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Stubble Mulch Farming In Southern Idaho

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Intoduction

THE seriousness of erosion on dry farmed lands in southeastern Idaho became apparent in the early nineteen thirties, when drought and severe wind erosion emphasized the problem. A survey conducted in 1936 indicated that from 25 to 75 percent of the top soil had been removed by erosion. In July, 1938, the Soil Conservation Service, Research Division, in cooperation with the Idaho Agricultural Experiment Station began a series of tillage crop residue management experiments dealing with the erosion problem at the Tetonia Branch Experiment Station. This progress report presents the results from these studies to date.

The area to which the results are applicable includes the dry farm wheat lands in the 13 southeastern Idaho counties and adjacent areas in other states having similar climatic and topographic conditions.

The climate of the area is characterized by a wide seasonal range in temperature, a low relative humidity, and a light annual precipitation ranging from 10 inches on the lower benches to 20 inches in the mountains. The soils may be divided in a general way into three groups: Group 1, soils occupying low open valleys where the precipitation is 10 to 13 inches, are light brown in color and resemble the Portneuf series; Group 2, soils occupying higher elevations where the rainfall is from 13 to 16 inches, are darker brown in color and resemble the Ritzville series; and, Group 3, soils found at still higher elevations where the rainfall is 16 to 19 inches, are dark brown in color and resemble the Walla Walla series.

The topography of the area ranges from level valley floors to sloping bench lands to steep mountain slopes. A large part of the cultivated dry land is gently rolling to steep and has slopes from 5 to 40 percent.

The Tetonia Branch Experiment Station

The Station is located in Teton County, 7 miles northwest of Tetonia, Idaho, and 30 miles east of Rexburg, Idaho, on Highway No. 33. It is located at an elevation of 6,000 feet. The soil corresponds to the Ritzville series. The average annual precipitation is 13.1 inches.

Purpose and Plan of Experiments

The purpose of the study has been to determine the effect of straw mulch on erosion, moisture conservation, and yields of wheat under a summer fallow system. The study has involved comparisons between (1) burning of residues, and (2) returning them to the soil. Where returned to the soil they were handled in the following manner: (a) left on the surface as a mulch; (b) mixed with the surface soils; and, (c) plowed

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under. Studies were also made on types of implements adapted for initial tillage and subsequent tillage, both where stubble was burned and where it was returned to the soil. The implements used for initial tillage were the moldboard plow, one way disk, lister bottom plow, modified moldboard plow, and the rod weeder with shovel attachments. These implements are illustrated in figures 4, 6, and 8. Any working of the soil prior to the initial tillage operations such as the use of a double or tandem disk is referred to as preparatory tillage. To carry the program through the entire cropping cycle, studies were started in 1941 to include methods of fallowing and seeding on soil tilled with the above types of implements. The fallowing studies included the practices of straw burning, rod weeding immediately after initial tillage, rod weeding only when necessary for weed control, and disking in the fall and spring before plowing. All crops were harvested with a combine.

Experimental Results

Favorable results from stubble mulch tillage for 4 successive years indicate that it has a definite place in the dry farm agriculture of southern Idaho.

Soil Losses

The value of crop residue for erosion control depends upon the amount utilized and its placement as affected by tillage operations. In these studies, three placements of straw residues were used: (1) turned completely under with the moldboard plow; (2) mixed with the surface soil with the one way disk; and (3) left on the surface with the subsurface tillage implements. In order to differentiate the effects caused by placement of residue by different tillage implements and the effects caused by utilization of the residues as compared to burning them, all tillage methods were replicated three times on soil where all the residues were burned.

The soil losses in tons per acre are given for the various initial tillage treatments in Table 1. Soil losses were determined by the rill method in the early spring of 1943 after the land had been fallowed in 1942 and seeded to winter wheat in the fall of that year. In the rill method of determining soil losses the area of each rill or gully within a plot is de-

Table 1.—Soil losses in tons per acre from various initial tillage and residue treatments, 1943.

Method of initial tillage	Soil losses in tons par acre				
	With straw burned prior to initial tillage	With straw utilized			Average losses with straw utilized
		Weeded when necessary	Weeded immediately	Disked before initial tillage	
Moldboard	46	7	10	9	8.7
One way disk	40	5	9	9	7.7
Lister bottom	33	trace	4	2	2.0
Modified moldboard plow	33	trace	3	3	2.0
Disk before plowing modified moldboard	48	3	5	4	4.0
Rod weeder with shovel attachment*	68	4	5	2	3.7

*Only one replication was used for the rod weeder with shovel attachments. Triplicate 1/6-acre plots randomized, were used for all other methods.

termined by measuring its width, depth, and length. The amount of soil displaced is then figured from the total area of all the rills and the volume weight of the soil. In these tests the straw residue amounted to 4,500 pounds per acre. The land slope was 15 to 20 percent, and the wheat was seeded on the contour.

