Furrow Dikes.

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R.L. Baumhardt
United States Department of Agriculture

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Ordie R. Jones (Retired)
R. Louis Baumhardt
United States Department of Agriculture (USDA), Bushland, Texas, U.S.A.

INTRODUCTION

Furrow dikes are small earthen dams formed periodically between the ridges of a ridge-furrow tillage system or, alternatively, small basins created in the loosened soil behind a ripper shank or chisel. The furrow diking practice is known by many names, including tied ridges, furrow damming, basin tillage, basin listing, and microbasin tillage.[1] The dikes or basins store potential runoff on the soil surface, allowing the water to infiltrate (Fig. 1) thus, decreasing storm or irrigation runoff and increasing storage and plant available water in the soil. Furrow diking is a soil and water conservation practice that is adaptable to both dryland and irrigated crop production. It is most often used on gently sloping terrain in arid and semiarid areas where crops are grown under water deficit conditions. This practice has become widely adopted due to new herbicide technologies to control weeds, herbicide tolerant crops, and improved mechanical equipment for constructing the dikes.

HISTORY

Furrow diking was first used on the Great Plains, U.S.A., in 1931 by C.T. Peacock, a wheat farmer at Arriba, Colorado.[1] By the late 1930s, commercial diking equipment was available and furrow diking was practiced extensively in the central Great Plains.[2] Research on the effectiveness of furrow diking for conserving soil and water and increasing crop yields was conducted at several central Great Plains sites, including Colby Kansas,[3] Hayes, Kansas,[4] Woodward, Oklahoma,[5] and at other locations. Most research involved the wheat–fallow rotation, and no consistent increases in yield due to diking were shown. Yield responses were more consistent for systems involving summer row crops.

Concurrent with development of furrow diking in the U.S. Great Plains, the practice was adapted for use in the arid and semiarid tropics, mostly in Africa. Farmers in the cotton (*Gossypium hirsutum* L.) growing regions of Tanzania used hand-tied basins in the 1940s to retain runoff. Research on tied ridges was conducted in Tanzania and Nigeria.[6–8] The U.K. National Institute of Agricultural engineering (NIAE) pioneered the development of mechanized methods of constructing tied ridges in the tropics.[9]

By 1950, the practice of furrow diking on the Great Plains had been abandoned because of the slow operating speed of basin forming equipment, poor weed control, erratic yield responses, and difficulty with seedbed preparation and subsequent tillage.[1] Another factor in the demise of furrow diking was the rapid adoption of stubble-mulch tillage for wheat production in the 1940s and 1950s. Stubble-mulch tillage also leaves the surface flat with crop residues remaining to protect the soil against wind erosion, a prevalent problem in the Great Plains.[2]

A resurgence in furrow diking began in the 1970s and 1980s when diking equipment improved,[10] and herbicides achieved more effective weed control. Favorable responses to furrow diking were obtained with cotton grain sorghum [*Sorghum bicolor* L. (Moench)], and sunflower (*Helianthus annuus* L.).[1,11,12] The furrow diking practice was rapidly adopted by farmers of the Great Plains, and by 1984, an estimated 800,000 ha were being furrow diked, mostly on land cropped to cotton. The practice continues to be widely used with dryland cotton and sorghum, and is used extensively with center pivot irrigation systems to reduce irrigation runoff and to improve the efficiency of irrigation application.

EQUIPMENT

Equipment for constructing dikes or basins ranges from hand hoes and shovels to complex hydraulic motor-tripped mechanical units. Commercially available diking equipment includes the raising shovel, tripping shovel, basin implantation, and "chain" diker types.[13] Currently, the most commonly used equipment is the tripping shovel type, which has one, two, or three paddles that trip when filled with soil, thus depositing the soil and forming a small basin and dike between rows (Fig. 2). Most units trip independently due to the pressure of soil accumulating in

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Fig. 1 Runoff of rain is retained by furrow dikes for continued infiltration (right), but this water is lost from undiked (left) fields.

Fig. 2 The most common type of furrow diker is the tripping paddle type, which is often used concurrently with cultivation of ridge till fields after planting.

front of the paddle and work well in loose, mellow, sandy, or loamy soils. Spacing between dikes within the row depends on soil conditions and tractor speed, but a 1 m–2 m spacing is common.

Furrow diking with the commonly used tripping shovel units is usually performed in conjunction with another tillage operation such as listing, planting, or cultivation in row crop production. Thus, a separate tillage operation is not required, and furrow diking can be performed very economically.[14] Some operators do not construct dikes in traffic furrows, thus facilitating cultivation, spraying, and other cultural operations.

