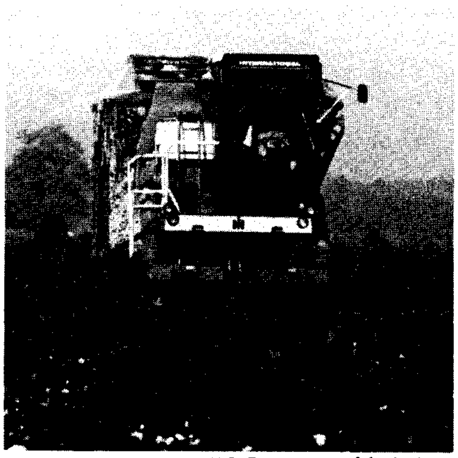

U.S. Department of Agriculture

Agricultural technology and conservation in the Southern High Plains

By O. R. Jones, P. W. Unger, and D. W. Fryrear

WATER conservation has become increasingly important in agricultural production on the 15.6 million acres of cultivated land in the semiarid Southern High Plains. A tenfold increase in irrigation pumping costs since 1973 and a declining water table in the Ogallala Aquifer have necessitated better conservation measures. Many irrigation farmers now consider precipitation as their primary source of water for crop production, and they are applying less water per irrigated acre. Other farmers have reverted to dryland production. In 1977 about 46 percent of the cultivated area in the Southern High Plains was dry-farmed. By 1982 the acreage of dry-farmed cropland had increased to 54 percent.

Soil and water conservation practices in the Southern High Plains vary, depending on whether the operator dry farms, irrigates, or uses a combination of the two systems. Changing technologies also affect soil and water conservation practices, which include conservation tillage, land leveling, furrow diking, irrigation pumping and water distribution and application systems, skip-row cropping, and alternate irrigated-dryland cropping.

Dryland farming

Traditional practices. Tillage and conservation practices developed in response to the "Dirty Thirties" are still the mainstays on dry-farmed land in the region. Stubble mulch tillage, contour tillage, and broadbase terraces are commonly used means of controlling wind and water erosion. In comparison to clean tillage, stubble mulch tillage conserves 20 percent more soil water and increases wheat yields about 12 percent (*7*).

The small amounts of residue remaining after harvesting most dryland crops, usually less than 1,800 pounds per acre, are sufficient to control wind erosion in most areas if the residues are maintained on the field surface. However, such residue levels are not sufficient to prevent the loss of most precipitation via runoff and evaporation. In a wheat-sorghum-fallow sequence, only 15 to 20 percent of the precipitation that occurs during fallow is stored as soil water, even with stubble mulch tillage. The remaining 80 to 85 percent is lost through runoff, evaporation, or transpiration from weeds and volunteer crop plants. Conservation practices that reduce runoff and evaporation offer great potential for increasing dryland yields.

The Soil Conservation Service (SCS) recommends use of broadbase parallel terraces and contour tillage when soil slopes exceed one percent. Terraces effectively reduce slope length and control soil erosion. But they do little to increase water conservation, except in the terrace channel, which comprises only a small portion of the terrace interval. Much dry cropland is not terraced because slopes do not exceed one percent; however, even on these "A" slopes considerable runoff occurs (*10*).

Landowners and operators sometimes till with listers, chisels, or moldboard plows to control wind erosion, particularly on the deep, coarse-textured soils in the southern portion of the Southern High Plains. Wind erosion is a major problem in this area because nearly all of the cultivated land is planted to cotton, which does not produce enough residue to control wind erosion.

Tillage effectively controls wind erosion if the soil has enough moisture to produce a rough, cloddy surface when tilled (*12*). The rough, cloddy surface remains effective until rainfall melts the surface clods (*5*). As soon as the soil surface begins to dry after a rain, farmers must use additional shallow tillage to restore the rough, cloddy surface condition. Moldboard plowing and listing increase the percentage of nonerodible aggregates on the fine sandy loam soils on which most cotton is grown. But for tillage to be effective in reducing wind erosion, any loose sand on the field surface must be covered (*4*).

