931	45	82	15	53	88	22	67	95	39	75	108	39	72	99	40	61	93	28	52	78	13
1932	49	74	30	54	87	26	62	97	30	71	100	39	70	98	32	61	92	35	45	81	14
1933	42	73	12	47	87	22	68	96	36	76	102	49	70	103	38	64	94	34	54	81	26
1934	53	82	22	63	89	31	63	93	32	76	103	44	74	100	46	60	94	19	†	†	†
1935	45	76	22	50	80	26	66	96	33	73	101	42	72	97	44	64	93	32	†	†	†
1936	45	74	27	61	86	32	66	98	34	76	101	56	75	99	50	67	94	36	†	†	†
1937	45	75	27	60	86	31	64	100	31	74	102	51	75	101	49	66	94	34	†	†	†
1938	47	81	16	53	84	24	67	94	39	72	103	38	73	102	40	†	†	†	†	†	†
1939	43	84	22	†	†	†	64	97	30	73	104	46	74	100	51	†	†	†	†	†	†
1940	47	74	28	60	89	32	69	104	32	76	102	48	75	103	47	58	90	27	†	†	†
1941	41	66	22	56	88	31	61	94	35	†	†	†	70	96	44	†	†	†	†	†	†
Totals	1482			1734			2108			2392			2323			1852			1214		
Avg.	45			54			64			75			70			62			49		

*Source: Original weather records of Nephi Station.
†No record.

Table 6. *Frost-free period at Nephi Station,* 1908 *to* 1935, *inclusive*

Year	Days	Year	Days	Year	Days
1908	69	1917	95	1926	136
1909	105	1918	100	1927	126
1910	142	1919	112	1928	88
1911	113	1920	115	1929	120
1912	80	1921	81	1930	117
1913	143	1922	126	1931	114
1914	99	1923	87	1932	73
1915	93	1924	153	1933	140
1916	108	1925	112	1934	115
				1935	119

Average = 110 days (28 year average for which complete records are available.)

Table 7. *Average hourly wind velocity at Nephi Station for the months of April to October, inclusive, over the period of* 1909 *to* 1941, *inclusive**

	Hourly wind velocity						
Year	April	May	June	July	Aug.	Sept.	Oct.
				miles per hour			
1909	4.73	4.57	4.22	4.09	3.30	3.65	3.55
1910	5.00	4.30	5.40	4.30	4.40	3.90	3.30
1911	4.02	6.04	4.90	3.67	4.39	4.55	3.32
1912	4.40	5.20	4.80	4.30	3.90	4.10	3.20
1913	5.70	4.60	4.40	4.20	3.50	3.30	3.20
1914	3.60	3.70	4.00	3.10	3.30	4.40	3.50
1915	4.10	4.10	3.80	4.10	3.30	3.40	3.70
1916	4.80	5.00	4.40	3.80	3.60	3.90	3.50
1917	3.80	2.50	3.00	2.90	3.20	2.80	3.00
1918	4.24	4.23	1.73	2.88	2.80	2.63	2.22
1919	4.20	3.99	4.83	3.60	3.38	3.91	3.50
1920	3.20	3.40	3.40	2.90	2.50	3.10	3.60
1921	3.90	3.00	2.50	2.80	3.00	3.40	3.00
1922	3.80	4.00	3.90	3.10	2.70	2.60	3.30
1923	3.60	3.00	2.90	2.70	2.60	2.90	2.70
1924	4.30	3.80	4.60	3.70	3.80	3.00	4.00
1925	4.30	2.90	2.80	3.40	3.10	3.20	2.90
1926	3.40	3.10	3.30	3.00	3.80	3.80	2.13
1927	3.80	3.90	3.80	2.50	3.20	3.20	2.90
1928	3.60	3.10	3.60	2.70	1.80	3.30	3.20
1929	3.70	3.50	3.50	2.60	2.30	3.60	2.30
1930	3.40	3.10	3.40	2.90	2.30	2.50	2.00
1931	3.20	2.90	3.20	2.60	2.80	4.00	2.70
1932	†	3.50	2.90	2.10	3.40	2.60	3.20
1933	4.40	3.40	3.10	2.70	3.10	3.90	2.40
1934	3.30	4.20	4.40	4.30	3.50	4.00	†
1935	4.00	3.40	2.80	3.10	2.80	2.60	†
1936	3.30	3.20	2.90	2.60	2.30	2.90	†
1937	3.70	3.00	2.80	2.40	2.80	2.82	†
1938	2.68	2.60	2.82	2.86	3.12	2.52	†
1939	4.30	3.05	3.09	2.98	2.60	†	†
1940	3.08	2.57	2.75	3.62	2.73	2.15	†
1941	3.16	3.36	2.31	†	1.69	†	†
Totals	124.71	120.21	116.25	102.50	101.01	102.63	76.32
Average	3.90	3.64	3.52	3.20	3.06	3.31	3.05

*Source: Original weather records of Nephi Station.
†No record.

