Irrigating Row Crops from Sod Furrows to Reduce Erosion[1]

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ABSTRACT

Kentucky bluegrass (*Poa pratensis* L.) sod furrows were established to stabilize the soil. The furrows were used to irrigate corn (*Zea mays* L.), wheat (*Triticum aestivum* L.), barley (*Hordeum vulgaris* L.), beans (*Phaseolus vulgaris* L.), and sugar beets (*Beta vulgaris* L.). The sod strips containing the furrows were 0.3-m wide and managed as a permanent living entity. A strip mowing machine and a miniature rotary ditcher were developed to maintain the sod furrows. Crops were grown in clean tilled strips 0.9-m wide between the sod strips. Normal use of fertilizer, herbicides, and cultivation was utilized for the crop rows in the clean tilled strips. This management system eliminated soil erosion, at least doubled the infiltration rate of irrigation water, and allowed the production of satisfactory yields of wheat, barley, dry beans, and corn for silage. Sugar beet production was unacceptable due to competition from the sod.

Additional Index Words: **infiltration, soil compaction, root growth, living mulch.**

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Water running in small, closely spaced furrows serves to irrigate many crops throughout the more arid regions of the world. These furrows may be subject to severe erosion, particularly when the slopes are >1%. There are some management practices that increase soil structure stability (Kemper and Rosenau, 1984), but the more dramatic reductions in erosion are obtained through plant residue management (Miller and Aarstad, 1983). Straw placed in furrows reduced erosion of silt loam by 70% and increased infiltration by 50%, while unprotected control furrows were eroded at the rate of 50 Mg ha^{-1} (50 metric tons ha^{-1}) each growing season (Brown, 1985). Straw may not be adequate when slopes >2%. In these cases some growers have resorted to expensive sprinkler systems, but another possibility is to use a permanent living plant cover. Some orchards and ornamental plant nurseries use this approach for erosion control and for interrow trafficability during wet weather (Finch, 1981). Information is limited, however, on permanent living plant covers in conjunction with the production of annual row crops (Welch, 1966; Akobundu and Okigbo, 1984).

A system in which crop plants are grown between permanent sod irrigation furrows does offer some inviting possibilities for sloping land susceptible to severe erosion. The energy requirements are much less than sprinkler irrigation, infiltration rates are increased, and soil erosion is negligible. A permanent pattern for wheel traffic is established reducing compaction in the crop rows. Permanent grass rows encourage earthworm activity and improve soil fertility and structure. On the other hand, sod may be difficult to establish and special implements are needed to keep the furrows clean, and to mow the grass so that it does not shade the crop seedlings. Water and nutrient competition from the sod may be a problem and weed management can be difficult. The study described here was undertaken to begin developing methods that favor crop production, in unison with soil stabilization provided by perennial bluegrass sod strips.

METHODS

The study was conducted on field plots in south central Idaho on the erosion-prone Portneuf silt loam (Durixerollic Calciorthids). Kentucky bluegrass (*Poa pratensis* L., variety, Park) was established one or more seasons before the cropping tests by broadcasting the seed and irrigating with sprinklers or furrows. The sod furrows were cleaned or formed in the early spring, using conventional corrugating implements or a miniature rotary ditcher. The area between the grass-edged furrows was rototilled and conventional crop herbicides were incorporated together with normal amounts of fertilizer. Row crops were planted in the rototilled strips. Selective broadleaf herbicides were sometimes used on the sod furrows, but the growth of grass and weeds was largely controlled by mowing. A custom designed flail mower was used to cut a 0.3-m swath centered over each furrow. Tractor wheels always traveled on the sod strips. Water flow was measured at the upper and lower ends of the field plots with trapezoidal flumes to obtain the infiltration rates of individual furrows. The plots were at least 100-m long and 50-m wide. Crop yields were determined from three to six samples from each plot and are summarized as the mean and standard deviation of these samples. Sugar beets (*Beta vulgaris* L.), dry beans (*Phaseolus vulgaris* L.), and corn (*Zea mays* L.) forage were hand harvested, while the wheat (*Triticum aestivum* L.) and barley (*Hordeum vulgaris* L.) were sampled with a small plot combine.