Figure 1.—Erosion resulting from burning of straw residues. Plot seeded to winter wheat, 15 percent slope. Contour seeding was not sufficient protection. 1943.

Without exception, the average soil losses from the straw burned plots were significantly greater than the corresponding losses from the straw utilized plots, especially when the stubble and straw were used as a mulch on the surface. The losses range from about 6 to 33 times greater on the straw burned plots. The greatest soil loss, 68 tons per acre, occurred on the straw burned plots tilled with the rod weeder with shovel attachments. The least loss, a trace, occurred on the straw utilized plots tilled with the moldboardless plow. A higher soil loss was expected on the moldboard straw utilized plots, but due to the length of the straw, much of it remained on the surface after the initial tillage. The protection afforded by a straw mulch is shown in Figures 1 and 2.

In comparing the effect of initial tillage on erosion in the case of the straw burned plots, the data show that the average soil losses from plots tilled with the modified moldboard plow and the lister bottom plow were less than from plots tilled with the other types of implements. The more effective erosion control was due largely to the fact that these implements left the surface in a much cloddier condition, thereby giving some protection from erosion.

As indicated in Table 1, any excess working of the soil before or during the fallow season has a tendency to increase erosion. The least erosion occurred when the fallow was cultivated only when necessary to control weeds. Since all of the plots were seeded on the contour, it is evident from these data that contour seeding alone is not sufficient protection against soil erosion.

Winter Wheat Yields

The data indicate that the straw mulch type of tillage is effective for erosion control. With this method yields can be obtained that are equal to or greater than those obtained from the present practice of burning the straw and plowing with the one way disk. The yields of wheat in

bushels per acre for the various tillage and straw utilization methods are given in Table 2. A comparison of the yields obtained with the use of the lister bottom plow and utilization of the straw shows an increase in yield of 2.9 bushels per acre over the common method of burning the straw and the employment of the one way disk. A similar comparison indicates an increase of 1.3 bushels per acre over the method of burning the straw and the use of the moldboard plow.

Figure 2.—Little erosion occurred when summerfallow was protected by straw mulch. Plot was seeded on contour to winter wheat on a 15 percent slope. Burned plot with accompanying erosion may be seen in background. 1943.

In comparing the yield data for the straw utilized plots, surface utilization of straw gave higher yields than where it was mixed with the surface soil or where it was turned completely under. The average yield for initial tillage with the lister bottom plow leaving all straw on the surface was 34.6 bushels per acre as against 31.4 for the one way disk, and 31.6 for the moldboard. These differences are large enough to be significant.

The average yield obtained from all methods when the stubble was burned was 1.1 bushels greater than where the straw was returned to the soil; however, this difference is not great enough to be significant. In years with light straw, such as 1940, the yield obtained the following year from the straw utilized plots was higher than it was when the straw was burned.

Extra working of the soil during the summer-fallow season has not resulted in any increased yields. The yields of wheat for the various summer-fallow practices are given in Table 3.

As indicated in Table 3, rod weeding only when necessary for weed control gave the highest average yields for the last two years. Rod weeding immediately after plowing has not resulted in increased yields; it increased erosion and the practice added one extra operation. In some instances rod weeding immediately after plowing may be necessary to kill weeds not killed in the initial tillage operation.

Disking as a preparatory tillage operation did not show increases in yields for all initial tillage methods; it did, however, facilitate later tillage and seeding operations. By early spring disking with the tandem double disk the stubble is not only broken up but many small weeds that have started are killed. This makes it possible to delay initial tillage operations

Table 2.—Yields of wheat in bushels per acre for various initial tillage and straw utilization methods for the years 1940 to 1943, inclusive.

Treatments		1940	1941	1942	1943	Average
Moldboard	Straw burned	28.3	31.5	35.7	37.8	33.3
	Straw utilized	25.8	29.2	36.5	34.8	31.6
One way disk	Straw burned	26.7	31.4	36.7	32.1	31.7
	Straw utilized	23.9	30.1	40.5	31.2	31.4
Lister bottom	Straw burned	31.8	37.5	37.0	37.4	35.9
	Straw utilized	28.4	33.0	41.5	35.4	34.6
Averages of all initial tillage methods	Straw burned	28.9	33.5	36.5	35.8	33.7
	Straw utilized	26.0	30.8	39.5	33.8	32.5
Averages of all methods of straw utilization	Moldboard	27.1	30.4	36.1	36.3	32.5
	One way disk	25.3	30.8	38.6	31.7	31.6
	Lister bottom	30.1	35.3	39.3	36.4	35.3

until later in the spring when more favorable plowing conditions usually occur. Disking before plowing with the modified moldboard plow did give a higher yield in 1943 than disking before plowing for the other initial tillage implements. This may indicate that this practice may be better adapted to this particular implement.