Table 8. *Monthly evaporation from free water surface at the Nephi Dry Land Experimental Farm for the seven months April to October, over the period* 1908 *to* 1941*

Year	Evaporation							
	April	May	June	July	Aug.	Sept.	Oct.	Total
				inches				
1908	†	†	7.879	10.343	9.331	6.234	2.410	36.197
1909	3.645	5.990	8.803	9.466	7.036	5.600	4.428	44.968
1910	5.702	7.451	10.898	9.596	9.882	6.008	3.662	53.199
1911	4.936	8.403	8.680	8.702	10.469	6.695	3.547	51.432
1912	3.543	6.301	9.280	9.236	8.889	6.162	2.981	46.392
1913	4.350	7.474	8.313	9.526	8.252	5.250	2.742	45.907
1914	2.943	9.448	7.377	7.409	9.520	7.767	3.769	48.233
1915	4.300	4.785	8.434	11.165	10.653	6.157	5.143	50.637
1916	5.495	7.787	9.931	9.392	8.823	7.357	2.361	51.146
1917	3.558	3.954	8.220	9.525	9.172	6.242	4.811	45.482
1918	4.357	6.886	8.408	8.839	9.214	7.727	2.818	46.249
1919	4.684	8.189	11.396	12.476	9.476	5.705	2.587	54.398
1920	3.205	5.086	8.512	9.896	7.067	6.839	2.913	43.518
1921	2.587	5.259	7.142	9.150	8.485	5.926	3.613	42.162
1922	3.157	5.840	9.634	9.997	7.340	6.639	4.142	46.749
1923	2.736	5.638	7.259	8.602	8.266	5.971	3.717	42.189
1924	4.475	7.797	10.325	9.832	7.896	6.869	3.578	50.772
1925	4.169	6.591	6.199	8.728	7.791	5.598	3.154	42.230
1926	2.859	5.580	9.932	9.294	9.715	6.643	2.279	46.302
1927	4.187	6.697	8.000	9.537	8.334	6.638	4.074	47.467
1928	4.121	5.800	9.266	11.380	9.460	7.760	4.248	52.035
1929	2.855	6.484	8.166	8.011	7.042	5.724	3.386	41.668
1930	4.341	5.329	9.666	10.416	7.184	5.589	2.988	45.513
1931	4.472	6.798	10.040	12.238	8.857	8.290	4.102	54.797
1932	4.721	6.420	7.662	10.256	9.888	7.151	4.321	50.419
1933	3.922	4.539	9.608	9.379	9.857	8.304	5.217	50.826
1934	5.798	9.028	10.261	12.145	10.180	8.362	†	55.774
1935	3.579	4.616	9.611	11.404	9.755	7.858	†	46.823
1936	5.355	9.041	8.810	8.292	8.913	6.957	†	47.368
1937	5.263	7.525	8.229	9.376	10.085	6.564	†	47.042
1938	3.950	5.101	8.987	10.051	10.152	†	†	38.241
1939	5.314	7.958	9.009	12.012	9.520	†	†	43.813
1940	4.324	7.993	10.792	13.276	10.867	†	†	47.252
1941	3.129	6.209	7.738	†	7.652	5.690	†	30.418
Totals	136.032	217.997	302.467	328.823	305.023	204.276	92.991	1587.618
Average	4.1	6.6	8.9	10.0	9.0	6.6	3.6	47.8‡

*Source: Original weather records of Nephi Station.
†No record.
‡Average total evaporation, April to October, over the 25 year period, 1909 to 1933.

Table 9. *Forage yields on a dry weight basis obtained at Nephi Station, 1936-1943, inclusive, by years*

Species or mixture	1936	1937	1938	1939	1940	1941	1942	1943	Avg.
						tons per acre			
Yellow sweetclover	2.92	—	—	—	—	1.52	—	—	2.22
White sweetclover	2.22	—	—	—	—	—	—	—	2.22
Crested wheatgrass	0.89	0.80	1.11	0.31	0.63	0.69	0.38	0.06	0.61
Smooth bromegrass	0.21	0.38	0.59	0.04	0.28	0.26	0.26	0.00	0.25
Western wheatgrass	0.46	0.08	0.34	0.00	—	—	—	—	0.22
Perennial ryegrass	0.38	0.21	0.32	0.04	—	—	—	—	0.24
Rye (cut in bloom)	0.48	0.68	0.60	0.66	0.69	1.02	0.57	—	0.67
Rye (cut in dough)	0.20	0.44	0.96	0.56	0.97	0.67	0.46	—	0.60
Alfalfa	—	—	0.39	0.22	1.03	1.41	0.55	0.18	0.63
Slender wheatgrass	—	—	—	0.05	—	—	—	—	0.05
Alfalfa and crested wheatgrass	—	—	—	—	0.29	0.77	0.49	0.57	0.53
Average of 3 replications.									
"F" for species	37.18**	7.57**	27.22**	48.77**	16.45**	16.24**	3.28	78.76**	
L.S.D. .05	0.51	0.31	0.18	0.11	0.25	0.34	(not	0.10	
L.S.D. .01	0.71	0.44	0.26	0.15	0.35	0.49	sig)	0.15	
C.V.	30.07	39.93	16.59	27.47	21.09	21.07	24.84	25.00	

**Significant at .01 level.

Table 10. *Winter wheat yields on land plowed at various depths and times, Nephi Station, Part* 1, 1910-1949 *inclusive; Part* 2, 1916-1949, *inclusive*

