

Western SD Crop Rotation Study

Principal Investigators:

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Objectives:

1. To determine crop productivity in varied rotations with different crop intensities and diversity.
2. To determine economic returns from crop rotations with varied levels of crop intensification and diversity.
3. To determine weed pressure and weed dynamics in different crop rotations.
4. To determine the effect of crop sequence on crop productivity.

Justification:

The typical rotation in southwestern South Dakota when this study started in 1994 was winter wheat-fallow. This study was initiated to see if rotations with more continuous cropping and more crop diversity could be successful in the region. Currently the study has nine rotations ranging from two to six years with a conventional winter wheat-fallow rotation as a comparison. Reduced and no-till production practices are used to grow the crops except for the winter wheat conventional fallow treatment. The results have shown that the inclusion of broadleaf crops, sunflower, safflower, and peas; along with warm season grass crops like corn and millet, helps to break weed and disease cycles and improve winter wheat yields. However, drought in the last six years has adversely affected yield of most crops making it difficult to achieve consistent profitability. We continue to make cropping changes in an attempt to improve crop performance under dry conditions. For example, we have lowered plant populations for corn and sunflowers. The last few dry years have shown us that our plant populations were probably unrealistically high. We have introduced flexible cropping options to save moisture including introducing annual forage crops in some rotations.

Procedures / Methods:

This long-term rotation study was started in 1994 near Wall, South Dakota. The experimental design is a randomized complete block design with treatments replicated four times. Plots are 80 ft. x 25 ft. in size. This small size allows all the plots to be located on the same soil type and reduces variability due to soil characteristics. Currently a total of nine rotations, ranging from two to six years in duration, are being evaluated and one full cycle for each rotation has been completed. All phases in each rotation are grown each year.

A remote weather station is located at the research site and provides additional information on crop stresses during the growing season. We also have soil temperature probes within the no-till and conventional tilled fallow plots in the rotation study to record soil temperatures during the winter months. The variety of crops planted within the rotation study requires that we be at the plots each week during the summer (planting, spraying, harvesting, and taking notes). This is the most time consuming and visual study we conduct during the year. Presently we are collaborating closely with other agronomy researchers from SDSU and USDA to maximize use of the already established

long-term crop rotation plots and evaluate weed population shifts, crop diseases, and crop water use.

Detailed records of all the cultural practices including spraying for control of weeds, insect pests, and are kept and cost of each practice assessed. This allows for yield and economic comparisons to be made each year. Measurements that are taken each growing season include:

- Weed pressure assessment three times per years (April, July, and October).

- Grain yield for each grain crop.

- Test weight for each grain crop.

- Protein content for grain and forage crops.

- Forage yield for forage crops.

Progress Report:

Long term results have shown that the inclusion of broadleaf crops such as sunflower, safflower, and peas; along with warm season grass crops like corn helps to break weed and disease cycles and can improve wheat yields and profitability

The nine year (1999-2007) average yield of winter wheat following millet in a rotation where a broadleaf crop or corn was grown prior to the millet was 45.0 Bu/A. The winter wheat grown in a continuous winter wheat-millet rotation had a nine year average yield of 36.3 Bu/A. This indicates an 8.7 bushels per acre difference due to introducing a broadleaf or warm season crop into the rotation as the same management practices were applied in both rotations over the nine year period. These results indicate the importance of crop diversity in a rotation system. For comparison, the winter wheat in the winter wheat-fallow rotation had an average yield of 48.3 Bu/A while winter wheat following fallow in the diversified rotation (rotation 2a) yielded 55.9 bushels per acre over the 9 year period (Table 1).

