TECHNICAL BULLETIN 39 FEBRUARY 1957

Longtime Tillage Experiments On Eastern Oregon Wheat Land

Merrill M. Oveson
William E. Hall

Agricultural Experiment Station, Oregon State College and the Agricultural Research Service, U.S. Department of Agriculture, Cooperating.

Contents

AUTHORS: Merrill M. Oveson, Superintendent, Pendleton Branch Experiment Station, and Agronomist, Soil and Water Conservation Research Branch, ARS, USDA, Pendleton, Oregon; and William E. Hall, Superintendent, Sherman Branch Experiment Station, Moro, Oregon.

ACKNOWLEDGMENTS: Tillage experiments reported in this bulletin were conducted by J. J. C. Umberger, David E. Stephens, and G. A. Mitchell. Robert B. Hoskinson and William R. DeWitt, Farm Foremen at the Sherman and Pendleton Branch Experiment Stations, were largely responsible for farm operations.

Longtime Tillage Experiments On Eastern Oregon Wheat Land

Introduction

Settlers began pioneering the wheat-producing area of eastern Oregon about 1860. Early operations were primarily in connection with livestock enterprises. Wheat farming did not assume major prominence until about 1880. With wheat becoming a major crop, problems on cultural practices, along with many others, soon presented themselves.

In 1911, experiments were established at the Sherman Branch Experiment Station near Moro*, Oregon to determine the effect of different tillage treatments on yield and quality of wheat.

To sample the area more fully, similar tillage experiments were established at the Pendleton Branch Experiment Station in 1930. This station is located in the higher rainfall area of the Columbia Basin. Soils there are more productive and average wheat yields higher than at Moro.

This bulletin presents the data from these longtime tillage experiments. Data from the tillage experiments at the Sherman Station up to and including 1929 were reported by David E. Stephens, H. M. Wanser, and Aaron F. Bracken in U.S. Department of Agriculture Technical Bulletin 329.

In later years other tillage treatments, which include stubble mulch in the tillage practice, were introduced at both stations. Methods of handling wheat stubble as a protective mulch against wind and water erosion are being studied. These experiments also include the use of nitrogenous fertilizers, and give data on the interaction of nitrogen fertilizer with tillage methods. The results will be reported by the authors in another bulletin.

Description of the Problem

Tillage problems of the wheat farmer can be broken into three classifications: (1) preplowing, (2) plowing, and (3) postplowing. First, it must be determined how best to get the field and crop residue in condition to plow. One must know what practices will allow the

* Hereafter in this paper the location designating Moro is employed for the Sherman Branch Experiment Station. Pendleton is used synonymously with Pendleton Branch Experiment Station.

greatest moisture penetration during the first winter following the crop, and what measures are needed to control volunteer wheat and weed growth to prevent depletion of moisture and plant food during the fallow season.

At plowing time there are questions on method, depth, and time of plowing. The farmer must prepare a fallow that will conserve moisture and allow nitrification to increase available nitrogen in the soil.

After plowing, methods of cultivation must conserve moisture and nitrates. The fallow must be a suitable seedbed when finished. The problem of controlling weeds by cultivation after seeding is sometimes presented.

At all times the farmer must be aware of the danger of erosion by wind and water. Some practices may be dictated by this danger. Finally, he must consider the economic value of each practice; whether it will increase the yield of wheat sufficiently to pay for the operation.

Description of the Stations

The altitude at Pendleton is approximately 1,400 feet, and at Moro approximately 1,800 feet.

Soils

The soil at Pendleton is classified as Walla Walla silt loam. The area on which these experiments were conducted is almost flat with slopes ranging from 0 to 3 per cent, and soil depth from 4 to 6 feet. These soils will hold approximately 20 per cent moisture. Wheat crops will reduce this to about 8 per cent. The soils are representative of a large agricultural area located mostly in Umatilla County.

The soil at Moro is a very fine sandy loam, also of the Walla Walla series, but classified as Walla Walla light phase. This soil is lighter in texture and a little lower in organic matter and nitrogen than that at Pendleton. The area on which the experiments were conducted has a slope of from 3 to 5 per cent, and a soil depth of 4 to 8 feet over the entire area. These soils will hold approximately 14 per cent moisture. The wheat crop will reduce this to approximately 6 per cent.

Climatic data

Precipitation. Table 1 shows average precipitation by months and total annual average precipitation at Pendleton and Moro. At Pendleton the data are shown for the years 1929 to 1954, inclusive, and at Moro for the years 1910 to 1954, inclusive. During this time, precipitation at Pendleton varied from a low of 10.57 inches in 1935 to a high of 21.85 inches in 1950. At Moro the low was 6.43 inches in 1939, and the high was 17.33 inches in 1953. Table 1 also shows the average rainfall by months for the years of record at each of the stations. Table 1 of the Appendix shows the annual rainfall by crop years and growing seasons for the entire period at each station.

Table 1. AVERAGE MONTHLY AND ANNUAL PRECIPITATION AT PENDLETON AND MORO

Month	Average precipitation		Month	Average precipitation	
	Pendleton 1929-1954	Moro 1910-1954		Pendleton 1929-1954	Moro 1910-1954
	Inches	*Inches*		*Inches*	*Inches*
January	1.80	1.70	July	.26	.18
February	1.55	1.26	August	.23	.20
March	1.63	.88	September	.61	.66
April	1.47	.75	October	1.41	1.01
May	1.24	.80	November	1.73	1.71
June	1.63	.74	December	2.11	1.65
			Total	15.67	11.54

Evaporation. Table 2 shows the evaporation from a free water surface at both Pendleton and Moro for the months April through September. These records have been maintained at Moro since 1911 and at Pendleton since 1930.

Table 2. AVERAGE MONTHLY EVAPORATION FROM A FREE WATER SURFACE AT PENDLETON AND MORO

Month	Average evaporation		Month	Average evaporation	
	Pendleton 1930-1954	Moro 1911-1954		Pendleton 1930-1954	Moro 1910-1954
	Inches	*Inches*		*Inches*	*Inches*
April	3.59	4.31	July	8.56	9.74
May	5.25	6.26	August	7.64	8.36
June	5.96	7.54	September	4.71	5.08
			Total	35.71	41.29

Temperature. The mean monthly temperature at Moro for 44 years and at Pendleton for 26 years is shown in table 3.

Table 3. AVERAGE MEAN TEMPERATURE, BY MONTHS, AT MORO AND PENDLETON

Month	Average mean temperature		Month	Average mean temperature	
	Moro 1911-1954	Pendleton 1929-1954		Moro 1911-1954	Pendleton 1929-1954
	Degrees F.	*Degrees F.*		*Degrees F.*	*Degrees F.*
January	30	30	July	69	70
February	34	36	August	68	69
March	42	44	September	60	60
April	48	50	October	50	49
May	55	57	November	39	39
June	61	62	December	32	36

The average frost-free period for the 44 years records have been kept at Moro is 148 days, with the shortest frost-free period occurring in 1921 with 107 days and the longest in 1955 with 211 days. May 10 is the average date for the last frost in the spring, and October 5 is the average date for the first frost in the fall. The average frost-free period at Pendleton for the 26 years of record is 128 days, with the shortest frost-free period occurring in 1949 with 74 days, and the longest frost-free period occurring in 1943 with 166 days. May 21 is the average date of the last frost in the spring, and September 27 is the average date for the first frost in the fall.

Methods and Materials

Tillage experiments at both stations have included the following treatments:

- Disking stubble in the fall.
- Disking stubble in early spring.
- Different dates of plowing.
- Different depths of plowing.
- Preparation of fallow with the double disk and with the one-way disk plow.
- Different methods of cultivating the summer fallow following plowing.

The plots at both stations on which these experiments were conducted were one-tenth acre (33 by 132 feet) in size. Plots were separated by an alley of 4½ feet at Moro and 5 feet at Pendleton. Prior to 1944, all plots at Moro were harvested by cutting with a binder and threshing with a stationary thresher. By this method nearly all wheat straw was removed from the plots each year. After 1944 the plots were harvested with a small self-propelled combine. At Pendleton the plots were always harvested with a small combine, thereby leaving all wheat straw on the land. Conventional equipment was used to perform tillage operations on all plots. The work was completed in season unless designated differently by the experiment. No nitrogen or other fertilizers were used at any time on the experiments reported.

Moving averages have been selected as the best means of presenting yield data from comparable treatments. These averages are determined for the initial 10-year or 5-year periods of the experiments. Then by dropping the yield of the first year and adding the yield of the succeeding year, a new average is determined. By continuing this process a series of 10-year and 5-year moving averages is established. This reflects the trend in wheat yields resulting from a tillage practice, and minimizes yearly fluctuation. Since approximately 40 years' data are available at Moro, 10-year moving averages were selected for this station. At Pendleton, 22 years data are presented and 5-year moving averages were used.

When these experiments were established, replication of treatments was not considered except through the combination of a given practice with several other practices. It is therefore not possible to analyze these data by the analysis of variance method. It is believed the number of years covered by these experiments somewhat overcomes the lack of replication.

All data presented in this bulletin are given in detail in tables appearing in the Appendix.

Treatment of Land Before Plowing

Fall disking

This treatment was set up at Pendleton to compare the effects on wheat yields of duplicate fall-disked plots with plots not disked. All other tillage operations on these plots were the same. Rex M1 winter wheat was grown during the period of this experiment.

At Moro, data on effects of fall disking were taken from single adjacent plots superimposed on plots of date-of-plowing and depth-of-plowing treatments. Turkey red winter wheat was grown throughout the experiment. All plots were plowed with a moldboard plow, and the summer tillage practices were the same on comparable treatments.

Spring disking

At Pendleton, duplicate plots were disked in the early spring before plowing to compare with plots not disked. In this experiment, it was possible to compare fall disking with spring disking, and each of these with a nondisked treatment. The same tillage methods were applied to summer fallow, and the same variety of wheat was grown on all treatments.

At Moro, the fall and spring stubble disking variables were superimposed on certain plots of the series plowed in April and in June in the date-of-plowing experiments. Prior to 1936, data on effects of disking stubble were obtained from single plots; after 1936, effects were measured on 3 plots plowed at each date.

Burning stubble

Stubble burning was introduced at Pendleton in 1938 as a variable on single plots in the date-of-plowing (fall, early spring, medium early spring, late spring) and depth-of-plowing (5 inches and 9 inches) experiments. Straw was burned on 8 plots and effects on yields were compared on these and 8 plots on which stubble was not burned. Tillage treatments were uniform.

At Moro, effects of straw burning before plowing were compared with those of plowing the straw under. Treatments were compared on duplicate adjacent plots, similarly tilled. From 1923 to 1944, wheat on these plots was harvested with a binder and threshed, then the straw was returned and distributed evenly over the plots.

Plowing

Experiments were established at each station to determine the best date and depth of plowing for summer fallow. Rex M1 winter wheat and Turkey red winter wheat were grown on the depth-of-plowing and date-of-plowing experiments at Pendleton and Moro, respectively.

Depth of plowing

Two depths of plowing were used at each station. At Moro, plowing depths were 5 inches and 10 inches, each depth being employed on 8 plots. Eight tillage practices, which were applied before plowing or to the summer fallow following plowing, were superimposed on the 8 plots of each plowing depth.

At Pendleton, the experiment included 20 plots, 10 plowed 5 inches deep, and 10 plowed 9 inches deep. Superimposed on these 20 plots were 4 dates of plowing and 3 methods of handling the land before and after plowing.