Year	Part 1: Fall plowed 5 in. deep	Fall plowed 8 in. deep	Fall plowed 10 in. deep	Sub-soiled 15 in. deep in fall	Sub-soiled 18 in. deep in fall	Part 2: Plowed 8 in. fall and 3 in. spring	Plowed 3 in. fall and 8 in. spring	Plowed 8 in. fall and 8 in. spring
	bushels per acre					*bushels per acre*		
1910	12.0	12.0	13.0	13.0	14.0			
1911	27.0	29.0	29.0	29.0	28.0			
1912	20.0	22.0	21.0	19.0	18.0			
1913	10.0	4.0	7.0	6.0	4.0			
1914	39.5	45.5	38.8	41.3	38.6			
1915*	—	—	—	—	—			
1916	13.3	19.3	15.7	15.8	16.2	16.5	14.5	15.7
1917	28.5	27.8	28.2	27.2	27.7	26.2	28.2	26.8
1918	13.7	16.2	17.3	20.3	16.5	18.2	14.3	15.8
1919	23.8	19.3	25.5	23.7	19.0	17.3	15.5	17.0
1920	22.5	27.1	24.5	24.5	26.8	32.0	28.0	27.5
1921	42.7	48.0	48.2	43.4	44.2	41.1	38.7	38.4
1922	12.7	15.7	14.2	17.2	15.2	14.8	13.3	12.5
1923	20.0	23.0	25.5	21.5	22.5	20.3	17.8	19.0
1924	19.2	23.8	23.5	20.8	22.2	21.2	18.8	16.5
1925	23.0	30.2	29.2	31.0	30.8	26.9	24.3	24.9
1926	45.2	52.7	51.3	49.2	52.7	50.0	48.7	40.7
1927	17.3	18.5	20.2	15.7	17.7	16.2	16.3	14.7
1928	25.2	26.8	26.3	26.8	25.7	27.3	24.2	27.8
1929	16.0	16.8	17.3	12.2	14.2	12.7	15.5	14.5
1930	20.0	22.3	21.7	19.2	15.0	22.8	21.8	16.7
1931	21.3	25.0	23.0	24.0	23.2	22.8	20.8	21.0
1932	17.7	19.0	17.0	18.2	18.0	18.7	18.0	16.3
1933	16.3	17.7	15.7	17.7	16.8	12.2	14.5	12.7
1934	15.2	14.5	15.2	15.0	12.7	15.3	15.7	14.7
1935	20.0	17.7	19.5	20.3	16.3	24.5	22.5	22.5
1936	16.9	16.0	17.7	17.0	15.5	17.5	16.0	15.8
1937	22.5	28.0	23.7	20.5	24.3	21.5	21.7	20.7
1938	30.8	32.8	31.8	30.3	29.0	28.3	28.7	28.5
1939	15.3	15.8	16.7	14.7	13.3	13.0	12.0	11.2
1940	26.2	27.3	27.5	28.7	30.3	31.5	27.8	24.0
1941	28.3	32.5	34.2	32.0	31.5	30.8	30.2	27.8
1942	33.0	30.3	26.6	28.3	30.8	30.3	31.3	20.6
1943	22.2	21.8	24.0	24.0	20.5	20.5	19.5	19.3
1944	22.8	24.5	25.0	22.0	23.3	26.3	24.2	26.0
1945	27.3	25.0	28.0	26.2	26.0	23.7	21.8	21.7
1946	20.3	23.3	20.0	24.2	26.0	22.5	19.0	17.7
1947	24.0	30.2	29.8	26.0	30.8	33.0	20.8	26.7
1948	18.0	19.3	21.8	24.2	18.6	19.7	17.2	16.2
1949	22.0	23.3	26.0	24.3	22.3	24.3	19.8	19.8
Total	871.7	944.0	940.6	914.4	898.2	799.9	741.4	711.7
39 yr. avg. (Part 1); 34 yr. avg. (Part 2)	22.3	24.2	24.1	23.4	23.0	23.5	21.8	20.9

*1915 results not available

Table 11. *Winter wheat yields on fall and spring plowed land treated in various ways, Nephi Station,* 1916-1949, *inclusive*