It should also be noted that Rotation 11 (Winter Wheat / Corn / Millet) has no broadleaf crops included and wheat yields are equally as good as those for continuous crop rotations that have broadleaf crops as part of the rotation. The two warm season grass crops (corn and millet) have high demand for soil moisture late in summer while winter wheat has high demand for soil moisture early in spring. The winter wheat in this rotation seems to benefit from the diverse soil moisture use pattern of the crops. The diversity of crops in this rotation makes for easier weed management. During mid-April the millet segment of the rotation is totally weed free indicating that after corn fall spraying, before planting to millet in the following June, is timed very well. The corn crop in mid-July has very minimal weed pressure. The wheat in mid-July has just traces of weed pressure (prickly lettuce and prostate spurge). The corn ground going to millet is totally clean in mid-October, eight months before planting to millet. The only weed flare up in 2007 for this rotation was in October after the wheat crop was harvested. It should be noted also that our best corn yields and respectable millet yields come from rotation 11.

Introducing safflower, sunflower, and pea crops in the winter wheat-millet rotation would be expected to increase demand for soil moisture and thus decrease winter wheat yield compared to the winter wheat-millet rotation. The winter wheat in rotations with safflower, sunflower, and pea, however, yielded more than the winter wheat-millet rotation, indicating the increasing problem with root diseases in the undiversified winter

wheat-millet rotation (Table 1). The increased income from the higher yields of winter wheat along with the opportunity to produce a profitable broadleaf crop like sunflower or safflower can increase the net income of these rotations, particularly in the wetter years.

We continue to refine the strip tillage system that we use for corn, sunflowers, and safflower. The fertilizer is injected in the fall using a narrow point opener which leaves about a four inch area strip tilled. We have added some reverse mounted closing disks to fill the trench formed by the injector, but still having minimal soil disturbance. In the spring, corn, safflower, and sunflowers are planted over the same strips. Since going to this system, plant stands of corn and sunflowers have improved. The residue managers on our planter work better in the strip tilled wheat stubble and it has the added bonus of putting the fertilizer right where the new planted crop will utilize it. We have lowered plant populations for corn and sunflowers.

In 2007, corn, safflower, and sunflower yields were low because of lack of subsoil moisture. The proso and hay millet did well because these crops are shallow rooted and do not require a lot of soil moisture, additionally, 1.92 inches of rain received in August helped these crops along. Winter wheat yields were fairly good because of good stands in the fall, decent snow catch in the winter months to help the young crop along, and favorable moisture in April, May, and June.

Recent cropping changes in this study include: 1) in Rotation 5a, substituting feed barley for spring wheat, 2) in Rotation 6a, growing dry peas for grain rather than spraying them off as a green manure crop, and in 9a, using hairy vetch as a green fallow option rather than using forage peas (the hairy vetch stubble holds better to the soil surface than the field pea stubble), 3) in 2007; Rotation 10 was changed to winter wheat / millet / chickpea (this places the chickpea ahead of the wheat crop which gives nitrogen credit toward the wheat crop and allows more time between chickpea harvest and wheat planting time), 4) in Rotation 2a, in 2007 we substituted Golden German hay millet where proso millet was. Proso millet yields in this rotation have been historically the lowest in the entire trial. The hay millet stands were good in 2007. We plan to introduce some flex-cropping options dependant upon moisture conditions that will help us to decide which crop to plant or whether to fallow.

Table 2 shows the long-term economic trends for the study. The returns for alternative crops have been negative in recent years due to drought stress. The overall positive economic returns observed in 2007 were due to high prices for winter wheat. It should be noted that we do not include any farm program payments except loan deficiency payments (LDP) when applicable, in our economic analysis.

The study is fully published in the West River Annual Progress Report and is available on the internet at <http://wrac.sdstate.edu/pubs/plant/plant.html> Producers can review this publication and determine all the management practices and costs of production that goes into each rotation.

