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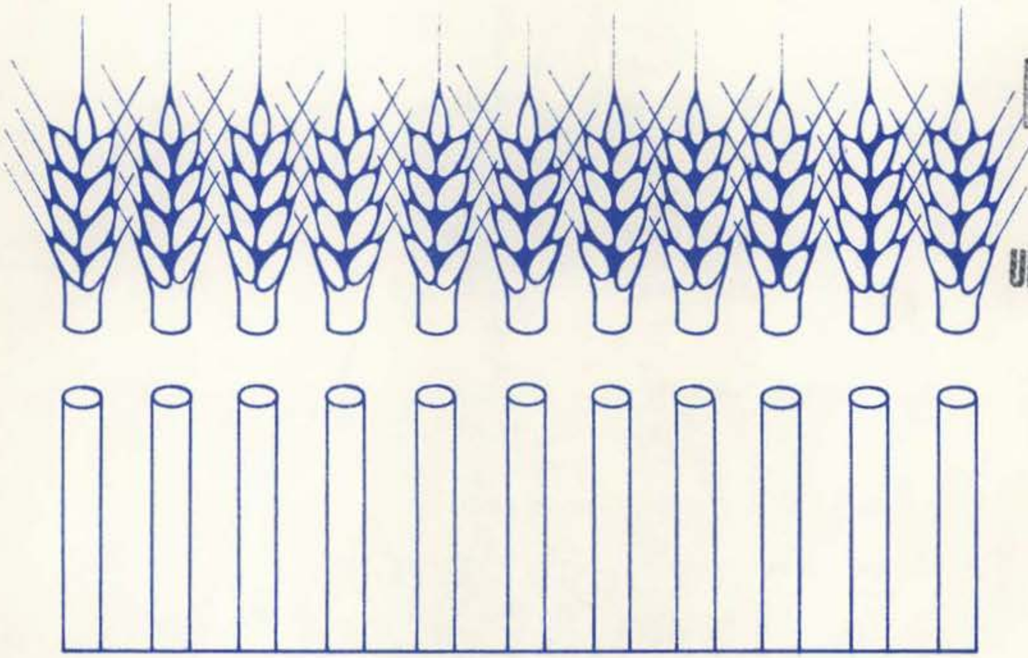
Improving Dryland Wheat Production In Eastern Idaho With Tillage and Cropping Methods



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Summary

This research showed that allowing stubble to stand overwinter after harvest trapped snow and increased soil moisture. Winter wheat yields were increased 5 bushels per acre for each additional foot of snow trapped. Fall burning or disking stubble reduced snow cover and yields accordingly.

Where runoff and associated erosion were potential problems, fall chiseling after harvest also increased yields by storing extra overwinter moisture from snowmelt. In three fall experiments, chiseling increased winter wheat yields 2.4 bushels per acre and increased annually cropped spring wheat yields 4.9 bushels per acre.

Early stubble mulch tillage for summerfallowing conserved more moisture for fall germination of winter wheat and produced highest yields. Although burning stubble in the spring before fallowing increased wheat production for the first 6 years, yields then decreased to well below those for unburned treatments. Shallow-tilled mulch (3 inches deep) was slightly better than deeper tillage. Care is needed with disking to obtain complete weed control and to retain a stubble mulch. Rod weeding, normally used for the remaining tillage operations, should result in a weed-free fallow and a firm seedbed.

Early fall seeding of winter wheat (August 15) resulted in the best potential yield, but also in the greatest incidence of crown, foot and root rots and most severe downy brome (cheatgrass) infestations. Although snow mold infections are most severe with early plantings, the early-seeded wheat plant is better able to recover since it is larger and has abundant crown tissue for regrowth in the crop year. For locations similar to Tetonia, a September 1 planting date is a good compromise. It is after the dates of severe disease susceptibility and early enough to capitalize on good yield potentials.

Nitrogen fertilizer yield responses were similar from either fall or spring of crop year applications on winter wheat. However, the most favorable responses have been during wet crop years, and from early to mid-date plantings. Plantings after September 15 have not responded well.

Annual cropping spring wheat has an economic advantage in years when overwinter moisture storage is deep — over 3 1/3 feet in medium-textured soils. Annual cropping requires additional weed control and nitrogen fertilizer.

Improving Dryland Wheat Production In Eastern Idaho With Tillage and Cropping Methods

Truman Massee and Hugh McKay

About 2 million acres in eastern Idaho are in dryland agriculture, primarily wheat-fallow (Fig. 1). This Intermountain dryland area is one of the highest risk farm regions in the United States. Although the eastern Idaho soils are usually deep and potentially fertile, low rainfall together with drying winds often dominate during the crop year. To survive, farmers have had to devise methods to counter these adversities. Their success is evidenced by the fact that some farm lands are now being tilled by the third and fourth generations of the original settlers.

Even better farming methods need to be developed, however. The normal summerfallow stores less than 30% of the precipitation in the soil between harvest and the spring of the crop year for future crop use. If another 10% could be stored, yields could be increased by 16%. Only 1 or 2 weeks delay in starting summerfallow tillage in some years has directly reduced winter wheat germination and cheatgrass control. This bulletin summarizes information obtained through research in this dryland area of eastern Idaho and provides soil-water-management guidelines for farmers in the region.

Much of this research was conducted on the University of Idaho's Tetonia Research and Extension Center farm by both University and USDA Agricultural Research Service personnel. Other experiments were conducted at the ARS Snake River Conservation Research Center at Kimberly, at Newdale and in the Rockland-Roy area.

Off-station experimental sites were provided by Clarence Ard and Rolland Hubbard, Clementsville; Wallace and John Hayes and Jack Richards, Roy; Ben Hayden and Deon Hubbard, Crystal; Lee Martineau, Newdale; Bill Miller, Drummond; Elmer Nelson, Tetonia; Ed Porath, Rockland; Jack Randall, Ed Covington, Leonard Sharp and Bill Webster, Rexburg. Their contributions are appreciated.

Other workers whose results are included include the late W. A. Moss, former superintendent of the Tetonia Research and Extension Center, and F. H. Siddoway, who was ARS Project Supervisor at Tetonia from 1951 to 1957. Assistance was given by the UI campus staff, including D. O. Everson, R. W. Harder, G. C. Lewis, C. I. Seely and the late G. O. Baker. Research from other areas is cited where the results are directly applicable to this Intermountain area.

Improving Overwinter Soil Moisture First Winter After Harvest

Between harvest and early spring, soil moisture from snow and rainfall may penetrate deeply into the soil if correct management is followed. An increase in stored soil moisture will normally increase yields substantially under either a summerfallow or annual cropping system. In fact, success with annual cropping depends primarily on soil moisture storage during this period.

How much moisture is stored in the soil depends on several factors. Among them are drifting snow, evaporation and soil infiltration characteristics, which in turn will vary with soil temperature, soil structure and amount of moisture present in the soil. These factors determine whether the snow and rainfall moisture is stored or evaporates or contributes to runoff and erosion.