Table 3.—Yields of wheat in bushels per acre for the various summer-fallow methods. Average of 1942 and 1943.

Initial tillage	Straw burned	Straw utilized		
	Weeded when necessary	Weeded immediately then—when necessary	Weeded when necessary	Disked before initial tillage* Weed when necessary
Moldboard	36.8	33.8	35.7	34.2
One way disk	34.4	35.4	35.9	30.1
Lister bottom	37.2	35.8	38.5	34.1
Modified moldboard plow	40.7	37.8	38.3	35.0
Disked before plowing with modified moldboard	38.1	34.8	39.9	35.8
Average	37.4	35.5	37.7	33.8

*Only 1943 data available for this practice.

Moisture Data

Due to the lack of effective summer rainfall at Tetonia, no increase in moisture is expected during the fallow period of 3 to 4 months. An increase in soil moisture from spring to fall is experienced only in abnormally wet years. Table 4 gives the inches of water gained or lost during the summer-fallow season for the last 5 years.

As indicated, the highest average soil moisture loss during the fallow season occurred under the lister bottom type of initial tillage which produced the highest yields. The similarity in moisture loss, regardless of whether the straw is utilized or not, indicates that straw on the surface does not appreciably reduce evaporation from the soil in this area. The

greatest value of straw on the surface in this area is to prevent runoff and resulting erosion in the spring. There was a slightly greater average moisture loss for the straw burned plots than for the stubble utilized plots but the difference is not significant.

Table 5 gives inches of water lost during the fallow season for the various fallow treatments. It is evident from the data in Table 5 that even under the different fallow methods there is no significant difference in moisture loss during the fallow period. Under these conditions of evaporation it would seem that the most practical and economical method of fallow is to cultivate only when necessary to control weeds.

Nitrate Data

In the area under study the accumulation of nitrates depends largely upon the amount of moisture and straw present in the soil during the fallow season. Table 6 gives parts per million of nitrate nitrogen at the time of seeding for the plots with various initial tillage and straw treatments.

As shown in Table 6, the straw burned plots had more nitrates at seeding time in 3 out of the 5 years than did plots where the straw was utilized. The straw residue was quite heavy in these 3 years, from 4,000 to 5,000 pounds per acre. In the other 2 years, 1940 and 1941, only a light straw

Table 4.—Average inches of water gained or lost during the fallow season in 6 feet of soil for the various initial tillage and straw residue methods, 1939-1943, inclusive.

Treatment	1939	1940	1941	1942	1943	Average
Moldboard						
Straw burned	—0.51	0.69	0.21	—1.68	—2.41	—0.74
Straw utilized	—0.73	0.98	0.89	—1.79	—1.96	—0.52
One way disk						
Straw burned	—3.37	0.63	2.27	—2.16	—1.42	—0.81
Straw utilized	—0.22	0.41	2.82	—2.27	—2.69	—0.39
Lister bottom						
Straw burned	—3.32	0.34	1.35	—2.19	—1.87	—1.14
Straw utilized	—2.57	0.49	0.93	—2.94	—1.61	—1.14
Average all methods	—1.79	0.59	1.41	—2.17	—1.99	—0.79
Precipitation between dates of sampling, inches	3.82	6.61	6.39	2.02	2.99	4.37
Total water lost, inches	—5.61	—6.02	—4.98	—4.19	—4.98	—5.16

Table 5.—Average inches of water lost during the fallow season to a 6-foot depth for the various fallow treatments, 1941-1943.

Initial treatment	Straw burned	Straw utilized	
	Weeded when necessary	Weeded immediately	Weeded when necessary
Moldboard	1.29	1.11	0.95
One way disk	0.44	0.83	0.71
Lister bottom	0.81	0.72	0.91
Average	0.85	0.89	0.86

Table 6.—Average total nitrate nitrogen as p.p.m. for a 2-foot depth at time of seeding for various initial tillage and straw utilization methods, 1939-1943.