	Fall plowed				Spring plowed			Fall plowed and spring plowed	
Year	Ordinary cult. of fallow*	No cult. of fallow; weeds hoed	Frequent cult. of fallow†	Fall plowed after fall disking	Ordinary cult. of fallow*	No cult. of fallow; weeds hoed	Frequent cult. of fallow†	Spring plowed after fall disking	Frequent cult. of fallow†
				bushels per acre					
1916	19.3	17.8	17.3	18.8	18.3	19.5	18.3	16.0	17.6
1917	27.8	31.2	27.0	25.7	31.8	29.2	26.4	24.7	28.5
1918	16.2	13.2	13.6	15.8	14.5	13.0	13.5	11.2	16.7
1919	19.3	21.7	21.0	16.7	23.7	23.0	19.3	17.3	22.5
1920	27.1	23.8	23.7	30.5	27.5	27.7	28.5	28.0	28.0
1921	48.0	45.7	42.3	40.2	38.4	42.2	35.9	36.9	44.3
1922	15.7	12.5	15.1	15.5	12.8	12.2	15.3	13.8	15.2
1923	23.0	23.3	21.0	20.7	24.5	25.8	20.8	21.0	22.8
1924	23.8	22.0	21.2	22.8	21.7	21.3	22.7	22.8	20.5
1925	30.2	29.0	26.7	28.7	30.4	26.8	27.5	23.7	31.3
1926	52.7	40.0	52.0	51.5	42.0	41.7	48.5	45.8	55.2
1927	18.5	17.8	17.2	16.3	17.0	18.7	16.7	14.5	18.5
1928	26.8	24.5	23.5	26.2	28.8	30.5	28.7	27.8	23.7
1929	16.8	16.7	13.0	15.7	20.0	20.0	17.7	11.3	11.0
1930	22.3	21.8	21.5	22.8	23.0	23.3	23.2	23.5	21.7
1931	25.0	20.0	21.0	21.7	26.3	21.0	22.8	22.5	23.5
1932	19.0	17.8	15.2	18.2	18.7	17.2	18.2	19.5	20.3
1933	17.7	12.7	14.0	12.0	20.3	22.0	15.2	13.3	15.2
1934	14.5	14.0	14.8	14.8	17.2	17.3	18.8	17.0	16.8
1935	17.7	15.0	21.8	21.1	22.2	18.8	25.6	26.2	22.7
1936	16.0	12.8	16.7	16.2	18.5	18.7	18.0	16.8	13.5
1937	24.0	25.3	23.0	21.7	28.0	28.0	23.3	21.0	22.3
1938	35.8	34.0	32.8	33.2	32.8	32.5	31.2	30.5	29.2
1939	15.8	14.5	14.8	11.7	14.8	15.2	14.3	12.3	15.8
1940	27.3	29.3	26.0	28.7	30.0	34.2	27.2	27.7	25.8
1941	32.5	36.5	28.7	29.3	29.3	32.5	29.8	27.7	31.7
1942	27.1	28.3	37.0	29.5	30.3	31.6	31.8	27.3	25.3
1943	21.8	21.2	22.5	20.0	21.0	23.0	19.0	19.2	19.0
1944	24.5	21.0	25.0	25.2	23.3	25.0	25.3	28.0	25.8
1945	25.0	26.3	25.8	22.3	25.3	23.2	23.2	20.5	25.3
1946	23.3	23.0	19.3	21.7	22.5	24.8	21.3	23.5	17.7
1947	30.2	30.7	26.0	24.8	30.7	28.0	26.7	24.3	26.0
1948	19.3	18.2	21.5	23.2	19.0	18.3	21.1	22.8	25.2
1949	23.3	23.7	21.8	21.5	20.0	22.0	21.0	19.3	24.3
Total	827.3	785.3	783.8	784.7	824.6	828.2	796.8	757.7	802.9
34 year avg.	24.3	23.1	23.0	23.1	24.2	24.3	23.4	22.3	23.6

*Under ordinary cultivation fall plowed land was harrowed in the spring as soon as possible, followed by one or two weedings as necessary, followed by a leveling and another harrowing. Spring plowed land was harrowed twice and leveled with one weeding required only in occasional years.

†Under frequent cultivation land was worked every two weeks during the fallow period (received about eight cultivation treatments.)

Table 12. *Winter wheat yields as influenced by time of plowing and frequency of tillage, Nephi Station* 1939-1950, *inclusive*

Treatment	1939	1940	1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	12 year avg.
							bushels grain per acre						
Fall pl. – no till.*	10.2	26.7	31.8	31.7	21.3	24.1	23.7	26.7	34.9	23.2	28.7	25.1	25.7
Fall pl. – med. till.†	12.3	23.4	28.9	29.3	23.4	23.1	23.0	25.1	34.2	22.4	29.2	21.5	24.7
Fall pl. – freq. till.‡	12.0	24.1	29.3	27.6	22.2	22.9	23.1	26.2	33.1	20.4	29.2	21.1	24.3
Spring pl. early – no till.*	10.7	30.1	27.7	29.2	20.8	24.2	22.2	25.7	30.0	24.0	23.8	27.2	24.6
Spring pl. early – med. till.†	10.0	28.5	26.4	31.3	20.7	22.9	22.2	30.8	26.9	22.3	23.2	26.8	24.3
Spring pl. early – freq. till.‡	11.4	24.9	31.0	27.3	18.5	24.2	26.5	27.0	31.8	21.3	23.2	21.1	24.0
Spring pl. 2 wks. late – no till.*	10.3	26.3	24.3	26.1	23.5	23.0	25.6	26.4	30.1	21.5	25.5	25.1	24.0
Spring pl. 2 wks. late – med. till.†	9.6	29.0	25.4	29.5	18.6	25.3	24.1	30.7	29.7	24.8	26.1	28.5	25.1
Spring pl. 2 wks. late – freq. till.‡	10.3	23.7	22.4	28.2	20.2	22.8	21.5	28.1	25.1	20.6	25.3	26.6	22.9
Spring pl. 4 wks. late – no till.*	7.7	25.6	18.8	18.9	18.0	20.9	18.5	25.9	26.1	19.6	25.9	26.8	21.1
Spring pl. 4 wks. late – med. till.†	10.2	25.3	24.6	23.1	20.9	20.3	20.0	25.7	29.9	20.4	27.4	26.6	22.9
Spring pl. 4 wks. late – freq. till.‡	6.5	27.3	21.7	23.3	16.4	22.2	20.7	24.7	26.9	19.9	24.7	27.7	21.8
Spring pl. 6 wks. late – no till.*	5.5	27.1	16.3	12.2	13.5	11.5	15.7	20.3	20.9	17.4	19.4	21.3	16.7
Spring pl. 6 wks. late – med. till.†	2.4	27.5	18.9	11.3	9.6	14.1	15.2	23.1	29.1	19.2	24.2	24.9	18.3
Spring pl. 6 wks. late – freq. till.‡	6.3	23.8	19.2	12.6	15.2	12.4	18.1	21.0	20.0	15.2	18.0	20.5	16.9
"F" for treatments	6.73**	1.27	4.67**	6.70**	8.64**	7.15**	4.14**	4.03**	1.64	1.99	1.31	2.86**	8.14**
L.S.D. .05	3.10	(not	6.47	7.59	3.79	4.87	4.77	4.24	(not	(not	(not	4.83	3.00
L.S.D. .01	4.19	sig)	8.73	10.25	5.11	6.58	6.44	5.72	sig)	sig)	sig)	6.52	4.05
C.V.	20.58	11.99	15.82	18.80	11.97	13.91	13.37	9.80	20.63	14.61	19.61	11.70	
Average of 3 replications													