Technology's effects. Dryland conservation practices have been developed to retain precipitation and thereby increase crop yields. As precipitation is retained, runoff and soil erosion by water are reduced. Some practices completely eliminate water erosion. Also, the greater amounts of residue produced as a result of higher crop yields help control wind and water erosion. Among the practices recommended are land leveling, conservation bench terraces, furrow diking, and conservation tillage.

Land leveling is the most effective means of conserving runoff and preventing soil erosion. It is also the most expensive. Little leveling has occurred on dryland. But with laser-controlled equipment, leveling costs are declining and precision is increasing.

Practical, narrow bench terraces (minibenches) can be constructed for $50 to $100 per acre on the gently sloping soils (0

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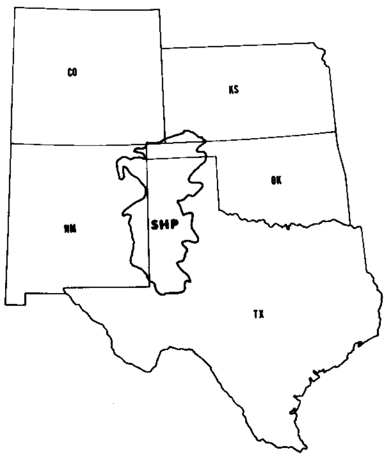
to 2 percent slope) in the Southern High Plains. Grain sorghum yield increases of 300 to 600 pounds per acre per year are required to pay for installing and maintaining a minibench terrace system. At Bushland, Texas, average grain sorghum yields on land with minibench terraces are 1,040 pounds per acre higher than yields with graded furrows. With minibench terraces only one or two equipment widths wide, shallow soil cuts reduce soil fertility problems normally associated with land leveling, and much less soil is moved (*9*).

Conservation bench terrace systems also have proven effective for conserving water and fuel on slowly permeable soils in the Southern High Plains (*8*, *10*). With conservation bench terraces, the lower one-third of the terrace interval is leveled to capture runoff from the cropped watershed. At Bushland, Texas, on a clay loam soil with average rainfall of 18.1 inches per year, the leveled bench in such a terrace system receives an average of 4.2 inches more water annually than adjacent sloping land. This conserved runoff provides enough water for annual cropping of sorghum, wheat, sunflowers, and alfalfa on bench terraces.

Furrow diking developed in the Great Plains in the 1930s. The practice generally was abandoned by 1950, however, because of problems with the slow operating speed of diking equipment, poor weed control, difficulty with seedbed preparation and subsequent tillage, and increased erosion when dams washed out. Engineers at Bushland and Lubbock, Texas, revived the practice in 1975 by designing improved equipment, using herbicides to control weeds, and applying the practice to summer-grown crops that could benefit more than wheat by preventing runoff during the spring and summer when the potential for runoff is highest (*3*). Furrow diking (basin tillage) is a proven soil and water conservation practice that farmers have adopted rapidly for both dryland and irrigated crop production in the Southern High Plains and Red Rolling Plains. An estimated 2 million acres were diked in 1983.

Dryland farmers are adopting conservation tillage systems, including no-till, in which herbicides replace all or some tillage operations. Increasing fuel and equipment costs often make it more economical to apply herbicides than to perform tillage (*23*). While research has shown little difference in soil water accumulation or yield between stubble mulch tillage and no-till on dryland (*21*, *22*), the additional crop residues retained on the soil surface with conservation tillage provide increased protection against wind erosion.



Southern High Plains (SHP) Land Resource Area (*1*).

With no-till, applying atrazine to wheat stubble immediately after wheat harvest to control weeds through the 11-month fallow and into the sorghum growing season is particularly successful in a wheat-fallow-sorghum-fallow sequence. This eliminates three to five subtillage operations and possibly one or two cultivations. Problems with grassy weeds during fallow may require an application of glyphosate or subtillage with sweeps.

Glean[1] (chlorsulfuron) was labeled for use on wheat in 1982. In research trials Glean has controlled weeds and volunteer sorghum during fallow, after sorghum, and during the wheat growing season. The economics of Glean in the wheat-fallow-sorghum-fallow sequence are not as favorable as for the triazines.

