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ALTERNATIVE CROP ROTATIONS TO WINTER WHEAT-FALLOW

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ABSTRACT

Adoption of reduced- and no-till production systems by farmers has increased the potential to crop more intensively than has traditionally been done with wheat-fallow. This paper reports the results from a study evaluating alternative crop production systems to wheat-fallow. Reported are observations for the first three years of data from several tillage and cropping systems. Crop yields are very dependent on the amount of soil available water, especially the amount of soil water recharge that took place since the harvest of the previous crop. Winter wheat appears to be most productive following a fallow period and corn following wheat in rotation. Proso millet yields are not influenced greatly by rotation, except after sunflower and safflower. A fallow period appears to be needed following sunflower and safflower to recharge the soil profile with sufficient water to obtain acceptable yields of the following crops. There is a combined favorable effect of more intensive crop rotations with less fallow and the use of reduced- and no-till systems on surface residue maintenance, soil organic matter, and potential soil erosion. Based on these preliminary results, it appears that farmers can crop more intensively than with the traditional wheat-fallow system.

INTRODUCTION

A sustainable, environmentally acceptable agriculture in the Central Great Plains largely depends on maximizing crop water use efficiency. Present cultural practices, using the winter wheat-fallow (W-F) system, have resulted in extensive erosion by wind and water and a dependence on government subsidies. Reduced- and no-till production practices have enhanced precipitation storage efficiency in the soil (Nielsen and Anderson, 1993). When this water is not used by crops, movement of soluble salts and agricultural chemicals toward the ground water is accelerated or unproductive saline seep areas may develop. National concerns for promoting an economically sustainable agriculture, which is environmentally sound, requires the development of dryland cropping systems that promote more efficient use of soil and water. Cropping systems that include spring crops provide extra benefits in the form of improved control of winter annual grassy weeds, such as jointed goatgrass, downy brome, and volunteer rye (Wicks and Smika, 1990). Halvorson (1990), Halvorson and Reule (1994), and Peterson et al. (1993) show the potential to crop more intensively under dryland in the Central Great Plains than is being done with the traditional crop-fallow system of farming. The objectives of this study are to: 1) evaluate/develop alternative crop rotations for more efficient water use and economic sustainability; 2) reduce chemical inputs for weed, disease, and insect control through crop rotation; and 3) protect the soil resource base, environmental quality, and ground water quality with cropping systems that utilize water and nutrients efficiently.

MATERIALS AND METHODS

Twenty crop rotations were initiated in the spring of 1990 on a Weld silt loam soil at the Central Great Plains Research Station at Akron, Colorado using a randomized, complete block design with 3 replications. Plot size is 30 x 100 ft. Based on N soil test and experience, sufficient ammonium nitrate fertilizer (for example, 50 lb N/a for wheat, 75-80 lb N/a for corn, sunflower, safflower) is applied preplant broadcast to each crop to optimize yield potential. Phosphorus, 50 lb P/a, was banded below the soil surface on all plots at study initiation. Three tillage treatments are being compared for the wheat-fallow rotation: 1) complete-till (CT); 2) reduced-till (RT) and 3) no-till (NT). Because RT or NT conditions are needed to efficiently store enough soil water between crops to make the more intensive crop rotations (other than W-F) successful, a NT or RT system is being used with all other crop rotations. Tillage in the reduced-till systems is for the purpose of herbicide incorporation or to achieve occasional weed control. Tillage is primarily with a Haybuster model 3200 undercutter with a rear mulch treader. Winter wheat is planted about September 20; oats, peas, and safflower about March 25; corn about May 1; soybeans about May 27; sunflower about June 1; and proso millet and forage millet about June 10. Soil water is monitored at planting and after harvest. Surface residue levels at planting are determined by physically collecting all of the plant residue on the soil surface from a 1 m^2 site within each plot. The effects of crop rotation on soil organic matter are being determine by measuring soil organic matter in the top 6" of soil. The forages are harvested with a forage harvester and grain crops with a plot combine.