Data given were first obtained at Moro in 1914, at Pendleton in 1934, and were secured each year until 1954 and 1955, respectively. Yields presented are from all plots plowed at the designated depths.

Dates of plowing

Wheat yields were obtained from 4 dates of plowing at the Pendleton Station. These included fall plowing (October 15), early spring plowing (March 15), medium early spring plowing (April 15), and late spring plowing (June 15). There were 20 plots in this experiment, 4 plowed in the fall, 6 in the early spring, 6 in the medium early spring, and 4 in the late spring.

At Moro, the experiment included 3 dates of plowing: early spring (April 1), medium early spring (May 1), and late spring (June 1). The experiment included 24 plots, 8 plowed on the early date, 8 on the medium early date, and 8 on the late date. After 1936, 9 plots were used for each of the 3 plowing dates.

Disking vs. moldboard plowing

This experiment included 12 plots: 4 plowed with the moldboard plow, 4 with the one-way disk plow, and 4 with the double disk. After 1941, only 2 plots were used for the double disk part of this experiment. In another experiment in which similar comparisons were made, another factor was introduced. The land was chiseled in the fall and double disked in the spring in preparation for fallow. In this experiment the treatments were on duplicate plots. Comparisons were made among four fallow preparations: moldboard plowed in early spring, one-way disked in fall and spring, double disked fall and spring, chiseled in fall and double disked in spring.

At the Sherman Station two plots were used for this experiment, one disked for fallow and the other plowed for fallow.

Cultivation of Summer Fallow

Harrowing and weeding summer fallow

After the land had been plowed in the spring, several cultivation practices were applied throughout the summer fallow season. These practices included (1) immediate spike tooth or spring tooth harrowing, (2) surface or subsurface packing, (3) no cultivation at all, and (4) delayed cultivation; that is, allowing the land to lie 30 days before the first cultivation.

All these practices, except no cultivation, were followed by weeding with a rod weeder. On the noncultivated plots, weeds were allowed to grow and then were removed with a hoe before going to seed. These plots were given one tillage preparation before seeding.

At Moro, the practice of harrowing immediately following plowing was compared to the no cultivation and the delayed cultivation treatments. Average yields for each tillage treatment were obtained from four plots that were part of the date-and-depth-of-plowing experiments.

At Pendleton, the two practices followed were immediate cultivation after plowing, and delayed cultivation after plowing. As at Moro in the delayed cultivation, the land was allowed to lie for 30 days before any tillage operation was applied. Four plots of each cultivation treatment were used for comparative yield data in this experiment. In all cases the rod weeder was used later in the season. At both Moro and Pendleton, these tillage practices were superimposed on the date-and-depth-of-plowing experiments.

Packing after plowing

Two methods of packing the fallow after plowing were compared on certain plots in the depth-of-plowing experiment at Moro. Both the Dunham packer which packs the surface and the Campbell packer which packs the subsurface of the fallow were used.

Single plots plowed at two depths were treated in this manner for the duration of the experiment (1914 to 1954). Average wheat yields resulting from treatments at the two depths have been used to compare effects of the different packing methods.

Harrowing Winter Wheat in the Spring

At Pendleton, wheat yields from plots harrowed in the spring and yields from plots not harrowed were compared. These were duplicate plots from the depth-of-plowing experiment. The spike tooth harrow was used from 1914 until 1952. After 1952 a Dunham rotary hoe was used. This experiment was not carried on at Pendleton.

Results

Treatment of Land Before Plowing

Fall disking

Figure 1 shows the yields of winter wheat at Pendleton, by 5-year moving averages, on plots where stubble was disked in the fall and not disked in the fall. The 22-year average yield for each tillage treatment also is shown. Plots not disked averaged 2.7 bushels per acre more than plots disked. No 5-year period showed a higher yield for disked land than for nondisked land, and the curve indicates a reasonable degree of consistency of the difference between the two methods. Annual and average yields obtained from this experiment are given in table 2 of the Appendix.

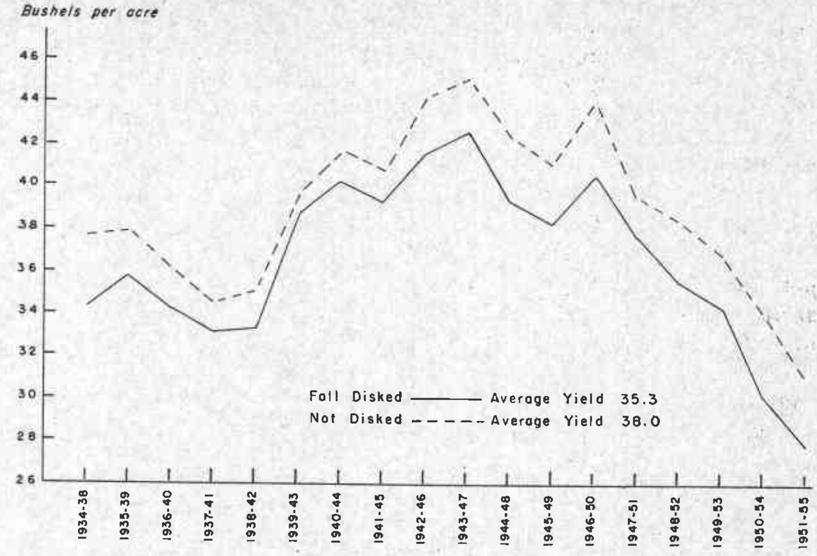

Figure 1. Yield of winter wheat by 5-year moving averages, on land fall disked and not disked, Pendleton.

Plots not disked in the fall had a 42-year average yield 0.7 of a bushel higher than fall-disked plots at Moro. This, and the 10-year moving averages of wheat yields from this experiment, are shown in figure 2. Annual and average yields of wheat from this

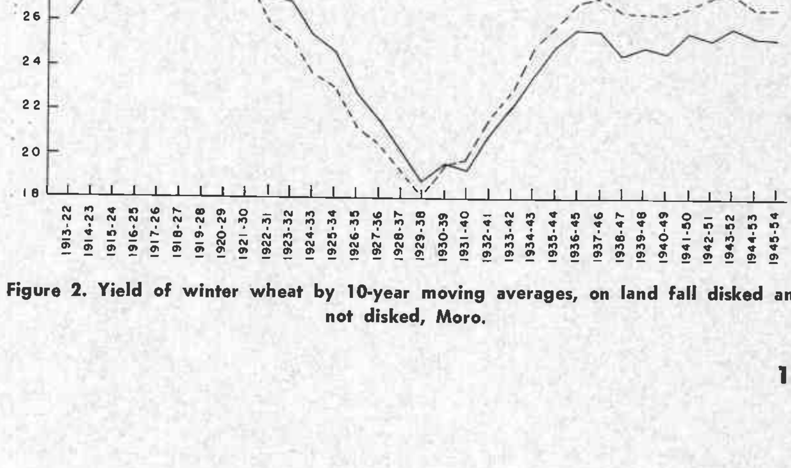

Figure 2. Yield of winter wheat by 10-year moving averages, on land fall disked and not disked, Moro.

experiment are shown in appendix table 3. As shown in figure 2, nondisked plots were higher yielding during years when yields were high, but from 1928 to 1938 when the 10-year average was declining, fall-disked plots were slightly higher yielding at Moro.

Spring disking

Figure 3 shows wheat yields on land disked in the spring before plowing, and not disked, at Pendleton. The 22-year average yields for the two methods are also given. This average yield is 1.5 bushels per acre in favor of the nondisked plots. The yield spread between spring disking and nondisking is not nearly as wide as in the case of fall disking. For the early years there was no difference in wheat yields. Again for the period 1946 to 1951, yields on the disked plots were equal to yields on nondisked plots. During most years the nondisked plots produced higher yields than the disked plots. Annual and average yields for the fall-disked, spring-disked, and nondisked plots are given in table 2 of the Appendix.

Spring disking has been advantageous at Moro only when land was plowed as late as June 1, as shown in figure 4. The 42-year average yield of wheat from spring-disked, April-plowed plots is 1.9 bushels lower than from nondisked, April-plowed plots. Spring disking of land plowed as late as June 1 gave a 42-year average yield increase of 4.7 bushels over land not spring disked. Annual and average yields of winter wheat from this experiment are shown in table 4 of the Appendix.

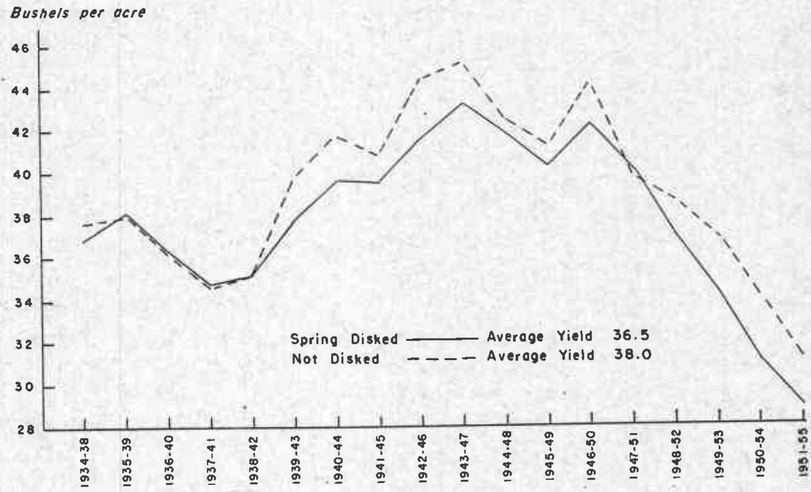

Figure 3. Yield of winter wheat by 5-year moving averages, on land spring disked and not disked, Pendleton.

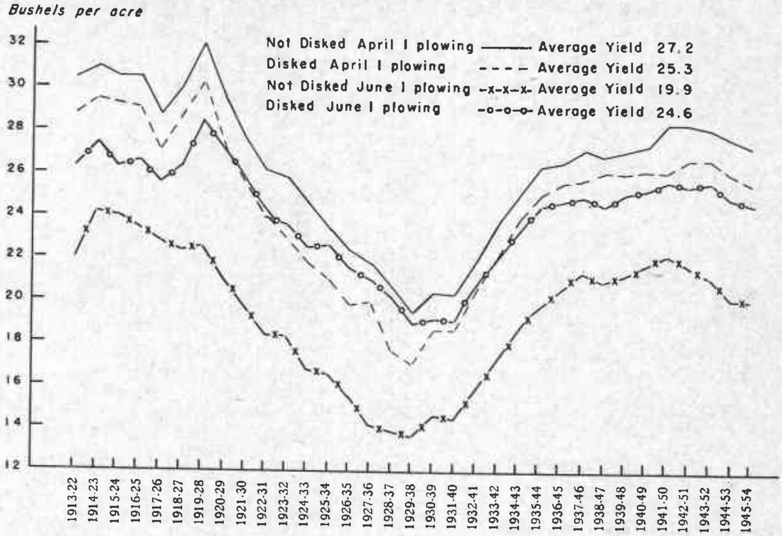

Figure 4. Yield of winter wheat by 10-year moving averages by time of disking, Moro.

Burning stubble

The 18-year results from burning wheat stubble at Pendleton are shown in figure 5. Yield differences between burned and nonburned plots were as much as 4 bushels per acre in the early years of the experiment. This spread in yield narrowed consistently as the experiment progressed, until the average yield on nonburned plots for the last 5 years has been equal to that on burned plots. For the 18-year period, the average wheat yield on burned plots has been 2.1 bushels per acre higher than on nonburned plots. Appendix table 5 gives annual and average wheat yields for this experiment over the years it was conducted.