Recent advances in application systems for glyphosate and paraquat make these contact herbicides economically attractive for controlling weeds and volunteer crops on dryland. By applying ultra-low volumes of carrier (3 gallons/acre of water) with controlled droplet applicators or less than 7 gallons per acre of water with fan-tips, rates as low as 0.25 pounds per acre of Roundup or paraquat have effectively controlled weeds (*6*). This is only 50 percent of the level recommended by the label for use with conventional sprayers.

Irrigated land

Traditional practices. Irrigation water on the Southern High Plains is pumped from the Ogallala Aquifer that underlies much of the area. Irrigation developed rapidly during the 1940s and 1950s. Now, the Ogallala is being mined because pumping greatly exceeds natural recharge, which is only about one-half inch per year (*17*). In areas where the aquifer's saturated thickness was thin, the aquifer was rapidly depleted, and irrigated land began reverting to dry farming by the 1960s. The reversion process has increased in recent years, although some new irrigaton development still occurs. In addition to a decreasing water supply, escalating fuel prices have forced many operators to pump less water and a few operators have quit irrigating, even though water is still available. This is particularly true in the northern portion of the Southern High Plains, where pumping lifts are commonly 300 to 500 feet and natural gas prices increased from $0.36 to $3.70 per thousand cubic feet between 1973 and 1983.

Furrow irrigation is the most common irrigation system in the Southern High Plains. Operators usually orient crop rows up-and-down slope, parallel to the fenceline or road, and use clean tillage, moldboard plowing or chiseling, disking, and listing. Under normal irrigation procedures, farmers let about 20 percent of the applied irrigation water leave the field so the lower end of the field is adequately wetted. Although many operators capture the tailwater and recycle it through the irrigation system, some of the water is lost. When precipitation occurs within a few days after an irrigation, much of the water is lost as runoff because the soil is wet and infiltration is reduced. High-intensity storms may result in some erosion but most slopes on irrigated fields are less than one percent; thus, erosion is not a severe problem.

Traditionally, operators schedule irrigation applications based on time rather than on the water-holding and infiltration capacities of the soil and the crops' water needs. This can result in inefficient water use. Irrigation sets typically are changed at 12-hour intervals on the moderately permeable soils and at 24-hour intervals on slowly permeable clay loams. Because very few wells are metered, most operators do not know how much water is applied. The experienced irrigator knows how many furrows can be irrigated during the set time, and flow into furrows is adjusted so that most will be "out" before the water is changed. Normally, during an irrigation set, water in wheel-traffic furrows advances to the end of the field several hours before that in nontraffic furrows, resulting in a large amount of tailwater runoff. In-

[1]Mention of a trade name or product does not constitute a recommendation or endorsement for use by the U.S. Department of Agriculture.

