Irrigation Practices for Reduced Water Application— Texas High Plains

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ABSTRACT

IRRIGATION inventories conducted in 1984 by the Soil Conservation Service indicated the Ogallala aquifer in the Texas High Plains supported 1.84 million ha (4.54 million acres) of irrigated crops in a 41-county area. County inventory estimates of water pumped for crops indicate that limited irrigation of drought tolerant crops was practiced on over one-half and perhaps two-thirds of the irrigated area. Water pumped for irrigation declined from an average of 9.12 km³ (7.39 million acre-ft) during the "full development" period represented by 1964, 1969, and 1974 inventory years to 6.37 km³ (5.16 million acre-ft) in 1984, and average per hectare application declined from 404 to 347 mm (15.9 to 13.7 in.).

The factors associated with reduced water application are increased sprinkler irrigation, recent adoption of surge-flow application to graded furrows, increased use of conservation tillage, increased use of wide-spaced furrows, tractor wheel compaction of irrigated furrows on moderately permeable soils, reduced tailwater runoff in graded furrow systems, reduced use or elimination of large preplant irrigations, and some shifts in crops to those that are successfully managed with reduced water application. Reducing irrigation water application offers opportunity for more effective use of rainfall that averages 472 mm (18.6 in.) annually.

INTRODUCTION

Irrigation from the Ogallala aquifer in the Texas High Plains began an expansion trend in the late 1930's that peaked during the mid 1960's to the mid 1970's. Groundwater decline and reduced well yields were the major factors associated with the leveling off of the area irrigated in a 41-county region shown in Fig. 1. By 1980, depletion of predevelopment recoverable storage had exceeded 50% in 8 counties, and 21 counties had depletion in the 25 to 50% range (Luckey et al., 1981). As groundwater depletion continued during the late 1970's to the present, interest in reducing water application has increased due to increasing pumping energy costs and relatively low commodity prices.

Irrigation management to reduce water application has resulted in substantial decline in groundwater pumped in the Texas High Plains. Irrigation inventories taken at 5-yr intervals by the USDA Soil Conservation Service (SCS) and reported by the Texas Department of Water Resources (1981) and the Texas Water Development Board (1986) show that pumping from the Ogallala aquifer in a 41-county area increased from 6.33 km³ (5.13 million acre-ft) in 1958 to 10.42 km³ (8.45 million acre-ft) in 1974. Pumping by 1984 had declined to 6.37 km³ (5.16 million acre-ft) applied to 1.84 million ha (4.54 million acres) of irrigated crops. The 1964, 1969, and 1974 inventory years represent a "full development" period and both above and below normal rainfall seasons. Water pumped for this "full development" period averaged 9.12 km³ (7.39 million acre-ft) per year. The inventory data for 1984 indicated that water pumped since the "full development" period had declined by about 30%.

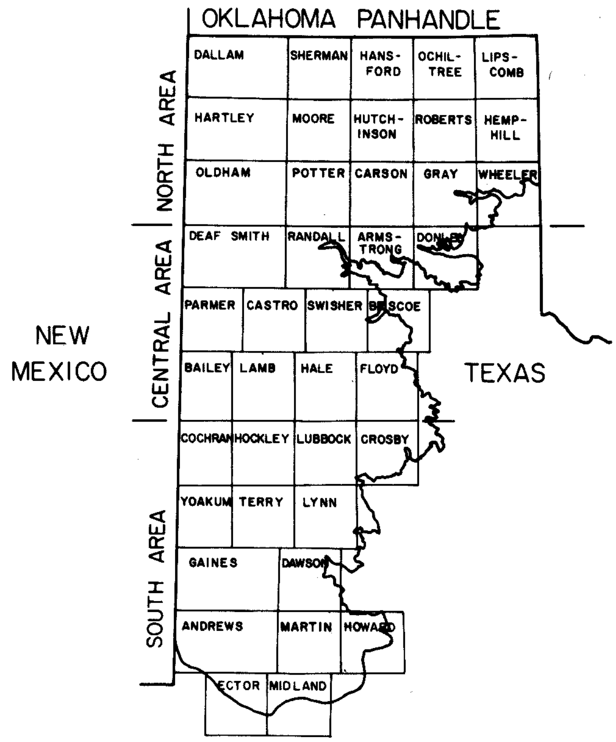

Fig. 1—The 41-county irrigated area of the Texas High Plains totally or partially overlying the Ogallala aquifer divided into the North 15-, the Central 12-, and the South 14-county areas.

