Saline Seep Management: Is Continuous Cropping An Alternative?

R. P. Schneider, B. E. Johnson, and F. Sobolik

Recrop wheat production is a means of controlling saline seep growth. Data presented show yield and water use efficiency on recrop land to be related to N fertilization, which can be predicted from soil test information.

INTRODUCTION

The growth and development of saline-seeps or dryland salinity in the Northern Great Plains has been discussed in many articles (4, 5, 6, 8, 9, 10). Brun and Worcester (2, 3) showed that alfalfa could be used to extract excess water from recharge areas of saline seeps and reduce their growth. Worcester, Brun, and Doering (9) characterized saline seeps and indicated that some management systems other than deep rooted crops may have potential when trying to reduce the saline seep problem. Brown (1) has shown the potential of winter wheat to utilize water to a depth of 6 feet and has also indicated that water use efficiency can be increased with fertilization. Olson et al (7) showed that water use efficiency of grain crops could be increased by 29% when optimum amounts of fertilizer were applied. These individuals also indicated that corn and grain sorghum extracted water from greater depths than did small grains.

Since saline seep management appears to be a function of soil water management, studies were initiated in North Dakota to evaluate recrop wheat production and soil water use.

PROCEDURES

Nine research sites in western North Dakota were used to evaluate the influence of N rates and N sources on recrop wheat production. For winter wheat, the N materials were broadcast on the soil surface and incorporated by rainfall. Nitrogen treatments on spring wheat were broadcast and incorporated with tillage. Ammonium nitrate and urea were used as comparative N sources on both winter and spring wheat. Nitrogen rates of 0, 25, 50, 75, and 100 lb/a (0, 28, 56, 84, 112 kg/ha) were applied in a randomized complete block design with 4 replications. Soil samples were taken to a depth of 4 feet (120 cm) at the time of fertilizer application. Soil test information and total plant available water were determined for each location. Rain gauges were installed and the rainfall events were recorded by the cooperators.

Grain was harvested using a modified plot combine. Individual samples were cleaned and yield, protein, and test weight were determined from the harvested material. Soil samples were taken again at harvest to evaluate total plant available water remaining in the soil. Total growing season water use was calculated from the soil water and precipitation information, assuming no losses from runoff or percolation below 4 feet (120 cm).

RESULTS

Three sites will be discussed individually and then all of the locations will be discussed as a summary.

The first location was a winter wheat trial conducted in 1976 in northwest North Dakota. The field has been cropped the previous 4 years and NO_3^--N by soil test was 21 lb/a-2 ft (24 kg/ha-60 cm). Nearly 7 inches (16.8 cm) of plant available water were present at the beginning of the growing season, to a depth of 4 feet (120 cm). During the growing season the location received 8.6 inches (21.8 cm) rainfall.

Growth differences at mid-June (Figures 1 and 2) are indicative of the tremendous N response. Significant yield increases were obtained as rates of N fertilization became greater (Table 1). As N increased from 0 to 75 lb/a (0 to 84 kg/ha), yields changed from 13.9 to 37.3 bu/a (940 to 2506 kg/ha). As yield increased, water use efficiency was improved, see Table 1. Water use efficiency is the ratio of weight of grain produced to the amount of water used. In fact, water use efficiency more than doubled as N rates increased. Not only did water use efficiency increase but total water used increased 1.5 inches (3.7 cm) as N rates increased from 0 to 75 lb/a (0 to 84 kg/ha). Similar findings have been observed by Brown (1) and Olson (7).

Table 1. Yield and water use efficiency of 'Froid' winter wheat as a function of N rate, Fortuna, ND, 1976.

N Rate		Yield[1]		WUE[2]	
lb/a	kg/ha	bu/a	kg/ha	bu/a/in	kg/ha/cm
0	0	13.9	940	1.0	27.6
25	28	21.4	1436	1.6	42.2
50	56	27.2	1831	1.9	49.5
75	84	37.3	2506	2.5	66.3
100	112	35.2	2365	2.5	66.2
LSD (0.05)		4.6	309	0.3	8.7

[1]Values given are means of four replications and two N sources.
[2]WUE = water use efficiency = yield/total water used.

Dr. Schneider is assistant professor and Johnson is assistant in soils, Department of Soils; Sobolik is Extension area-agent Soils, Williston, ND.

Figure 1. 'Froid' winter wheat without N fertilization, Fortuna, ND, 1976.

Figure 2. 'Froid' winter wheat with 100 lb/a N (112 kg/ha) applied in the spring, Fortuna, ND, 1976.

The second location was a spring wheat trial conducted near Battleview, North Dakota. Spring grain had been grown on the site the previous year. Soil test indicated 30 lb NO_3^--N/a-2 ft (34 kg/ha-60 cm). Initial plant available water was 8.3 inches/4 ft (21.2 cm/120 cm) of soil. Total growing season precipitation was 7.7 inches (19.5 cm).

Nitrogen responses were quite similar to those previously discussed. During the growing season those plots receiving N were easily distinguished from the check plot. In all cases the check treatments were yellow, poorly tillered, and exhibited thin weak stems, whereas the N fertilized plots were deeper green and had more tillers. Yield data (Table 2) show significant differences among N rates. As N rates increased yields also increased. Water use efficiency was doubled as N rates increased to 75 lb/a (84 kg/ha). Again total water used increased when optimum fertilizer N was applied.