RESULTS AND DISCUSSION

Crop rotations and tillage systems are shown in Table 1 with the 3-yr average yields for each crop in the rotation, annualized crop yields, and estimated annualized gross income. Winter wheat yields following a fallow period tended to be greater for all RT, NT, and more intensive cropping systems than with the CT wheat-fallow system. When wheat was not preceded by a fallow period, yields were reduced more than 50% except for the W-Pea and W-M rotations, which were reduced by 17% and 16%, respectively. Corn yields tended to be highest when winter wheat was the previous crop and lowest following sunflowers. Proso millet yields were more stable from year to year than the other crops and were not influenced as much by crop rotation. Proso millet yields tended to be highest following wheat and lowest following safflower or sunflower. Safflower yields averaged about 900 lb/a. Sunflower yields (2 yr average) were 1404 lb/a following corn and 1018 lb/a following proso millet, possibly reflecting greater soil water
Table 1. Average crop yields (1991-1993) within each rotation,

annualized rotation yield, and estimated rotation gross income.

Rotation	Till-age	Crop: W	C	M	SAF/ SUN	Pea/ SOY	Forage	Annualized Rotation Yield	Gross Income
		-----grain yield, lb/a-------					lb/a	lb/a	$/a
W-F	CT	2226	----	----	----	----	----	1113	75
W-F	RT	3126	----	----	----	----	----	1563	105
W-F	NT	2736	----	----	----	----	----	1368	92
W-C-F	RT	3258	2470	----	----	----	----	1909	108
W-C-F	NT	2604	2705	----	----	----	----	1770	97
W-M-F	NT	2670	----	2150	----	----	----	1607	103
W-C-M-F	NT	2970	2274	1680	----	----	----	1731	99
W-M-C-F	RT	3042	1383	2032	----	----	----	1614	96
W-M-C-F	NT	2700	1742	2273	----	----	----	1679	98
W-C-SAF-F	RT	2394	1910	----	920	----	----	1306	86
W-M	NT	1860	----	1800	----	----	----	1830	116
W-PEA	RT	1842	----	----	----	1160	----	1501	131
W-SC	NT	912	----	----	----	----	4862	2887[a]	91
W-C-M	NT	960	2094	1850	----	----	----	1635	88
W-SAF-M	RT	1050	----	1300	890	----	----	1080	82
W-SOY-OP	RT	876	----	----	----	630	1893	923[a]	53
C-SUN	RT	----	829	----	1404[b]	----	----	1116	95
M	NT	----	----	1700	----	----	----	1700	102
M-SUN	RT	----	----	1580	1018[b]	----	----	1299	103
M-C	RT	----	1439	1700	----	----	----	1570	82
FM-C	NT	----	1686	----	----	----	3896	2791	95
ALFALFA	NT	----	----	----	----	----	2265	2265	91
GRASS	NT	----	----	----	----	----	2208	2208	66

Symbols: ALF=alfalfa; C=corn; F=fallow; FM=forage millet; G=grass; M=proso millet; OP=oats + Tinga Pea; Pea=Austrian Winter Pea; SAF=safflower; SC=silage corn; SOY=soybean; SUN=sunflower; W=winter wheat.

[a]Includes forage yield.

[b]Gophers destroyed 1991 sunflower plots, therefore, only a 2 yr average.

Note: All forage yields are on an oven dry basis; wheat at 12% moisture; corn at 15.5%; sunflower and safflower at 10%; peas and soybeans at harvest moisture.

Economics assumes the following dollar per pound prices: W.Wheat = .067; Corn = .043; Proso Millet = .06; Sunflower and Safflower = .11; Peas = .12; Soybeans = .07; Silage Corn (SC) = .025; Alfalfa = .04; Grass, Forage Millet, and oat-Pea = .03.

storage due to more snow trapping during winter months in corn plots (Fig. 1). Forage yields on a dry matter basis were highest for silage corn (4862 lb/a) and forage millet (3896 lb/a). Alfalfa and the grass-alfalfa mixture had average forage yields of about 1.1 tons/a.