Managing Stubble to Trap Snow

A simple but important objective in managing fallow is to leave the stubble stand through the first winter. This traps snow and prevents it from blowing. Often snow depth is the same as the height of the stubble.

Three methods of managing stubble after harvest were compared in a study at the University of Idaho Research and Extension Center, located at an elevation of 6,200 feet in the dryland plains near Tetonia. The straw was (1) left standing, (2) cut and removed or (3) burned. Stored soil moisture the following spring was greatest for treatment 1 and least for treatment 3 (Table 1). Winter wheat yields after summerfallow were proportional to the amounts of moisture stored the winter after harvest.

Table 1. Available spring soil moisture before summerfallowing and corresponding winter wheat yields from three stubble treatments after harvest, Tetonia, 1954-58.

Stubble treatment	Available soil moisture (6-foot depth)	Yield
	(inches)	(bu/acre)
Left standing	9.8	29.0
Cut and removed	6.4	25.7
Burned	6.2	24.3

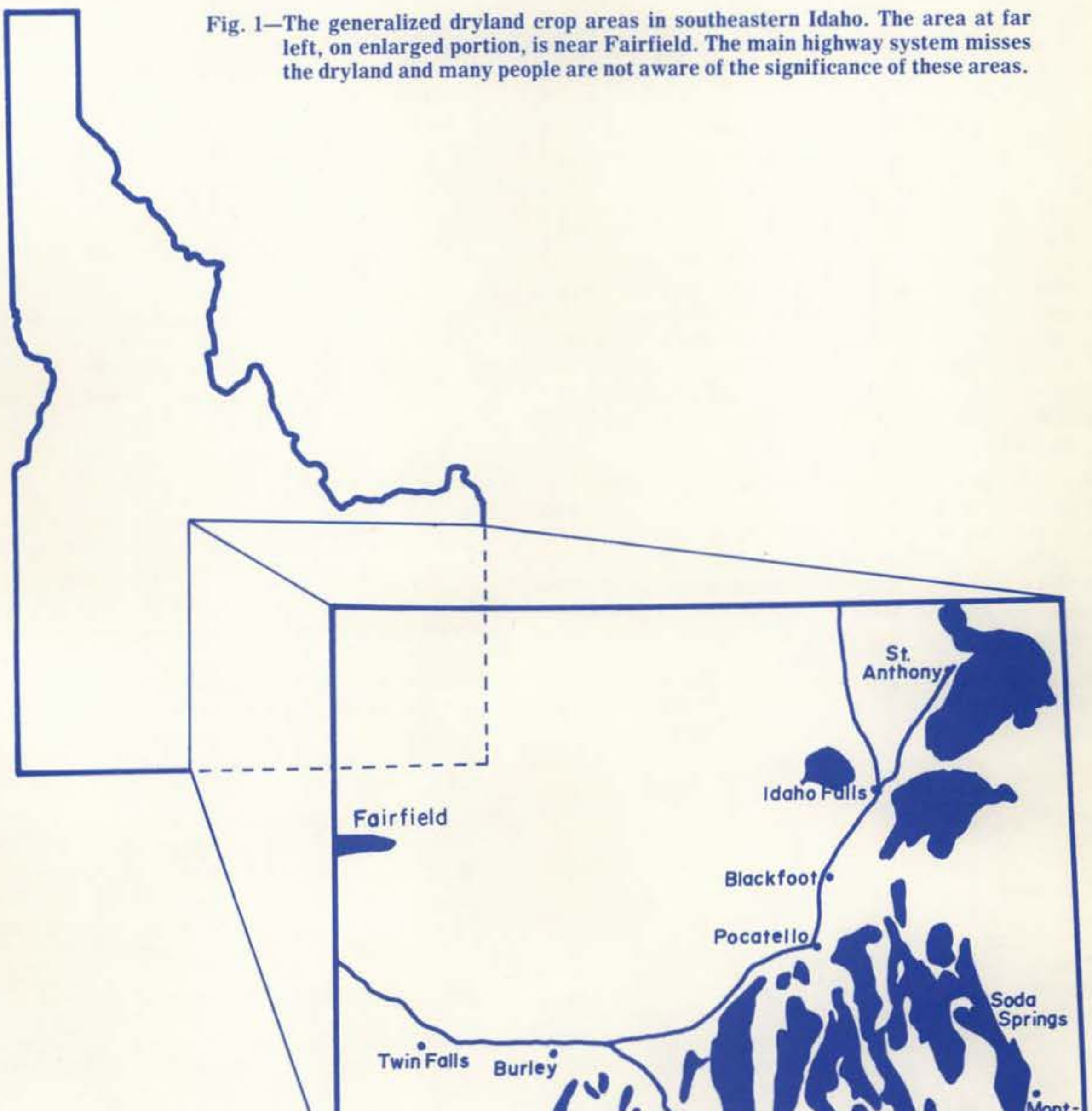


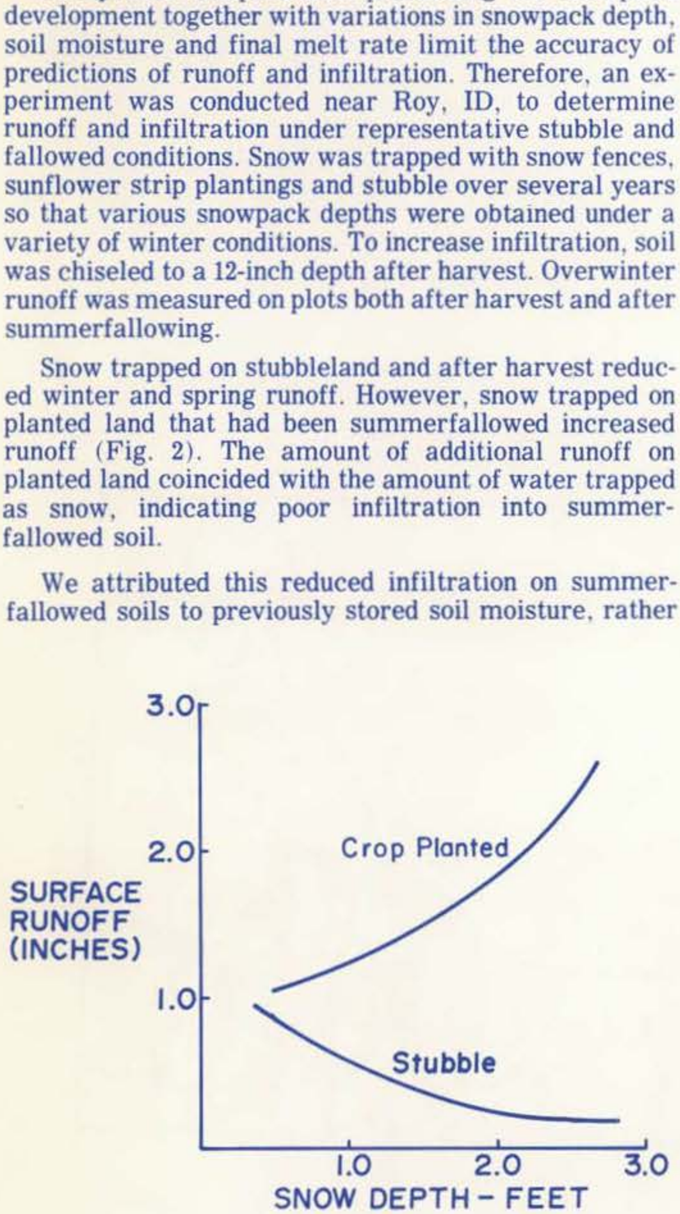
Fig. 1—The generalized dryland crop areas in southeastern Idaho. The area at far left, on enlarged portion, is near Fairfield. The main highway system misses the dryland and many people are not aware of the significance of these areas.

