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PRINCIPLES OF FALL WEED CONTROL AND RESIDUE MANAGEMENT IN A FALLOW-WINTER WHEAT ROTATION

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The application of conservation tillage practices has had a dramatic impact on wheat and sorghum yields in the Central Great Plains area and nationally. USDA figures show that average wheat yields increased nationally from 16.0 bushels per acre in 1951 to 33.7 bushels per acre by 1971. Likewise, grain sorghum yields improved from 19.1 to 54.5 bushels per acre during the same period. A wide variety of agronomic and management practices have been responsible for this remarkable rate increase in prodution.

The impact of improved use of straw mulches and fall weed control is dramatized by winter wheat yields obtained in a fallow rotation at the Central Great Plains Research Station at Akron (see Table 1). During the 1916-1960 period, average precipitation was 16.53 inches and average wheat yield was 19.6 bushels per acre. From 1961 to 1975 even with less precipitation (15.33 inches), wheat yields increased to 32.2 bushels per acre.

Table 1 - Evolution of Wheat Yields and Fallow Systems, Akron, Colorado.[a]

Time Period (Yrs.)	Changes In Fallow System	Avg. Precip. Inches	Wheat Yield B/A	Water-Use Eff.[b] B/A/In.
1916-1930	Shallow plow, harrow	17.28	15.9	0.46
1931-1945	One-way disk, rod weeder	15.83	17.3	0.54
1946-1960	Disk, begin mulching with sweeps and rod weeder (tongs)	16.38	25.7	0.78
1961-1975	Stubble mulch, begin fall weed control in 1967	15.33	32.2	1.05

[a] U. S. Central Great Plains Research Station.

[b] Assuming two years precipitation per crop in a fallow-wheat system.

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The higher wheat yields in recent years were directly related to the improvement of increased storage of soil water at seeding time, surface roughness to eliminate wind erosion, better wheat varieties, and improved tillage and planting equipment.

The Central Great Plains area encompasses eastern Colorado, southwestern Wyoming, western and southwestern Nebraska, and western Kansas. Along with high average wind velocities and evaporation, the 12 to 24 inches of annual precipitation is erratic for both short and long term durations. These hazardous conditions have naturally imposed more agronomic attention to improving water conservation and wind erosion control as high priority.

Years of research and experience in a fallow operation show:

1. Fallow land should be weed-free from the date of harvest to the date of planting (14 months).

2. Stubble should remain upright during winter months to retain snow and inhibit unexpected water runoff.

3. A straw mulch of 1,500 to 2,000 pounds per acre should be retained at seeding time.

4. Firm soil clods should be maintained during fallow and after seeding.

5. All the foregoing should be accomplished with the least tillage possible.

These objectives maximize soil water storage and soil nitrate supplies, assure better seed bed germination, and reduce the wind erosion potential to near zero.

Weed Control

Adequate weed control in fallow cannot be overemphasized. Research has shown that 10 common broadleaf weeds have an average water requirement of 525 pounds of water per pound of dry matter produced. This value of braodleaf weeds is nearly identical to the 507-pound value assigned to winter wheat. Water is also heavily consumed by grassy annual weeds and volunteer wheat itself.

The total growth of weeds from date of harvest to date of planting 14 months later in a fallow-winter wheat system can exceed 2,400 pounds dry matter per acre. Half of this growth is usually experienced from date of harvest to fall dormancy. Weeds consume about 30 pounds per acre of available nitrogen and 3.3 inches of water per 1,000 pounds per acre of growth. Such a heavy loss of both water and nitrogen will seriously reduce the ultimate yield potential of the succeeding crop. For example, the loss of one inch of available water will reduce the yield potential of winter wheat by 4 to 6 bushels per acre and its associated straw by 420 to 660 pounds per acre.

The ideal control system would include an instant and complete kill of all weeds from date of harvest until June 20 of the following summer. Although this ideal system is not yet available, control systems under study at Akron and at North Platte, Nebraska, have achieved positive economic results by the use of subtillage and/or herbicides. The reduction of fall growth of weeds in fallow by 600-800 pounds of potential growth per acre significantly increased the storage of soil water and soil nitrates. In turn, this increased the yield of grain by 6 to 8 bushels per acre of wheat (see Tables 2 and 3). The weeds already present were quickly killed after harvest, and the secondary weed growth was then suppressed with a pre-emergence treatment of atrazine. Sub-tillage or contact herbicides such as amitrol, paraquat, butyl ester, and roundup gave varying degrees of success with weeds already established. The use of herbicides seems especially desirable because of non-disturbance of stubble, and particularly when the quantity of stubble is initially low.