	1939	1940	1941	1942	1943	Average
Moldboard						
Straw burned	12.9	24.3	67.0	53.6	32.7	38.1
Straw utilized	9.5	34.3	71.8	33.1	28.6	35.5
One way disk						
Straw burned	16.2	18.9	64.0	37.8	39.4	35.3
Straw utilized	9.5	26.3	72.8	25.2	31.6	33.1
Lister bottom						
Straw burned	8.8	19.0	54.6	24.6	30.9	27.6
Straw utilized	8.1	22.3	68.6	19.0	15.9	26.8
Average						
Straw burned	....	....	....	....	....	33.7
Straw utilized	....	....	....	....	....	31.8

residue of 1,800 pounds was present and higher nitrates were found in the straw utilized plots. The higher amount of nitrates in the straw burned plots and light straw plots may be due to the fact that the nitrates that are developed during the fallow season are not used up in the decomposition of the straw residue. Tillage with the moldboard plow and one way disk has resulted in higher nitrates at seeding time than tillage with the lister bottom plow and other subsurface tillage implements. However, the average nitrates are nearly identical for the straw burned and straw utilized plots tilled with the lister bottom plow. The moldboard plots with an average of 36.8 parts per million of nitrates usually had the highest and the lister bottom with an average of 27.2 parts per million the least nitrates.

Table 7 gives the average parts per million nitrates at seeding time for the various fallow treatments. As shown in Table 7, weeding only when necessary gives a slightly higher amount of nitrates than weeding immediately after initial tillage, however, it was less than where the straw was burned.

Surface Residues Resulting from Various Tillage Operations

The erosion control value of crop residues depends upon how much of the residue remains on the surface during the summer-fallow and following seeding operations. The pounds of straw on the surface before plowing, after initial tillage and at the end of the summer-fallow season of 1939 for three methods of initial tillage, are shown in Table 8.

As compared to the moldboard plow and one way disk the lister bottom plow leaves a maximum amount of straw on the surface for erosion control. Only 5.5 percent of the straw was turned under as compared to 40.2 percent turned under with the one way disk, and nearly 100 percent turned under with the moldboard plow. During the fallow season, 17 percent of the straw was lost from the surface of the land that was one way disked, and 14.6 percent from the land that was lister bottom plowed.

Table 7.—Average total nitrate nitrogen as p.p.m. for a 2-foot depth at seeding time for the various fallow treatments, 1941-1943.

Initial treatment	Straw burned	Straw utilized	
	Rod weeded when necessary	Weeded immediately	Weeded when necessary
Moldboard	51.1	36.5	44.5
One way disk	47.1	42.4	43.2
Lister bottom	36.0	33.4	34.5
Average	44.7	37.4	40.7

Table 8.—Pounds of straw per acre on the surface before and after three different initial tillage operations and the pounds lost from the surface, 1939.

Type of plowing	Before plowing pounds per A.	After plowing pounds per A.	Pounds turned under	Percent turned under	Pounds surface time of seeding	Pounds lost from surface	Percent lost from surface	Percent left for erosion control
Moldboard ..	4977	0.0	4977	100.0*	....	...	...	0.0
One Way disk	4947	2955.0	1989	40.2	2454	501	17.0	42.8
Lister bottom	5052	4775.0	277	5.5	4075	699	14.6	79.9

*During years of long heavy straw, some residue remains on the surface.

Analyses of Virgin and Cropped Soil

In 1939 samples of virgin and cropped soils to a depth of 6 inches from two locations were obtained near the Station. These soils were analyzed for total nitrogen, carbon, and organic matter, and the results are shown in Table 9.

As shown in Table 9, this comparatively new soil in the Tetonia area with only about 25 crops taken off has lost 50.0 percent of the total nitrogen; and 49.0 percent of the organic matter. It is expected that the annual rate of loss will decrease but it is evident that a sound crop rotation program in conjunction with the use of all crop residues is necessary for the establishment of a permanent agriculture.

Application of Stubble Mulch Tillage

The success or failure of stubble mulch tillage, under field conditions, depends upon understanding and properly carrying out the correct tillage methods. Implements for cultivation vary widely in their effects on the soil. Some leave it pulverized, others form clods, some turn the surface, and others stir the top soil but do not turn it under. The use of straw as a surface mulch on summer-fallowed land makes some modification necessary in summer-fallow methods.

Table 9.—Analyses of virgin and cropped soils at Tetonia, Idaho, 1939.*

	Virgin soil percent	Cultivated soil percent	Loss percent
Total nitrogen	0.198	0.099	50.0
Inorganic carbon	0.045	0.018	60.0
Organic matter	3.390	1.730	49.0

*Analysis of soil samples made by the Department of Agricultural Chemistry of the University of Idaho.

Preparatory Tillage

The amount of crop residues varies from year to year, depending upon the amount of rainfall received during the growing season. When the residues are heavy, the straw should be broken into shorter lengths. This brings more of the straw in contact with the soil and helps to induce partial decomposition. The shorter straw facilitates later tillage operations by preventing its collecting on the standards of plows and rod weeders.