C.V. for error (a)	27.64
C.V. for error (b)	14.33
Generalized C.V.	15.87

*No tillage–fallow not tilled but weeds pulled.

†Medium tillage–fallow machine weeded when necessary and harrowed three times.

‡Frequent tillage–Fallow machine weeded when necessary and harrowed every two to three weeks from plowing time until seeded.

Combined analysis of variance for 1939 to 1950 data

Source	D.F.	S.S.	M.S.	"F"	.05	.01
Treatments	14	4407.0766	314.7912	8.14**	2.06	2.80
Reps.	2	969.4868	484.7434	12.53**	3.34	5.45
Error (a)	28	1083.1304	38.6832			
Years	11	1264.433	1149.2212	110.53**	1.82	2.31
Years x treats	154	3116.0667	20.2342	1.95**	1.27	1.46
Years x reps	22	1663.7685	75.6258	7.27**	1.59	1.91
Error (b)	308	3202.4610	10.3976			
Total	539	27,083.4230				

**Significant at .01 level

Table 13. *Comparative winter wheat yields resulting from the use of the moldboard plow, one-way disk, and disk harrow, Nephi Station, 1930-1950, inclusive*

Treatment		1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940
						bushels grain per acre						
Moldboard plow		23.1	20.0	18.9	15.0	18.2	21.1	15.0	22.4	32.0	12.1	31.7
One-way disk		22.2	19.2	18.3	16.0	16.9	24.3	14.5	21.1	33.7	14.7	30.7
Disk harrow		20.2	20.7	16.6	15.5	16.1	24.7	13.9	21.7	31.1	15.1	24.9
"F" for treatments		1.52	0.66	6.11	11.00	4.14	1.33	0.49	1.12	168.5**	36.13*	14.58
L.S.D.	.05	(not	(not	(not	(not	(not	(not	(not	(not	0.61	1.67	(not
L.S.D.	.01	sig)	sig)	sig)	sig)	sig)	sig)	sig)	sig)	1.40	—	sig)
C.V.		7.65	6.52	3.77	1.44	4.42	10.48	7.62	3.99	0.44	2.77	4.69

Treatment		1941	1942	1943	1944	1945	1946	1947	1948	1949	1950	21 year average
						bushels grain per acre						
Moldboard plow		25.0	22.3	20.3	22.1	23.2	24.3	24.3	17.7	14.3	17.3	21.0
One-way disk		20.4	19.1	21.6	19.8	19.9	24.5	24.3	17.2	14.6	16.1	20.4
Disk harrow		20.9	13.9	19.0	19.0	21.9	20.3	22.7	16.2	13.0	11.5	19.0
"F" for treatments		19.48*	12.22	0.98	34.20*	4.63	29.95*	1.14	1.02	5.13	17.85	1312.33**
L.S.D.	.05	3.50	(not	(not	1.67	(not	2.62	(not	(not	(not	(not	0.17
L.S.D.	.01	—	sig)	sig)	—	sig)	—	sig)	sig)	sig)	sig)	0.40
C.V.		3.68	9.22	9.30	1.91	5.11	2.63	5.06	6.24	3.91	6.83	5.71 Gen. C. V.

Average of 2 replications

Combined analysis of data for the twenty-one year period 1930-1950, *inclusive*

Source	D.F.	S.S.	M.S.	F.	.05	.01
Treatments	2	90.8133	45.4066	1312.33**	19.00	99.00
Reps	1	5.3651	5.3651	155.06**	18.51	98.49
Error (a)	2	0.0692	0.0346			
Years	20	2797.1802	139.8590	100.78**	1.83	2.36
Years x treatments	40	216.1501	5.4037	3.89**	1.658	2.07
Years x reps	20	54.3266	2.7163	1.96*	1.83	2.36
Errors (b)	41	56.8941	1.3877			
Total	125	3220.7986				

*Significant at .05 level.
**Significant at .01 level.