Another type of basin forming equipment, applicable to row cropping with flat tillage, is the Dammer-diker,[a] which uses blades (shovels) mounted on spikes in a wheel-type arrangement to "implant" small reservoirs or basins in loose soil as they rotate behind a ripper or chisel shank. The action of the blades would be similar to inserting a hand shovel into the ground and pivoting the handle forward, thus forming a depression in the soil. This rather intense tillage operation increases infiltration, reduces runoff, and is particularly applicable to crop production on sloping land under sprinkler irrigation.[15]

Another type of basin tillage equipment, applicable to flat tillage for small grain production and to range seeding or renovation, in the "chain" diker has been developed in Australia.[16] This device, called the "Conservation King,"[a] forms basins by using special shaped metal paddles welded onto links of ship anchor chain, lengths of which rotate between bearings spaced about 5 m apart. In field tests of a 5-m wide unit, the authors found that the equipment performed well on a flat, sweep-plowed field, creating numerous small basins with an estimated surface depression storage capacity of 25 mm. On a no-till fallow field, with consolidated surface soil (clay loam), indentations formed with the chain diker were small and ineffective for water storage.

DRYLAND APPLICATIONS

Crop yield responses to furrow diking are highly variable under dryland crop conditions. When rain was not timely for crop use or was insufficient to produce runoff, the benefits of diking were masked.[17] Negative responses usually result from poor weed control or from poor aeration due to ponding of excess water. The need to reduce runoff must be balanced with the need for surface drainage during wet periods, especially on soils that have low intake or water holding capacity.[18] A possible solution to this problem is to dike alternate furrows. This method proved highly successful in increasing the yield of cotton in Africa.[7]

Cotton responds well to the additional water provided by furrow diking since it is a deep-rooted crop usually grown under water deficit conditions on dryland. In Texas, Gerard et al.[12] reported a 82 mm decrease in storm runoff and a cotton lint increase of 116 kg ha^{-1} (32%) due to furrow diking. Clark[19] reported a 36% increase in cotton lint yield, also in Texas. Increased cotton yield in response

[a]The mention of trade or manufacturer names is made for information only and does not imply an endorsement, recommendation, or exclusion by USDA—Agricultural Research Service. Mention of a pesticide neither constitutes a recommendation for use nor it implies registration under FIFRA as amended.

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to furrow diking was also demonstrated in Tanzania and Nigeria.[7,20]

Grain sorghum also responds well to runoff conservation with furrow diking. In tests at Bushland, Texas, furrow diking and land leveling were equally effective in preventing runoff and increasing sorghum yield with an annual cropping system. The maximum yield increase due to furrow diking in this six-year study was 2460 kg ha^{-1} and averaged 760 kg ha^{-1}. The environmental and crop management factors that resulted in large sorghum yield responses to furrow diking were: 1) continual (annual) cropping that did not allow the soil water content of the root zone to be replenished during the noncrop period; 2) large rainfall/runoff events that occurred immediately before or early in the sorghum growing season with dikes in place to capture runoff; and 3) limited growing season precipitation that increased reliance on stored soil water.[1]

IRRIGATED APPLICATIONS

Furrow diking can be used with graded furrow and sprinkler irrigation systems. Operators often dike alternate furrows and irrigate the nondiked furrow, thus 50% of the land area can capture and store storm runoff. Stewart et al.[21] developed a limited irrigated-dryland (LID) farming system for the conjunctive use of rainfall and irrigation on graded furrows. The LID system uses a limited water supply to irrigate the upper-half of the field fully, which is fully fertilized and seeded for maximum production. The next quarter of the field has reduced inputs and is managed as a tailwater runoff section, with the lower quarter of the field used as a “sink” to capture and utilize both rainfall and irrigation runoff from the wetter sections of the field. Furrow diking was used to capture precipitation on alternate (nonirrigated) furrows in the fully irrigated and tailwater runoff sections, and to capture and prevent rainfall and irrigation runoff from all furrows in the dryland section. The LID system was not widely adopted by farmers because of the different seeding rates and management requirements of the system, but it used both precipitation and a limited amount of irrigation water very effectively for increased sorghum yield.

The primary use of furrow dikes in irrigated agriculture is to improve water application efficiencies of sprinkler and low energy precision application (LEPA) irrigation systems by reducing or eliminating surface runoff. These irrigation systems are linear or center pivots that use drop tubes with low-pressure orifice-controlled emitters. Water is delivered on to the soil surface over a small area as the system moves through the field in a circular fashion. Required furrow dikes prevent LEPA applied irrigation water from moving down the furrow, thus increasing infiltration and distribution uniformity across the field. Irrigation water application efficiencies can exceed 95% with the LEPA system.[22] With center-pivot irrigation, an LEPA system requires the furrow diked rows to run in a circular pattern for all growing crops.

CONCLUSION

Furrow diking is a soil and water conservation practice that is versatile and can be adapted to dryland or irrigated crop production. Reasonably priced equipment is available so that furrow diking can be used on most soils and with many crops. Cotton, sorghum, sunflower, and corn have responded well to furrow diking in field tests. Conditions conducive to positive crop responses to furrow diking on dryland are: 1) annual or intensive cropping, 2) large rainfall/runoff events occurring before or early in the growing season; and 3) limited growing season precipitation. Negative crop responses to furrow diking are usually due to poor weed control or to retention of excessive water on the soil surface, which may cause aeration problems or restrict timely planting and tillage.

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