At Moro, plots on which the straw has been utilized have a 32-year average yield 0.9 bushel greater than plots on which the straw has been burned. The 10-year moving averages for the yield of wheat from this experiment are shown in figure 6, and the 32-year annual and average yields are shown in appendix table 6. The 10-year moving averages show an almost steady increase in yield during this experiment. This is especially true when the yields after 1940 began appearing in the averages. Above average rainfall after 1940 was an important factor in the increasing yields of wheat.

During the earlier part of the experiment, plots utilizing the straw were much higher yielding than those on which the straw was burned. During the latter part of the experiment, when yields were

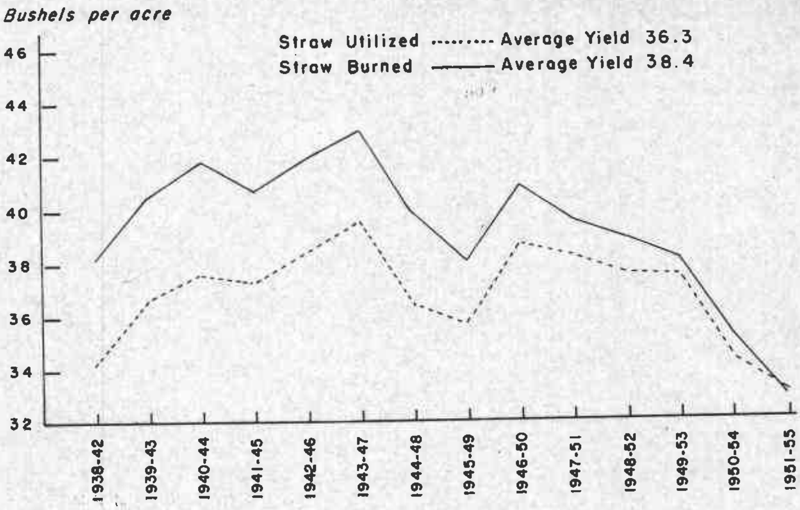

Figure 5. Yield of winter wheat by 5-year moving averages, on land with straw burned or utilized, Pendleton.

increasing, this was not true. During the last five 10-year periods, wheat yields from plots on which the straw was burned have been slightly higher than from plots on which the straw was utilized.

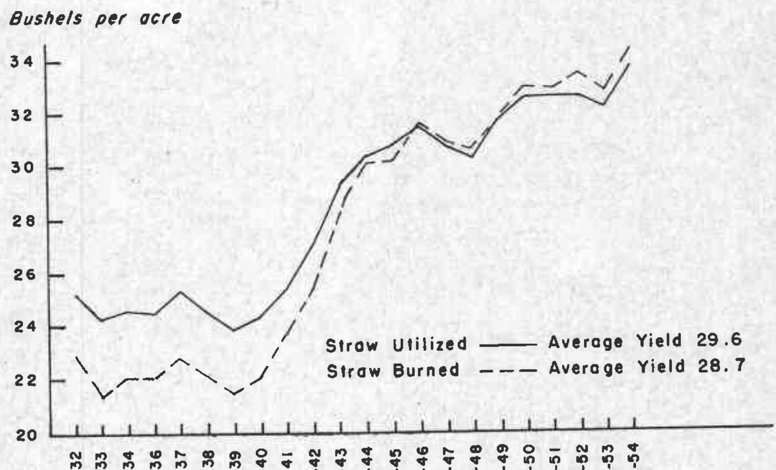

Figure 6. Yield of winter wheat and spring wheat by 10-year moving averages on land where all the straw was burned or utilized, Moro.

Plowing

In the date-and-depth-of-plowing experiment at Pendleton, depth of plowing is superimposed on date of plowing, and methods of handling the land before and after plowing are superimposed on both date and depth of plowing.

In table 4 the 18-year average yields from each tillage method are shown. These data show that: (1) deep plowing has been superior to shallow plowing on all dates; (2) early spring plowing has been superior to either fall plowing or plowing on or after April 15; (3) burning stubble has been better, yieldwise, than plowing it under on all dates and depths of plowing; and (4) delaying the cultivation following plowing has produced just as high wheat yields on deep-plowed land and practically as high yields on shallow-plowed land as immediate clean cultivation. Detailed data and discussion for each of these practices follow.

Table 4. Average Yields of Rex M1 Winter Wheat Grown on Date-and-Depth-of-Plowing Experiments at Pendleton

Treatment of fallow	Date of plowing				Average of four plowing dates
	Oct. 15	Mar. 15	April 15	May 15	
	Bu./acre	*Bu./acre*	*Bu./acre*	*Bu./acre*	*Bu./acre*
Shallow plowing (5 inches)					
Stubble burned, immediate cultivation	39.0	39.8	37.3	35.6	37.9
Stubble returned, immediate cultivation	36.5	37.2	35.3	32.9	35.5
Stubble returned, delayed cultivation	......	36.4	34.6	......	......
Average, stubble burned and stubble returned	37.8	38.5	36.3	34.3	36.7
Deep plowing (9 inches)					
Stubble burned, immediate cultivation	40.1	41.0	38.1	36.8	39.0
Stubble returned, immediate cultivation	37.7	38.6	37.1	34.7	37.0
Stubble returned, delayed cultivation	......	38.7	36.8	......	......
Average, stubble burned and stubble returned	38.9	39.8	37.6	35.8	38.0
Average, deep and shallow plowing	38.4	39.2	37.0	35.1	37.4

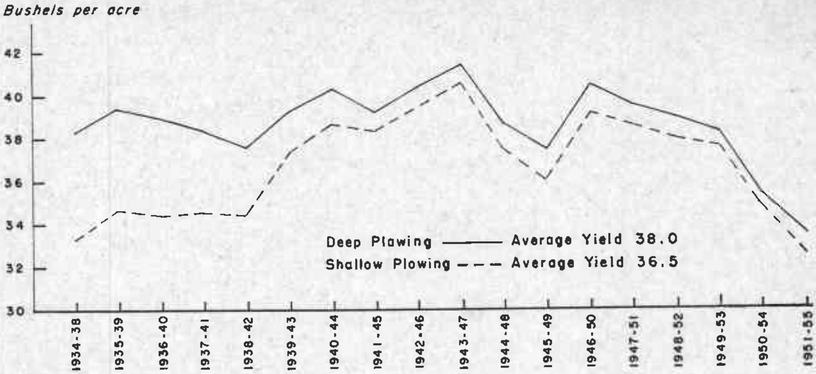

Figure 7. Yield of winter wheat by 5-year moving averages, on land plowed deep (9 inches) and shallow (5 inches), Pendleton.

Depth of plowing

At Pendleton, plots plowed 9 inches deep for fallow consistently produced higher yields than plots plowed 5 inches deep. The difference, however, is much narrower during the late years of the experiment. Figure 7 shows the 5-year moving average curve. During the first years the difference was as much as 5 bushels per acre for a 5-year period. During later years this difference has been greatly narrowed with 5-year average yield differences being as little as 0.6 bushel per acre. For the 22 years of data, deep-plowed plots

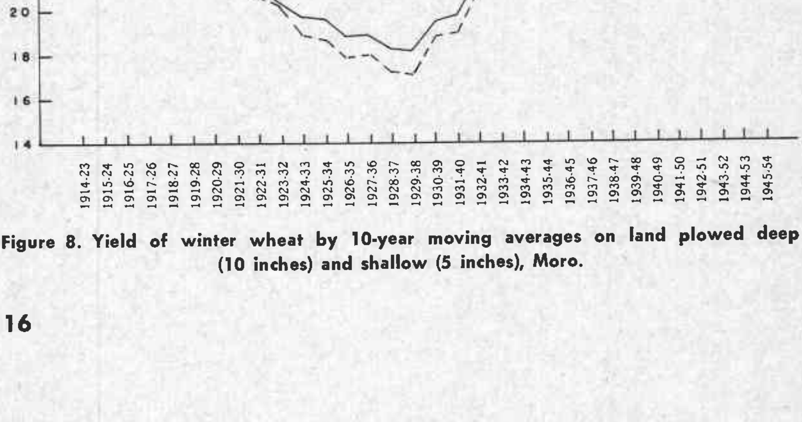

Figure 8. Yield of winter wheat by 10-year moving averages on land plowed deep (10 inches) and shallow (5 inches), Moro.

have averaged 2.1 bushels per acre more than shallow-plowed plots. The 22-year annual and average yields for this experiment are given in appendix table 7.

Yields of winter wheat in the depth-of-plowing experiment at Moro differ by only .5 of a bushel for the 41-year period, with the deep plowing yielding higher. Figure 8 shows winter wheat yield by 10-year moving averages for this experiment. The 10-year moving averages show a slight advantage for deep plowing, except for the three 10-year periods which include the years 1943 to 1945 when the shallow-plowed plots were slightly higher yielding. Annual and average yields are presented in appendix table 8.

Time of plowing

Figure 9 shows the yield trend of winter wheat at Pendleton by 5-year moving averages for plots plowed on four dates, fall (October 15), early spring (March 15), medium-early spring (April 15), and late spring (May 15). There is very little consistency in wheat yield variation resulting from different plowing dates at Pendleton over this 22-year period. Only for early spring plowing are the yields consistently higher than for other plowing dates. There have been periods during the experiment when fall plowed plots and medium-early spring plowed plots excelled early plowed plots in yield. On the average, yields from late-spring plowed plots were much lower than those secured from plots plowed at the three other dates.

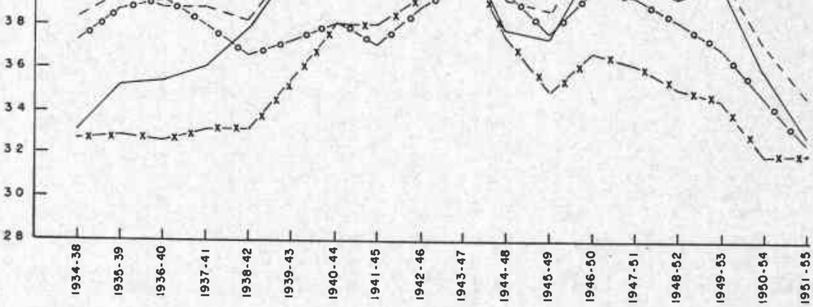

Figure 9. Yield of winter wheat by 5-year moving averages, on land plowed for fallow on four different dates, Pendleton.

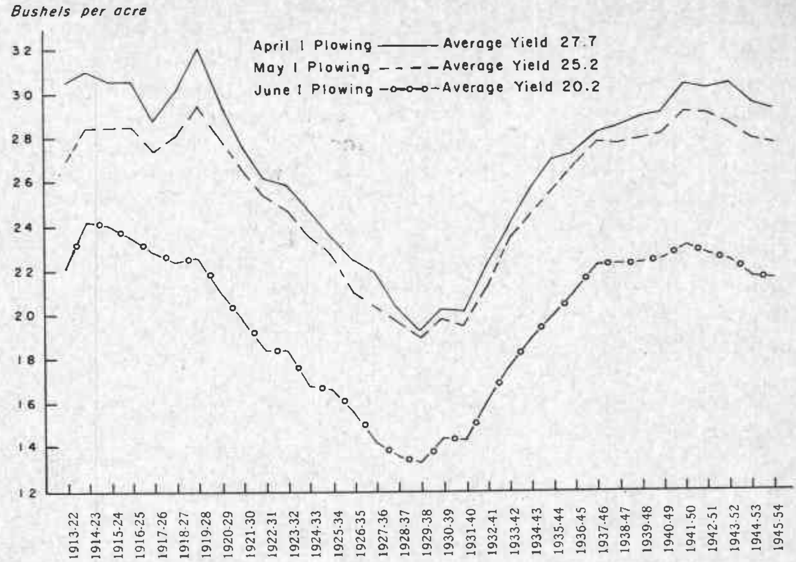

Figure 10. Yield of winter wheat by 10-year moving averages, on land plowed for fallow on three dates, Moro.