To obtain the greatest benefit, the preparatory tillage should be done in the early spring. This not only cuts the straw up into shorter lengths but also kills weeds that have started growth, making it possible to delay plowing until later in the spring. Fall disking causes a greater reduction in the straw through decomposition but plowing cannot be delayed in the spring because spring weed growth will be just as great on fields disked in fall as where no fall disking was done.

Figure 3.—Heavy residue, 4,500 pounds, after disking with a tandem double disk.

The implement used will depend upon what is available. The tandem double disk is the one most commonly used. The type of work done by this implement is shown in figure 3.

The one way disk can also be used. It is run very shallow, from 2 to 3 inches, in the fall. This is followed by a deeper plowing in the spring with the same implement. If residues are too light, the rotary subsoiler may be used in the fall to loosen the soil and leave depressions for better conservation of rainfall. The rotary subsoiler consists of a cylinder mounted in a frame. On the cylinder are teeth or points that penetrate the soil to a depth of 10 to 12 inches at intervals of approximately 2 feet.[2*]

Initial Tillage

Numerous implements are being used for initial subsurface tillage and plowing operations. Some are new implements, such as the large 30-inch sweep machines, and some are modifications of existing equipment. The one being used most extensively depends upon what is available with apparently none of them proving best under all conditions.

Subsurface Implements

Lister bottom plow — The lister bottom plow is a modification of the moldboard plow and is shown in Figure 4. The moldboards and shares

[2*]Refers to number of reference in list of references at end of bulletin.

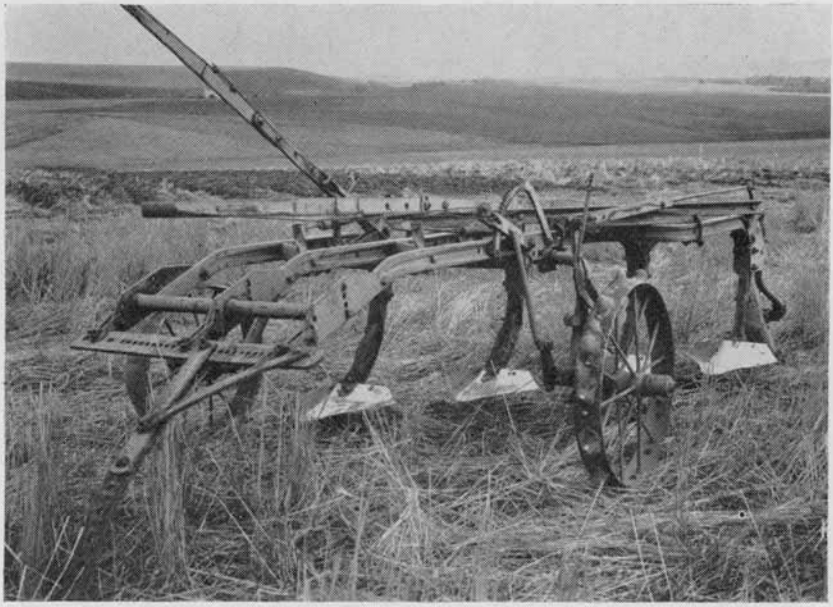

Figure 4.—Lister bottom plow converted from four bottom moldboard plow.

Figure 5.—Lister bottom plowing with 4,500 pounds of straw residue on the surface.

are removed and the ordinary 16-inch lister bottom share is attached to the beams by means of a special frog. The lister bottom passes under the residue, lifting and breaking the soil, leaving it quite cloddy with most of the residue on the surface, as shown in Figure 5.

Modified moldboard plow— The modified moldboard plow is a moldboard plow from which the moldboards have been removed. If the share is bolted on, nothing more need be done to the share; if it is a "quick detachable," it is necessary to support the share by a brace from the land side of the plow. In either case, a 3-inch wide steel strip the length of the share should be bolted on above the share as shown in Figure 6. This raises the soil sufficiently to allow it to break loose from the roots of volunteer wheat