Weed control within a growing crop is not less important than during fallow. Although winter wheat grows relatively clean, thin stands tend to become weedy later in the spring. Fall germinating weeds such as tansy mustard and downy brome can also be troublesome. When spring planted barley and oats are grown in place of winter wheat, crop success is generally determined by the quality of weed control in the crop's early stages.

Snow Control

Snow retention and water conservation are two important reasons for leaving stubble upright during the winter season. Snowmelt enters the soil at 64% to 70% efficiency compared with 0% to 15% efficiency from summer rainfall. Fall weed control by disking has proven detrimental for this reason. Water gains obtained by fall disking to eliminate weeds are more than canceled by the loss of snow retention.

The use of subtillage for fall weed control in fallow has been shown to be an economic and feasible practice in view of some restrictions on certain herbicides. Single subtillage leaves the stubble upright if the operation is conducted at 3½ to 4 inches depth. A second tillage, however, may knock down some stubble by weakening the stubble anchor clods. Therefore, it is important to conduct any second subtillage at 90 degrees to the first operation and at the same depth or deeper.

Stubble Mulch (see Table 4)

Before 1957, it was difficult to maintain a reasonable surface mulch of straw or stover. Poor weed control and mechanical bunching of stubble inhibited many operators from following a true stubble mulch program. However, recently developed wide sweep blades and rod weeders with attached tongs, in combination with vastly increased horsepower, now make stubble mulching relatively easy. Units of 30 to 60 feet operating width are now common, and planting in straw mulches and soil clods is seldom a problem with modern, deep furrow shoe-type drills.

Table 2 - Influence of Fall Weed Suppression in New Wheat Stubble in a Fallow-Wheat Rotation. Seven-Year Avg. (1969-1972; 1974-1976). Akron, Colorado.

	FALLOW SEASON INPUTS				
Fall Weed Control[a]	Fall Weed Growth	Tillage Operations	Soil Water at Planting	Fallow Eff.[b]	Soil Nitrates at Planting
	Lb/A	Avg. No.	Inches	%	Lb/A
Spring Disk, Check (Conventional Tillage)	1020	4.7	6.56	24	82
Fall Sweep, Single	580	5.6	7.24	28	95
Fall Sweep, Double (Maximum Tillage)	320	6.3	7.61	31	103
Fall Sweep (1) + Atrazine	270	4.3	7.70	31	108
Contact Herb. x Atrazine (Minimum Tillage)	290	3.0	7.88	32	110

	CROP SEASON OUTPUTS					
		Yield Winter Wheat				
Fall Weed Control[a]	Total Water Use - Wheat[c]	Grain	Straw	TDM	Water Use Eff.[d]	Protein Grain
	Inches	B/A	Lb/A	Lb/A	Lb/A/In.	%
Spring Disk, Check (Conventional Tillage)	15.16	36.5	3440	5630	365	10.6
Fall Sweep, Single	16.10	40.0	3820	6220	390	11.1
Fall Sweep, Double (Maximum Tillage)	16.46	43.0	4160	6740	405	11.3
Fall Sweep (1) + Atrazine	16.57	43.8	4160	6790	405	11.5
Contact Herb. + Atrazine (Minimum Tillage)	16.95	44.3	4380	7040	415	11.5

a = Applied within seven days after wheat harvest. Contact herbicides include Amitrol-T, Paraquat, and Roundup; b = Fallow efficiency is the net gain of soil water during 13½ months fallow x 100 ÷ fallow season precipitation; c = Soil water use by wheat + crop season precipitation from planting date to harvest; d = Total dry matter (TDM) produced (Lb/A) ÷ total water use (Inches).

Note: Avg. annual precipitation during years of experimentation was 14.20 inches.

Table 3 - Net benefits above conventional spring tillage, from fall herbicide weed control in after-harvest wheat stubble in a fallow-winter wheat rotation. Yearly results. Akron, Colorado.