Table 1: Long-Term Yield Trends for the Crops Grown in the Rotation Study (1999-2007)

Rotation & Crop	1999	2000	2001	2002	2003	2004	2005	2006	2007	Ave Yield (Bu/A) or (Lb/A) (1999-07)
<i>Rotation 1</i>										
Winter Wheat	70.9	58.3	38.6	28.6	77.1	17.7	60.0	31.0	52.2	48.3 bu
Fallow	0	0	0	0	0	0	0	0	0	0
<i>Rotation 2a</i>										
Winter Wheat-a	67.1	66.9	51.1	30.9	72.8	34.3	70.0	49.8	60.4	55.9 bu
Sunflower	2091	2602	2082	400	584	1093	860	1030	382	1236 lb
Millet	1500	1300	2000	326	0	449	1405	300	Hay millet 1.57T	1.57 Tons (2007)
Winter Wheat-b	62.8	46.0	40.2	10.7	46.3	27.1	50.0	38.1	43.7	40.5 bu
Corn	107.6	65.8	97.5	0	0	70.3	55.0	0	30	47.3 bu
Fallow	0	0	0	0	0	0	0	0	0	0
<i>Rotation 3</i>										
Winter Wheat	57.2	45.4	38.1	9.8	47.8	24.2	50.0	40.3	43.3	39.6 bu
Safflower	976	1391	1575	360	614	957	685	489	375	825 lb
Millet	1500	1266	2000	783	0	867	1906	400	1307	1114 lb
<i>Rotation 4</i>										
Winter Wheat	47.2	32.6	33.7	14.7	57.4	28.9	35.0	37.8	39.2	36.3 bu
Millet	1500	1370	1800	1182	1500	1888	1848	1000	1241	1481 lb
<i>Rotation 5a</i>										
Winter Wheat	36.5	47.6	33.1	3.4	34.9	34.1	49.7	37.0	37.6	34.9 bu
Corn	100.9	50.2	101.6	0	0	54.9	50.0	0	30	43.0 bu
Sunflower	2010	1958	1443	250	722	455	680	N/A	63	948 lb
S Wheat (99-04) to Barley (05-06)	36.3	31.8	28.4	1.6	26.2	0	41.6	15.8	37	31.4 bu
<i>Rotation 6a</i>										
Winter Wheat-a	63.9	60.8	48.0	10.8	35.9	34.5	55.6	25.5	45.6	42.3 bu
Winter Wheat-b	34.1	48.9	33.0	5.2	35.4	24.7	52.5	26.5	35.5	32.9 bu
Sunflower (99-04) to Safflower(05-06)	2210	2468	2011	200	1132	818	651 saff	548 saff	278 saff	492 lb saff
Pea Fallow (99-04) to Field Pea (05-06)	0-pf	0-pf	0-pf	0-pf	0-pf	0-pf	1405 fp	1308 fp	1170fp	1294 lb
<i>Rotation 9a</i>										
Winter Wheat-a	68.3	57.1	50.0	9.2	44.0	0	64.8	34.4	44.7	41.4 bu
Winter Wheat-b	29.8	43.0	38.2	4.9	31.7	27.5	56.8	35.2	36.4	33.7 bu
Safflower	1277	1546	1624	230	1106	617	885	516	539	927 lb
Pea Fallow (99-04) to H. Vetch (05-06)	0-pf	0-pf	0-pf	0-pf	0-pf	0-pf	0 - hv	0-hv	0-hv	0-hv
<i>Rotation 10</i>										
Winter Wheat	65.1	48.9	40.8	13.1	58.7	22.5	45.0	33.5	45.8	41.5 bu
Chickpea			1585	95	667	976	292	800	700	730 lb
Millet	1500	1524	2000	622	925	1197	2000	900	1420	1343 lb
<i>Rotation 11</i>										
Winter Wheat	54.2	37.8	42.2	13.5	59.4	28.2	53.0	41.7	45.0	41.6
Corn	99.2	60.2	106.4	0	39.7	76.6	55.0	0	35	52.4 bu
Millet	1500	1300	2000	829	0	1017	1634	600	1483	1151
Rainfall(Apr-Aug)	13.44 "	8.20 "	12.29 "	5.59 "	5.24 "	9.20 "	10.89"	5.72"	9.08"	

N / A = Sunflowers were destroyed by deer when heads were 2" in diameter.