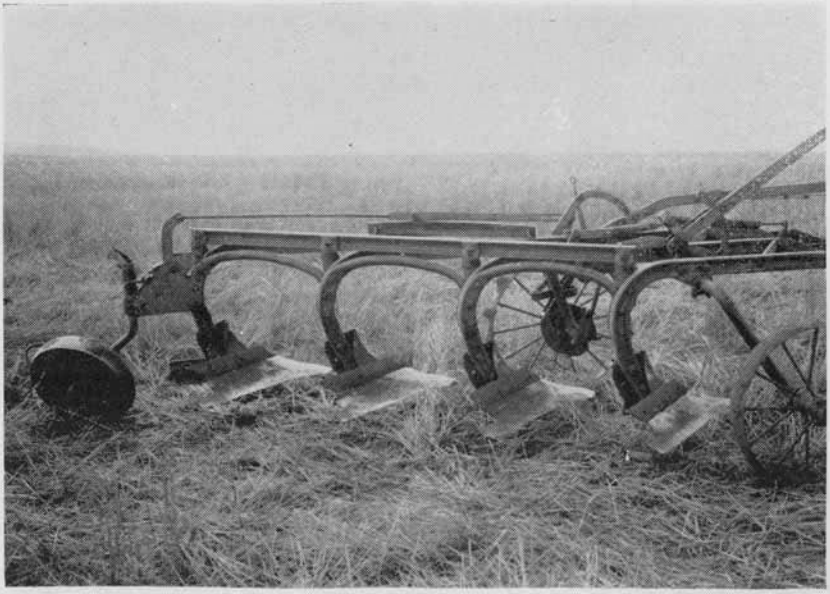

Figure 6.—Modified moldboard plow, converted from four bottom moldboard plow.

Figure 7.—Modified moldboard plowing with 4,500 pounds of straw on the surface.

and weeds, and to form larger clods. This implement covers a little more of the residue than the lister bottom, but the type of work it does is similar as shown in Figure 7.

Rod weeder with shovel attachments—One of the newest tillage implements used for subsurface tillage is the rod weeder equipped with shovel attachments, shown in Figure 8. The regular rod equipment is removed from the weeder and replaced by a heavy bar equipped with points or shovels that penetrate hard soil. This attachment has a rotating rod back of the shovels to prevent collection of trash on the bar supporting the shovels. This implement does a satisfactory job of subsurface tillage under light residue conditions, Figure 9. It will also do a satisfactory job in heavy straw if the straw is dry

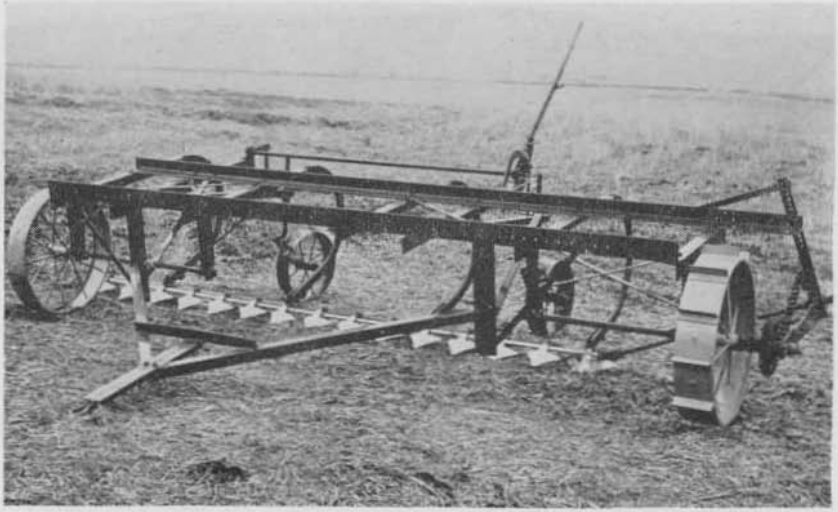

Figure 8.—Rod weeder with shovel attachment to enable penetration of hard fallow, or to be used for initial tillage on light soils.

Figure 9.—Field plowed with rod weeder with shovel attachment. Implement does satisfactory job in light stubble crop such as this.

and the soil not too wet and some preparatory tillage given. When it is used where the straw is heavy and the soil is quite wet, some difficulty is encountered. This implement should not be used in ground where large rocks are encountered.

On most soils in southern Idaho, all tillage operations for growing wheat can be carried out with a rod weeder and the shovel attachment. The initial tillage is done with the shovel attachment, for weeding the shovel attachment is removed and the regular rod used. This makes the purchase of several tillage machines unnecessary. The light draft of this implement enables tilling with the same power unit a strip much wider than that covered with the moldboard or one way disk, making the tillage cost much less.

Duckfoot shovels or sweeps—Standard sweeps may be attached to plow, cultivator, lister frames, toolbar machines, or to machines constructed especially for their use. On these special machines the frames are higher, the standards are farther apart, and the shovels larger and longer than those of the standard cultivator type.

In most commercial machines the large duckfoot shovels or sweeps are arranged in two rows to permit underspacing between the units. This spacing facilitates the passage of crop residues between the beams or units. A rolling coulter may be attached to each beam just ahead of the sweep to cut through heavy crop residues. Duckfoot shovels or sweeps operate parallel to the ground surface. They leave the stubble in an upright position, best for collecting and holding snow.