Annualized grain/forage yields (total grain/forage produced per rotation divided by years in rotation) show that all rotations and tillage systems except two, W-SOY-OP and W-SAF-M, had higher yields than the CT wheat-fallow rotation. These trends are exciting considering the fact that the summer crops tended to be grown under droughty conditions during 1992 and 1993. Under average rainfall conditions, yields of summer crops would be expected to be higher than those observed. All rotations except two, W-SOY-OP and GRASS-ALF, had higher estimated gross returns than CT wheat-fallow. An economic analysis is needed to determine net returns per rotation, which may show a different trend than gross income.

No-till planting of winter wheat into proso millet and silage corn stubble in these annual crop rotations has presented no problems other than wheat germination has been delayed due to lack of sufficient surface soil water at planting. The wheat planted in September 1991 and 1992 germinated between November and February in the W-M and W-SC rotations due to low soil water at planting and extended drought conditions into late fall. Acceptable wheat stands were present when the wheat broke dormancy and tillered in the spring of 1992 and 1993. The extremely low wheat grain yields in the W-SC rotation resulted to some extent from residual atrazine and Command damage following corn.

Weed control problems have been minimal. However, perennial grass proliferation in some of the NT rotations is becoming a problem. Perennial grasses causing problems in the NT plots are sand dropseed (Sporobolus cryptandrus), red threeawn (Aristida longiseta), and tumblegrass (Schedonnardus paniculatus). One tillage operation during the production system has reduced the spread of these species. These observations in NT are consistent with the proliferation of perennial species in NT systems across the U.S. (Gebhardt et al., 1985; Koskinen and McWhorter, 1986).

Proper management of surface residues protects the soil from erosion, but can also be important in the Central Great Plains for snow trapping and adding to plant available soil water the following spring. Figure 1 shows the snow depth in selected plots on 15 December 1992. Although these measurements are made in the center of small plots that are to some degree affected by drifting from the residue type in the surrounding plots, we feel that plot randomization within the three replications and the averaging of the data across reps and residue type do reflect relative differences in snow trapping capability. All the 1992 fallow plots

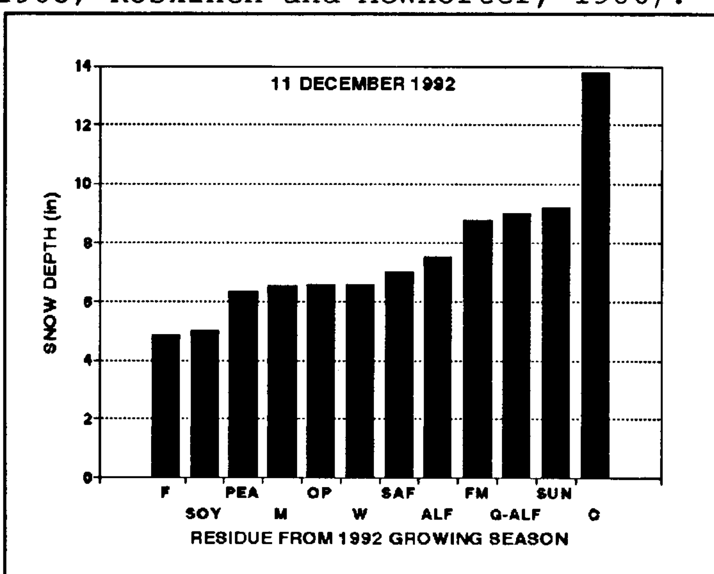

Figure 1. Snow trapping on Dec. 12, 1992 as a function of crop residue.

had very little standing residue left to trap snow after winter wheat planting. The corn residue was by far the most effective snow-trapping residue, collecting more than 2.8 times the depth of snow than was collected on the fallow plots. Forage millet, grass, and sunflower stubble trapped about 86% more snow than the fallow plots. Based on other data we have collected in plots where the sunflower residue was left more erect after harvest, we would expect a higher level of snow trapping than shown in Fig. 1. Safflower and alfalfa stubble trapped slightly more snow than the wheat stubble. Pea, proso millet, oat/pea mixture, and winter wheat stubble all trapped about 34% more snow than the fallow plots. Soybean residues had little effect on snow catch compared to the fallow plots.

