Soil Water Survey After Corn Harvest in Northwest Kansas

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ABSTRACT. *A survey of available soil water after corn harvest was conducted in Thomas and Sherman counties, Kansas, in 1988, 1989, and 1990. Soils in the region are deep, well-drained, silt loams in the Keith* (Aridic Argiustolls) *or Ulysses* (Aridic Haplustolls) *series. Eighty-two randomly selected fields were sampled to a depth of 1.5 m (5 ft) in 30-cm (1-ft) increments at two locations within each field. Each field was equipped with either a surface-irrigation or sprinkler-irrigation system. Available soil water (ASW) contents were found to be generally high, ranging from 31 mm (1.23 in.) to 287 mm (11.30 in.) and averaging 70% of field capacity. At sampling, some ASW contents were in excess of field capacity of the soil profile which is approximately 250 mm (10 in.) for the 1.5-m (5-ft) profile. Within-field variation in ASW was higher for the surface-irrigated fields than for the sprinkled fields. An analysis of data from a previously developed model to predict ASW in the spring based on available fall soil water suggested that preseason irrigation of corn should not be a recommended practice for the region.* **Keywords.** *Irrigation conservation.*

Irrigated agriculture is the largest water user in northwest Kansas and, because of declining groundwater supplies, is under pressure to reduce water consumption. One option to conserve water is to use management procedures that result in higher irrigation efficiency.

Declining water levels often cause reduced pumping capacity from wells, which some irrigators try to compensate for by using preseason irrigation. Others use preseason irrigation as insurance against deficient soil water conditions at planting. However, there is no need for preseason irrigation in corn production if irrigation scheduling procedures used by farmers leave a high level of water in the soil profile at harvest or over-winter precipitation is sufficient to recharge the crop root zone.

Irrigators often extend corn irrigation until late in the growing season, resulting in high residual soil water after harvest. A limited survey in Thomas County, Kansas, in 1980 and 1981 indicated that soil water after harvest averaged 80% of field capacity (Lamm and Rogers, 1982). A three-year study at Colby, Kansas (Lamm and Rogers, 1983), was conducted to determine the efficiency of water use of preseason irrigation and compared irrigation treatments applied in the fall (after harvest), spring, and late summer (before harvest), to a control of no preseason irrigation. In 1982, the control, (no preseason irrigation), did have lower available soil water (ASW) at planting, but ASW was still over 80% of field capacity. No significant yield differences among treatments were noted. Other studies in the region with corn (Banbury et al., 1977; Stone et al., 1987) indicated no yield benefit from preseason irrigation, when in-season irrigation was sufficient. A study by Lamm and Rogers (1985) indicated that the need for preseason irrigation of fully irrigated corn in northwest Kansas is minimal because over-winter precipitation is generally sufficient to recharge the crop root zone to near field capacity.

Water quality has become an issue in many areas. Low ASW at harvest could help reduce over-winter drainage losses and reduce residual pesticide and fertilizer losses to groundwater. Soil water content could also have influence on surface water quality because excess soil water movement contributes to stream flow and high soil water content increases the amount of direct runoff.

The focus of this study was to quantify post-harvest ASW in corn fields of northwest Kansas. An additional objective was to use the model developed by Lamm and Rogers (1985) to demonstrate the need, or lack thereof, for preseason irrigation with various levels of ASW found in irrigated fields.

Procedure

The study was conducted from 1988 through 1990 in Thomas and Sherman counties of northwest Kansas. Lists of individuals with irrigation water rights were obtained, and names were selected at random to contact for permission to sample their fields in the fall after harvest. A new random selection was made each year, since some fields are not in continuous corn. The nature of the project was discussed with the individual growers and no one refused to cooperate. Fields were sampled on 7 to 9 November 1988; 20 to 21 November 1989; and 10 to 12 December 1990. The random selection resulted in

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34 surface-irrigated fields and 48 sprinkler-irrigated fields, which may reflect the distribution of system types in northwest Kansas. The number of fields sampled were 28, 24, and 30 for 1988, 1989, and 1990, respectively. All sprinkler systems in this study were center-pivots.