Operation of Subsurface Implements

Initial tillage usually is done in the spring, but fall plowing is becoming more prevalent. Fall plowing with the modified moldboard helps in overcoming heavy residues in the initial tillage operations. The straw and stubble are dry and stiff following harvest and pass between the plow beams without clogging. Another advantage of fall plowing with the modified moldboard is that the soil is left quite rough, which reduces runoff from the stubble field.

In using subsurface implements the best results are obtained by plowing at a depth of about 5 inches. Deeper plowing tends to kill fewer weeds and leaves the fallow in a very loose condition.

A good straw mulch fallow depends upon the timeliness of operations and the ability to make minor adjustments to equipment to obtain a good job of initial tillage. The initial tillage should be accomplished as early in the spring as possible, before the volunteer wheat and weeds make much growth. If the volunteer and weeds are allowed to become well established they are difficult to eradicate with the subsurface type of tillage implement, and extra weeding will be necessary.

Tillage with subsurface implements should not be done during wet weather, as a poor kill of volunteer wheat and weeds will be obtained. If a rainy spell occurs after the tillage is completed but before all the weeds are dead, it may be necessary to go over the field with the rod weeder as soon as the weeds have produced regrowth.

Disks

One way disk—The one way disk has become widely used in the last 10 years. The size used, depends upon the soil and the quantity of residue present, the 22-inch disk with 8-inch spacing between the disk should be used on light soil and light residues. The larger 26-inch disk with 10-inch spacings should be used on heavier residues. A one way disk working in heavy residue is shown in Figure 10.

The entire surface soil is moved and slightly turned, covering some of the residues. Because of its weight, it will penetrate dry hard ground and cut through heavy dry stubble or vegetative growth, and leave it on or near the surface. On land with light residue the one way disk is not desirable because of the pulverizing action it has upon the soil as shown in Fgure 11.

Eccentric disk[2]—The eccentric disk differs from the one way in that on the individual disks the holes for the shaft are a short distance off

[2]Refers to number of reference in list of references at end of bulletin.

Figure 10.—One way disk working in 4,500 pounds of straw and stubble residue.

Figure 11.—One way disk plowing with only 1,800 pounds of straw residue. Note pulverized soil, a condition not desirable for erosion control.

center. The movement of the disks, therefore, digs up the soil and throws it away from the disks so as to leave basins on the field. These basins hold rainfall and thus reduce runoff. These disks are best used in the fall on heavy stubble as a preliminary operation.

Operation of Disks

The amount of residue left on the surface by the one way disk depends upon the speed of operation. For a stubble mulch fallow, it is desirable to run the disk at a slow speed so as to leave as much residue as possible on the surface. When run at a high speed, the residue is nearly completely covered. Also when the disk is run at a high speed the soil is pulverized more than desirable. It has been found that the one way disk is the implement best adapted for rocky ground; it tends to ride over the rocks without catching on them.

Cultivation of Straw Mulch Fallow

The straw mulch fallow in this area should be cultivated only when necessary to control weeds. No benefits have been derived from any extra working of the fallow. The use of a spike tooth harrow is not recommended because of its pulverizing action on the soil and its clogging in heavy straw. In some years when the soil mosture content is high it may be necessary to weed as soon as possible after plowing in order to obtain a complete weed kill. The rod weeder can be used in nearly all cases for weeding operations. Where the straw is extremely heavy the large blade equipment can be used for weeding operations as well as for initial tillage.

Rotary Rod Weeder

The rotary rod weeder consists of a rod mounted on a frame and provided with gears that rotate the rod opposite from the direction of the drive wheels. The weeders come in widths ranging from 8 to 12 feet. The general practice is to hook up 2 to 3 weeders into one unit, thereby making a better load for the larger tractors.

The number of weedings necessary during a fallow period will range from 2 to 4, depending upon rainfall and weed growth. The first weeding should be done at a depth of from 3 to 4 inches, and each weeding thereafter should be of shallower depth. Weeding should not be attempted during wet weather or when the surface soil is excessively wet as it will be difficult to obtain a complete kill of the weeds and the stubble will tend to ball up on the beams of the weeder.

Figure 12.—Rotary culti-hoe run in reverse is used for preparing a firm even seed bed before drilling.

Rotary Culti-hoe Packer

Stubble mulch fallow weeded with the rod weeder sometimes leaves the soil too loose and rough for a good seedbed. A rotary culti-hoe with the wheels reversed, as shown in Figure 12, can be used to compact the soil without covering the residue. It does not clog in trashy ground. It can be run over the field alone or attached immediately in front of the drill. A more uniform depth of planting and sometimes a better stand of wheat is obtained with the use of this packer. It also helps to break up large clumps of residue and to distribute it more uniformly over the surface of the soil. Further trials will be necessary before this implement can be recommended as an essential one for stubble mulch tillage.