Trapping snow by stubble after harvest not only increases stored soil moisture but also reduces the amount of runoff and erosion. The deeper snowpack is not melted as readily by a chinook wind as are shallower ones. Initially, a deep snowpack will absorb much of its own water as a layer of slush at the soil surface. This slush condition may persist for days or even weeks, allowing time for water to infiltrate. The snow crystals and water that make up the slush are both at 32°F. While the slush is under the snowpack, it is insulated from becoming either all water or all ice. Soil temperature, structure and moisture content determine whether infiltration, rather than runoff, occurs.

Soil profile temperatures preceeding the snowpack development together with variations in snowpack depth, soil moisture and final melt rate limit the accuracy of predictions of runoff and infiltration. Therefore, an experiment was conducted near Roy, ID, to determine runoff and infiltration under representative stubble and fallowed conditions. Snow was trapped with snow fences, sunflower strip plantings and stubble over several years so that various snowpack depths were obtained under a variety of winter conditions. To increase infiltration, soil was chiseled to a 12-inch depth after harvest. Overwinter runoff was measured on plots both after harvest and after summerfallowing.

Snow trapped on stubbleland and after harvest reduced winter and spring runoff. However, snow trapped on planted land that had been summerfallowed increased runoff (Fig. 2). The amount of additional runoff on planted land coincided with the amount of water trapped as snow, indicating poor infiltration into summerfallowed soil.

We attributed this reduced infiltration on summerfallowed soils to previously stored soil moisture, rather



RUNOFF DURING OVERWINTER

Fig. 2—The amount of runoff depends on whether the soil was just previously cropped or fallowed and on the depth of snow. Extra snow, on land just cropped, contributed to stored soil moisture but extra snow on land just fallowed largely ran off when it melted.

than to soil temperature or structure. Under deeper snowpacks, soil temperatures were usually just above freezing on both the stubble and after summerfallow treatments. Differences in soil structure could have favored infiltration into stubbleland, but the inherent soil structure was good and not easily altered during the summerfallow tillage season. Also, the infiltration rate of a soil having only a few inches of moist soil near the surface is many times greater than that of a soil that is wetted to several feet (Parr and Bertland 1960).

This study, with treatments using snow fences, sunflowers, etc., permitted greater differences in amount of snow trapped than the Tetonia study, and the effect of capturing snow on stubbleland was greater (Table 2).

Table 2. Effect of winter snowpack depth on increasing soil moisture and subsequent yields in a crop-fallow system.

Snowpack depth on stubble land	Spring summerfallow moisture in 5-foot profile	Winter wheat yields
(inches)	(inches)	(bu/acre)
6	5.1	22.1
12	5.7	23.1
18	7.3	26.2
24	8.4	28.5

These results showed that yields were increased about 5 bushels per acre for every foot of trapped snow. Therefore, every attempt should be made to leave tall stubble. A tall, stiff-strawed variety of wheat with other favorable characteristics has the added capability of helping to provide moisture for the next crop year. During harvest, combines should be operated with platforms as high as possible, even though this means cutting above a few short heads.

Cutting straw 6 inches higher than usual may increase wheat yields of the following crop by 10%. In areas where dwarf smut is prevalent, heads of the short plants are usually infected with dwarf-smut spores. Cutting plants 6 inches higher may make the difference as to whether or not the wheat is graded smutty.

Chiseling After Harvest

Chiseling is effective for increasing infiltration and reducing potential runoff water. Experiments have shown that chisel shank spacings of 3 feet are close enough to provide the needed entryway for infiltration. However, closer spacings, which require more energy, will help hasten next spring's tillage operation. Chiseling increases infiltration by leaving a rough, cloddy opening in the frozen soil surface. Chiseling that is too shallow — not reaching below the frost zone — will not improve infiltration effectively. During snowmelt, shallow chisel furrows may act like irrigation corrugations and the loose soil in the furrows will wash out.

Contour chiseling will help intercept runoff water. However, during mild winters or when snow was deep enough that the soil was not frozen, runoff was not a problem and, consequently, chiseling was not beneficial. These conditions may occur in 4 out of 10 years.

With chiseling, most overwinter precipitation on stubble ground is stored in the soil (Fig. 3). However, nonchiseled plots were not consistent in storing precipitation. Winter wheat in a fallow cropping system generally yields more because of extra soil moisture stored by chiseling. Table 3 summarizes several experiments comparing fall chiseling with no chiseling, where yields were averaged for both responsive and nonresponsive years.

Table 3. Average available soil moisture and winter wheat yields from chiseling after harvest at three experimental locations.

Experimental location	Available soil profile moisture spring of summerfallow		Yield of winter wheat after fallow	
	Chiseled	Not chiseled	Chiseled	Not chiseled
	(inches)		(bu/acre)	
Tetonia (UI R&E Center)	6.74	5.01	27.0	25.2
Newdale (Martineau farm)	7.07	6.51	26.9	25.1
Roy (Hayes farm)	—	—	23.0	19.3
Average	6.90	5.76	25.6	23.2

Various types of fall tillage have been tried in addition to chiseling. The rotary subsoiler was as effective as chiseling in Tetonia and Newdale trials, but this implement is no longer being manufactured. Neither a lister (with damming done) nor a 6-foot blade at 9-inch depth were effective in increasing soil water storage or in increasing yields because they did not produce soil openings to allow runoff to penetrate into the soil. Fall disking slightly reduced yields since it incorporated the stubble and reduced the amount of snow trapped.

Based on these results, we recommend chiseling after harvest. In addition to the benefits obtained with a wheat-fallow operation, chiseling will allow successful annual cropping in some years. This is discussed more in the section on annual cropping spring wheat.

Fall Weed Control

Some new weed growth usually occurs after harvest. Russian thistle, which may germinate and emerge quickly, and other broadleafed annuals may densely populate fields in wet falls. The first few hard frosts will eliminate most of these weeds. Volunteer spring wheat or barley seldom overwinters, but cheatgrass (also called downy brome or Junegrass), volunteer winter wheat, tumbling mustard, tansy mustard, fanweed and other winter annuals will survive. Even though these fall-germinating weeds slightly reduce next spring's soil moisture, tillage or chemical weed control in fall after harvest is usually not justified because of the cost.