The average amount of residue on the soil surface after planting of the 1992 and 1993 crops is shown in Table 2 for selected rotation and tillage systems. The lowest level of surface residue occurred with the CT wheat-fallow system. The residue level in the wheat-fallow rotations after wheat planting averaged 200, 1116, and 1782 lb/a for the CT, RT, and NT systems respectively. For the more intensive rotations that included a fallow period, the level of surface residue following wheat was 1610 lb/a and without a fallow period 1518 lb/a. Following corn in rotation, surface residue levels were approximately 2957 lb/a at next crop planting when a fallow period did not follow corn and 2439 lb/a following fallow for NT systems and 1713 lb/a for RT systems. Where proso millet was the last crop in rotation, residue levels were approximately 1785 lb/a when a fallow period did not follow millet and 1128 when a fallow period followed millet. Residue levels were approximately 1641 and 1160 lb/a for sunflower and safflower, respectively, after planting of the next crop in rotation without a fallow period. Residue levels were approximately 1212 lb/a following soybeans without a fallow period. With these residue levels, soil erosion potential is minimal. The only treatment with possible soil erosion problems would be the CT wheat-fallow system.

Although soil organic matter changes with rotation and tillage system are still preliminary, certain trends are apparent. In the 0 to 2 inch depth, the NT and RT systems show a 25 and 14% increase in organic carbon, respectively, over the CT wheat-fallow system. Adjusted for the 0 to 6 inch depth, this increase was only 11 and 6%, respectively, since the bulk of the organic carbon lost was in the top 2 inches (erosion and decomposition). Increases in the NT compared to CT, corrected for soil bulk density at the 0 to 6 inch depth, represented about 893 lb organic carbon/acre per 3 years. These increases should improve soil physical conditions and may act as storage for atmospheric CO_2 as organic matter buildup occurs.

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Table 2. Average surface residue level for selected rotations after planting for 1992 and 1993.

Rotation	Till-age	Wheat Planting		Corn Planting		P. Millet Planting		Other Crops Planting	
		lb/a	%cover	lb/a	%cover	lb/a	%cover	lb/a	%cover
W-F	CT	200	12	----	----	----	----	----	----
W-F	RT	1116	30	----	----	----	----	----	----
W-F	NT	1591	36	----	----	----	----	----	----
W-C-F	RT	2060	20	1904	71	----	----	----	----
W-C-F	NT	1898	32	1733	64	----	----	----	----
W-M-F	NT	969	19	----	----	1276	55	----	----
W-C-M-F	NT	1046	16	1672	67	2815	52	----	----
W-M-C-F	RT	1367	21	1432	66	1794	55	----	----
W-M-C-F	NT	2981	41	1470	71	1317	51	----	----
W-C-SAF-F	RT	nd[a]	nd	1577	62	----	----	3375	60
W-M	NT	nd	nd	----	----	1412	60	----	----
W-SC	NT	nd	nd	1215	44	----	----	----	----
W-C-M	NT	nd	nd	2567	70	3056	50	----	----
W-SAF-M	RT	nd	nd	----	----	1160	21	nd	nd
M	NT	----	----	----	----	1537	66	----	----
M-SUN	RT	----	----	----	----	1403	16	nd	nd
M-C	RT	----	----	1774	64	2878	41	----	----
FM-C	NT	----	----	2651	49	----	----	2016	37

[a]nd = not determined or only one year's data.