Soil samples were taken at two locations in each field in 30-cm (1-ft) increments to a depth of 1.5 m (5 ft) using a soil probe. Surface-irrigated fields were sampled near the head and near the tail-end of the run. Sprinkler-irrigated fields were sampled near the center of the outside span and near the center of the middle span, except in 1988, when only the outer sample was collected. These samples were weighed, oven-dried, and weighed again to determine gravimetric water content. This value was used to calculate the plant ASW for each sample and then totaled to obtain the profile ASW, based on representative soil information for the area. The soils in this two-county area are predominately Keith (*Aridic Argiustolls*) and Ulysses (*Aridic Haplustolls*) silt loams, which are generally deep and well drained. A 1.5-m (5-ft) soil profile of these soils will hold approximately 250 mm (10 in.) of plant-available soil water at field capacity. The exact holding capacity of these soils will vary between locations and with depth with changes in density. For the purposes of this survey, a constant bulk density of 1.2 was assumed. Although this does introduce some uncertainty into the sampling, the objective of determining whether fields are left wet or dry is largely accomplished.

Results and Discussion

The annual precipitation data in all three years (fig. 1) was 2.5 to 7% below the 97 year mean value of 474 mm (18.65 in). However, rainfall for 1988 and 1990 May through September corn seasons was near normal (table 1), and May precipitation for the same grow season in 1989 was 81 mm (3.2 in.), or 25% above normal. Corn water use requirements calculated at the Northwest Research Extension Center were 687, 575, and 592 mm (27.1, 22.6, and 23.3 in.), for 1988 to 1990, respectively, indicating that irrigation was required in each year to meet water-use demand of corn.

The ASW data for each irrigation system type for all three years are shown in figures 2 and 3. The average ASW is represented by the circle, the bar through the circle represents the range of the samples. High levels of ASW remained in the profile after harvest, particularly in 1989 and 1990. Available soil water in surface-irrigated fields varied more than in sprinkler-irrigated fields (figs. 1 and 2 and table 2). Table 2 also includes soil water variations expressed as a percentage. The mean and standard deviation of variation of surface-irrigated fields are larger than for the sprinkler-irrigated fields. A standard statistical *t* test compared ASW at the head and tail-ends of the surface-irrigated fields. Based on this test, the null hypotheses of equal soil water levels was rejected at a significant level of less than 0.001 ($F > 0.001$). A similar *t* test compared ASW for the center and outer spans of the sprinkler-irrigated fields. There was not enough evidence to reject the null hypotheses of equal soil water levels at even a relatively low significance level of 0.35 ($F > 0.35$). However, average values of ASW for surface and sprinkler-irrigated fields were similar regardless of the year (table 2). A standard statistical *t* test compared the mean ASW for the two irrigation system types. Based on this test, there was not enough evidence to reject the null hypotheses of equal soil water levels for the two system types at even a low significance level of 0.24 ($P > 0.24$). Averaged across both irrigation system types and years, the ASW was 176 mm/1.5 m (6.92 in./5 ft) or about 70% of field capacity.

Lamm and Rogers (1985) developed an empirical model to predict spring-available soil water (SASW) based on the fall-available soil water (FASW) and winter precipitation (P):

Table 1. Growing season, non-growing season, annual and average precipitation for various years in northwest Kansas, NWREC, Colby, KS

	1988 mm (in.)	1989 mm (in.)	1990 mm (in.)	97 Year Average mm(in.)
May-Sept.	336 (13.23)	403 (15.84)	309 (12.18)	323 (12.65)
	1988 to '89	1989 to '90		
Oct.-April	54 (2.11)	121 (4.81)	---	152 (6.00)
Annual	442 (17.40)	463 (18.21)	460 (18.12)	474 (18.65)

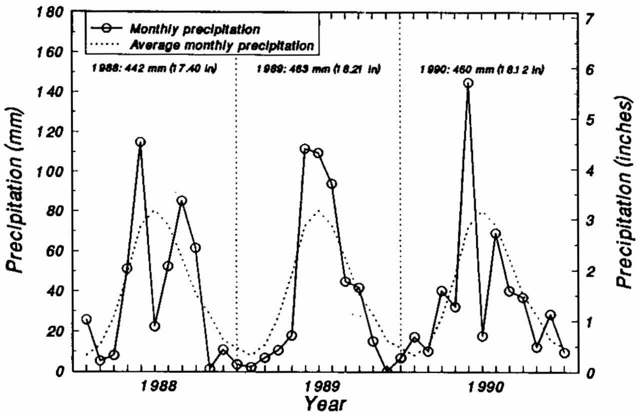

Figure 1–Monthly and average monthly precipitation for northwest Kansas, NMREC, Colby, KS.