Irrigation was scheduled with the automatic gypsum block method (Cary and Fisher).[3]

RESULTS AND DISCUSSION

In 1983 sod furrows were spaced 0.6-m apart. A 0.3-m strip was rototilled between each furrow and planted to dry beans or corn. The furrows accumulate soil and plant residues so they must be occasionally cleaned. This was first done with standard furrow shovels, but the sod was pulled loose in long strips that either fell back into the furrows, blocking water flow, or was thrown into the crop row space making the area very rough. This caused problems with planting and later tillage. The bean yield was unsatisfactory because of a poor stand and competition from grass and broadleaf weeds (Table 1). The corn grew over and dominated the grass and weeds, but a late planting date and an early autumn freeze resulted in a poor yield. These preliminary results showed that a better method was needed to form and clean the sod furrows, and that more space was needed between the furrows to accommodate tillage for seedbed preparation, weed control, and the harvest of root crops.

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[3] J.W. Cary, and H.D. Fisher. Criteria for irrigation timing based on water absorption by roots, submitted to Applied Agriculture 1986, and available from the author on request.

Table 1. Yields by year of several crops irrigated from sod furrows.†

Year	Crop	Yield, kg m^{-2}	SD	Yield rating
1985	Sugar beets, std N rate	4.12	1.08	50%
	Sugar beets, std N + 14 g N/m^2	5.47	0.49	80%
	Barley (spring)	0.57	0.07	100%
	Wheat (winter), 1 mow	0.52	0.02	90%
	Wheat (winter), no mow	0.70	0.04	100%
	Beans (dry pinto), 2 mow	0.27	0.02	90%
1984	Beans (dry pinks), 3 mow	0.41	0.04	>100%
	Beans (dry pinks), 2 mow	0.34	0.04	100%
	Corn (oven dry mass)	2.98	0.56	100%
1983	Corn (oven dry mass)	1.91	0.51	80%
	Beans (dry pinto)	0.14	--	50%

† The yields rating compares individual treatment yields to those obtained by commercial growers the same year in south central Idaho. The term "2 mow" indicates that the grass furrows were mowed twice after the crop emerged.

The yields listed in Table 1 for 1984 and 1985 were obtained using sod furrows spaced 1.2-m apart with a clean-tilled strip 0.9-m wide between sodded furrows. No germination problems related to soil water were encountered with the crops listed in Table 1. The corn, beans, and beets were planted in rows 35 cm from the center of each sod furrow leaving 50 cm of bare tilled soil between each row. The small grain was drilled on an 18-cm spacing over the whole plot area so that some of the seed was planted in the sod along the edge of the furrows. Germination in the center of the clean-tilled strip occurred from natural spring and fall precipitation.

The sod furrows were formed and maintained with the miniature rotary ditcher shown in Fig. 1. The cutting discs, 15 cm in diameter, followed directly behind the tractor wheels. They were chain and sprocket driven, turning two times for each rotation of the tractor's power take-off shaft. The two blades on each spinning disc removed and scattered the sod and plant residue away from the furrows, thus eliminating the excessive roughness that occurs with standard furrow implements.

The furrows were mowed with a two-row tractor attachment that used metal flails turning in the same direction as the tractor wheels. One set of flails, 0.3-m wide, was mounted behind each rear tractor wheel. Each set was shielded with a lifter on the front that moved the crop plant leaves out of the cutting path. While this system is rugged and worked well, one might also use blades spinning in a horizontal plane (similar to rotary, home lawn mowers). The former method left the clippings in the furrow, while the horizontal blades may be used to spread the clippings over the crop row to control germinating weeds (Cary et al., 1975, p. 8).

A view of the cropping system during the course of irrigating dry beans is shown in Fig. 2. Infiltration rates on one group of 140-m long sod furrows ranged from 1.4 to 3.6 cm h^{-1}. This is three to seven times greater than the infiltration rates measured in furrows on adjoining clean-tilled fields of the Portneuf silt loam. This, in itself, offers some flexibility in the future design of automated surface irrigation systems.