Table 2. Yield and water use efficiency of 'Olaf' spring wheat as a function of N rate, Battleview, ND, 1978.

N Rate		Yield[1]		WUE[2]	
lb/a	kg/ha	bu/a	kg/ha	bu/a/in	kg/ha/cm
0	0	16.8	1128	2.1	55.8
25	28	28.8	1936	3.5	93.5
50	56	37.2	2500	4.1	109.4
75	84	40.0	2685	4.5	120.2
100	112	43.6	2930	4.3	113.5
LSD (0.05)		3.5	234	0.7	18.3

[1]Values given are means of four replications and two N sources.

[2]WUE = water use efficiency = yield/total water used.

The data presented in Table 1 and Table 2 are examples of soil moisture conditions ideal for recrop production. Adequate moisture was present at the beginning of the growing season and adequate precipitation was received during the growing season.

The third location near Arnegard, North Dakota was considerably different than the previous two. Dry soil conditions were evident at the time of planting spring wheat. Only 1.7 inches (4.4 cm) of plant available water were measured in the top 4 feet (120 cm) of soil. Rainfall during the growing season was 6.6 inches (16.7 cm). Initial soil NO_3^--N was 30 lb/a-2 ft (34/ha-60 cm).

Yield and water use efficiency data from this location (Table 3) are more striking than the previous two. Significant yield increases were obtained. Yields increased as rates of N increased. The most fascinating was the water use efficiency information. Extremely high water use efficiencies were associated with increased nitrogen supplies. Water use efficiencies of such magnitude are seldom found but indicate the importance of adequate plant nutrition in a dry growing season.

Table 3. Yield and water use efficiency of 'Olaf' spring wheat as a function of N rate, Arnegard, ND, 1978.

N Rate		Yield[1]		WUE[2]	
lb/a	kg/ha	bu/a	kg/ha	bu/a/in	kg/ha/cm
0	0	33.4	2243	5.7	150.0
25	28	42.2	2836	7.0	184.4
50	56	47.1	3164	8.0	210.5
75	84	46.5	3127	7.7	204.1
100	112	49.1	3301	8.1	213.6
LSD (0.05)		2.6	175	0.5	12.3

[1]Values given are means of four replications and two N sources.

[2]WUE = water use efficiency = yield/total water used.

Combined yield and water use efficiency data for the 1976, 1977, and 1978 crop years is given (Table 4). The data covers the range of growing season precipitation, from relatively dry, 4.3 inches (11 cm), to above normal, 8.6 inches (22 cm). Initial plant available water ranged from 1.7 in/4 ft (4.4 cm/120cm) of soil to 6.6 in/4 ft (16.8 cm/120 cm) of soil. The yield data show that given adequate nutrient additions recrop wheat is a viable option in western North Dakota. Averaging the yields from the 9 locations, 75 lb/a (84 kg/ha) of N fertilizer resulted in 16 bu/a (1075 kg/ha) increase in yield. Farm managers utilizing soil test information could obtain similar results if fertilizer recommendations were followed, assuming adequate plant available water.

Table 4. Yield and water use efficiency of recrop wheat in nine western North Dakota locations as a function of N rate.

N Rate		Yield		WUE[1]	
lb/a	kg/ha	bu/a	kg/ha	bu/a/in	kg/ha/cm
0	0	17.6	1184	2.2	57.0
25	28	24.8	1664	2.9	76.8
50	56	24.8	1663	2.8	74.6
75	84	33.5	2248	3.8	99.2
100	112	34.5	2318	3.7	98.6
LSD (0.05)		3.9	265	0.6	15.5

[1]WUE = water use efficiency = yield/total water used.

Water use efficiency and total water use are the main goals of recrop production in relation to saline seep control. Both were increased as N rates increased. Two factors should be considered. First, given equal amounts of water used, production efficiency was dramatically increased. Second, total water use was increased at most of the locations as N rates increased.

CONCLUSION

The concept of recrop production to alleviate saline seep growth is sound. Data from western North Dakota show recrop wheat yield can be produced comparable to fallow wheat. Several factors must be considered, however. First, at least 2.0 inches/4 ft (5 cm/120 cm) of plant available water should be present at the beginning of the growing season. However, if any standing residue remains on the soil surface over winter, adequate amounts of moisture should be available. Second, soil tests should be made and recommendations followed. With normal growing season precipitation acceptable yields can be obtained.

Some saline seep problems can be corrected using recrop production. Such seeps would be those characterized by shallow root zones over dense subsurface layers. By growing a crop each year the amount of water moving through the soil and out of the root zone would be minimized. County agents and SCS conservationists could recommend such practices where feasible.

Finally, recrop does not mean an entire farm should be cropped continuously. Of significant importance is that the recharge area associated with a saline seep be continuously cropped. If a complete management program is followed, generally acceptable production can be maintained. Complete management would include weed control, crop rotation and disease resistant varieties, in addition to soil testing, fertilization, and assessment of plant available water for the crop.

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