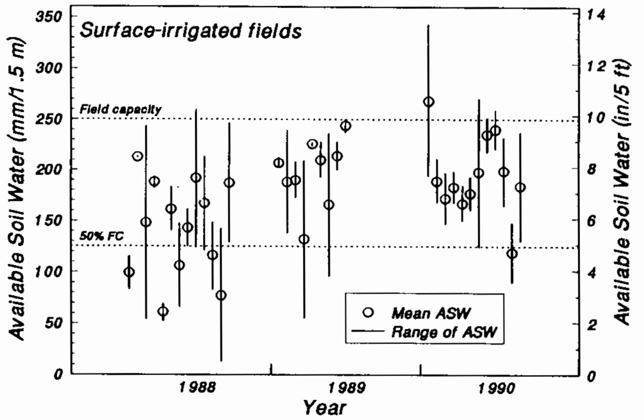

Figure 2–Available soil water content of surface irrigated fields surveyed after corn harvest in northwest Kansas.

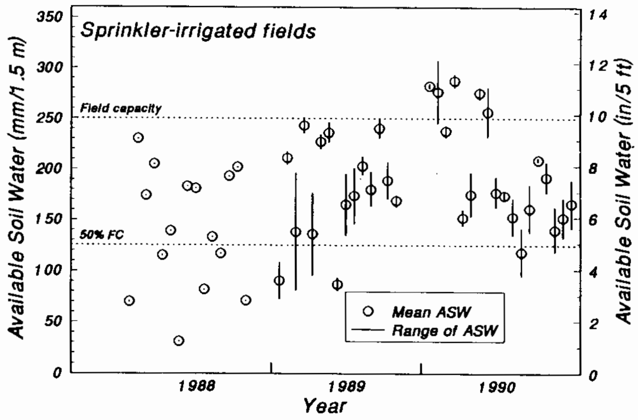

Figure 3–Available soil water content of sprinkler-irrigated fields surveyed after corn harvest in northwest Kansas.

$$SASW = FASW + ((1.16 - 0.0043\ FASW) \cdot P) \quad (1a)$$

$$SASW = FASW + ((1.16 - 0.11\ FASW) \cdot P) \quad (1b)$$

where all variables are expressed in millimeters for equation 1a and in inches for equation 1b. As with every empirical model, certain limitations exist. Although the model should be reasonably valid over a wide range of precipitation amounts, any SASW value in excess of the allowable storage amount should be truncated back to an acceptable storage value for the soil. At no or very low fall-to-spring precipitation the model would tend to over-predict SAWS, since some evaporation and precipitation losses would likely continue. The average ASW across both irrigation system types was 186 mm (7.33 in.) in 1989 and 197 mm (7.76 in.) in 1990. Using an FASW of 190 mm (7.5 in.), a value similar to the soil water data collected in 1989 and 1990, and the mean December-through-May rainfall at Colby of 182 mm (7.17 in.), the model predicted an SASW of 253 mm (10 in.) or field capacity. For these two years, preseason irrigation appears to be unnecessary. The driest field in 1989 and 1990 had an FASW of 87 mm (3.43 in.), and using this, the model predicted a SASW value of 230 mm (9.0 in.), which is about 90% of field capacity, assuming mean over winter precipitation. Most systems have sufficient irrigation capacity to supply water in excess of corn water use in May and June, which would allow at least partial replenishing of a deficient soil-water profile during this period.

Although the 1989 and 1990 data analysis suggested that preseason irrigation should not be recommended, particular fields may have sufficiently low soil water to effectively store some preseason irrigation. Stone and Gwin (1982) suggested preseason irrigation would be a relatively efficient practice if the fall ASW is less than 50% of field capacity. Examination of 1989 and 1990 field data, using the 50% or less available soil water [125 mm/1.5 m (5 in./5 ft)] as a critical point, showed that three sprinkler-irrigated fields and one surface-irrigated field met this criterion.

The randomly selected fields should reflect the typical distribution of system capacities for the region. A number of sprinkler systems exist in the region that have capacity of much-less-than-average seasonal evapotranspiration rate and therefore cannot maintain a stable level of ASW during the peak water use period of the growing season. Thus, the survey might be expected to find some fields with very low ASW. In the case of sprinkler-irrigated systems, which can add small increments of water during the growing season, extremely low fall ASW suggests the need for spring preseason irrigation to raise ASW to mid-range. However, additional irrigation above the amount required to bring the profile to 50% of field capacity has a high probability of being lost or wasted.

Surface-irrigated systems, in general, require more labor and management than sprinkler systems, but can obtain relatively high irrigation efficiency if designed and operated properly. However, the surface-irrigated systems in northwest Kansas tend to be operated at less overall irrigation efficiency than sprinkler systems, which may be partially reflected by the higher within-field variability in soil water (fig. 1 and table 2).