During the "full development" period, estimated water pumped for the irrigated area averaged 404 mm (15.9 in.) compared with 347 mm (13.7 in.) in 1984 (an average rainfall year). The decline in depth applied since "full development" has averaged 26%. A major decline in annual groundwater pumping was projected by the Six-State High Plains-Ogallala Aquifer Regional Resources Study conducted by High Plains Associates

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(1982) for the U.S. Dept. of Commerce. For the MS-1 management strategy, the reduction is from a projected 10.16 km³ (8.24 million acre-ft) per year in 1977 to 4.86 km³ (3.94 million acre-ft) in the year 2020. Water application depth was projected to decline from 422 mm (16.6 in.) in 1977 to 180 mm (7.1 in.) in 2020. The MS-1 strategy was baseline projection of current water conservation and use practices plus research, education, and demonstration programs to encourage voluntary reduction in groundwater pumping not reflected in the baseline. Part of the decline projected for water application involved shifts from higher water use crops such as corn to crops that require less irrigation water.

Technology for reducing irrigation water application in a major region of groundwater depletion is receiving greater emphasis in water resource planning and irrigation research. In recent years, users are becoming more interested in new and more efficient irrigation water management technologies and are more receptive to their adoption to the extent that economics permit. This paper examines some current water application and management practices and reviews research results that have potential for widespread adoption in reducing water application.

CROPS FOR REDUCED APPLICATION

The 1984 irrigation inventory data, examined on a county-by-county basis, indicate that limited irrigation is widely practiced on over one-half and perhaps two-thirds of the total area irrigated. Limited irrigation is the predominant practice for two major irrigated crops, cotton and winter wheat. Also, grain sorghum is primarily grown under limited irrigation in southern counties, where well yields are lower and sorghum is a secondary summer irrigated crop to cotton. Where sorghum is secondary in area to corn and where it is the primary summer irrigated crop, it is widely grown under both limited and adequate and inadequate irrigation. Corn is the major crop grown under adequate irrigation for high grain yields. The complete inventory of irrigated crops grown in 1984 and the estimated water application are presented in Table 1.

Irrigation management for reduced water application involves decisions on the crops to be grown. The most dramatic shift in recent years has been the major decline in irrigated corn and sorghum and a much smaller increase in irrigated wheat and cotton. The inventory estimate of average water application for corn in 1984 was 597 mm (23.5 in.), compared with 305 mm (12.0 in.) for winter wheat and 237 mm (9.3 in.) for cotton. The shift to less area in irrigated corn and sorghum and more in irrigated wheat also extends the total irrigation season and the area that can be irrigated with a limited rate of water supply from wells. In the cotton subarea, a significant shift has occurred from sorghum to cotton, with a reduction in water applied.

IRRIGATION SYSTEMS AND PRACTICES

The Texas High Plains is irrigated almost entirely by graded furrow and sprinkler application methods. Graded furrow irrigation, the predominant method, peaked at about 1.86 million ha (4.95 million acres) in 1974 and has since declined to 1.16 million ha (2.87 million acres) in 1984, sprinkler irrigation expanded to 0.70 million ha (1.18 million acres in 1979 and has remained nearly constant through 1984. An 8% decline in sprinkler irrigated area in the southern part of the Texas High Plains (largely stationary systems) was compensated for in the total area values by expansion of center pivot systems in the central and northern part of the area. In 1984, 37% of the total area was irrigated by sprinkler application. Mobile systems were used to irrigate 96% of the sprinkler irrigated crop area. Sprinkler irrigation as a percentage of the total irrigated area continues to expand primarily because of the decline in furrow irrigation.