But even this late plowing had a period in which wheat yields were higher than on medium-early spring plowed land. As an average of 22 years, early spring plowing produced a yield of 38.8 bushels per acre, with fall plowing and medium-early spring plowing producing practically the same with yields of 36.9 and 36.6 bushels per acre, respectively. Late-spring plowed plots yielded approximately 2 bushels less, with 34.5 bushels per acre. Annual and average yields of winter wheat grown on this experiment are shown in appendix table 9.

Early plowing (April 1) has produced higher average wheat yields at Moro. It has a 42-year average advantage of 1.7 bushels over May 1 plowing, and 7.5 bushels over June 1 plowing. The 42-year average and the 10-year moving averages for this experiment are shown in figure 10. Annual yields of wheat from this experiment are shown in appendix table 10.

Differences between the 10-year average for each date of plowing are less during the 10-year period which includes the years 1938 to 1948; otherwise, there is remarkable consistency between the average yields from the three plowing dates.

Disking vs. moldboard plowing

Results of comparing the double disk, the one-way disk plow, and the moldboard plow as implements for producing fallow at

Pendleton are shown in figure 11. This graph shows the trend in wheat yields by 5-year moving averages for each plowing method. The 22-year average wheat yield was 36.2 bushels for moldboard plowing, as compared to 32.8 bushels for double disking and 31.7 for one-way disk plowing. Wheat yields produced by moldboard plowing throughout the experiment were superior. Double disking and one-way disk plowing showed similar yield trends, with yields from double disking being higher through the period 1939 to 1947. During the latter part of the experiment, yields from these two methods of preparing summer fallow were practically the same. Annual and average wheat yields from this experiment are shown in appendix table 11.

Another experiment comparing similar methods also was conducted at Pendleton. In addition to the one-way disk plow and the double disk, a series of plots were chiseled in the fall and double disked in the spring. The results are shown in figure 12. The moldboard plowed plots showed the highest average yield throughout the experiment. Yields from one-way disk plowed plots appeared slightly higher than those from double disked plots, and equal to plots chiseled in the fall and double disked in the spring for fallow. In early years of the experiment the three disking methods resulted in almost identical yields, but during later years the fall chiseled and spring double-disked plots and the one-way disked plots appeared superior

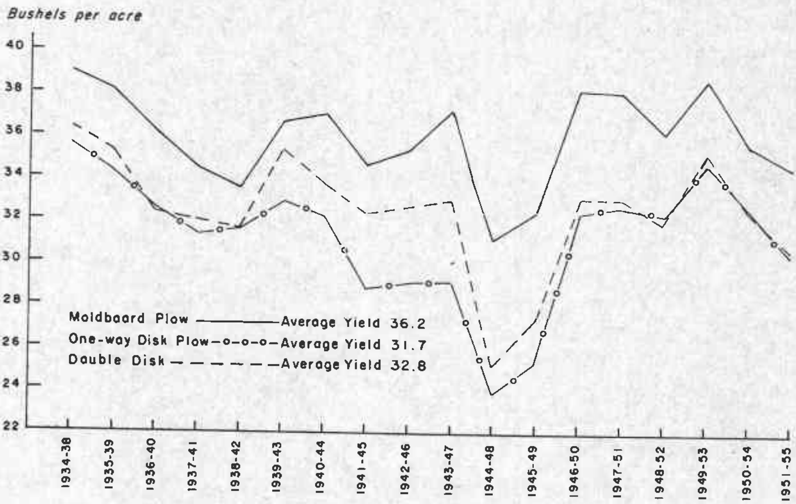

Figure 11. Yield of winter wheat by 5-year moving averages on land plowed with moldboard plow, double disk, and the one-way disk plow, Pendleton.

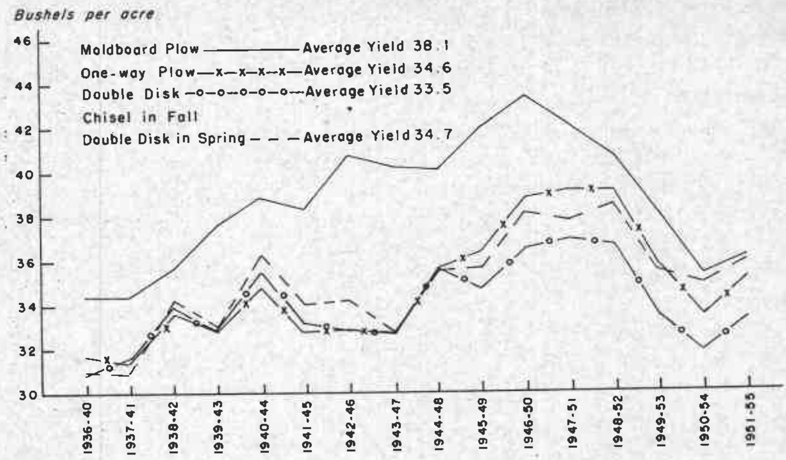

Figure 12. Yield of winter wheat by 5-year moving averages on land plowed with moldboard plow, one-way disk plow, double disk, and chisel in the fall and double disk in spring, Pendleton.

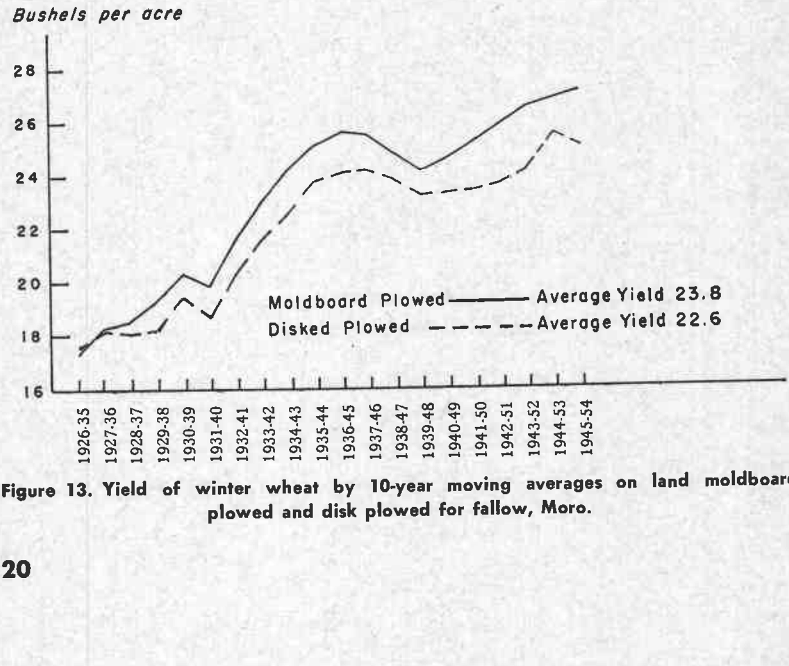

Figure 13. Yield of winter wheat by 10-year moving averages on land moldboard plowed and disk plowed for fallow, Moro.

in wheat production to the double disked. Annual and average wheat yields from this experiment are shown in appendix table 12.

Fallow plots prepared at Moro with the moldboard plow yielded an average of 1.2 bushels more wheat per acre for a 29-year period than those prepared with the disk plow. The 29-year average and the 10-year moving averages are shown in figure 13. Annual and average wheat yields are shown in appendix table 13. The difference between the 10-year averages becomes wider as the experiment progresses. Wheat yields from both methods of fallow have also increased steadily. This is in part due to the increase in precipitation over the past few years.

Cultivation of Summer Fallow

Harrowing and weeding summer fallow

At Pendleton there was very little difference between wheat yields produced on fallow plots cultivated immediately after plowing and those on which cultivation was delayed. The response of wheat to immediate clean cultivation was 0.4 bushel higher than when a delayed (30 days after plowing) cultivation practice was followed. The 22-year average yields were 37.2 and 36.8 bushels per acre, respectively. The trend in wheat yields resulting from these two

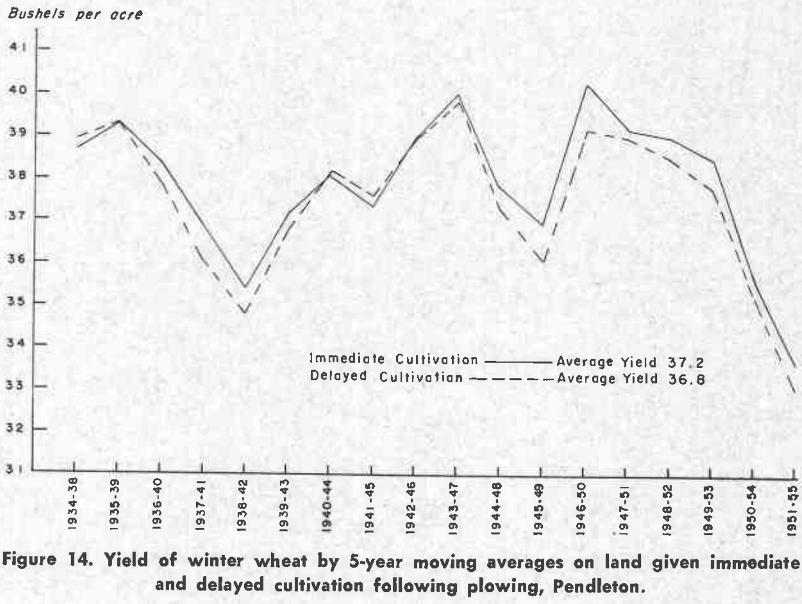

Figure 14. Yield of winter wheat by 5-year moving averages on land given immediate and delayed cultivation following plowing, Pendleton.

methods of handling the fallow is shown by 5-year moving averages in figure 14, and annual and average yields for the 22-year period are given in appendix table 14.

Immediate clean cultivation and delayed cultivation of fallow resulted in wheat yields nearly the same at Moro, there being only 0.3 bushel difference between the 28-year averages. At Moro, a non-cultivated treatment was included. The noncultivated plots yielded 1.6 bushels less than those of the delayed cultivation. The 42-year averages and the 10-year moving averages on this experiment are shown in figure 15. Annual yield of wheat is shown in appendix table 15.

For most 10-year periods there has been a slight advantage in yield from the delayed cultivation plots; never has the 10-year average of a noncultivated plot exceeded that of the clean or delayed cultivated plots.

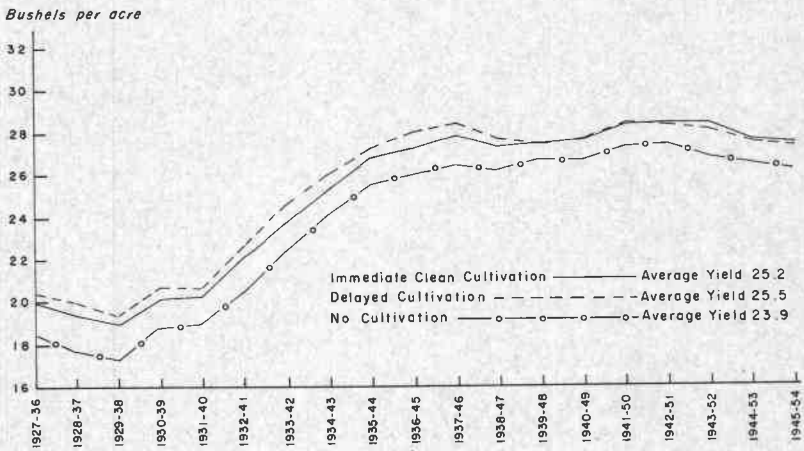

Figure 15. Yield of winter wheat by 10-year moving averages on land given three methods of cultivation following spring plowing, Moro.