When cheatgrass is serious, a light fall disking will cause most of the seeds to germinate before next spring's summerfallow tillage. The disking tends to increase runoff, but without it wheat yields may be reduced by one-third under severe cheatgrass competition. Moderate cheatgrass infestations can be controlled by practices discussed in sections on initial summerfallow tillage, weeding before fall planting and planting dates. Perennial weed problems are not discussed in this bulletin but do require special attention.

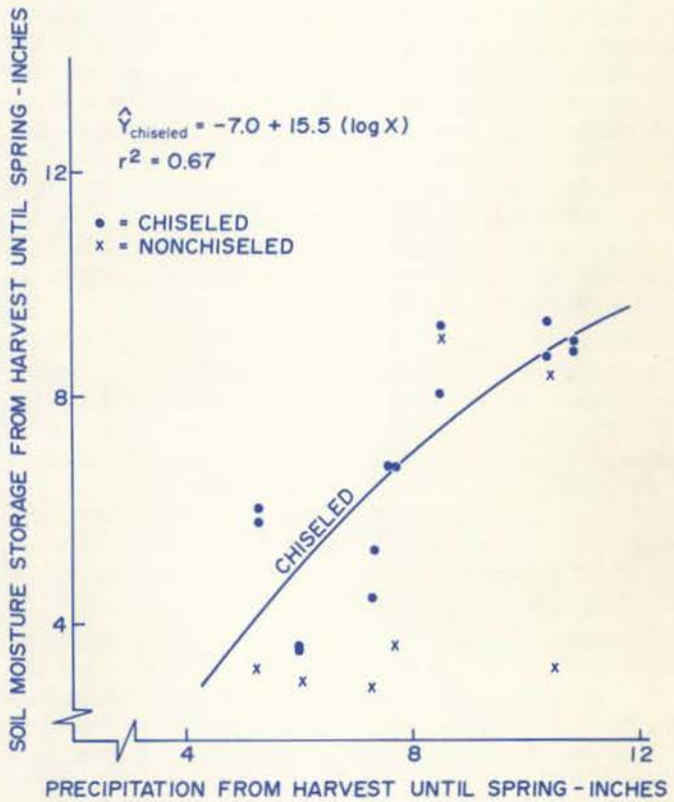


Fig. 3—From harvest until next spring, a large share of any precipitation is stored in the soil if chiseling (solid circles) has been done. Without chiseling (X), storage of precipitation is not dependable and runoff is increased.

Improving Summerfallow Practices

A net loss of soil profile moisture and an increase in available nitrogen and sulfur — released through organic matter decomposition — usually occur during the summerfallow period. Tillage for weed control also pulverizes the soil, leaving it more susceptible to erosion.

The soil should be managed to retain as much soil moisture as possible, especially in the seed zone for winter wheat planting. Summerfallow practices should also retain good soil physical properties for future crop growth, guard against erosion, control weeds and prepare a suitable seedbed.

Controlling Weed Growth With Minimum Cultivations

Soil moisture is usually best saved by controlling weed growth with the fewest cultivations. Theoretically, the ideal soil condition for retaining moisture is loose surface mulch which causes a discontinuity of pores between the surface and the deeper moist subsurface soil. This discontinuity will restrict the capillary rise of moisture to the surface and thus reduce evaporation. In addition, a deep stubble mulch adds an extra layer of insulation that results in a cooler soil and reduces temperature fluctuations so that moisture is not driven to the surface by temperature gradients.

Tillage to create these conditions must coincide with needed weeding operations, since each tillage causes some moisture loss. Each tillage also works some of the existing surface stubble into the ground, losing it as mulch. These factors prohibit cultivating just to create a soil mulch. Likewise, rapid moisture loss after a rainstorm must be overlooked because by the time implements can be operated in the field, the evaporation rate will have decreased, a new crop of weeds may be starting and cultivating will be needed a few days later.

Stubble mulching has not been a major key to saving soil moisture in this area because stubble amounts are too low. If fields produced enough stubble to maintain a half-inch layer of mulch, the effects could be dramatic (Wiegand and Taylor 1961). A stubble mulch lowers initial evaporation rates. However, after sufficient drying time, the mulched surface soil will finally dry to nearly the same moisture content as a clean fallow. Therefore, the main advantages of stubble mulch tillage are to control erosion and maintain fertility.

In deciding how long to allow weeds to grow on summerfallow before tilling, be careful that they don't dry down the seedbed moisture. Once seedbed moisture has been lost, it usually is not replaced before fall seeding time. Small weeds will initially reduce seedbed moisture and reduce winter wheat germination. If weeds are allowed to grow larger, they will also materially waste soil moisture stored deeper in the profile and use the available nitrogen.

Use Shallow Tillage, Do Not Till Wet Soil

Tillage has two major purposes — to control erosion and to maintain good soil physical conditions. Leaving stubble on the surface will provide protection from both water and wind erosion. Also, since severe runoff may erode soil to the tillage depth, shallow tillage (2 to 4 inches deep) is a practical and economic way to insure against extreme erosion.

Soil physical conditions in this dryland area are naturally good for plant growth, with a few exceptions. To retain these conditions, avoid working the soil when it is so wet that tilling compacts it. You can easily detect such compacted areas by digging into the soil with a shovel after it has dried.

Soil Chemical and Microbiological Conditions

The best chemical and microbiological conditions in these soils are obtained by managing tillage to provide good moisture and erosion control.

The most important fertility considerations are to maintain adequate supplies of nitrogen, phosphorus and sulfur. Phosphorus is usually abundant, but this should be verified periodically with soil tests, especially on eroded soils. Sulfur is needed only on acid, leached soils, like those in the Teton Basin and Fairfield areas (Massee et. al 1975). Sulfur may become limiting if commercial fertilizer nitrogen has been used over a period of years. When no nitrogen fertilizer is applied, most soil nitrogen comes from natural decomposition of organic matter. The organic matter, itself derived from plant material, is balanced with a nitrogen-to-sulfur ratio of about 15:1 needed for new plant growth. Adding nitrogen fertilizer can overbalance the nitrogen side of this ratio and cause sulfur to be in short supply.

Stubble mulch keeps soils cooler. This in turn slows decomposition of organic matter, reduces the release of nitrogen and sulfur and ultimately lowers protein content of grain (see section on mulch tillage). Applying nitrogen fertilizer will increase soil nitrogen and offset the effect of stubble mulch. Stubble that has been incorporated into the soil may remain undecomposed for some time on dryland. You can observe this at planting time when drills plug with straw, or when straw that was plowed under two years earlier is plowed up. We recommend management practices that will shorten straw length and leave the stubble on the surface, rather than attempting to hasten the decomposition. The straw cover can be handled by using mulch-clearing drills (see section on deep furrow drills).

Adding Organic Materials

We have encountered several microbiological and other soil conditioners. While some organic materials from reliable companies have a stabilizing effect for preventing crusting or erosion control and are of limited value in intensive agriculture, we believe that most of those materials promoted for dryland are ineffective.