Limited irrigation is successfully practiced under both furrow and sprinkler application methods. The practice is most successful when used on drought tolerant crops when seasonal rainfall is in the range of normal to above normal, where water is applied in relation to the more critical crop development stages for water stress, and when applied to soils having moderate to high water storage capacities available for plant use. However, all of

TABLE 1. IRRIGATED AREA AND GROUNDWATER APPLIED BY CROPS FOR THE 41-COUNTY AREA PARTIALLY OR TOTALLY OVERLYING THE OGALLALA AQUIFER, TEXAS HIGH PLAINS, 1984. (DATA FROM COUNTY IRRIGATION INVENTORY REPORTS, SOIL CONSERVATION SERVICE)

	Area irrigated		Groundwater applied			
			Total		Average	
Crop	ha	acre	km³	ac-ft	mm	in.
Sunflower	8 000	19,700	0.018	14,800	230	9.0
Cotton	645 500	1,593,800	1.530	1,240,100	237	9.3
Barley-oats	17 800	44,100	0.047	38,300	265	10.4
Winter wheat	447 300	1,104,300	1.362	1,103,400	305	12.0
Vineyard	1 000	2,400	0.003	2,600	327	12.9
Forage-ensilage	54 700	135,100	0.183	148,400	335	13.2
Pecans	1 800	4,500	0.007	5,400	369	14.5
Grain sorghum	316 900	782,600	1.259	1,021,100	398	15.7
Other permanent hay-pasture	7 200	17,900	0.029	23,700	405	15.9
Soybeans	32 800	81,000	0.135	109,800	413	16.3
Vegetables other than potatoes	10 500	26,000	0.044	35,600	417	16.4
Peanuts	14 100	34,900	0.068	55,300	483	19.0
Sugar beets	14 000	34,500	0.071	57,500	507	20.0
Irish potatoes	6 200	15,300	0.034	27,400	548	21.6
Corn for grain	227 500	561,800	1.358	1,100,800	597	23.5
Alfalfa	32 100	79,200	0.222	180,000	693	27.3
Total or avg.	1 837 400	4,537,100	6.370	5,164,200	347	13.7

these conditions do not have to be present for limited irrigation to be successful. An additional aspect of limited irrigation management is the practice of using a limited water supply to irrigate a larger area to maximize total farm production, which normally consists of both irrigated and dryland cropping. Also, irrigated wheat is commonly grazed by livestock from about mid November to early spring growth (late February to mid March), and limited irrigation is managed from both forage and grain production. The practices discussed for reduced water application apply to graded furrow irrigation.

WIDE SPACED BED-FURROW SYSTEMS

Wide spaced furrows and alternate furrow irrigation have been tested in both the Texas High Plains and the adjoining Oklahoma Panhandle. In the Oklahoma tests, the practice was successfully tested for major reduction in irrigation water application with little or no crop yield reduction compared with conventional furrow spacing (Stone et al., 1979; Stone et al., 1982). In five crop seasons of tests with sorghum, sugar beets, and potatoes on Pullman clay loam in the Texas High Plains, irrigating alternate furrows compared with every furrow irrigation reduced water intake by 13 to 33% (Musick and Dusek, 1974). The best of the wide furrow spacings tested on the slowly permeable Pullman clay loam was 1.5 m (60 in.) since the wider 2.0-m (80-in.) spacing caused excessive yield reduction on the lower part of the field. The 1.5-m (60-in.) irrigated furrow spacing is increasingly being used with 0.75-m (30-in.) crop row spacing.

Comparing results from locations having similar average seasonal rainfall of 200 to 250 mm (8 to 10 in.) but different soils (Pullman clay loam at Bushland, TX; and Richfield clay loam at Goodwell, OK) suggests that irrigation of wide spaced furrows is more successful on the medium-textured soils that are moderately permeable and subject to significant deep percolation when irrigated with conventional furrow spacings. In the Texas High Plains, rainfall normally provides about 30 to 40% of the crop water requirements and contributes to the success of wide spaced furrow irrigation. Irrigations that do not fully rewet the profile, such as is accomplished with wide spaced furrow irrigation, can provide some storage capacity for rainfall occurrence following irrigation.

The use of wide farming equipment and every furrow irrigation results in irrigating both wheel and non-wheel track furrows. This practice causes variability in water advance rates and can cause excessive runoff from the wheel track furrows. Irrigation of wide spaced furrows permits more uniformity of water advance by maintaining wheel traffic on the beds. A wide bed-furrow system was successfully tested for irrigated wheat and sorghum at Bushland by Allen and Musick (1972).