Seeding

The amount of residue on the surface determines the type of drill that can be used successfully. A drill must be able to cut through the straw mulch and deposit the seed in the soil. Both disk and shovel type furrow openers are in use. Press wheel drills are more desirable because they firm the soil around the seed. The drills with furrow openers 6 to 7 inches apart are either double disk or single disk drills; the ones that seed 10 inches apart are semi-deep furrow drills; and the ones that seed from 12 to 14 inches apart are deep furrow drills.

Single Disk Drills

The single disk with 7-inch spacing can be used only when a small amount of residue is present. If used in heavy straw mulch, the straw will not pass between the disks. If the only drill available is a single disk drill and a heavy residue is present, the field must be given sufficient preparatory tillage so that the straw will be broken up into pieces small enough to pass between the disks.

Deep Furrow Drills

When heavy crop residues are present, the deep furrow drill does the most satisfactory job of seeding. There are deep furrow drills with two types of furrow openers, the disk type and the shovel type. The furrow openers are spaced far enough apart to permit the straw to pass between them. Sometimes extra pressure has to be applied to the disks to enable them to cut through the residues. The deep furrow drills move the loose soil and trash from the place where the seed is to be placed and permit the placing of seed in moist soil. The ridges afford some protection to young grain against wind and retain snow and rain. Sometimes the water retained by the furrows freezes, causing some winter killing. This is especially prevalent on northern slopes.

Essential Implements for Stubble Mulch Farming

In selecting implements for stubble mulch farming, much will depend upon the implements already available to the farmer that can be converted and what is available for purchase. All of the discussed implements are not necessary but are being tested to find which is the most satisfactory. One of each group of the following implements is necessary for stubble mulch farming:

1. Straw spreader attachment for combine.
2. Tandem double disk, to be used in preparatory tillage on straw residue and for killing weeds early in the spring.
3. Initial tillage implements:
   a Rod weeder with shovel attachments.
   b Large 30-inch sweep subsurface tiller.
   c Modified moldboard or lister bottom plows.
4. Weeders:
   a Revolving rod weeder.
5. Drills:
   a Deep furrow drills in heavy residue area.
   b Single disk drills in light residue area.

A few preliminary recommendations can be made from results and experiences to date in regard to handling wheat straw as a stubble mulch:

General Recommendations

Previous wheat yield *Bushels*	*Approximate stubble* *Pounds per acre*	*Practice recommended at present*
10-20	Up to 2500	Any subsurface implement such as duckfoot or modified moldboard plow or rod weeder with shovel attachments. No extra disking on stubble needed. Use any drill for seeding.
20-35	2500-4000	Spring or fall disking of stubble, spring preferred. Spring till with subsurface implement. Seed with deep furrow drill if straw is heavy
Over 35	Over 4000	Best method known at present is to fall plow with modified moldboard. If the stubble is extremely heavy and the ground plowed in the spring, both spring and fall preparatory disking should be done. Weed with rod weeder and seed with deep furrow drill. In areas adapted to spring seeding, spring wheat should be used. Some mechanical method of breaking up the stubble into small pieces before plowing would help greatly in all later operations.

Conclusions and Recommendations

From the results of the experiments and experiences for the 4-year period, the following conclusions can be drawn:

1. Burning straw residues is the greatest single factor contributing to erosion of crop land in the southeastern Idaho dry farm area.
2. Working summer-fallow more than is necessary to control weeds has a tendency to increase erosion.
3. For wheat yields and erosion control surface utilization of straw is superior to mixing it with the surface soil or turning it completely under.
4. Under conditions of heavy straw, burning gave a small increase in yield, but under conditions of light stubble, no advantage was gained by burning. The burning of stubble in all cases contributed to the erosion problem.
5. After initial tillage, the method of cultivating the fallow giving best results, was rod weeding only when necessary.

6. Subsurface implements leave from 90 to 95 percent of the straw and stubble on the surface.
7. The low organic matter and nitrogen content of the surface soil of southern Idaho wheat lands strongly indicates the necessity of not only utilizing all crop residues, but also of adopting crop rotations to maintain soil fertility.
8. The success of stubble mulch tillage depends upon the timeliness and quality of operations. All initial tillage and fallow operations should be completed before the weeds and volunteer wheat have made much growth. No subsurface tillage should be undertaken during wet weather.
9. Straw spreaders should be used on all combines.

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