Stubble Mulch Tillage Implements

We recommend stubble-mulch fallowing which leaves the stubble on and near the surface to protect the soil from erosion. Mulch tillage implements should be set to till shallowly so the deeper soil is not disturbed and made more subject to erosion. Stubble in this area does not provide a heavy mulch. Yet the tillage implements must have good clearance and be non-clogging. They should have low-draft requirements, be easily adjusted for varying soil conditions and uneven topography and should complete a tillage job in a once-over-the-land operation. Furthermore, the implement should permit operating at a speed so that tillage is accomplished on time. After the initial mulch tillage, summerfallow operations normally consist of rodweeding as needed to control weed growth and obtain a firm seedbed. Many commercial implements are available. Some major mechanical differences are pointed out in the following discussion:

Subsurface Sweeps

This general class of tools includes sweeps that vary in width from 8-foot blades to narrow "bull-tongue" chisels. For dryland operations, they are normally mounted on wheels and hydraulically adjusted. Sweeps do not tend to produce tillage pans because they do little vertical soil lifting that would need to be balanced by downward pressure from the implement or to be transferred through the drawbar to the tractor wheels. They leave 75 to 90% of the stubble on the surface. The draft requirement for sweeps is moderate, ranging from 200 to 800 pounds per foot width.[1]

A 16- to 18-inch duckfoot is normally set to completely cultivate and weed the soil in a single operation. This size sweep is easy to adjust for depth control. It incorporates more residue into the soil than the wider blades because it has more shanks to stir the soil. A duckfoot needs several gangs, or bars, so the shanks can be staggered forward to rear, to avoid plugging with stubble and root-soil mass. Using 3 bars and attaching shanks on each bar that are 1.5 times the width of the individual duckfoot will result in a complete overlap and do a good tillage job. If less overlap is used or more sub-surface stirring is needed for weeding, a weeder attachment (Fig. 4) will eliminate the need to follow with a separate rodweeding.

The use of narrower duckfeet, including "diamond points" or "bull tongues" will produce more stirring action and loosening of the soil. Shank spacing may not be much closer than with 16- to 18-inch duckfeet, but this tillage needs to be followed soon afterward with a tool that completely weeds the land, such as a wider sweep, a rodweeder or a rodweeder attachment.

Disk Harrows

Three different types of disk harrows commonly used are the tandem disk, the offset disk and the one-way disk. As tools for starting summerfallow tillage, disk harrows must have adequate penetration capabilities and must be controllable to avoid excess stubble incorporation and draft requirements. Penetration capability depends on balde spacing, gang angle and weight —200 to 300 pounds per foot width may be needed. We believe "cut-outs" in the front disk gang or cone-shaped vs. standard spherical-shaped blades are less important than weight, angle and blade spacing.

The tandem disk is popular because it is easily adjusted, does not leave large furrows and requires minimum draft (100 to 280 pounds per foot) so large acreages may be tilled in a desired time. However, some light tandem disks are manufactured for use as a pulverizing and smoothing tool. These lighter disks are not suited for initial tilling of dryland. Heavier tandem disks with normally spaced blades (7 to 10 inches on the front gang, the same or narrower on the rear gang) and hydraulic wheel lift adjustment are recommended for stubble-mulch tillage.

The sharp gang angle of the one-way disk makes it good for penetration although its weight is only moderate. Therefore, it requires more draft (180 to 400 pounds per foot) than the tandem disk. With a shallow setting, it will do a suitable stubble-mulch job since it tends to skim and slide the surface soil with minimum inversion. The one-way disk is best adapted for straight cultivation runs. It does not have the inherent no-ridging ability of the tandem disk, especially on turns.

Fig. 4—Weeder attachments like this one are rugged. Using such an attachment takes the place of an additional rodweeding operation.

[1]Pounds drawbar pull required to move the implement forward. Figures given are ASAE quotations for normal operating speeds.

The offset disk has traditionally been built with a heavy frame and wider-spaced, larger disk blades. Manufacturers usually recommend it for more difficult jobs such as turning under light sod and cover crops. Its larger-rated draft (250 to 400 pounds per foot) results from the weight and disk blade size, not from any difference in the basic design as compared with the right half of a tandem disk. Offset disks must be adjusted to avoid excess penetration, ridging and surface-soil inversion. To help limit depth of tillage for mulching, the distance between disk blades should be restricted, preferably to 8 or 9 inches.

Rolling Harrows, "Skew Treaders," Rotary Hoes and Cultipackers

These implements will do a good job of "busting" standing stubble and, sometimes, in scattering bunched straw. Their operation results in less stubble incorporation and less soil pulverization. The teeth on "tooth disks," "crow feet" or "spiders" sometimes are shaped so they pack the soil when pulled in one direction and throw the soil up when pulled in the reverse direction. Under field conditions where they make a 100% weed kill, they are a useful alternative to disking or rodweeding.

Rodweeders

This implement is the main one used for tillage and seedbed preparation for winter wheat after the initial summerfallow operation. The rodweeder packs the soil under the rod, which helps to firm the seedbed. However, the packing action may become excessive and will result in a tillage pan if the soil is too moist when rodweeded. Under normal conditions, the draft requirement of a rodweeder is only 60 to 120 pounds per foot, allowing use of wide implement widths. It fits well into a stubble-mulch program since it leaves 85 to 90% of the residue on the surface and is free of plugging.

Two alterations are commonly made on rodweeders. One is to attach a flat bar behind the rod and bolt narrow duckfeet shanks to the bar. The shanks reach ahead of the rod, where the duckfeet are attached. This helps penetration and is used in hard or heavy soil. The second adaptation is to use a rod that contains a spiral. This increases the lifting and stirring of the soil. It is especially useful where cheatgrass is heavy and more shaking is needed to loosen the soil from roots for a complete kill.

Mulch Tillage

Three methods of initial summerfallow tilling were compared in early research at Tetonia. The experiments compared sweep-mulch tillage, disking and moldboard plowing. Since yields averaged 1 bushel per acre higher from sweep-mulch tillage and protein content was slightly lower (Table 4), we recommend mulch tillage for both erosion control and for top production.

Table 4. Average winter wheat yields and protein contents as influenced by methods of fallowing, University of Idaho Research and Extension Center, Tetonia, 1940-1958.

Initial fallow treatment	Yield	Protein content
	(bu/acre)	(%)
Sweep mulch	24.5	14.2
Oneway disk	23.6	14.6
Moldboard plow	23.3	14.5

Spring Burning

The effects of burning stubble were also studied at Tetonia between 1940 and 1958. Burning was usually done in the spring before starting summerfallow, so snow trapping was not affected. Therefore, these results show the effects of residue as mulch and as a source of soil organic matter. Burning increased yields slightly for the first 6 years of the study, then yields on burned plots decreased (Table 5).