Table 14. *Winter wheat yields obtained with various manuring treatments, Nephi Station, 1915-1949, inclusive*

Year	a	b	c	d	e	f	g	h	i	j	k	l	m
						Treatment							
						bushels grain per acre							
1915	11.0	10.6	9.8	11.7	13.4	10.9	11.8	13.5	11.9	12.7	13.1	13.6	13.7
1916	15.1	14.9	15.2	15.1	17.8	15.1	18.2	18.1	15.5	17.1	17.2	21.9	20.0
1917	27.9	27.5	27.0	30.0	30.3	26.8	29.1	30.5	30.1	32.4	28.8	31.0	29.8
1918	14.8	15.9	14.9	16.1	18.5	16.5	16.3	15.1	17.1	15.7	16.5	16.3	16.0
1919	21.1	21.3	22.3	25.0	26.1	22.5	23.3	25.0	22.3	23.8	23.0	22.5	24.0
1920	23.9	22.1	23.3	25.5	28.4	22.4	25.5	25.2	26.6	24.0	25.1	25.3	24.4
1921	34.6	37.2	36.2	41.5	45.6	37.8	36.9	45.0	35.3	36.1	34.7	38.1	40.7
1922	11.3	12.5	11.5	13.1	14.1	12.5	13.6	13.2	12.3	13.3	12.2	12.3	13.6
1923	22.9	26.0	25.3	30.3	35.0	24.0	27.0	28.8	25.3	27.0	27.3	26.8	26.1
1924	20.8	20.3	21.5	22.1	23.6	20.2	20.4	22.3	20.9	20.1	21.4	21.3	20.4
1925	31.1	32.7	38.2	38.9	49.7	36.1	38.9	43.2	32.6	37.5	32.8	34.0	35.2
1926	37.0	36.8	37.9	39.3	39.6	36.6	36.8	39.0	37.0	37.3	37.8	38.6	39.9
1927	16.5	18.1	19.8	22.2	23.3	17.0	18.0	20.6	17.5	18.0	19.3	19.3	18.8
1928	26.4	26.0	29.5	33.2	35.1	29.6	33.5	33.0	26.2	27.1	27.5	30.8	30.5
1929	21.1	21.6	23.1	25.8	26.0	21.8	24.6	28.7	22.7	21.3	22.5	21.0	22.7
1930	20.3	22.6	25.0	24.2	21.5	24.2	25.0	24.0	21.3	20.0	20.0	23.5	23.3
1931	24.7	23.3	27.3	25.1	21.6	26.3	23.1	29.2	25.3	25.3	26.0	24.8	25.3
1932	18.0	17.5	19.6	22.0	25.8	21.6	22.6	22.9	18.3	17.8	17.6	20.6	19.1
1933	18.0	19.0	19.6	19.5	19.3	19.3	21.6	19.6	19.1	17.8	17.1	17.3	18.0
1934	19.7	19.3	18.7	19.1	20.7	19.7	19.6	19.0	20.0	19.3	15.5	16.8	17.0
1935	21.2	22.4	22.9	20.3	16.6	22.6	21.8	20.3	20.3	19.7	20.8	21.6	19.5
1936	14.9	16.5	15.3	20.5	24.0	18.3	20.5	20.7	16.5	16.6	13.5	15.1	16.1
1937	24.7	26.4	25.5	28.4	29.6	25.1	26.2	27.8	25.5	25.7	25.3	25.6	25.6
1938	35.0	35.5	36.1	36.8	33.2	35.1	34.3	35.2	37.1	34.3	35.3	32.8	36.8
1939	13.1	13.3	13.3	14.1	15.3	14.5	14.6	14.0	13.8	13.4	13.5	13.4	12.0
1940	32.8	32.1	34.8	38.3	36.8	39.5	43.1	41.5	29.0	29.3	32.6	35.0	33.6
1941	26.2	28.3	31.7	36.8	45.0	27.8	31.0	38.7	25.5	28.8	26.1	28.8	33.6
1942	22.5	19.8	25.4	23.2	15.6	21.7	23.6	21.5	19.3	22.6	23.0	22.6	18.8
1943	22.3	24.2	24.3	27.3	23.2	23.0	23.6	25.5	22.1	21.1	22.2	24.5	23.3
1944	27.3	25.6	31.9	34.0	35.3	32.6	34.0	38.6	26.9	26.8	28.1	29.0	28.5
1945	21.5	25.1	27.8	32.5	33.0	22.6	25.8	33.3	21.5	23.0	23.4	23.3	23.1
1946	28.0	28.1	30.3	28.6	26.0	33.5	33.1	30.6	28.0	26.0	27.0	28.1	27.8
1947	27.3	22.5	32.3	34.6	44.3	33.0	33.7	40.3	28.0	26.7	27.2	25.3	31.5
1948	21.6	19.3	23.0	23.0	25.5	23.5	24.5	24.8	20.3	20.3	22.0	21.5	23.0
1949	24.4	27.6	28.3	34.3	30.5	26.1	29.3	31.7	22.9	23.0	23.8	25.8	26.1
Avg.	22.8	23.2	24.8	26.6	27.7	24.6	25.9	27.4	23.3	23.5	23.4	24.2	24.4