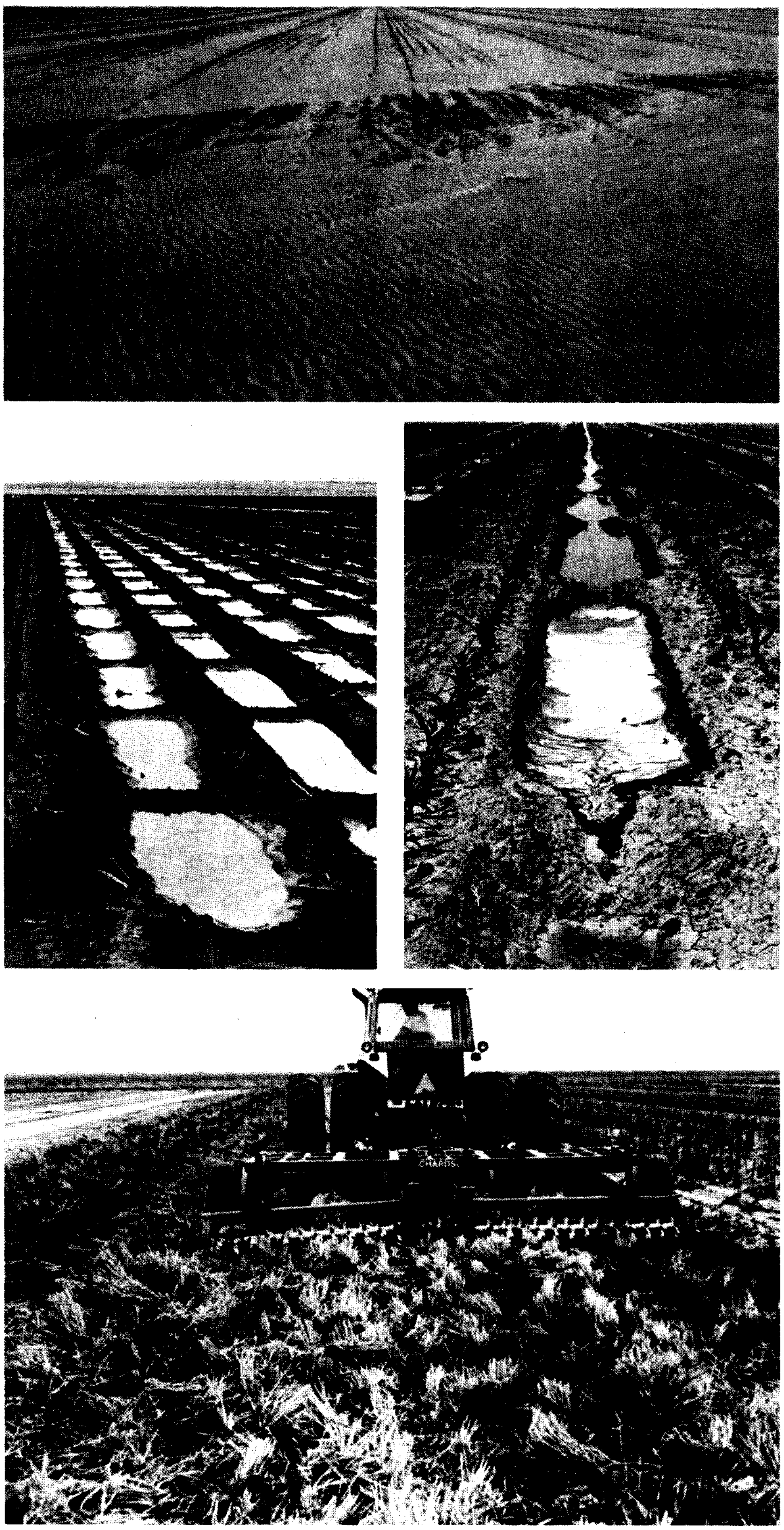
filtration in the wheel-traffic furrows is limited, but is fairly uniform from one end of the field to the other. On nonwheel traffic furrows, percolation below the root zone may occur on the upper ends of the fields where higher infiltration rates occur for longer times.

Sorghum, cotton, and wheat are commonly irrigated with limited water supplies because they can withstand periods of water stress without a great yield reduction. Corn, however, usually is fully irrigated to meet evapotranspiration requirements because water stress during any stage of growth can greatly reduce yields (*13*). Alfalfa, soybeans, and sugar beets are among the other irrigated crops grown in the Southern High Plains.

Technology's effects. Most irrigators are becoming more efficient at managing water to meet crop needs. Many are testing engines and pumps to determine where inefficiencies exist and are replacing or repairing inefficient equipment with well-engineered installations. Several agencies, including SCS, Texas A&M University, and the respective underground water conservation districts, provide testing assistance. Many operators also are installing water meters on well discharges to help them manage their water and to detect problems when they occur.

Water distribution and application systems are being improved. Open ditch systems that were prevalent 25 to 30 years ago have been almost completely replaced with concrete or plastic pipelines. This has drastically reduced water transmission losses. Many operators have installed high-and low-pressure center-pivot irrigation sprinklers to make precise applications of water in response to plant needs. One irrigation system, the low-energy precision applicator, uses very low pressure and drop tubes to achieve a 98 percent application efficiency when used in conjunction with furrow diking (*11*). For furrow irrigators, surge irrigation, in which water is applied intermittently to the furrows, is increasing water application efficiencies by reducing infiltration and increasing the uniformity of water distribution in the soil from the upper ends to the lower ends of fields (*2*).