Table 5. Relative yields from burning stubble as compared with not burning, University of Idaho Research and Extension Center, Tetonia, 1940-1958.*

Number of years stubble burned	Yield on burned plots (% of non-burned)
1st to 6th experimental year	103.4
7th to 12th experimental year	96.3
13th to 18th experimental year	89.3

*Multiple regression analysis of Tetonia data showed that the ratio was also slightly affected by the relative unburned production in any one year as compared with the 18-year average. This relation indicated that burning was most detrimental during low production years and least detrimental during high production years. This effect was statistically removed from the data presented so that the years shown are all based on the same production potential.

Similar studies at Nephi, UT (Bennett et. al 1954) and Pendleton, OR (Oveson 1966) indicated that the initial yield increase from burning followed by a reduction is common under many soil and climatic conditions.

Early Shallow Spring Fallowing Assures Moisture for Fall Germination

Soil moisture content in the seedbed at fall planting will closely resemble the amount present when initial spring tillage is done. This is important in southeastern Idaho where summer and fall rainfall is limited and fall wheat stands may be sparse. Amounts of seedbed moisture from three different times of initial tillage under a stubble mulch fallow system are shown in Fig. 5. These data indicate that adequate moisture for germinating winter wheat may be assured by early fallow. With early fallow, winter wheat stands averaged 86%. Delaying the initial tillage operation 2 weeks (the

Table 6. Yields of winter wheat* resulting from date of initially tilling summerfallow and planting date (5-year averages).

Initial tillage date	Yields of winter wheat			
	Plant Aug. 15	Plant Sept. 1	Plant Sept. 15	Average
	(bu/acre)			
Early	30.2	31.1	38.4	29.9
Medium	27.0	28.9	27.7	27.9
Late	23.2	23.4	23.4	23.3

*Includes spring wheat yield that was replanted one year when the late tillage date resulted in stand failure.

medium treatment in Fig. 5) resulted in 79% stands. The late treatment (5-week delay from early treatment) resulted in only 53% stands, which included one failure in the 5-year experiment. Average yields as affected by both tillage data and planting date are shown in Table 6.

Tillage depths of 3, 6 and 12 inches were also tested at each date of tillage. Slight differences were noted in soil moisture and yields favoring the 3-inch depth. We recommend shallow tillage to conserve machinery and fuel and possibly to reduce erosion.

Using Chemical Fallow

Innovations such as chemical evaporation suppressants and sunlight reflectants have been tested for increasing wheat yields, but have not been successful. Using herbicides to control weeds (chemical fallow) resulted in slower initial drying of the soil surface, but at later drying stages the total evaporation from chemical fallow was the same as from tilled soil. This method holds limited promise unless economical, selective herbicides are discovered.

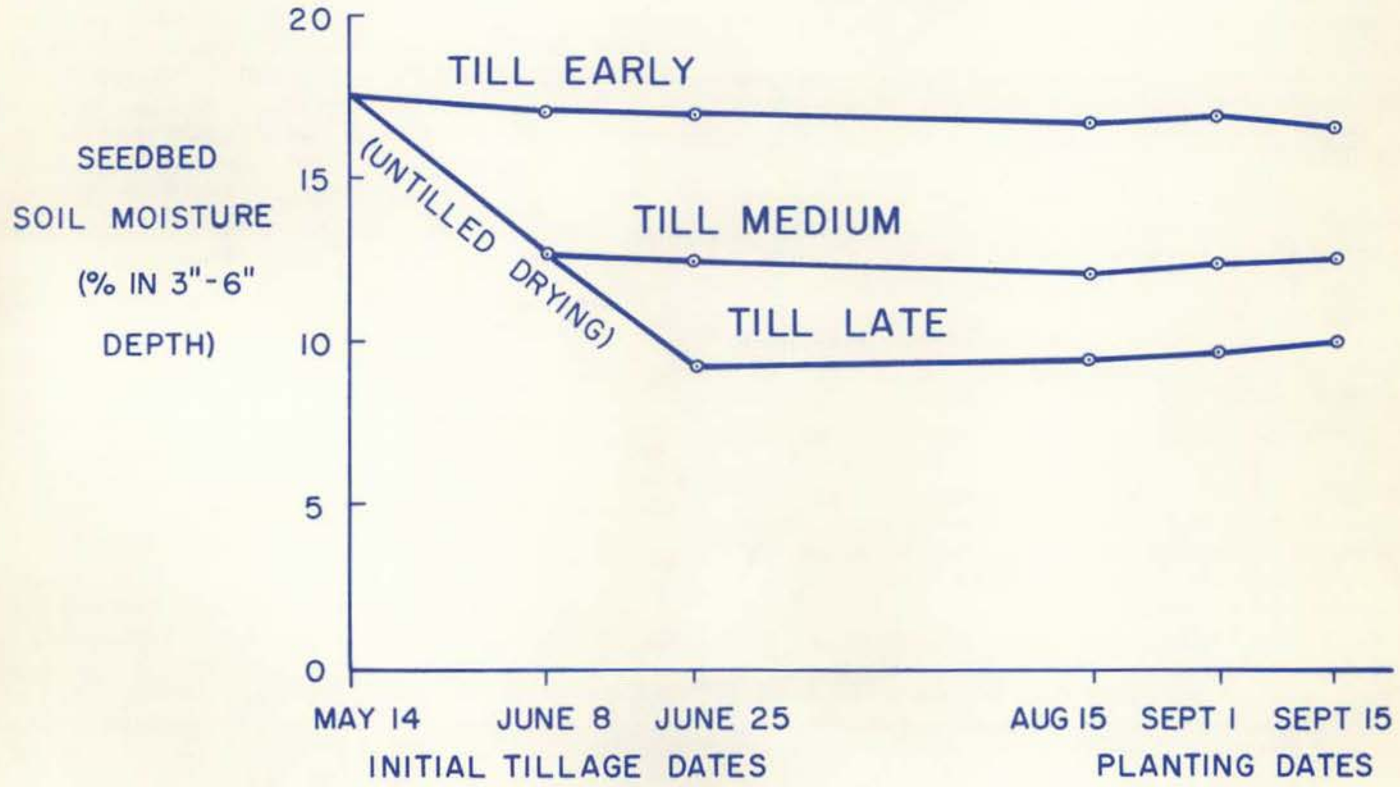


Fig. 5—Fall seedbed (3- to 6-inch) moisture content is largely determined by when the initial spring tillage is done. With good summerfallow management, there will be the same amount at fall seeding time as at the spring tillage.

Timing Final Fall Tillage

If recommended fallow operations are followed, the result will usually be a firm seedbed ready for planting winter wheat. If weeds and volunteer plants are present, the fallow ground should be rodweeded just before planting.

The final tillage operation is especially important on ground with a cheatgrass problem. In a cheatgrass control experiment at Tetonia, cheatgrass was controlled by initially tilling early as recommended and seeding late (September 15) with a final rodweeding just before seeding (Table 7). Early initial tillage helped the soil to retain enough moisture to germinate the cheatgrass seeds before late planting so the weed could be killed by rodweeding. On plots with late initial tillage (not included in Table 7), as many as 300 cheatgrass plants per square yard were observed.