After corn harvest in 1989, one surface irrigated field (fig. 2) had an average ASW amount of 132 mm (5.19 in.), slightly above 50% of field capacity. However, ASW was extremely variable, with a maximum ASW at the head of the field of 209 mm (8.22 in.) compared to the minimum ASW at the tail-end of the field of 55 mm (2.16 in.). To conserve water resources, the farmer might decide to use pre-irrigation on only the lower portion of the field. In the future, the farmer should consider other in-season management options, such as shorter surface runs or surge application that would improve the overall distribution efficiency of irrigation water.

Table 2. Summary of results from a soil water survey after corn harvest in Thomas and Sherman counties, Kansas (1988-1990)

	Surface-Irrigated Fields				Sprinkler-Irrigated Fields			
	1988	1989	1990	Mean	1988	1989	1990	Mean
	Plant Available Soil Water [mm/1.5 m soil profile (in./5 ft soil profile)]							
Average	143 (5.63)	198 (7.78)	194 (7.65)	178 (7.02)	146 (5.69)	179 (7.06)	199 (7.83)	174 (6.86)
Standard deviation	48 (1.89)	34 (1.32)	39 (1.53)	40 (1.58)	59 (2.33)	50 (1.98)	55 (2.18)	55 (2.16)
Maximum value	213 (8.37)	244 (9.61)	268 (10.57)	242 (9.52)	230 (9.05)	243 (9.57)	287 (11.30)	253 (9.97)
Minimum value	61 (2.39)	132 (5.19)	119 (4.70)	104 (4.09)	31 (1.23)	90 (3.55)	118 (4.63)	79 (3.12)
	Variation in Soil Water (ASW) Within Field, %, calculated as 100 ((Max ASW – Min ASW) / Max ASW)							
Average	40	26	28	31	—	19	15	17
Standard deviation	26	26	14	22	—	16	10	14
Maximum value	91	74	54	73	—	58	32	45
Minimum value	0	2	13	5	—	5	1	3

The surface-irrigated fields in 1988 also included several with very poor water distribution characterized by large differences in the maximum and minimum available soil water amounts which generally occurred at the head and tail-ends of the field, respectively. Three of the fields, in addition to having average ASW amounts less than the 50% of field capacity criteria, had poor water distribution and could be considered for either partial preseason irrigation treatment or some other change in in-season irrigation management to improve overall water distribution, as previously discussed. Three other surface-irrigated fields which had average available soil water amounts above the 50% criteria could benefit from alternative in-season irrigation management procedures because of poor water distribution as reflected by the differences in their maximum and minimum available soil water amounts.

The soil water profiles for 1988 were much drier and variable than those for either 1989 or 1990. In 1988, five surface-irrigated fields and five sprinkler-irrigated fields met the 50% or less soil water criterion for preseason irrigation consideration.

There were two surface-irrigated fields with average available soil water amounts less than 40% of field capacity and could be considered candidates for needing preseason irrigation. However, the model predicted the fields will be at nearly 90% of field capacity by spring with average December-through-May rainfall. Because the first surface irrigation application is generally the least efficient, it might be wise to withhold preseason irrigation and use the early part of the season to recharge the soil profile with water, if the seed can be germinated and plant growth established. This would allow the maximum amount of precipitation to be stored. Another management option is to reduce the irrigated portion of the field. One strength of a surface-irrigated system is more flexibility in adjusting the total irrigated area under a given well to match the irrigation system capacity with crop water needs.

Conclusions

A three-year survey of ASW in 82 surface-irrigated and sprinkler-irrigated corn fields, after harvest in northwest Kansas, indicated the fields had an average of 176 mm (6.92 in.) of ASW remaining in the profile. Using this figure in a model developed by Lamm and Rogers (1985), which predicts ASW in the spring based on fall soil water, would indicate that preseason irrigation is an unnecessary practice. However, individual irrigators should determine their need for preseason irrigation by evaluating their ASW and applying the model with an estimate of winter precipitation. Preseason irrigation field preparation and application of water on surface-irrigation often occurs in the fall. Evaluation of fall ASW to predict spring ASW would help convince irrigators of the lack of need for preseason irrigation, sparing them of field preparation and pumping expenses. Mean available soil water for the two system types were similar. However, surface-irrigated fields had larger within-field variations in available soil water than the sprinkler-irrigated fields. This suggests the need for either more careful in-season management to increase uniformity of water application or a reduction of the irrigated area for surface-irrigated fields to insure all parts of the field have adequate soil water in order to assure high crop yields.

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