Packing after plowing

Plots packed with the Campbell subsurface packer and plots harrowed after plowing yielded practically the same. There was only 0.5 bushel per acre difference in favor of the subsurface packed plots for the 41-year average at Moro. Surface packed plots averaged 0.3 bushel less than harrowed plots, and 0.9 bushel less than subsurface packed plots. The 41-year averages and the 10-year moving averages for these treatments are shown in figure 16. Annual winter wheat yields are shown in appendix table 16.

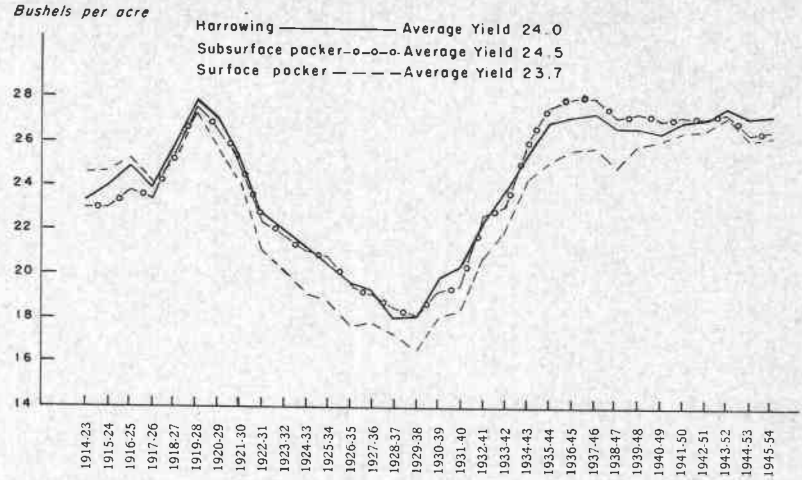

Figure 16. Yield of winter wheat by 10-year moving averages on land given three methods of tillage immediately after spring plowing, Moro.

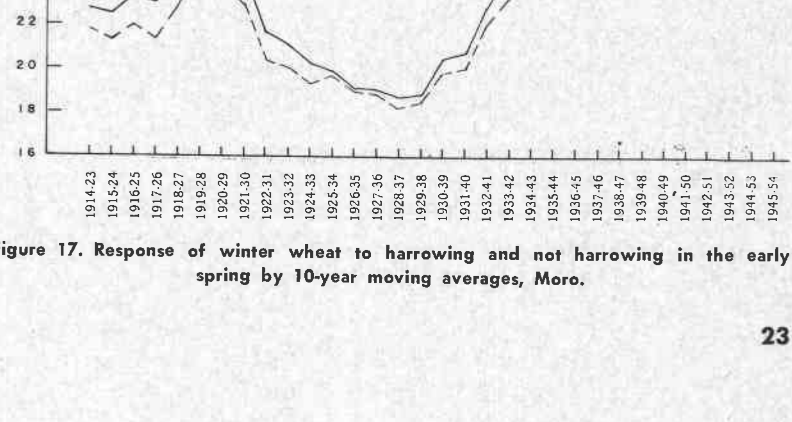

Figure 17. Response of winter wheat to harrowing and not harrowing in the early spring by 10-year moving averages, Moro.

Harrowing Winter Wheat in the Spring

The 41-year average yields from plots harrowed and not harrowed in the spring differed by only 0.3 bushel. The advantage was in favor of spring harrowing. The 41-year averages and the 10-year moving averages from this experiment at Moro are shown in figure 17. Annual and average yields are shown in appendix table 17.

While the 41-year average difference between these two treatments is slight, the moving averages show no 10-year period during which the wheat not harrowed yielded higher than the wheat from harrowed plots. Differences between these two practices were least for the 10-year period including the years from 1934 to 1941.

Discussion

Treatment of Land Before Plowing

Fall disking

There are three principal reasons for disking stubble in the fall:

1. It kills weeds and cheatgrass which may have started growth after wheat harvest.
2. It covers weed seeds as well as grain so they germinate more quickly.
3. It hastens stubble decomposition.

Of these three reasons, probably the last mentioned is most important in the minds of farmers. Farmers believe that to be able to plow under stubble the following spring without burning, especially following a high yielding crop, it is necessary to disk in the fall. This treatment breaks up the stubble and chops it into the soil, thereby placing it in an environment suitable for starting its decomposition. Experimental results show that fall disking the stubble may decrease the infiltration of winter precipitation.* Protection against snow blowing is lost by cutting down the stubble, often resulting in drifting on land that has been fall disked. The disking action pulverizes the soil, causing a mulch on the surface which readily absorbs and holds the surface water, but retards its deeper penetration, thus subjecting the moistened surface to more serious evaporation.

The question is often asked, "Is it profitable to disk stubble in the fall in spite of handicaps that may result from this practice?"

Experimental results at Pendleton and Moro show quite conclusively that it is not profitable, yieldwise, to disk the stubble in the

* Annual reports from the Pendleton and Sherman Branch Experiment Stations.

fall. At Pendleton, 22 years' results show that nondisked plots yield 2.7 bushels per acre more than fall disked plots. At Moro the difference was 0.7 bushel in favor of the nondisked plots. As shown in figure 1, this difference is consistent throughout the experiment at Pendleton. In no year did the yields from fall disked plots exceed those from nondisked plots. The evidence is not as conclusive at Moro, as shown in figure 2. The data here indicate that it would not matter whether or not the stubble was disked. However, years with the greatest yield difference are those in which yields were highest on the nondisked plots.

Spring disking

Following establishment of the spring disking experiments at Moro, farmers soon accepted the practice of early spring disking. At that time the land was being plowed with horse-drawn equipment, and plowing went on until the late spring and early summer. Results soon demonstrated that when plowing was continued into the early summer, spring disking gave a marked increase in wheat yields. The reason for such favorable results from early spring disking on late-spring plowed land is that weeds and volunteer growth are killed which would otherwise use valuable soil moisture and available plant food. As shown in figure 4, this difference is consistent throughout the history of the experiment. The 42-year average yield was 4.7 bushels in favor of spring disking when plowing was delayed as late as the first of June. These same results did not hold when land was plowed early in the spring. Under these conditions, disked plots have an average yield of 1.9 bushels per acre less than those not disked.

At Pendleton, spring disked plots averaged 1.5 bushels per acre less than nondisked plots. The results, however, have not been consistent, since there are periods in which spring disked plots have given just as high yields as nondisked plots. During the 22-year experiment, the 5-year moving averages have shown the nondisked plots to yield slightly higher than the disked plots. With little possibility of increasing wheat yields by spring disking and some possibility of decreasing yields, farmers have practically abandoned this practice. Only in cases where large tracts of land are to be plowed, and plowing is likely to run into the late spring, can spring disking be recommended. Under these conditions farmers will disk only that portion of their land which will be plowed later in the season.

Burning stubble

Burning the stubble before plowing was a common occurrence not many years ago. Frequently the stubble and straw on the land to be plowed was so heavy that much difficulty was experienced in plowing the stubble under. Plows were not built with enough height and width to allow the straw to pass through. Extra amounts of straw accumulated immediately behind the combine in the straw row. Only in more recent years have straw spreaders been attached to the combines, making it possible to scatter the straw, thus eliminating the heavy straw row and making plowing easier. Because of these difficulties, a considerable percentage of the straw on the fields was burned before plowing. It was felt that burning this organic matter year after year would eventually have an adverse effect on wheat yields, and especially on the physical condition of the soil.

At Moro, experiments were set up to show the effect of straw burning on wheat yields as compared to plowing the straw under. For the 32-year period, plots on which the straw was utilized have an average yield 0.9 bushel per acre higher than plots on which the straw was burned. As shown in figure 6, differences between utilizing the straw and burning it were greatest in the early part of the experiment, and have been declining in recent years. The 10-year averages for the most recent years show that yields are slightly higher on plots where the stubble was burned than on those where straw was plowed under. This difference in the yield relationship of the two practices is possibly due to rainfall differences between the early and more recent years. Incorporation into the soil of large amounts of organic matter such as straw is known to reduce the amount of available soil nitrogen. During low rainfall years the extra nitrate in the burned plots resulted in depressed yields, while in more recent years when rainfall has been more favorable the larger amounts of nitrate nitrogen in the straw-burned plots has resulted in increased wheat yields.

At Pendleton the picture has been slightly different, as shown in figure 5. At Pendleton, in the early part of the experiment, the spread in wheat yields between straw-burned and nonburned plots was fairly wide and in favor of the burned plots. As this experiment progressed, this yield difference gradually narrowed until in recent years the plots on which the straw was utilized yielded just as high or slightly higher than the plots on which the straw was burned. It is difficult to explain why the yields gradually turned in favor of the straw utilized plots at Pendleton, while at Moro the opposite occurred. It has been pointed out that soil fertility is more of a limiting factor at Pendleton than available moisture, while the opposite is the case at Moro. It is possible that at Pendleton, where soil fertility has such an important bearing on wheat yield, the continuous burning of organic matter has lowered fertility, compared to nonburned plots, to a point of reduced yields. Nonburned plots, while lower yielding in the early part of the experiment due to immobilization of nitrates by large amounts of low nitrogen organic material, have maintained inherent soil fertility until it now surpasses that of burned plots. In another experiment at Pendleton, not reported in this bulletin, similar results were obtained. *

Plowing

Depth of plowing

Depth of plowing for fallow at Moro has had little influence on wheat yields. When land was plowed 5 inches and 10 inches deep, yields averaged almost the same over the long period of years, with only 0.5 bushel difference in favor of the deeper plowing. As shown in figure 8, this advantage has been consistently in favor of deep plowing. It is questionable if this 0.5 bushel advantage is enough to pay the expense of plowing the extra depth.

At Pendleton, where the depth of plowing has been 5 and 9 inches deep, differences in wheat yields have been consistently in favor of deep plowing. In the early years of the experiment the 9-inch plowing depth was more advantageous than the 5-inch. During the later years this difference has narrowed. Over the 22-year period deep plowing has averaged 2.1 bushels per acre higher than shallow plowing.

Time of plowing

During the tenure of this experiment at Moro, the change from horse- to tractor-drawn equipment has speeded up farming operations. When farmers plowed with horse-drawn equipment, plowing was started early in the spring and often extended into midsummer. Now most plowing is done in 2 to 3 weeks, and is completed by mid-April. The experiment has shown that plowing in early spring, about April 1, has produced higher average yields at Moro than plowing at the later dates. This yield difference was so pronounced from the beginning of the experiments, that early plowing was soon adopted where possible by the farmers throughout the area. Early plowing stopped growth of weeds and volunteer wheat, thereby conserving moisture and plant food for the coming crop. Early plowing also put a seedbed into more of a mulched condition, maintaining moisture near the surface where bacterial activity would result in mineralization of available plant nutrients for the coming crop.