Key to treatments:

a — no manure
b — 1 ton manure per acre every 2 years
c — 2½ tons manure per acre every 2 years
d — 5 tons manure per acre every 2 years
e — 10 tons manure per acre every 2 years
f — 2½ tons manure per acre every 4 years
g — 5 tons manure per acre every 4 years
h — 10 tons manure per acre every 4 years
i — 2½ tons manure per acre in 1915 — none subsequently
j — 5 tons manure per acre in 1915 — none subsequently
k — 10 tons manure per acre in 1915 — none subsequently
l — 15 tons manure per acre in 1915 — none subsequently
m — 20 tons manure per acre in 1915 — none subsequently

Table 15. *Winter wheat yields on Nephi Station with different methods of stubble disposal, alternate winter wheat, summer fallow system* 1916-1953, *inclusive*

	Treatment				
Year	Binder harvest straw returned plowed under	Grain headed long straw plowed under	Binder harvest straw removed stubble plowed	Binder harvest straw returned burned	Grain headed long straw burned plowed
			bushels per acre		
1916	11.1	10.8	14.4	12.6	10.9
1917	22.7	25.6	24.2	24.4	26.1
1918	20.2	18.2	17.8	20.5	17.1
1919	20.7	23.4	22.2	21.7	25.3
1920	28.6	27.6	25.5	29.0	26.1
1921	39.2	40.9	39.5	40.8	42.7
1922	14.2	14.7	13.8	16.3	15.1
1923	19.2	21.3	19.6	22.0	25.0
1924	20.4	19.7	18.1	20.2	19.8
1925	30.4	32.7	31.4	30.3	32.7
10 yr.	22.7	23.5	22.6	23.8	24.1
avg.	23.1			24.0	
1926	44.9	48.3	45.6	46.1	49.3
1927	16.0	17.1	15.3	17.6	18.3
1928	22.0	22.8	22.0	24.9	24.2
1929	19.1	20.1	18.1	18.7	21.1
1930	23.8	24.8	21.2	25.2	23.6
1931	21.4	24.1	22.6	22.4	24.9
1932	18.8	18.6	16.7	19.1	18.6
1933	14.8	12.9	13.9	12.6	13.5
1934	15.0	14.2	14.8	16.6	14.6
1935	19.4	19.8	19.3	20.4	19.2
10 yr.	21.5	22.3	21.0	22.4	22.7
avg.	21.9			22.6	
1936	19.4	18.8	14.9	18.0	15.4
1937	19.4	19.9	19.0	20.2	20.8
1938	33.4	31.6	31.3	33.2	32.8
1939	12.6	13.0	12.8	11.7	13.2
1940	26.2	28.0	29.8	28.2	32.8
1941	30.5	31.6	30.6	32.1	31.0
1942	29.0	31.0	28.3	29.0	32.6
1943	20.6	21.6	21.5	19.5	21.0
1944	22.2	24.4	28.4	25.6	28.2
1945	19.0	19.0	20.8	18.9	21.4
10 yr.	23.2	24.0	23.7	23.6	24.2
avg.	23.6			23.9	
1946	22.7	22.1	24.6	23.0	24.4
1947	23.0	26.6	25.1	26.4	28.4
1948	19.8	20.8	17.3	17.8	18.9
1949	17.7	17.2	20.9	18.9	19.1
1950	24.2	21.8	21.2	23.4	21.2
1951	26.2	26.0	26.5	25.8	24.4
*					
1953	12.7	11.8	12.4	11.7	10.6
7 yr.	20.9	20.9	21.2	21.0	20.7
avg.	20.9			20.8	
37 yr.	22.2	22.8	22.2	22.8	23.4
avg.	22.5			23.1	

*No data obtained in 1952.

Table 16. *Crop yields by treatments and years, all rotations, Nephi Station,* 1904-1953