Table 7. Effects of planting date and date of last rodweeding on cheatgrass populations in wheat crop (all plots initially tilled early).

	Cheatgrass plants per square yard	
Planting date	Final rodweeding 20 days before planting	Final rodweeding 1 day before planting
Sept. 1	62	76
Sept. 15	32	3

Time of Seeding

Recommended date of seeding winter wheat will depend on the moisture supply in the surface 3 inches and the elevation (which determines the length of growing season in the fall). In 6 years of trials at Tetonia, yields varied only 4 bushels per acre for the various seeding dates during wet years; during the dry years, the difference was 12 bushels per acre favoring September 1 over October 1 seeding date (Table 8).

Table 8. Average yield during wet and dry years for various seeding dates at two rates of nitrogen fertilizer.

	Wet years		Dry years	
Date of seeding	0 N	40 lb. N	0 N	40 lb. N
		(bu/acre)		
August 15	42.0	52.3	34.7	34.2
September 1	41.2	48.5	38.8	32.5
September 15	44.5	46.7	28.9	25.9
October 1	40.3	44.4	23.1	23.0

During wet years, adding 40 pounds nitrogen on earlier seedings increased yield 8 to 10 bushels per acre. During dry years, yield decreased when nitrogen was applied. Fertilizer trials in recent years have shown that 40 to 50 pounds per acre of actual nitrogen should be applied every crop year. Time of application will depend upon type of fertilizer used. Anhydrous and liquid nitrogen must be applied in the fallow before seeding. If dry nitrogen fertilizer is broadcast, we found little difference between fall and spring application. However, part of the fall-applied fertilizer could be wasted if a winter wheat crop is lost to snow mold.

During the last few years of the experiment, wheat plants from August 15 seeding were seriously infected with root, crown and foot rots. Yields were reduced as much as 30% some years. Wheat plants from September 1 seeding showed some infection but not enough to reduce yield.

The August 15 and October 1 seeding dates had the least winter kill from snow mold. The August 15 plots contained a high level of mold infection but the plant crowns were vigorous enough to recover. The wheat plants from October 1 seeding usually had so few leaves that they were not infected. However, this relative freedom from snow mold did not influence yield enough to make these seeding dates the highest yielding.

Percent protein increased from 11.2 to 15.9% when the seeding date was delayed. Higher protein from the later seeding dates coincided with lower yields.

Optimum seeding rate also depends upon seeding date. A 20-pound seeding rate at Tetonia was sufficient for August 15, 40 pounds for September 1, 50 pounds for September 15 and 60 pounds for October 1.

For locations similar to Tetonia, we recommend the September 1 seeding date, 40-pound seeding rate and application of 40 pounds nitrogen to obtain the highest yield and highest quality wheat.

Deep Furrow Drills

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 moist soil. While double- and single-disk drills with 6- to 7-inch disk spacing will drill through light residues satisfactorily, they are not recommended for winter wheat. During dry falls, they would not be able to penetrate the seedbed sufficiently to place the seed in moist soil.

When heavy residues are present, deep-furrow disk or shovel drills with 14-inch spacing are preferable. The deep-furrow drills now available are designed for stubble-mulch tillage and will drill through stubble residue found in southern Idaho's dryland areas. The later model shovel-opener-type drills worked better in heavy residues than the disk drills because their clearance is higher and the arrangement of the openers is staggered. Using these drills helped trap snow for better wheat survival.

Annual Crop or Summerfallow

Comparing nitrogen-fertilized spring wheat yields over several years shows that yields were always proportional to the amount of water available (Fig. 6). The actual quantity of water available for evapotranspiration was most important, not when it was stored. Plots that were fall chiseled after harvest had nearly as much moisture stored by the next spring as those that had undergone an entire fallow operation. In comparison, nonchiseled plots stored erratic amounts of moisture during the first winter, sometimes gaining as much as the chiseled plots but usually much less. The average soil profile moisture and resulting yields are shown in Table 9.

Table 9. Average soil water stored at seeding and wheat yields for three cropping methods (all with 20 pounds per acre nitrogen fertilizer).

Cropping method	Soil profile moisture	Yield
	(inches)	(bu/acre)
Annual crop (nonchiseled)	4.8	12.2
Annual crops, fall chiseled stubble	6.8	17.1
Crop on fallow, fall chiseled stubble	7.9	19.2

Fig. 7 illustrates the relationships of soil moisture storage to expected annual cropping yield compared with anticipated yield after fallow. Variations in local soils and yearly weather will cause fluctuations in soil moisture and yield compared to those in Fig. 7. However, this figure incorporates a cause-and-effect approach which should make individual situations meaningful. Under dryland, moisture will penetrate to a distinct visual depth during the first winter after harvest. Yields in Fig. 7 are based on average crop-year rainfall. In a fallowing system, the change in soil moisture from one spring to the next is largely controlled by the amount of soil moisture the first spring. A more constant — but not always greater — amount of soil moisture is expected after fallowing. These relationships illustrate that in some cases a fallow period is needed to insure against near crop failure but in other cases annual cropping offers an economic advantage.

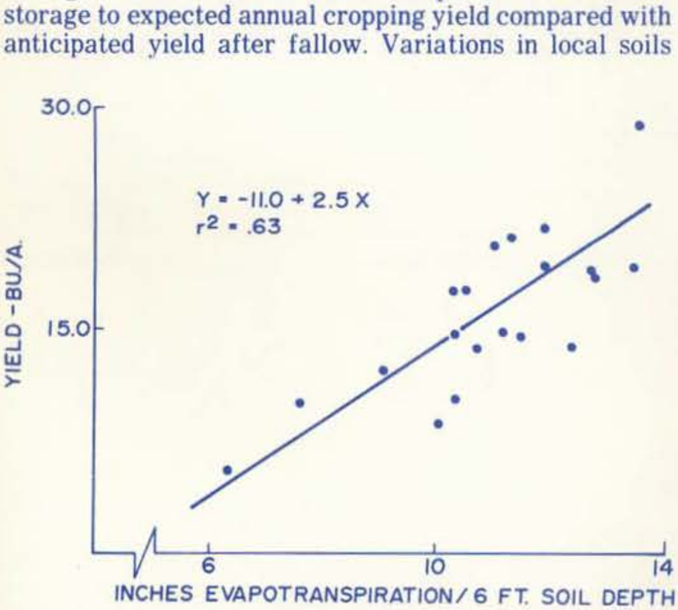


Fig. 6. Yield differences of spring wheat directly result from the total moisture available and used from stored sources plus cropping precipitation (for soil evaporation and plant transpiration), and are quite independent of previous cropping (except as previous cropping cause stored moisture differences).

Fig. 7 is based on relationships expected with varying depths of moisture penetration in medium-textured silt loam soils. Coarser-textured soils will have less water available for plants per foot of moisture penetration. Before deciding on cropping method, also consider that annual cropping requires extra weed control and nitrogen fertilizer.