REDUCTION IN TAILWATER RUNOFF

One of the dramatic visual changes in reducing water application in recent years has been the reduction in tailwater runoff from graded furrows. During the period of irrigation development through the 1950's, tailwater runoff was mostly considered a waste and water accumulated in roadside ditches and playa lakes. Reuse systems were initially used extensively in the 1960's to reduce labor requirements for managing water application in addition to reuse of runoff. During the 1960's and into the early 1970's, tailwater pits were frequently observed to overflow. When tailwater reuse systems were installed in the North Plains Water Disrict counties of the Texas Panhandle, data from farmer fields indicated that tailwater runoff amounts were increased from about 25% of water applied before systems were installed to about 35% (J. W. Buchanan, North Plains Water Conservation District, personal communication).

Demonstration tests of irrigation scheduling on farmer fields involving 122 irrigation sets on Pullman clay loam during 1977-80 indicated that tailwater runoff as managed by farmers averaged 32% of water applied (L. L. New, Texas Agricultural Extension Service reports). The percent runoff was similar on 400- to 800-m (one-fourth to one-half mile) length field. After evaluating results, one farmer who ran 39% tailwater runoff from 20 irrigation sets one season reduced average runoff to 22% for the same number of sets on the same field during the second season without any reduction in corn yields.

In cooperative tests by ARS and SCS in the Texas High Plains, tailwater reuse was measured from large fields of Pullman clay loam, Olton clay loam, and Acuff loam, three major irrigated soils having a range of increasing permeability and water intake. Over a 2-yr period, reuse averaged 20% of the water applied. By soil types, reuse averaged 16% for Pullman clay loam, 20% for Olton clay loam, and 23% for Acuff loam. These results suggest that on the more permeable soils, the larger stream sizes needed for rapid advance to the end of the field for good distribution uniformity can result in increased tailwater runoff.

In graded furrow studies at Bushland, applications have been managed to limit tailwater runoff to 5 to 15% of water applied on Pullman clay loam (Musick et al., 1973; Schneider et al., 1976). Under conditions of reduced tailwater runoff, some yield reduction occurred on the lower part of the field. However, the water stored on the lower part was efficiently used for crop production. In a study by Musick et al. (1973), average irrigation water intake for the upper, center, and lower one-third sections of a 550-m (1,800-ft) length of run was 137, 114, and 86 mm (5.4, 4.5, and 3.4 in.) per irrigation, respectively. Sorghum yields in the favorable rainfall season averaged 7.56, 7.62, and 7.44 Mg/ha (6,750, 6,800, and 6,640 lb/acre); and irrigation water use efficiencies for grain production averaged 1.35, 1.65, and 2.11 kg/m^3 (306, 373, and 478 lb/acre-in.) of net intake, respectively, for the field segments. In a drier season, greater yield reductions would have been expected from the lower part of the field due to reduced tailwater and lower intake opportunity time. However, based on the results of reducing water applications from 100 to 50 mm (4 to 2 in.) in controlled plot studies (Musick and Susek, 1971a), the drier lower field section would still result in higher irrigation water use efficiency than the upper section for grain production.

FURROW COMPACTION

Furrow compaction by tractor wheels is being practiced in the Texas High Plains on moderately permeable soils to reduce the excessive irrigation water intake and the substantial losses that can occur to deep percolation (Musick et al., 1985; Musick and Pringle, 1986). The largest excessive application is normally the first one following primary tillage, either as a preplant or crop emergence application or the first seasonal irrigation where a preplant or emergence irrigation was not applied. When the preplant or emergence irrigation was applied, frequently the first seasonal irrigation is excessive in amount needed to rewet the profile. In a 3-yr spring preplant irrigation study at Etter, TX, on Sherm clay loam, water intake under five tillage treatments averaged 466 mm (18.3 in.) (Undersander and Regier, in press). During the early vegetative period as roots extend into moist soil, depth of water depletion is limited and smaller irrigations normally can replenish profile soil water. Irrigation of furrows that have experienced wheel traffic compaction can provide adequate water intake and profile wetting while substantially reducing deep percolation. Surface layer soil compaction from wheel traffic does not appear to adversely affect crop rooting under irrigated conditions.

