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Twenty Years of Soil Management Studies

at Central Substation, Highmore, South Dakota

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Current soil studies at the Central Substation, Highmore, concern improved methods of management for Williams[2] soils. This soil is a major series on the Missouri Coteau. The Missouri Coteau is an uneven upland in the north central part of the state between the Missouri River and the James River lowland.

Williams soils occur on the smoother slopes in upland drainageways of hilly portions of the Coteau. They are also on crests and upper slopes of undulating portions of the northeastern quarter of the Missouri Coteau in South Dakota. These soils are developed in glacially deposited material high in lime usually referred to as calcareous glacial till.

Weather conditions in this area are quite variable. The growing season averages about 135 days per year and the average annual precipitation is about 17 inches. Because average conditions (temperature and day length) are such that potential evaporation exceeds average precipitation by 8 inches or more per year, water rarely leaches soluble salts from the soil profile. The zone of calcium carbonate accumulation is fairly close (about 1½ feet) to the surface. This short moisture supply is also conducive to a native vegetation of short grasses. Short grasses produce less organic matter than the taller grasses growing on soils east of the area.

The water holding capacity, structure, and general fertility of Williams soils are favorable for growing crops. In order that these soils might be managed for longtime maximum crop yields, it is desirable to study the soils and understand them better.

The South Dakota State College Central Substation near Highmore serves as a site to study the management of Williams soils. Field plots were used to follow the influence of several soil treatments on crop production.

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[2]Williams is a tentative series name assigned to soils discussed in this report. For a more complete description of the soils and geology of this area refer to South Dakota Agricultural Experiment Station Circular 124, 1956.

FALLOW AND RESIDUES

One experiment included a cropping sequence of spring wheat-sorghum compared to a cropping sequence of spring wheat-fallow.

Three residue treatments were superimposed over the cropping sequences. The residue treatments were:

1. All crop residues removed except 6-inch stubble
2. All crop residues removed except 6-inch stubble; barnyard manure added to the soil at 8 tons per acre each crop year
3. All crop residues of straw or stover returned.

The wheat yields of these plots for the period from 1942 through 1961 are recorded in table 1.

Crop responses to different soil treatments vary to some extent with years because weather conditions are quite variable. Environmental factors such as wind, cloudiness, soil moisture, and temperature influence growing plants. Since these factors affect crops and because it is impossible to predict seasonal variations in environmental factors, it is difficult to know the proper soil management practices to use each individual season. Since combinations of weather conditions seem to repeat over a period of years, it is easier to determine general practices that might be used. For these reasons it is more beneficial to observe crop yields on soil fertility field plots for a period of several years rather than just one year at a time. Thus in studying table 1, reference is made to wheat yield averages for the period 1942-1961.

The return of crop residues or the use of barnyard manure slightly increased spring wheat yields in the fallow sequence. In the spring wheat-sorghum sequence the average increase in spring wheat yield from manure was about 3 bushels per acre. In table 1 the 20 year average spring wheat yield for all plots following fallow was about 3 bushels per acre more than the spring wheat yield following sorghum. However on the manured plots the spring wheat yields were only about 1½ bushels per acre less after sorghum than after fallow.

The spring wheat-sorghum sequence produced a crop of sorghum during the season that the spring wheat-fallow sequence resulted in no crop. Thus only half as many crops are produced in spring wheat-fallow sequence.

The spring wheat yield following fallow was only about 3 bushels per acre greater than that following sorghum. Besides producing a crop, sorghum protected the soil somewhat from wind damage, while fallow soil frequently was subject to wind erosion. Considering the above observations, it may be more desirable to include sorghum in the cropping sequence rather than to fallow this soil.

FERTILIZER, TILLAGE, AND RESIDUES

A second experiment was a fertilizer study superimposed on the same three residue treatments used

above. The cropping sequence, started in 1942, was spring wheat-oats-sorghum. The following fertilizer treatments were added in 1957:

1. No fertilizer
2. 17 pounds of phosphorus (40 pounds P_2O_5 per acre)
3. 20 pounds of nitrogen and 17 pounds of phosphorus per acre
4. 40 pounds of nitrogen and 17 pounds of phosphorus per acre

This experiment included two types of tillage on adjacent narrow strips. One strip is moldboard plowed after the spring wheat and oats crops; the other is subsurface tilled with a Noble blade.

Crop yields for this study are reported in tables 2-5. Again reference is made to yield averages for the entire period.

The crop yields reported here were obtained on narrow strips where wind erosion was not a major factor. Subsurface tillage helps in decreasing wind erosion and increasing water infiltration. However, a few general observations suggest that seedbed preparation, stand establishment, and weed control are somewhat easier following a moldboard plow than a subsurface blade. On these narrow strips the 1942-1961 average crop yields from plowed plots were larger than those from subsurface tilled plots. In years such as 1959 and 1961, when soil moisture was short, some crop yields were lower following the moldboard plow than following the subsurface blade. Yields during these dry years were so low that they did not add much to the 20-year total and thus did not overcome the advantage of the moldboard plow in favorable years such as 1958 and 1960. With advancements in seeding, weed control, etc. these yield differences may decrease.

New studies might consider adjusting tillage to the situation; that is, in seasons when soils are dry and more subject to wind erosion, use subsurface tillage. In years with a great deal of straw, when weeds are prevalent and soil moisture is more favorable, a moldboard plow may be better.

Tables 2-4 also show the influence of residue management on the crop yields for the 20 years. Return of crop residues or use of manure alone did not greatly improve yields of sorghum forage. Spring wheat yields were slightly increased with manure treatments; both residues and manure increased oats production with the highest yields following manure.