In addition to improving irrigation sys-



Wind erosion on land cropped annually to cotton (top) near Big Spring, Texas. Conservation of stormwater runoff (middle left) and irrigation (middle right) with furrow dikes in a limited irrigation-dryland farming system in Texas. Stubble mulch tillage (bottom) protects Southern High Plains cropland against wind and water erosion.

tems, operators are applying water in response to plant needs and are irrigating to limit wetting to the plant root zone, thereby avoiding water loss by overirrigating and the subsequent loss of plant nutrients by leaching. A few operators are using computer services to predict evapotranspiration and schedule irrigations so that only enough water is applied to meet plant needs for the desired yield level. Many operators also use tensiometers, electrical resistance blocks, or the neutron method to determine soil water depletion.

Limited irrigation

Major agronomic improvements have been made in using limited precipitation and irrigation water to produce crops. Farmers are irrigating alternate furrows and using dikes in the nonirrigated furrows to capture runoff. Thus, even after an irrigation, storm runoff can be conserved on 50 percent of the land. In some areas where groundwater is extremely limited and only a small part of the land can be irrigated, farmers use skip-row cropping, with two rows planted and one or two rows left unplanted. The furrow between the cropped rows is irrigated while the remaining furrows are diked. In a two-in, one-out cropping pattern, water infiltration for one irrigation for corn and sorghum was reduced from 5 to 2.3 inches, 46 percent of the infiltration where every furrow was irrigated. When compared to every row cropping and irrigation, skip-row cropping and irrigation reduced yields on a total area basis but increased yields and irrigation water use efficiencies on a planted-row basis (*14*). Operators also extensively use skip-row cropping and irrigation systems in cotton production.

The limited irrigation-dryland (LID) system efficiently uses both precipitation and irrigation for sorghum production. The system was developed for use with furrow irrigation on slowly permeable soils (*16*). With LID, the upper one-half of the field is managed as fully irrigated. The next one-fourth is managed as a tailwater runoff section to capture furrow runoff from the fully irrigated section. The lower one-fourth of the field is managed as a dryland section with dikes to conserve runoff from rainfall or irrigation water from the wetter sections. Fertilizer applications and sorghum seeding rates vary according to expected yield levels on the three sections of the field. In tests at Bushland, furrow dikes retained all water on the field, eliminating tailwater and storm runoff and subsequent erosion. The LID system also increased sorghum grain yield an average of 350 pounds per acre-inch of added irrigation water, compared to an increase of 215 pounds per acre-inch of water added with conventional furrow irrigation. To facilitate seeding rate changes in the different management sections of the field, a John Deere Max-emerge planter was modified so that seeding rate changes could be made without stopping the tractor (*15*).

Irrigated-dryland systems

Alternating irrigated wheat with a no-till dryland summer crop effectively uses both precipitation and limited irrigation water. Residues from wheat irrigated for high yields average about 7,100 pounds per acre, and these residues can be used effectively to increase precipitation storage efficiencies during the 10- to 11-month fallow period between wheat harvest and planting of a dryland summer crop. In no-till, applying atrazine and 2,4-D at 3.0 and 1.0 pounds per acre, respectively, immediately after irrigated wheat harvest controlled weeds and volunteer wheat during fallow and eliminated three to four tillage operations. Increased soil water storage due to no-till during fallow increased sorghum yields 540 and 970 pounds per acre over yields obtained with sweep and disk tillage, respectively (*18, 19, 20*).

The irrigated-wheat-to-dryland-sorghum crop sequence using no-till is attractive because of improved water conservation, reduced energy inputs, and lower production costs. High crop residue levels on the soil surface greatly reduce the potential for wind and water erosion (*23*).

Future systems

Future crop production systems in the Southern High Plains will feature innovative combinations of soil and water conservation practices, crops, and cropping practices that use irrigation and precipitation efficiently. Farmers will base many of their management decisions on computerized crop, climate, and economic models.

Within the next three to five years a majority of farmers in the Southern High Plains will turn to the use of conservation tillage on both irrigated and dry-farmed cropland to not only conserve soil and water resources but to increase yields and reduce operating costs.