In a 2-yr study of corn irrigation on Olton clay loam, treatments were evaluated with irrigations applied to 1.5 m (60-in.) spaced furrows that had been compacted to about 1.6 Mg/m^3 (1.6 g/cc) bulk density, designated as HARD, and to nonwheel traffic furrows having bulk densities of 1.2 to 1.3 Mg/m^3 (1.2 to 1.3 g/cc), designated as SOFT. Four seasonal irrigations were evaluated in 1982, and seven were evaluated in 1983. In the 1983 test, a management option was evaluated in which the fourth and fifth seasonal irrigations in the HARD furrow treatment were switched to SOFT furrows for "catch up" and to meet water requirements during a very dry high evaporative demand period. Since the HARD furrow treatment had 30 mm (1.2 in.) less soil water storage approaching the critical pollination period, switching irrigations to the SOFT furrows was successful as "catch up" to prevent yield reduction.

The HARD furrow treatment reduced average water advance time for a 400-m (one-fourth mile) field length by 48%, water intake by 33%, and estimated deep profile drainage by two-thirds with no adverse effect on grain yields (Musick et al., 1985; Musick and Pringle, 1986). An additional benefit from reducing deep profile drainage losses can be reduced nitrate leaching. Nitrogen deficiency syptoms have been observed on the upper part of irrigated fields where moderate nitrogen rates were used. However, since high N rates were used in this study, no crop deficiencies were observed.

Irrigation water requirements for crops in the Texas High Plains vary primarily with seasonal rainfall and the evaporative demand of the climate. Higher water use rates associated with prevailing dry weather can appreciably increase irrigation water requirements. Having alternating SOFT and HARD furrows permits some flexibility in managing irrigation water intake to meet conditions of variable evaporative demand and profile storage needs.

Reducing seasonal irrigation water application to HARD furrows reduced irrigation pumping energy requirements. This reduction in water pumped by an electric-powered irrigation well [39.7 L/s flow rate (630 gpm)] reduced calculated pumping costs ($0.08 kWh) by $48.47 per ha ($19.62 per acre) in 1982 and $82.87 per ha ($33.55 per acre) in 1983.

Previous studies have shown that wide-furrow spacing reduced irrigation water intake. In a more recent study, a wide-furrow spacing was combined with wheel compaction to further reduce excessive water intake on the moderately permeable soils (Musick and Pringle, 1986). The 2-yr test demonstrated the success of the system in reducing water application by 20 to 30% without affecting grain yields. The reduced intake more closely corresponded to profile storage capacity at the time of irrigation.

SURGE FLOW MANAGEMENT

Surge flow application to graded furrows is being rapidly adopted in the Texas High Plains. A survey of manufacturers and distributors by the High Plains Underground Water District, Lubbock, TX, indicated that sales of surge units increased from about 100 in 1983 to 1,567 in 1984. Sales slowed in 1985, and in 1986 continued at about 1,000 units per year (personal communication with industry representatives). A slowdown in sales was attributed to the state of the farm economy in the High Plains.

Surge flow irrigation (the use of a controller and valve assembly in gated pipe for intermittent application of water in a series of on and off modes of constant or variable time spans) tests on Olton clay loam have demonstrated that this method of water application can be managed to reduce excessive water application and intake and improve irrigation efficiencies (Musick et al., 1987). For a full season surge application test consisting of preplant plus six seasonal irrigations for corn, water application was reduced by 32%, intake by 28%, tailwater runoff by 57%, and estimated deep percolation below a well-defined root zone to caliche (1.4 m, 4.4 ft) by 64%, compared with conventional steady flow application to graded furrows. Surge flow resulted in a slight (6%) reduction in both seasonal water use and grain yield. The surge flow effect reduced intake by 32% when surface soil was in a loosened condition after tillage. After surface soil was reconsolidated following irrigation, surge flow reduced average intake by 16% during four subsequent irrigations.