Table 5 shows the influence of nitrogen and phosphorus fertilizer on crop yields in the spring wheat-oats-sorghum sequence. Fertilizer treatments improved crop yields but the spring wheat increase from the use of phosphorus was the only case in which the increase was sufficient to pay for the fertilizer application.

SUGGESTIONS

If no legumes or manures are used in cropping systems on Williams soils, feed grains should be fertilized with moderate rates of

nitrogen and phosphorus. This may be especially true when the feed grains are to be utilized by the grower because of the possibly improved protein and phosphorus content of fertilized grain.

Even though the 20-year crop yield averages reported here for narrow strips favor moldboard plowing over subsurface tillage, the results for individual years suggest seasonal adjustment of tillage. For example, use subsurface tillage when there are small amounts of crop residues and when soils are dry and more subject to wind erosion. When soil moisture is more favorable and weeds are a major problem and there is a great deal of straw, it may be better to use a moldboard plow.

Results of this study suggest the following practices be included in the management of Williams soils for producing spring wheat:

1. Substitute sorghum for fallow in the cropping sequence, if there is a market or need for livestock feed.
2. Return all residues not used for livestock to the soil.
3. Incorporate all available manure into the soil.
4. Apply phosphorus fertilizer when seeding small grain crops, particularly wheat.
5. Use nitrogen fertilizer where manure is not available or a crop does not follow fallow.

Other studies indicate that it is practical to fertilize with a drill attachment at about 20-30 pounds of nitrogen and 5-10 pounds of phosphorus (10-20 pounds P_2O_5) per acre. This could be supplied by 60-100 pounds of 33.5-0-0 and 25-50 pounds of 0-46-0.

Table 1. Bushels of Wheat per Acre Following Organic Treatments in a Sorghum-Spring Wheat and a Fallow-Spring Wheat Sequence

	Average for period of years									
	1942-47		1948-53		1954-59		1960-61		1942-61	
Treatments	After fallow	After sorghum	After fallow	After sorghum	After fallow	After sorghum	After fallow	After sorghum	After fallow	After sorghum
Residues removed	21.0	19.5	17.6	12.2	16.2	12.7	15.1	12.1	17.9	14.5
Residues returned	20.8	19.2	19.2	13.7	17.8	13.9	16.7	13.8	19.0	15.4
Manure	20.7	19.9	19.9	16.8	18.0	16.8	16.7	16.3	19.2	17.7
Average	20.8	19.5	19.5	14.2	17.3	14.5	16.2	14.1	18.8	15.9

Table 2. Hundredweights of Sorghum Forage per Acre Following Organic Treatments on Plowed Plots and on Subsurface Tilled Plots

	Average for period of years									
	1942-47		1948-53		1954-59		1960-61		1942-61	
Treatments	Plow	Subsurface	Plow	Subsurface	Plow	Subsurface	Plow	Subsurface	Plow	Subsurface
Residues removed	47.3	36.2	41.7	26.6	24.4	18.9	36.6	33.9	37.7	27.9
Residues returned	46.5	37.5	42.6	30.8	24.8	19.6	35.1	30.4	37.7	29.4
Manure	49.3	37.0	41.7	31.4	24.6	19.2	39.6	35.6	38.6	29.8
Average	47.7	36.9	42.0	29.6	24.6	19.2	37.1	33.3	38.0	29.0

Table 3. Bushels of Wheat per Acre Following Organic Treatments on Plowed Plots and on Subsurface Tilled* Plots

	Average for period of years									
	1942-47		1948-53		1954-59		1960-61		1942-61	
Treatments	Plow	Subsurface	Plow	Subsurface	Plow	Subsurface	Plow	Subsurface	Plow	Subsurface
Residues removed	18.8	19.9	16.3	12.4	16.0	12.1	15.5	14.0	16.9	14.7
Residues returned	19.4	20.9	16.3	13.9	16.4	13.0	13.8	14.0	17.0	15.7
Manure	19.6	20.8	19.7	17.4	17.4	14.6	14.4	14.8	18.4	17.3
Average	19.3	20.5	17.4	14.7	16.6	13.2	14.6	14.3	17.4	16.0

*Subsurface tillage and plowing occurred only before oats and sorghum and not before wheat; seedbed for wheat was prepared with disc and drag.

Table 4. Bushels of Oats per Acre Following Organic Treatments on Plowed Plots and on Subsurface Tilled Plots

	Average for period of years									
	1942-47		1948-53		1954-59		1960-61		1942-61	
Treatments	Plow	Subsurface	Plow	Subsurface	Plow	Subsurface	Plow	Subsurface	Plow	Subsurface
Residues removed	47.0	41.3	37.8	33.1	34.4	26.4	44.2	33.1	40.2	33.6
Residues returned	48.6	45.4	41.8	33.7	35.2	26.4	46.8	33.9	42.4	35.0
Manure	53.1	48.9	43.8	39.7	39.2	29.9	43.3	43.4	45.2	39.9
Average	49.6	45.2	41.1	35.5	36.3	27.6	44.8	36.8	42.6	36.2

Table 5. Annual Average Yields in a Spring Wheat-Oats-Sorghum Sequence as Influenced by Nitrogen and Phosphorus Fertilizers at Highmore from 1957-1961

	No fertilizer	17 lbs. P/acre*	20 lbs. N/acre 17 lbs. P/acre	40 lbs. N/acre 17 lbs. P/acre
CWT sorghum forage per acre	27	31	31	30
CWT sorghum grain per acre	7.7	7.8	8.2	8.1
Bushels of oats per acre	37	37	39	41
Bushels of wheat per acre	16	18	18	17

*The fertilizer application of 17 lbs. P/acre is equivalent to 40 lbs. P_2O_5 per acre.