Fallow and Crop Year	Extra Fallow Soil Water	Extra Fallow Soil NO_3-N	Extra Wheat Yield Components			
			Grain	Straw	TDM[c]	Protein
Exp. No.	Inches	Lb/A	B/A	Lb/A	Lb/A	%
Colo. A-67-1						
1968-69	.92	15	3.8	545	775	0.3
1969-70	2.34	46	13.7	1180	2000	1.7
1970-71	1.71	39	5.5	1030	1360	1.2
1971-72[a]	1.38	10	4.7	515	795	0.0
1971-72[b]	.72	27	6.9	565	930	0.8
Colo. A-72-2						
1973-74	1.41	41	8.3	980	1480	1.9
1974-75	1.76	25	11.0	800	1460	0.6
1975-76	1.52	14	5.6	760	1095	0.0
Avg. All Tests	1.47	27	7.4	795	1240	0.8

[a] = East field exp. [b] = West field exp. [c] = Total dry matter.

Note: Herbicide combinations include atrazine and amitrol T, atrazine and paraquat, and atrazine and roundup.

Table 4 - Residual wheat straw remaining at end of fallow in top 3 inches of soil one month after seeding. Three-year average (1974-1976) Akron, Colorado.

Fall Weed Control	Mechanical Tillage	Residual Straw
	Avg. No.	Lb/A
None, spring double disk	4-1/3	1800
None, spring sweep + rod weeder	4-1/3	3500
Double fall sweep	6	2820
Fall sweep + atrazine	3-2/3	3390
Paraquat + atrazine	2-2/3	4080

The conservation benefits of mulching are well known. Greater water conservation is obtained by mulching both through improved water intake and decreased evaporation. Recent tests at three semiarid western locations have shown an average 0.7 to 1.7 inches net gain in moisture content of fallow, using from 1,500 to 6,000 pounds of mulch per acre. The net gains credited to higher application and maintenance of straw mulches were significant at the 95% level of probability in 12 to 16 years of testing.

Wind erosion potential is greatly reduced by using as little as 500 to 1,000 pounds of mulch per acre. However, 1,500 to 2,000 pounds per acre at planting time is preferable because some stubble is buried during wheat planting. The anchorage of stubble on the drill ridge with hard soil clods is important for overwinter protection.

Large quantities of stubble are known to reduce soil nitrate quantities from 5% to 15%, but this is not out of balance with the level of soil water available for the crop in semiarid areas.

Soil Clods

Only a small percentage of moist fine soil is needed around a planted seed for germination. The greater part of the surface soil should serve as a micro-climate modifier, similar to the straw mulch. Firm clods (0.1 to 3 inches in diameter) are highly resistant to wind erosion, will anchor straw, reduce the flow speed of running water during a torrential rain, offer shade and physical protection for young plants, and do not provide a good seed bed for competitive weeds. When the level of straw production is low due to prolonged drouth, then deliberate clod farming is the first line of defense.

Minimum Tillage

Since the mid-1940's and early 1950's, the number of tillage operations used in fallow have gradually been reduced from 8-12 to 4-6. Some variation will always exist because of seasonal changes in rainfall and weed population patterns. The former method of burning, plowing, or deep disking of stubble in the initial spring operation tended to greatly deplete straw and clods early in the fallow season and hence require extra tillage later to "break the crust."

Attempts to reduce tillage requirements in fallow to zero have not been economically successful. Weeds can be controlled entirely with repeated applications of herbicides but the expense is usually prohibitive. Also much of the cultivated lands of the semiarid west contain enough clay in much of the surface soils to eventually form a restrictive crust several inches deep late in the fallow season; thus making a poor seed bed for planting. It therefore appears that a massive "no-till" program in unlikely now or in the foreseeable future.

As earlier stated, the most favorable opportunity to reduce total tillage requirements and still increase water conservation and yield potential revolves around herbicide control of weeds immediately following harvest and lasting until June 20 of the next summer. The cost of the herbicides about equals the cost of similarly effective tillage. After June 20th, stubble and weeds can be handled by one sweep or disk operation (initial) and one or two rod weedings with tongs attached for weed control and/or seed bed preparation. The average number of mechanical tillages can thus be reduced from 5 to 2½ on a commercial farming operation.

Summary

The successful use of summer fallow is a complex process. Improved fallow efficiencies have been achieved over a period of years by the periodic upgrading of knowledge and tools. Factors now recognized as affecting fallow efficiency include: length of fallow season climatic conditions occurring within and prior to the fallow season; quantity and management of mulches; quality of weed control; soil texture and soil reflectance; depth to inhibiting soil layers; tillage implements and herbicides used to modify the soil surface; previous crop in the rotation cycle; and fertilizer practices.

These factors will continue to provide the basis for fallow efficiency improvements whenever possible. Maximum utilization of available resources is and always will be the motivation behind agricultural advances, reaching toward total integration of all positive factors in the agronomic game.

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