Nitrogen Fertilizer for Annual Cropping

The yields in Table 9 and those predicted in Fig. 7 are from applying only 20 pounds per acre of actual nitrogen, the lowest nitrogen rate that will fully use available soil moisture and thus produce top yields. Some crops grown after summerfallow did not respond to nitrogen because the soil in the experimental areas was naturally quite fertile. The 20 pound amount causing response on annual cropped plots corresponds closely to the amount of nitrogen released from soil organic matter decomposition during a fallow period. This indicates that a minimum of 20 pounds per acre of nitrogen will be needed for annual cropping, in addition to the amount needed on other soils to produce top yields with fallowing.

Annual cropping in a 1975 test at Tetonia indicated that up to 50 pounds per acre actual nitrogen is needed to obtain maximum yields (Table 10). Response to nitrogen fertilizer was also much greater in the 1975 trials than it was earlier. Wheat and barley yields increased over 100%; oats yields 77%.

Table 10. Yields of wheat, barley and oats on annual cropping plots with and without nitrogen fertilizer at Tetonia, 1975.

Variety	No N	50 lb. N
	(bu/acre)	(bu/acre)
Borah wheat	18.1	39.6
Steptoe barley	29.6	61.1
Cayuse oats	38.4	60.5

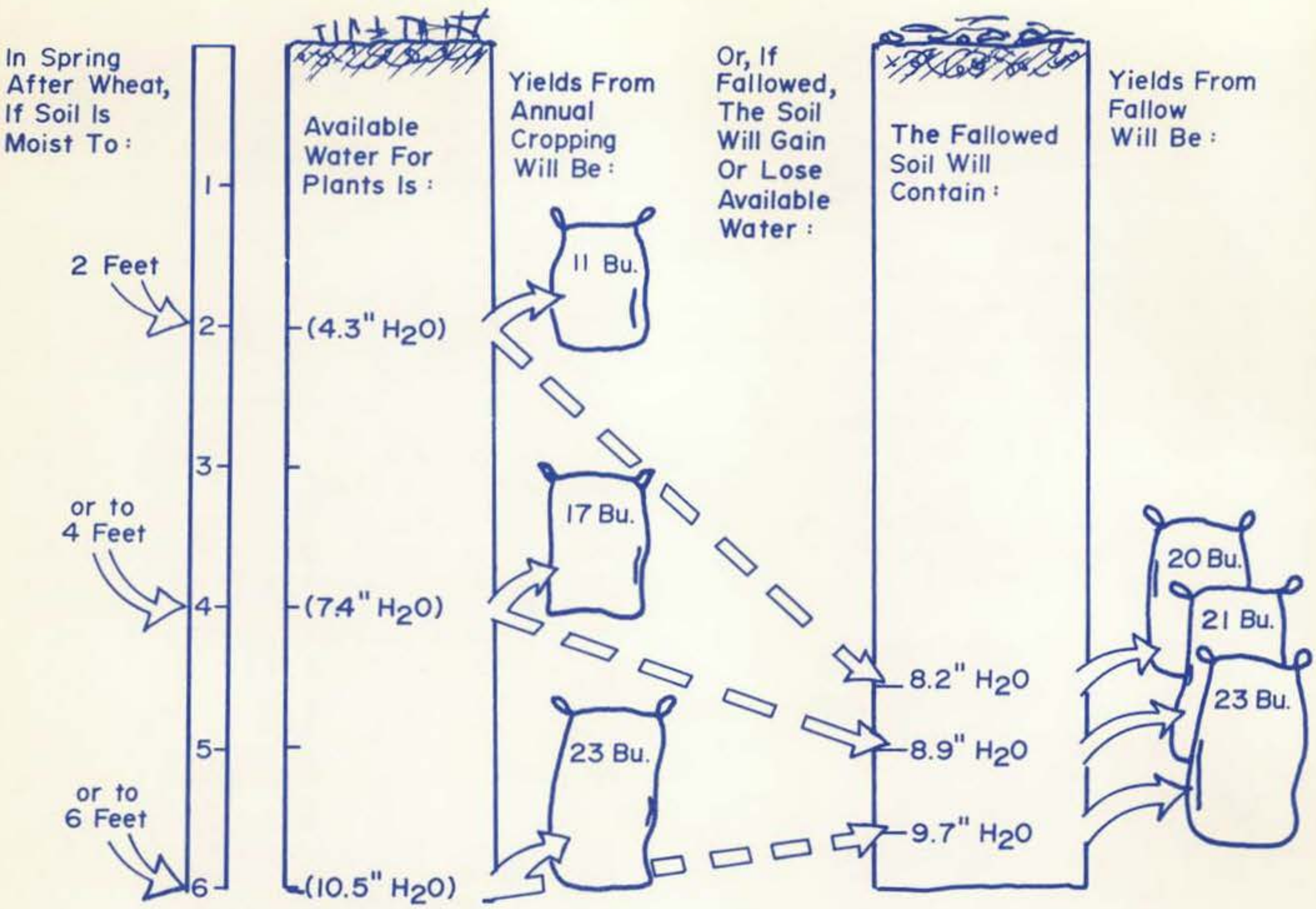


Fig. 7. To determine whether to annual crop instead of fallowing, determine soil moisture depth and follow scheme showing expected annual cropped yields and alternate expected summerfallow moisture changes and fallowed yields. The date was taken from research results at Tetonia for yield and soil moisture changes. (The "$\hat{Y}$" is a statistical symbol indicating the quantities immediately following it are an "expected" result.)

$\hat{Y}$ (inches "available water for plants") = (feet wetted) 1.75 + [6 - (Feet wetted) (0.2)]

$\hat{Y}$ (crop yield from annual cropping) = 3.24 + 1.89 (stored H_20/6' soil depth) $r = 0.82$

$\hat{Y}$ (moisture gain or loss by fallowing) = 7.09 - 0.75 (Stored H_2O/6' depth in spring of summerfallow year) $r = 0.81$

$\hat{Y}$ (crop yield from fallowed land) = 4.24 + 1.89 (stored H_2O/6' soil depth) $r = 0.82$

Literature Cited

Bennett, W. H., D. W. Pittman, D. C. Tingey, D. R. McAllister, H. B. Peterson and I. G. Sampson. 1954. Fifty years of dryland research at the Nephi Field Station. Utah Agr. Exp. Sta. Bull. 317.

Massee, T. W., R. C. Rosenau, C. W. Case and C. G. Painter. 1975. Cropping and fertilizing wheat and barley in the Camas Prairie-Fairfield area. Univ. of Idaho CIS 278.

Oveson, M. M. 1966. Conservation of soil nitrogen in a wheat-summerfallow farming practice. Agron. J. Vol. 58:444-447.

Parr, J. F., and A. R. Bertland. 1960. Water infiltration into soils. Advances in Agronomy 12:311-363. Academic Press, NY.

Wiegand, Craig L., and Sterling A. Taylor. 1961. Evaporative drying of porous media. Utah State Univ. Special Report No. 15.

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