The surge flow tests were conducted on a 400-m (one-fourth mile) run that was conventionally irrigated as 12-h sets. For the surge flow set, the water supply was used to irrigate an area 2.2 times that of the steady flow set which reduced furrow stream size from 2.41 to 1.85 L/s (38 to 29 gpm) and efficiently managed the surge set as a 24-h application, thus reducing the irrigator's time in changing sets. Reducing the furrow flow rate by 23% was successful in managing the surge flow applicaton to reduce tailwater runoff. If the same furrow flow rate was used for both application methods, surge flow would have increased tailwater runoff or the set would have needed changing earlier (during the night) at less convenient times.

Surge flow will be most beneficial for reducing intake during the preplant and/or the first seasonal irrigation when the surface soil layer is loosened by tillage. On the slowly permeable soils, normal seasonal irrigations in graded furrow systems result in about 75 to 125 mm (3 to 5 in.) of water intake. Frequently, the intake amounts only partially rewet the profile. Under these conditions, surge flow application to reduce water intake may be of little or no benefit. However, surge flow application during the growing season on the slowly permeable soils may improve distribution uniformity with length of run and may be managed to reduce tailwater runoff.

Surge controllers are available that can be programmed for continuous flow to both sides of the unit during the runoff phase as a cutback furrow stream or for a short cycle time during the runoff phase. Both methods of using surge controllers will reduce tailwater runoff for the same lower field intake opportunity time. Some farmers have indicated the ability to manage surge flow to nearly eliminate tailwater runoff (personal communication). The ability of surge flow to greatly reduce intake rates after the first surge advance resulted in increased uniformity of water storage with length of run in the tests of Olton clay loam.

ELIMINATING THE PREPLANT IRRIGATION

The need for a preseason irrigation before or after planting is related to the benefits of timely crop stand establishment and/or a fully wet soil profile to begin the growing season. Annual precipitation distribution in the Texas High Plains is favorable for establishment of late spring seeded summer crops and early fall seeding of small grains. This normally favorable distribution contributes to the success of dryland farming with cotton, sorghum, and winter wheat. The most reliable 30-day rainfall period of the year is mid May to mid June. This favorable period coincides with the planting period of sorghum. Timely early planting is more critical for corn, soybeans, and cotton, and preplant irrigation becomes more important to assure stand establishment.

Dryland management practices emphasize profile soil water storage at planting. The recommendation for preplant irrigation to insure a fully wet soil profile to about the 1.8-m (6-ft) depth at planting evolved from the early irrigation research in the Texas High Plains (Jones and Gaines, 1941; Thaxton and Swanson, 1956; Swanson and Thaxton, 1957). However, later tests showed relatively low yield response to preplant irrigation compared with seasonal irrigations. When compared with dryland production, the yield response to preplant irrigated sorghum at Bushland averaged 0.91 kg/m^3 (206 lb/acre-in.) of applied water to level border plots during 8 years of tests, while the response of seasonal irrigations averaged 1.85 kg/m^3 (419 lb/acre-in.) (Jensen and Sletten, 1965; Musick and Dusek, 1971a; Musick and Dusek, 1971b). Thus, the yield response to water applied as seasonal irrigation was about double the response per unit of water applied as preplant irrigation.

In a 3-yr test by Musick et al. (1971), the yield increase from preplant irrigation was very low when two or three seasonal irrigations were applied. By deleting the preplant irrigation, irrigation water use efficiency for grain production was increased in 1964 from 1.26 to 1.68 kg/m^3 (286 to 381 lb/acre-in.) and in 1965 from 1.44 to 2.69 kg/m^3 (326 to 610 lb/acre-in.). This study, which involved an evaluation of 20 preplant irrigations, indicated that about three units of preplant irrigation were required for an additional unit of profile water storage at planting. However, additional storage at planting is normally efficiently used by the crop. The exception is when early season rainfall is excessive in comparison to early season crop water requirements and the excess rainfall negates the benefit of additional profile storage at planting.

Preplant irrigations are frequently excessively large when applied in graded furrow systems. The high intake rates are associated with loosened surface soil conditions caused by primary tillage, by winter freezing and thawing, and sometimes by the water flow retarding effects of "rough" furrows and crop residues in reduced tillage systems. Undersander and Regier (in press) found that over winter changes in soil properties caused water intake during graded furrow irrigation of Sherm clay loam to be increased from 237 mm (9.3 in.) for fall application after sorghum harvest and tillage to 466 mm (18.3 in.) for spring application. Both intake quantities greatly exceeded storage capacity and resulted in the same increased profile storage of 85 mm (3.3 in.) to the 1.8-m (6-ft) depth.