Table 2: Long-Term Economic Trends of the Rotation Study (1999-2007) (Net Income - \$ per acre)

Rot	Crop	1999	2000	2001	2002	2003	2004	2005	2006	2007	Average Net Return (\$) (1999-2007)
1	W. Wht	\$90.54	\$70.94	\$10.04	\$25.01	\$116.40	\$-30.23	\$46.30	\$21.88	\$236.39	65.27
	Fallow	-59.62	-61.35	-57.03	-72.57	-66.64	-56.29	-73.72	-59.50	-86.26	-65.88
	<i>Ave Inc.</i>	15.46	\$4.79	-23.49	-23.78	24.88	-43.26	-13.71	-18.81	75.06	-.31
2a	W. Wht-a	82.99	95.54	40.94	42.76	107.49	21.04	96.03	102.54	309.85	99.90
	Sunflower	40.45	84.65	39.43	-109.29	-92.02	3.19	-80.10	-29.44	-113.89	-28.55
	Millet	-27.28	4.37	-19.28	-57.29	-77.58	-73.57	-22.11	-76.21	-9.97	-39.88
	W Wht-b	24.74	19.17	9.61	-69.50	39.15	-19.59	21.67	21.64	170.92	24.20
	Corn	36.30	-25.08	56.84	-160.22	-125.56	-14.84	-51.30	-133.25	-68.70	-53.97
	Fallow	-47.40	-52.47	-62.28	-58.69	-52.82	-44.25	-63.08	-49.25	-86.26	-57.38
<i>Ave Inc.</i>	18.30	21.03	10.87	-68.70	-33.55	-21.33	-16.48	-27.32	33.65	-9.28	
3	W. Wht	20.18	14.85	4.42	-72.08	34.93	-34.58	3.41	31.09	157.74	17.77
	Safflower	-23.86	17.92	51.48	-84.25	-46.52	23.70	-33.35	-57.25	-72.94	-25.00
	Millet	-27.28	11.01	-19.28	-1.81	-77.58	-45.38	7.12	-56.00	-5.90	-23.90
	<i>Ave Inc.</i>	-10.32	14.59	12.20	-52.71	-29.72	-18.75	-7.60	-27.38	26.30	-10.37
4	W Wht	4.41	-9.30	-11.92	-58.02	57.89	-15.32	-41.08	40.01	114.40	9.00
	Millet	-28.73	9.27	-35.90	49.06	-48.44	0.25	3.96	-30.94	-11.50	-10.33
	<i>Ave Inc.</i>	-12.16	-.01	-23.91	-4.48	4.72	-7.53	-18.56	4.53	51.45	-.66
10	W. Wht			9.91	-62.61	69.60	-33.43	12.56	15.01	174.58	26.51
	Chickpea			72.63	-155.62	-14.54	87.41	-129.58	-20.73	-19.53	-25.70
	Millet			-19.28	-25.53	-62.01	-23.64	16.34	-29.77	-22.84	-23.81
	<i>Ave Inc.</i>			21.08	-81.25	-2.31	10.11	-33.56	-11.83	44.07	-7.67
11	W. Wht	23.06	-1.29	16.24	-61.47	65.64	-15.14	7.31	37.08	179.68	27.90
	Corn	15.42	-34.38	73.76	-160.22	-62.72	-3.44	-51.30	-133.25	-53.00	-45.45
	Millet	-27.85	13.60	-19.28	16.85	-87.98	-35.30	-9.53	-52.99	8.40	-21.56
	<i>Ave Inc.</i>	3.54	-7.35	23.57	-68.28	-28.35	-17.96	-17.84	-49.72	45.02	-13.04