These were all-important factors in the early history of wheat production in the Columbia Basin. While April plowing consistently resulted in higher yields than May 1 plowing, the difference between

* Annual Reports, Pendleton Branch Experiment Station.

them was not pronounced. When the plowing date was extended to June 1, the difference was 7.5 bushels per acre in favor of the early plowing date. The difference in yield between April 1 plowing and May 1 plowing was 1.7 bushels over the 42-year period. This difference is wide enough to make it very profitable for the farmer to plow his land early in the spring.

At Pendleton this experiment included four plowing dates. Fall plowing was introduced as well as early spring, medium spring, and late spring. While fall plowing assists farmers in getting their work done a little earlier it has not proved better than early spring plowing. For the 22-year period, early spring plowing produced an average wheat yield of 1.9 bushels per acre more than fall plowing, and 2.2 bushels per acre more than medium spring or April 15 plowing. When land was plowed by mid-March or soon after, yields have been consistently higher than when plowing was done April 15 or May 15. When land was plowed as late as May 15 at Pendleton, yields decreased by 4.3 bushels when compared to March 15 plowing, and 2.1 bushels when compared to April 15 plowing. The disadvantage of not plowing the land until May 15, or late spring, is volunteer wheat and weed growth, which rob the soil of available plant food and necessary moisture for the succeeding crop. The most probable cause for lowered yields on late plowed land is that the soil is dry plowed. Frequently, summer rains are not sufficient to improve this condition, hence soil bacteria cannot function under optimum conditions in the mineralization of nutrients. Because of this, available nutrients would be the first limiting factor and lower yields would result. Fertilizers were not applied to any plots in this experiment. It is possible that the addition of nitrogen fertilizers on late plowed land would result in wheat yields more comparable to those on early plowed land.

Disking vs. plowing for fallow

In the two experiments at Pendleton which compared different methods of preparing summer fallow, moldboard plowing in both cases proved superior to one-way disk plowing or double-disk plowing. In earlier years, the one-way disk plow and the double disk were compared with the moldboard plow. The 22-year average yield for moldboard plowing was 36.2 bushels per acre compared to 31.7 bushels for the one-way disk plow, and 32.8 bushels for the double disk. This difference was consistent throughout the experiment. Where summer fallow was prepared with the one-way disk plow, or the double disk, weeds were a factor in the early years of the experiment. Considerable amounts of straw residue mixed in the surface soil made cultivation difficult. Weed seeds were not buried deep enough to kill them, or in some instances to germinate them, before wheat was seeded in the fall. Disked plots were almost always weedier than moldboard-plowed plots. This, no doubt, was a factor in the greater yield differences between these plowing methods during the early years. During the last 8 years of the experiment, the herbicide 2,4-D was used to control annual weeds, with the result that yield differences between these tillage methods narrowed. Even in the later years, however, moldboard plowing resulted in higher yields than either of the other two methods.

In one of the experiments at Pendleton, the same three methods were used with the modification that the one-way disk and double disk were employed in both fall and spring. In addition to these three types of plowing, some plots were chiseled in the fall and double disked in the spring. The moldboard-plowed land again produced higher wheat yields than either of the other methods of preparing summer fallow. Where land was chiseled in the fall and disked in the early spring, yields were slightly higher than where the double disk was used fall and spring. On the other hand, the one-way disk plow used fall and spring resulted in slightly higher yields than the double disk, and yields similar to those produced by fall chiseling and double disking in the spring.

Judging from the results of these experiments, the moldboard plow is superior to either the one-way or double disk in the preparation of summer fallow at Pendleton.

At Moro, fallow prepared with the moldboard plow also gave higher wheat yields than fallow prepared with the disk plow. This greater yield at both stations can be at least partly attributed to the greater nitrification in the fallow soil, and partly to less weed competition on moldboard-plowed land. Yield differences between the two practices has been increasing at Moro over the past years. This also may be a reflection of the nitrate-rainfall relationship. During the early part of the experiment, rainfall was so low that nitrates were not the limiting factor. In more recent years rainfall has been great enough that nitrates were limiting, and the plots with higher nitrate buildup gave higher yields.

Cultivation of Summer Fallow

Harrowing and weeding summer fallow

Immediate clean cultivation of summer fallow after plowing has proved to be an unnecessary practice at both Pendleton and Moro over the years these experiments have been carried on. At Pendleton the two practices, immediate clean cultivation and delayed cultivation of summer fallow, produced practically the same yield, there being only 0.4 bushel in favor of immediate clean cultivation.

By delaying cultivation for 30 days after plowing, a cloddier mulch is formed which aids in erosion control. Also, a satisfactory seedbed can be prepared and at least one tillage operation eliminated, such as one rod weeding for weed control. This is the result of delayed germination of weed seeds and poorer growing conditions for the weeds. At Pendleton, plots which received immediate clean cultivation produced an average yield of 37.2 bushels per acre, compared to 36.8 bushels for land not cultivated for at least 30 days after the plowing date.

At Moro three methods of cultivating summer fallow were followed: (1) immediate clean cultivation, (2) delayed cultivation, and (3) no cultivation. In the no cultivation practice the land was not worked following the plowing date. Weeds were allowed to grow and were taken off just prior to seeding. Under these conditions yields declined. Because of this weed growth, moisture and available plant food were lost and a poor seedbed resulted. Delayed cultivation at Moro proved as successful as immediate clean cultivation, with the elimination of at least one tillage operation during the summer fallow season. The 27-year average yield at Moro shows 0.3 bushel in favor of delayed cultivation, while the difference between delayed cultivation and no cultivation was 1.6 bushels per acre. The yield curve shows delayed cultivation and immediate clean cultivation to have about the same effects throughout the years of the experiment, while the yield curve for the no cultivation treatment is definitely below that of the other two.

Packing after plowing

Packing the summer fallow after plowing with a packer other than the harrow showed no advantage at Moro. This is in agreement with findings of the experiment on immediate and delayed cultivation. If there were no advantage to harrowing immediately after plowing, there would be no advantage to packing the soil after plowing. As shown in figure 16, the 10-year average yields from surface-packed plots are consistently below those from plots that were harrowed or subsurface packed. Yieldwise, subsurface packing produced slightly higher average yields than harrowing or surface packing.

Harrowing Winter Wheat in the Spring

Harrowing the growing wheat crop in the early spring has long been practiced by some wheat farmers. Reasons given are that it kills weeds, creates a mulch, and lessens moisture loss by evaporation. Some harrowed to stimulate tillering and thus increase the stand of wheat; others harrowed to thin the stand of wheat. More recently farmers are harrowing to partially fill the deep furrows resulting from seeding with deep furrow drills. Elimination of the deep furrow drill marks makes for easier harvest. The 41-year average wheat yields from plots harrowed and not harrowed are practically the same at Moro. It is questionable whether weeds are killed by harrowing, especially if they are well established. The advantage of harrowing as shown by the 10-year moving averages in figure 17, is confusing in view of the slight differences. Study of the annual yields shows that in 24 years the harrowed wheat was higher yielding, and in 17 years the wheat not harrowed was higher yielding. From the data obtained, it is not recommended that winter wheat be harrowed in the spring. It is interesting to note that the advantage from harrowing is greatest in the high yielding years of greater rainfall.

Conclusions

Treatment of Land Before Plowing

Fall disking the stubble land and plowing early in the spring for fallow decreased winter wheat yields at Moro and at Pendleton compared with early spring plowing without fall disking. The yield decrease was 1.7 bushels for a 42-year period at Moro, and 2.7 bushels for a 22-year period at Pendleton.

Spring disking the stubble land increased wheat yields at Moro by 4.7 bushels per acre when the land was plowed for fallow as late as June 1. When land was plowed early in the spring for fallow, spring disking of stubble before plowing decreased the yield 1.9 bushels at Moro and 1.5 bushels at Pendleton.

Burning the total straw at Moro resulted in a decrease in wheat yields of 0.9 bushel per acre over a 32-year period compared with plowing the stubble under or utilizing the straw. The yield spread in favor of straw utilization was wider during early years of the experiment. During later years, the land on which the straw was burned produced slightly higher yields.

At Pendleton, over an 18-year period, plots on which the straw was burned before plowing produced yields averaging 2.1 bushels per acre more than those on which the straw was plowed under or utilized. During the early years the difference in favor of burning the straw was greater, while during the later years burning the straw slightly decreased the yield.

Plowing

Plowing 10 inches deep at Moro has given an average yield increase of only 0.5 bushel over plowing 5 inches deep for fallow. At Pendleton plowing 9 inches deep for fallow has given an average yield increase of 2.1 bushels per acre over plowing 5 inches deep.

Land plowed early in the spring (March 15) at Pendleton produced higher wheat yields by 1.9 and 2.2 bushels per acre, respectively, over land plowed in the fall (October 15), or medium early in the spring (April 15). Land plowed as late as May 15 showed a further decrease in wheat yields.

Land plowed April 1 at Moro produced a 42-year average yield of 1.7 bushels per acre more than land plowed May 1, and 7.5 bushels per acre more than land plowed as late as June 1.

When summer fallow was prepared with the one-way disk plow or the double disk at Pendleton, wheat yields were reduced 4.5 and 3.4 bushels per acre, respectively, compared to summer fallow prepared with the moldboard plow. Chiseling in the fall and double disking in the early spring resulted in a yield increase of 1.2 bushels over land double disked fall and spring, but a yield decrease of 3.4 bushels per acre compared to preparation of summer fallow with the moldboard plow.

Plowed fallow land yielded 1.2 bushels per acre more than disked fallow land at Moro over a period of 29 years.

Cultivation of Summer Fallow

Delaying the initial cultivation of summer fallow for 30 days following plowing at Moro increased wheat yields 0.3 bushel per acre over immediate cultivation, and 1.6 bushels per acre over no cultivation. Delaying the initial tillage operation on summer fallow at Pendleton produced 0.4 bushel per acre less than immediate cultivation.

At Moro, packing the land with the subsurface packer soon after plowing gave a yield increase of 0.5 bushel over the conventional treatment of harrowing, and 0.8 bushel over surface packing.

Harrowing Winter Wheat in the Spring

Harrowing winter wheat in the spring has neither increased nor decreased wheat yields at Moro. The 41-year average yield was 23.8 bushels per acre for harrowed plots and 23.4 bushels for those not harrowed.