REFERENCES CITED

1. Austin, M. E. 1965. *Land resource regions and major land resource areas of the United States.* Handbk. 296. U.S. Dept. Agr., Washington, D.C.
2. Bishop, A. D., W. R. Walker, N. L. Allen, and G. J. Poole. 1981. *Furrow advance rates under surge flow systems.* J. Irrig. and Drain. Div., ASCE 107(No. IR3): 257-264.
3. Clark, R. N., and O. R. Jones. 1981. *Furrow dams for conserving rainwater in a semiarid climate.* In *Crop Production with Conservation Tillage.* Am. Soc. Agr. Eng. St. Joseph, Mich. pp. 198-206.
4. Fryrear, D. W. 1981. *Tillage influences erodibility of sandy soils.* In *Crop Production with Conservation Tillage.* Am. Soc. Agr. Eng., St. Joseph, Mich. pp. 153-163.
5. Fryrear, D. W., and J. D. Downes. 1975. *Consider the plant in planning wind erosion control systems.* Trans., ASAE 18: 1,070-1,072.
6. Green, J. J., E. W. Chenault, D. E. Lavake, and A. F. Wiese. 1982. *Weed control with a controlled droplet applicator.* Prog. Rpt. 4025. Tex. Agr. Expt. Sta., College Station.
7. Johnson, W. E., C. E. Van Doren, and E. Burnett. 1974. *Summer fallow in the Southern Great Plains.* Cons. Res. Rpt. No. 17. Agr. Res. Serv., U.S. Dept. Agr., Washington, D.C. pp. 86-109.
8. Jones, O. R. 1975. *Yields and water-use efficiencies of dryland winter wheat and grain sorghum production systems in the Southern High Plains.* Soil Sci. Soc. Am. J. 39: 98-103.
9. Jones, O. R. 1981. *Land forming effects on dryland sorghum production in the Southern Great Plains.* Soil Sci. Soc. Am. J. 45: 606-611.
10. Jones, O. R., and W. C. Johnson. 1983. *Cropping practices: Southern Great Plains.* In H. E. Dregne and W. O. Willis [eds.] *Dryland Agriculture.* Am. Soc. Agron., Madison, Wisc. pp. 365-385.
11. Lyle, W. M., and J. P. Bordovsky. 1980. *New system for precision irrigation and energy conservation.* Paper No. 80-2069. Am. Soc. Agr. Eng., St. Joseph, Mich.
12. Lyles, L., and N. P. Woodruff. 1963. *Effects of moisture and soil packers on consolidation and cloddiness of soil.* Trans., ASAE 6: 273-275.
13. Musick, J. T., and D. A. Dusek. 1980. *Irrigated corn yield response to water.* Trans., ASAE 23: 92-98, 103.
14. Musick, J. T., and D. A. Dusek. 1982. *Skip-row planting and irrigation of graded furrows.* Trans., ASAE 25: 82-87, 92.
15. Stewart, B. A. 1983. *Automated seeding rate selector.* Agron. J. 75: 152-153.
16. Stewart, B. A., J. T. Musick, and D. A. Dusek. 1983. *Yield and water-use efficiency of grain sorghum in a limited irrigated-dryland farming system.* Agron. J. 75: 629-634.
17. Theis, C. V. 1937. *Amount of ground-water recharge in the Southern High Plains.* In Trans., 18th Annual Meeting, Am. Geophys. Union, New York, N.Y. pp. 565-568.
18. Unger, P. W. 1978. *Straw-mulch effect on soil water storage and sorghum yield.* Soil Sci. Soc. Am. J. 42: 486-491.
19. Unger, P. W. 1984. *Tillage and residue effects on wheat, sorghum, and sunflower grown in rotation.* Soil Sci. Soc. Am. J. 48: (in press).
20. Unger, P. W., and A. F. Wiese. 1979. *Managing irrigated winter wheat residues for water storage and subsequent dryland grain sorghum production.* Soil Sci. Soc. Am. J. 43: 582-588.
21. Wiese, A. F., D. E. Lavake, and E. W. Chenault. 1980. *Limited tillage in a wheat-sorghum-fallow cropping sequence on dryland.* Agron. Abstracts: 193.
22. Wiese, A. F., E. Burnett, and J. E. Box, Jr. 1967. *Chemical fallow in dryland cropping sequences.* Agron. J. 59: 175-177.
23. Wiese, A. F., and P. W. Unger. 1983. *Irrigation + dryland farming + limited tillage: A profitable combination.* J. Soil and Water Cons. 38: 233-236. □