In addition to indicating that excessive intake can be reduced by fall compared with spring application in graded furrow systems, test results involving tillage treatments indicated that excessive intake was reduced (a) by multiple disking that reconsolidated surface soil below the depth of disk penetration after loosening by chiseling or moldboard plowing, and (b) by wheel traffic compaction in furrows. Cultivation of bed-furrows resulted in wheel traffic compaction in every other furrow. During the spring preplant irrigation when intake averaged 466 mm (18.3 in.) in a 3-yr test, water intake by wheel track furrows during the advance time to the end of the field was one-half the intake by nonwheel track furrows. Compaction of all furrows by tractor wheel traffic would have greatly reduced excessive intake and increased furrow advance uniformity.

Preplant irrigation following harvest and tillage in late fall can reduce the quantity of water applied but can allow the surface soil seeding zone to become dry before spring planting time. Stand establishment from spring planting on the fall preplant irrigated plots has been successful by operating a planter to push the dry soil off the beds and place seed into moist soil. Furrow openers can be used to clean out furrows during cultivation prior to the first seasonal irrigation.

Irrigating to fully rewet the soil profile soon after harvest largely prevents additional soil water storage of winter and spring precipitation. About 40% of annual precipitation in the Texas High Plains normally occurs between harvest and planting in annual cropping systems. The study by Undersander and Regier (in press) dramatically illustrates the difficulty of obtaining efficient profile storage from preplant irrigation for later use by a crop.

Conservation tillage practices are currently being tested at Bushland for sorghum establishment without preplant irrigation by using limited tillage and crop residue management (Allen and Musick, 1986). Water furrows are established during cultivation prior to the first seasonal irrigation. The flat tillage management (without bed-furrows) that involves fewer operations and shallow operating depths potentially enhances spring seed zone moisture for stand establishment. Flat tillage with surface residue management reduces runoff from intense May-June thunderstorms compared with conventional bed-furrow management. Having beds and furrows enhances storm runoff by functioning as an excellent field surface drainage system. The potential range of planting dates for sorghum, mid May to mid June, normally provides good flexibility for planting after spring rains without needing the preplant irrigation.

CONCLUDING DISCUSSION

County irrigation inventories by 5-yr intervals in the Texas High Plains indicate the "full development" of the Ogallala aquifer for irrigation spans an approximate 10-yr period from the mid 1960's to the mid 1970's. Data for the following decade reflect two significant trends: (a) a transition trend to dryland agriculture; and (b) a trend to reduced water application. Since the 1984 inventory data reflect an average rainfall season, the average 30% decline in water application over the 1964-74 "full development" period reflects the influences of several changes that have been taking place. Some of the reduction is associated with a shift in cropping are from the higher water requirements of irrigated corn and fully irrigated sorghum to increased practice of limited irrigation of sorghum, wheat, and cotton. The primary dryland transition crops are wheat and cotton.

The reduced water application associated with irrigation systems are: a very significant reduction in graded furrow irrigated area while the sprinkler irrigated area remains essentially constant; graded furrow management that substantially reduces tailwater runoff; a reduction in graded furrow water intake by using wide-spaced furrows; limited but increasing use of tractor wheel compaction of furrows; and surge-flow application to graded furrows. Reduced water application for the drought tolerant crops of wheat, sorghum, and cotton (also the major dryland crops) is increasingly being managed by eliminating the normally large preplant irrigation and by applying fewer irrigations during the growing season in relation to critical stages of plant development. The most common practice is to apply one or two graded furrow seasonal irrigations.

Gutentag et al. (1984) reported that 70% of the groundwater depletion in the regional Ogallala aquifer has occurred in the Texas High Plains. Because of the critical decline in the water table and well yields, along with high pumping energy costs and relatively low commodity prices, an assessment of county irrigation inventory data indicates that limited irrigation is practiced on over half of the irrigated land. The adoption of limited irrigation is projected to continue as the region continues a transition to dryland agriculture.

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