Appendix

Table 1. Precipitation for the Crop Year (September 1-August 31) and the Growing Season (March 1-July 31)

Precipitation, crop year			Precipitation, growing season		
Year	Moro	Pendleton	Year	Moro	Pendleton
	Inches	*Inches*		*Inches*	*Inches*
1910-11	8.47	....	1911	2.29	....
1911-12	14.19	....	1912	3.24	....
1912-13	11.08	....	1913	5.06	....
1913-14	12.53	....	1914	3.67	....
1914-15	13.31	....	1915	4.91	....
1915-16	16.62	....	1916	7.07	....
1916-17	8.62	....	1917	2.84	....
1917-18	12.43	....	1918	1.75	....
1918-19	10.72	....	1919	2.11	....
1919-20	11.35	....	1920	3.28	....
1920-21	12.24	....	1921	2.92	....
1921-22	10.32	....	1922	2.03	....
1922-23	12.84	....	1923	4.39	....
1923-24	7.72	....	1924	.92	....
1924-25	12.16	....	1925	3.56	....
1925-26	9.52	....	1926	1.96	....
1926-27	14.22	....	1927	2.60	....
1927-28	12.62	....	1928	3.21	....
1928-29	8.07	10.45	1929	1.88	3.53
1929-30	7.78	12.75	1930	1.32	4.94
1930-31	9.48	13.88	1931	4.45	6.30
1931-32	12.23	15.46	1932	4.60	6.22
1932-33	9.68	14.29	1933	3.23	6.15
1933-34	9.95	12.86	1934	2.12	3.39
1934-35	9.40	13.32	1935	2.19	4.64
1935-36	11.00	13.04	1936	3.16	4.10
1936-37	11.05	14.90	1937	6.35	9.48
1937-38	12.51	15.74	1938	4.27	5.79
1938-39	7.67	12.43	1939	1.95	4.34
1939-40	12.14	16.08	1940	3.93	5.73
1940-41	13.01	19.87	1941	3.41	8.46
1941-42	13.46	20.78	1942	3.77	8.75
1942-43	16.49	19.83	1943	3.80	8.31
1943-44	9.42	11.88	1944	2.96	5.00
1944-45	10.14	15.51	1945	3.30	7.39
1945-46	11.78	18.02	1946	3.36	6.91
1946-47	8.35	16.89	1947	3.75	8.09
1947-48	17.65	23.63	1948	4.78	10.48
1948-49	10.49	13.25	1949	2.11	3.63
1949-50	11.19	16.83	1950	3.79	7.56
1950-51	16.78	18.28	1951	3.79	4.34
1951-52	11.58	15.75	1952	3.46	6.03
1952-53	15.46	17.26	1953	4.68	7.41
1953-54	12.32	14.41	1954	2.81	4.95
1954-55	8.60	12.89	1955	3.81	6.48
Total	518.52	420.28		187.84	168.40
Average	11.52	15.57		4.17	6.24

Table 2. YIELD OF REX M1 WINTER WHEAT OBTAINED ON PLOWED LAND BY TYPE OF DISKING, PENDLETON

Year	Fall disked	Spring disked	Not disked
	Bushels/acre	*Bushels/acre*	*Bushels/acre*
1934	28.5	30.3	34.0
1935	39.3	39.4	41.0
1936	31.9	33.9	35.3
1937	41.0	41.4	43.4
1938	30.6	38.8	34.1
1939	35.7	36.8	35.6
1940	31.4	30.3	31.9
1941	26.8	27.5	27.5
1942	42.2	43.1	46.2
1943	56.4	52.0	57.3
1944	44.8	45.7	45.6
1945	26.0	29.2	27.6
1946	38.8	38.1	44.9
1947	46.9	51.6	50.1
1948	40.5	44.8	44.4
1949	39.2	37.6	39.2
1950	37.5	38.8	42.1
1951	24.4	27.1	29.9
1952	36.3	36.3	37.0
1953	34.4	31.9	35.7
1954	18.0	20.9	26.3
1955	26.9	28.4	26.4
Average	35.3	36.5	38.0

Table 3. YIELD OF TURKEY WINTER WHEAT OBTAINED ON PLOWED LAND BY TIME OF DISKING, MORO

Year	Fall disked	Not fall disked	Year	Fall disked	Not fall disked
	Bu./acre	*Bu./acre*		*Bu./acre*	*Bu./acre*
1913	23.0	25.1	1935	9.5	7.7
1914	25.6	26.9	1936	18.3	21.7
1915	23.6	26.3	1937	28.4	27.9
1916	34.3	41.3	1938	30.8	33.5
1917	21.2	25.0	1939	27.2	27.0
1918	17.3	22.3	1940	11.0	17.4
1919	38.3	38.5	1941	31.2	30.1
1920	25.0	29.7	1942	27.4	26.7
1921	36.5	31.3	1943	37.2	38.8
1922	17.3	22.0	1944	27.8	27.5
1923	37.3	34.7	1945	17.8	18.6
1924	22.7	23.7	1946	16.7	23.5
1925	28.3	26.2	1947	17.8	21.9
1926	30.3	28.0	1948	34.6	32.9
1927	43.1	40.5	1949	24.9	26.5
1928	44.2	45.2	1950	19.9	20.9
1929	18.7	12.7	1951	28.1	33.4
1930	14.3	14.8	1952	32.7	28.6
1931	15.5	11.8	1953	33.6	32.5
1932	14.8	14.8	1954	27.2	27.5
1933	22.3	19.5			
1934	15.2	16.7	42-year average	25.5	26.2

Table 4. Yield of Turkey Winter Wheat on Land Previously Disked in the Early Spring, and on Land Not Disked Before Plowing, Moro

Year	April plowed		June plowed	
	Disked	Nondisked	Disked	Nondisked
	Bushels/acre	*Bushels/acre*	*Bushels/acre*	*Bushels/acre*
1913	25.1	30.0	23.0	7.3
1914	26.9	32.0	27.7	21.6
1915	26.3	26.4	23.9	20.5
1916	41.3	45.7	34.3	34.8
1917	25.0	25.7	23.0	24.7
1918	22.3	23.5	20.3	26.0
1919	38.5	39.7	32.3	19.5
1920	29.7	32.8	29.0	26.5
1921	31.3	31.7	32.5	25.2
1922	22.0	17.5	16.5	13.7
1923	32.0	34.7	34.7	29.0
1924	24.2	28.0	16.3	19.8
1925	24.3	27.0	26.8	16.0
1926	21.5	27.5	25.0	27.5
1927	40.2	39.0	30.7	20.3
1928	38.8	42.8	40.8	28.7
1929	9.2	14.7	19.5	3.3
1930	13.0	13.7	15.0	14.3
1931	14.2	17.2	14.3	11.2
1932	12.7	14.2	12.8	13.5
1933	20.8	22.8	23.7	13.5
1934	16.7	16.5	18.2	17.2
1935	11.7	16.3	15.6	6.3
1936	22.4	21.7	20.5	13.2
1937	17.3	27.8	22.6	18.1
1938	33.1	30.5	28.2	26.4
1939	25.1	24.2	22.5	12.8
1940	13.0	12.8	12.8	12.3
1941	32.1	32.9	30.2	25.7
1942	29.5	32.4	29.3	28.8
1943	38.1	37.3	35.1	27.5
1944	28.7	29.4	29.3	27.4
1945	17.7	18.2	17.7	14.9
1946	23.8	27.8	22.1	20.4
1947	20.7	24.0	18.9	13.8
1948	31.8	32.9	34.2	29.5
1949	27.2	26.9	24.8	17.5
1950	22.5	23.3	16.7	17.4
1951	28.4	32.3	27.6	20.6
1952	28.9	30.5	31.4	24.4
1953	31.2	32.6	27.0	15.7
1954	24.1	25.4	26.3	27.6
42-year average	25.3	27.2	24.6	19.9

Table 5. Yield of Rex M1 Winter Wheat Obtained on Summer Fallow Land with Stubble Plowed or Burned, Pendleton

Year	Stubble plowed under	Stubble burned
	Bushels/acre	*Bushels/acre*
1938	41.6	43.0
1939	36.9	39.3
1940	29.1	36.3
1941	27.5	33.6
1942	36.6	38.7
1943	53.3	55.1
1944	42.1	45.9
1945	26.8	30.7
1946	33.2	39.6
1947	42.7	43.5
1948	37.9	39.8
1949	37.9	37.1
1950	41.8	44.5
1951	30.9	33.2
1952	39.6	40.1
1953	37.2	35.6
1954	22.2	22.4
1955	35.7	33.4
Average	36.3	38.4

Table 6. Yield of Winter and Spring Wheat Obtained on Summer Fallow Land with Stubble Plowed or Burned, Moro

Year	Stubble plowed under	Stubble burned	Year	Stubble plowed under	Stubble burned
	Bu./acre	*Bu./acre*		*Bu./acre*	*Bu./acre*
1923	31.9	31.3	1939	26.1	26.1
1924	14.6	10.3	1940	19.7	18.2
1925	27.0	26.0	1941	35.7	39.0
1926	26.1	23.2	1942	37.5	36.1
1927	37.9	36.5	1943	45.1	46.4
1928	32.4	32.3	1944	32.1	33.0
1929	14.5	12.5	1945	21.5	19.6
1930	25.1	22.7	1946	34.0	36.2
1931	21.5	16.1	1947	26.4	24.7
1932	22.3	17.6	1948	25.1	26.5
1933	22.0	16.9	1949	40.6	37.4
1934	17.3	16.1	1950	28.2	31.4
1935	*	*	1951	35.6	37.8
1936	26.7	25.9	1952	38.0	42.4
1937	34.7	31.3	1953	39.9	38.2
1938	29.2	29.3	1954	47.8	49.5
			32-year average	29.6	28.7

* No yield obtained.

Table 7. Yield of Rex M1 Winter Wheat Obtained on Summer Fallow Land by Depth of Plowing, Pendleton

Year	Deep plowing (9 inches)	Shallow plowing (5 inches)
	Bushels/acre	*Bushels/acre*
1934	32.9	31.2
1935	36.3	30.8
1936	33.9	28.3
1937	42.1	37.4
1938	46.4	38.9
1939	38.3	37.4
1940	34.3	30.2
1941	30.7	28.8
1942	38.5	36.6
1943	54.7	53.6
1944	43.1	44.2
1945	28.8	28.1
1946	37.1	34.4
1947	43.3	42.3
1948	40.6	38.0
1949	37.4	37.1
1950	43.4	43.6
1951	32.6	31.6
1952	40.5	39.0
1953	37.2	36.1
1954	22.5	22.6
1955	34.1	33.9
Average	37.7	35.6

Table 8. Yield of Turkey Winter Wheat Obtained on Summer Fallow Land by Depth of Spring Plowing, Moro

Year	Deep plowing	Shallow plowing	Year	Deep plowing	Shallow plowing
	Bu./acre	*Bu./acre*		*Bu./acre*	*Bu./acre*
1914	13.3	15.0	1936	21.4	21.9
1915	16.8	15.6	1937	27.4	26.0
1916	31.1	29.4	1938	31.4	28.9
1917	19.1	15.9	1939	26.9	27.3
1918	13.4	13.3	1940	16.8	16.5
1919	21.1	22.0	1941	29.8	31.2
1920	24.6	22.0	1942	26.5	30.1
1921	37.4	35.8	1943	38.2	38.2
1922	18.4	17.5	1944	27.0	26.8
1923	28.9	28.9	1945	18.3	17.3
1924	14.2	14.4	1946	23.9	20.2
1925	23.2	23.8	1947	21.6	17.7
1926	21.2	21.5	1948	33.0	33.6
1927	33.4	32.7	1949	25.8	26.0
1928	32.7	31.3	1950	22.2	21.8
1929	11.9	9.8	1951	31.6	30.3
1930	13.8	14.8	1952	29.6	29.9
1931	12.1	11.8	1953	31.7	34.6
1932	12.8	13.4	1954	26.0	27.4
1933	22.6	15.5			
1934	12.8	12.6			
1935	15.8	16.0	41-year average	23.4	22.9

Table 9. YIELD OF REX M1 WINTER WHEAT OBTAINED ON SUMMER FALLOW LAND BY TIME OF PLOWING, PENDLETON

Year	Fall plowed (Oct. 15)	Early-spring plowed (March 15)	Medium early-spring plowed (April 15)	Late-spring plowed (May 15)
	Bushels/acre	*Bushels/acre*	*Bushels/acre*	*Bushels/acre*
1934	29.4	33.0	32.0	33.5
1935	33.4	39.6	32.1	27.3
1936	29.4	33.8	33.5	25.4
1937	30.1	42.2	43.1	41.0
1938	43.3	43.5	46.0	36.3
1939	40.3	38.2	39.5	34.5
1940	34.3	36.8	33.7	26.0
1941	32.5	33.3	27.8	28.4
1942	39.3	39.3	36.0	35.9
1943	57.3	56.6	49.6	53.1
1944	43.4	41.6	44.1	47.3
1945	30.0	31.4	28.0	25.6
1946	36.5	38.0	36.2	35.0
1947	43.0	43.3	42.1	43.9
1948	36.2	42.2	42.1	34.6
1949	41.5	38.6	34.4	35.3
1950	48.1	48.5	53.7	34.8
1951	32.6	33.0	30.4	32.1
1952	38.1	43.2	39.7	38.4
1953	39.0	39.0	35.9	31.7
1954	21.5	23.0	22.7	22.0
1955	33.3	35.9	33.5	35.4
Average	36.9	38.8	36.6	34.5