	Yield per acre								
Year	Alternate fallow	Wheat after row crop oats, peas or corn	Cont. wheat all plots	Wheat in rot. with alfalfa all rots.	Potatoes after grain all rots.	Corn fodder preced-ing grain	Peas after grain	Peas forage after grain	Alfalfa all rots.
	bu.	*bu.*	*bu.*	*bu.*	*bu.*	*tons*	*bu.*	*tons*	*tons*
1904	24.5		17.7						
1905	16.9		08.1						
1906	35.6		17.9						
1907	37.7		16.5						
1908	26.9		13.4				3.7		
1909	06.9	03.7	14.6		84.7	0.62	0.0	.52	
1910	16.2	18.0	06.7		07.3	0.02	0.0	.02	
1911	29.7	30.0	05.7		04.0	0.02	0.0	.00	
1912	16.2	18.4	06.0		32.4	0.71	1.5	.16	
1913	05.7	06.5	04.5		34.5	0.37	0.4	.06	
1914	42.5	40.6	24.0		51.2	1.66	0.6	.09	
1915	27.0	32.1	12.8		25.7	1.04	4.2	.42	
1916	16.0	17.1	08.3	14.1	27.2	0.60	2.5	.30	1.00
1917	26.5	24.2	16.5	18.0	25.3	0.74	4.2	.44	1.26
1918	15.8	16.5	11.4	10.0	24.7	0.57	5.9	.50	1.34
1919	19.9	07.7	02.0	03.9	00.0	0.00	0.0	.00	.86
1920	24.8	20.3	13.7	10.5	09.4	0.27	5.3	.47	.88
1921	37.1	29.4	16.1	15.4	27.9	0.65	5.0	.57	1.08
1922	13.8	13.7	07.2	10.3	45.2	0.60	5.5	.49	1.29
1923	22.5	24.4	14.0	20.4	39.3	0.67	5.1	.44	1.18
1924	20.4	16.2	07.0	04.4	03.1	0.23	1.1	.23	.40
1925	30.1	31.7	20.4	30.0	30.4	1.65	5.5	1.07	1.73
1926	42.9	22.5	05.2	02.4	06.2	0.74	1.8	.44	1.00
1927	17.0	18.8	05.0	09.5	49.9	0.55	4.7	.42	.84
1928	26.3	24.4	05.2	06.3	03.8	0.22	1.4	.40	.57
1929	18.0	15.3	05.3	03.2	30.9	1.55	5.4	1.02	.39
1930	21.6	18.8	03.5	03.8	78.1	1.19	4.7	.74	.54
1931	22,3	05.7	07.0	01.1	00.0	0.16	0.4	.26	.17
1932	18.1	22.3	10.1	13.3	24.9	0.58	2.7	.50	.66
1933	16.2	13.6	08.3	02.8	11.2	0.56	1.5	.31	.47
1934	16.9	07.6	03.5	13.5	00.0	0.00	0.0	.00	
1935	21.4	17.5	11.2	28.7	26.8	0.19	1.4	.37	.76
1936	16.1	21.5	08.3	19.2	39.2	0.44	7.9	.95	.82
1937	22.7	20.9	15.5	17.3	26.5	0.67	2.9	.71	.20
1938	33.2	23.5	11.5	08.8	26.7	0.40	2.6	.64	.86
1939	13.3	11.2	02.4	03.2	06.7	0.13	1.1	.31	.30
1940	30.1	30.0	16.4	13.7	06.2	0.26	2.8	.50	.94
1941	28.4	36.6	14.2	28.8	25.1	2.87	3.6	.70	1.53
1942	26.3	15.9	14.5	17.5	00.0	0.00	0.0	.00	.74
1943	21.5	21.3	02.5	19.3	04.2	0.50	3.9	.76	.43
1944	26.5	21.1	10.7	30.2	18.6	0.72	3.8	.61	1.62
1945	22.1	21.1	03.7	10.5	54.1	1.28	5.0	.43	.52
1946	24.8	16.5	06.8	03.5	16.8	0.66	3.1	.30	.20
1947	26.6	27.1	05.8	33.3	05.3	0.57	6.0	1.46	.35
1948	20.7	18.0	04.7	13.7	00.0	0.02	3.9	.12	.70
1949	22.4	25.6	08.5	16.8	09.6	0.03	4.3	.13	.92
1950	21.4								
1951	27.4								
1952	02.5		02.3						
1953	12.8								

Table 17. *Crop yields by treatments and years, all rotations, Nephi Station,* 1916-1949, *inclusive*

	Yield per acre			
Year	Potatoes after fallow	Corn fodder after fallow	Peas after fallow	Peas fodder after fallow
	bushels	*tons*	*bushels*	*tons*
1916	32.1	0.30	3.0	0.29
1917	31.7	0.82	4.7	0.54
1918	33.3	0.36	6.4	0.58
1919	00.0	0.00	0.0	0.00
1920	10.0	0.36	5.3	0.44
1921	16.8	0.63	5.3	0.68
1922	32.0	0.23	2.5	0.41
1923	10.7	0.60	5.2	0.53
1924	09.0	0.12	0.7	0.16
1925	16.8	0.96	7.0	1.08
1926	07.3	0.36	1.9	0.48
1927	22.5	0.13	3.7	0.34
1928	06.7	0.18	3.5	0.50
1929	40.0	0.88	4.3	0.92
1930	39.0	0.26	4.6	0.68
1931	00.0	0.09	0.8	0.28
1932	13.2	0.10	2.5	0.38
1933	05.8	0.30	2.0	0.35
1934	00.0	0.00	1.7	0.21
1935	15.8	0.31	1.7	0.38
1936	12.5	0.28	3.0	0.28
1937	05.8	0.14	4.8	0.72
1938	20.6	0.04	2.8	0.54
1939	09.7	0.02	1.1	0.46
1940	02.0	0.03	2.5	0.38
1941	06.7	0.80	3.2	0.72
1942	00.0	0.00	0.0	0.00
1943	00.0	0.36	3.3	0.70
1944	04.2	0.15	2.0	0.65
1945	19.5	1.26	6.0	0.59
1946	03.5	0.13	2.5	0.28
1947	03.7	0.00	4.0	0.96
1948	00.0	0.02	5.0	0.15
1949	07.5	0.01	3.0	0.09

1 plot per year