Table 10. YIELD OF TURKEY WINTER WHEAT OBTAINED ON SUMMER FALLOW LAND BY TIME OF PLOWING, MORO

Year	Plowed April 1	Plowed May 1	Plowed June 1
	Bushels/acre	*Bushels/acre*	*Bushels/acre*
1913	30.0	19.0	7.3
1914	32.0	27.0	21.6
1915	26.4	24.7	20.5
1916	45.7	38.0	34.8
1917	25.7	24.7	24.7
1918	23.5	24.7	26.0
1919	39.7	30.0	19.5
1920	32.8	31.0	26.5
1921	31.7	29.8	25.2
1922	17.5	20.0	13.7
1923	34.7	34.0	29.0
1924	28.0	26.8	19.8
1925	27.0	25.5	16.0
1926	27.5	27.5	27.5
1927	39.0	30.8	20.3
1928	42.8	39.0	28.7
1929	14.7	14.2	3.3
1930	13.7	17.0	14.3
1931	17.2	18.2	11.2
1932	14.2	13.7	13.5
1933	22.8	22.7	13.5
1934	16.5	18.2	17.2
1935	16.3	8.6	6.3
1936	21.9	20.2	13.2
1937	21.7	24.9	14.7
1938	32.8	31.0	25.5
1939	24.4	23.7	14.4
1940	13.3	13.3	13.2
1941	36.7	35.0	28.0
1942	32.2	35.0	30.4
1943	41.1	35.1	25.5
1944	29.7	30.1	27.9
1945	18.9	19.4	17.4
1946	31.1	30.6	24.5
1947	24.3	23.6	15.2
1948	36.9	32.7	26.2
1949	27.1	26.8	16.8
1950	25.5	23.3	19.1
1951	35.3	34.0	23.5
1952	34.2	30.5	27.5
1953	32.1	27.7	18.6
1954	26.5	28.5	27.0
42-year average	27.7	26.0	20.2

Table 11. YIELD OF REX M1 WINTER WHEAT OBTAINED ON SUMMER FALLOW LAND BY TYPE OF PLOW, PENDLETON

Year	Moldboard plow	One-way disk plow	Double disk
	Bushels/acre	*Bushels/acre*	*Bushels/acre*
1934	38.3	38.4	39.1
1935	39.1	37.1	38.9
1936	36.9	30.3	30.5
1937	41.4	40.0	40.8
1938	39.1	31.9	32.9
1939	34.0	32.3	33.3
1940	29.6	28.2	24.5
1941	28.2	27.4	28.3
1942	37.3	38.5	39.5
1943	54.5	38.7	51.2
1944	35.8	27.7	25.8
1945	17.7	12.2	17.2
1946	31.7	28.6	29.9
1947	46.6	38.8	41.5
1948	24.2	12.3	11.8
1949	41.7	35.2	36.4
1950	47.0	47.7	45.8
1951	31.2	29.4	30.0
1952	37.1	36.8	35.8
1953	37.1	24.9	28.4
1954	26.7	24.8	22.8
1955	41.1	36.4	36.3
Average	36.2	31.7	32.8

Table. 12. YIELD OF WINTER OR SPRING WHEAT OBTAINED ON SUMMER FALLOW LAND BY TIME AND TYPE OF PLOWING, PENDLETON

Year	Moldboard plow	One-way disk fall and spring	Double disk fall and spring	Fall chisel double disk spring
	Bushels/acre	*Bushels/acre*	*Bushels/acre*	*Bushels/acre*
1936	32.0	33.4	30.5	32.6
1937	40.5	32.5	31.8	29.9
1938	40.5	40.7	39.8	42.4
1939	28.9	24.8	23.8	23.7
1940	30.0	27.0	28.8	26.4
1941	32.2	31.9	33.9	32.3
1942	47.0	44.0	42.9	46.7
1943	50.5	37.0	34.5	36.3
1944	34.7	34.0	37.8	39.6
1945	27.7	16.9	17.0	15.1
1946	44.0	32.5	31.9	33.6
1947	44.8	43.3	42.1	39.6
1948	49.1	51.2	49.0	49.3
1949	44.3	38.3	33.5	35.3
1950	34.6	28.5	26.2	32.9
1951	37.6	34.0	33.5	31.9
1952	37.7	43.3	40.8	43.3
1953	36.3	33.8	33.4	33.9
1954	30.4	27.2	24.9	32.5
1955	38.5	37.2	33.6	37.3
Average	38.1	34.6	33.5	34.7

Table 13. YIELD OF WINTER WHEAT OBTAINED ON FALLOW LAND BY TYPE OF CULTIVATION, MORO

Year	Plowed fallow	Disked fallow	Year	Plowed fallow	Disked fallow
	Bu./acre	*Bu./acre*		*Bu./acre*	*Bu./acre*
1926	15.8	14.0	1941	29.4	28.9
1927	23.5	22.9	1942	31.8	28.0
1928	25.2	30.7	1943	31.9	27.2
1929	9.1	9.3	1944	28.5	31.3
1930	19.7	20.8	1945	15.8	15.0
1931	12.1	13.3	1946	24.2	22.0
1932	17.7	14.3	1947	19.6	18.5
1933	19.1	17.6	1948	25.7	24.9
1934	20.0	20.0	1949	23.6	22.0
1935	11.3	12.0	1950	22.0	16.5
1936	25.4	20.7	1951	36.0	31.7
1937	26.4	22.4	1952	39.0	32.9
1938	32.3	31.2	1953	34.1	41.4
1939	18.6	21.2	1954	31.5	24.6
1940	15.8	14.7	29-year average	23.6	22.4

Table 14. Yield of Rex M1 Winter Wheat Obtained on Fallow Land by Time of Cultivation, Pendleton

Year	Immediate cultivation	Delayed cultivation
	Bushels/acre	*Bushels/acre*
1934	34.0	33.8
1935	36.8	36.9
1936	35.0	35.9
1937	44.6	43.8
1938	43.0	44.1
1939	36.9	35.9
1940	32.7	30.0
1941	27.7	26.9
1942	36.6	37.2
1943	52.3	53.9
1944	41.3	42.9
1945	28.9	27.2
1946	34.8	33.2
1947	42.1	42.0
1948	41.3	41.4
1949	37.3	36.7
1950	44.7	42.7
1951	30.7	32.3
1952	41.1	32.4
1953	38.5	37.7
1954	23.6	23.7
1955	34.1	32.2
Average	37.2	36.8

Table 15. Yield of Turkey Winter Wheat Obtained on Fallow Land by Time of Cultivation, Moro

Year	Clean	Delayed	Non-cultivated
	Bushels/acre	*Bushels/acre*	*Bushels/acre*
1927	34.4	34.6	34.6
1928	36.5	40.8	32.1
1929	12.6	13.0	10.1
1930	14.9	15.1	15.0
1931	13.8	13.5	15.0
1932	14.0	14.1	13.1
1933	22.3	22.1	16.5
1934	15.3	16.5	14.3
1935	14.3	13.6	14.3
1936	21.4	21.1	21.3
1937	28.6	30.2	25.5
1938	32.8	34.5	27.5
1939	25.0	25.8	25.5
1940	15.4	15.3	16.5
1941	32.6	33.4	30.2
1942	30.7	33.8	32.0
1943	37.5	36.9	35.1
1944	29.3	28.6	28.1
1945	19.4	19.9	18.3
1946	27.8	26.0	26.5
1947	23.4	23.1	22.5
1948	33.5	31.9	32.1
1949	26.7	27.3	25.6
1950	22.8	22.8	22.9
1951	34.1	33.3	31.3
1952	29.3	31.2	26.0
1953	30.2	30.7	31.8
1954	27.8	27.2	24.8
28-year average	25.2	25.5	23.9

Table 16. Yield of Turkey Winter Wheat Obtained on Fallow Land by Type of Tillage, Moro

Year	Harrowing	Subsurface packing	Surface packing
	Bushels/acre	*Bushels/acre*	*Bushels/acre*
1914	14.5	15.8	16.7
1915	16.3	16.6	16.2
1916	31.3	34.5	34.7
1917	17.3	17.5	20.5
1918	13.2	13.8	15.3
1919	22.5	21.7	22.3
1920	24.9	29.3	30.9
1921	39.8	36.4	37.0
1922	18.0	20.7	22.9
1923	29.4	28.1	29.2
1924	13.7	21.0	17.1
1925	25.3	25.9	21.0
1926	23.7	25.7	24.3
1927	36.4	33.2	31.7
1928	34.4	37.3	35.2
1929	8.8	12.0	7.3
1930	16.1	11.9	14.6
1931	10.8	11.9	8.0
1932	14.1	13.4	13.2
1933	23.5	20.4	18.4
1934	13.8	13.7	15.2
1935	13.2	17.0	10.7
1936	22.4	21.8	23.5
1937	32.0	27.7	27.2
1938	33.7	32.4	27.8
1939	28.8	29.1	22.7
1940	18.3	16.4	17.1
1941	32.8	32.5	32.4
1942	27.1	26.6	26.4
1943	40.5	39.2	40.5
1944	27.9	27.6	24.1
1945	16.6	19.4	15.1
1946	21.7	22.7	24.6
1947	21.5	20.9	18.3
1948	33.7	32.1	38.2
1949	25.8	27.4	24.2
1950	21.0	22.0	21.6
1951	31.5	32.6	32.6
1952	30.3	32.0	33.0
1953	31.2	35.1	29.5
1954	27.1	28.3	29.2
41-year average	24.0	24.5	23.7

Table 17. Yield of Turkey Winter Wheat Obtained on Fallow Land by Harrowing vs. Not Harrowing Wheat in Spring, Moro

Year	Harrowed	Not harrowed	Year	Harrowed	Not harrowed
	Bu./acre	*Bu./acre*		*Bu./acre*	*Bu./acre*
1914	14.9	13.8	1935	16.8	16.1
1915	17.0	16.9	1936	20.6	21.7
1916	29.4	29.7	1937	30.6	27.9
1917	19.2	19.3	1938	33.4	33.5
1918	14.9	12.5	1939	28.3	27.0
1919	20.9	20.7	1940	16.3	17.4
1920	24.5	23.8	1941	31.4	30.1
1921	37.0	35.2	1942	30.5	26.7
1922	19.8	17.4	1943	40.9	38.8
1923	29.2	28.4	1944	28.3	27.5
1924	13.1	9.6	1945	18.8	18.6
1925	25.1	23.0	1946	21.8	23.5
1926	21.5	24.0	1947	17.7	21.9
1927	32.5	34.0	1948	31.9	32.9
1928	33.0	32.0	1949	27.0	26.5
1929	11.1	11.3	1950	22.0	20.9
1930	14.3	14.5	1951	32.0	33.4
1931	10.5	9.9	1952	33.0	28.6
1932	13.0	14.1	1953	34.6	32.5
1933	20.6	21.8	1954	26.4	27.5
1934	9.9	13.3			
			41-year average	23.7	23.4