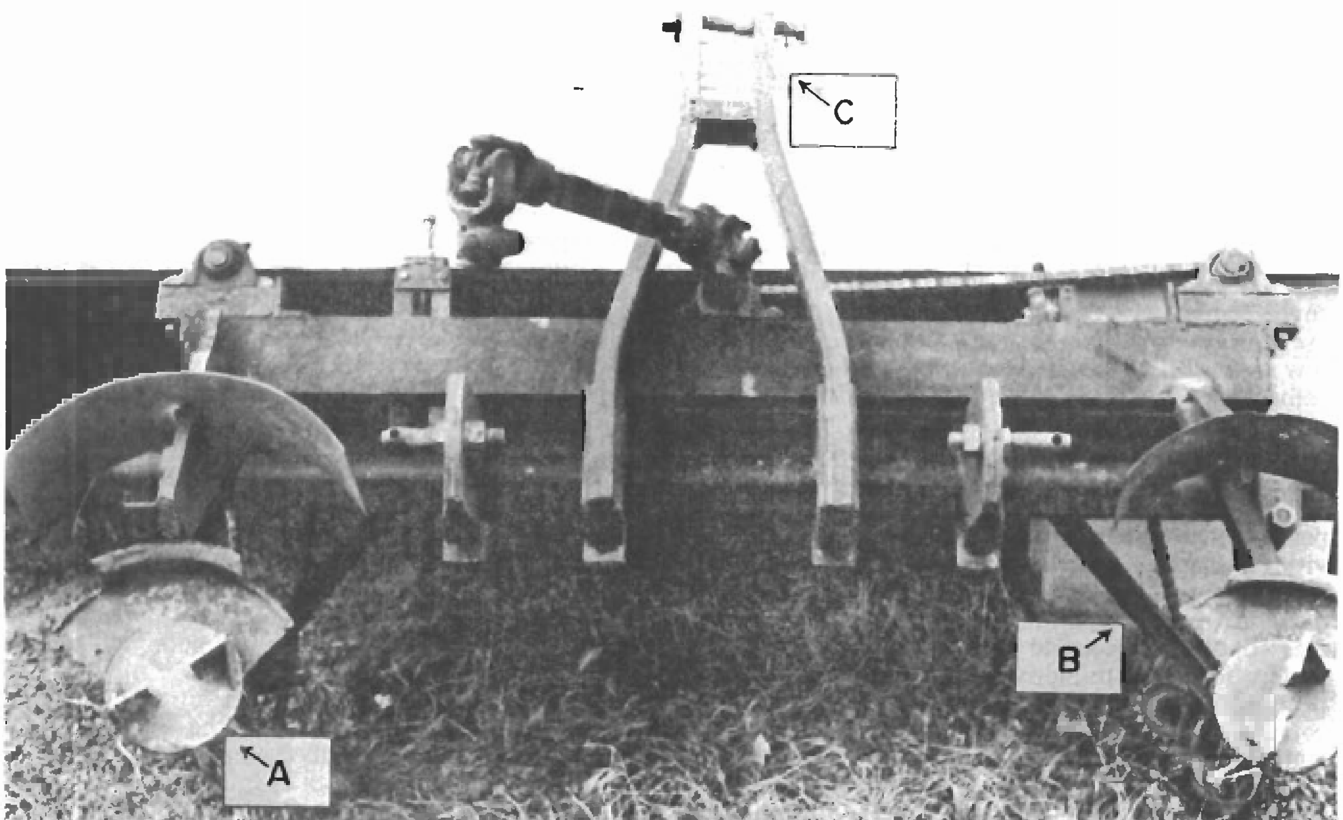

Fig. 1. Photograph (front view) of the miniature rotary ditcher used to make and clean sod furrows. (A) is one of the 15-cm diam cutting plates with two blades, (B) is a drive chain, and (C) is a connecting point for the three-point tractor hitch.

The prolific fine root system of the bluegrass sod made soil erosion negligible. There was no visual sign of any sediment load in the water, undercutting along the furrow sides, or deposition of sediment where the water velocity decreased.

Kentucky bluegrass (*Poa pratensis* L.) is moderately difficult to start from seed, but once established, it is very competitive under southern Idaho's irrigated conditions. One practical method for developing bluegrass sod furrows is to broadcast the seed into and along the edge of the furrows used to irrigate a small grain crop. This is done as soon as possible after harvest. With the tractor tires pressing the seed into the soil and the strip mower cutting the straw stubble, a mulch is formed over the furrows. Irrigation, carefully monitored to avoid excessive erosion in the straw-mulched furrows, will then produce a stand of bluegrass and volunteer grain. The furrows must be accurately spaced because they become permanent features of the field, providing the advantages of a fixed-wheel traffic pattern (Voorhees and Lindstrom, 1984).

The wheat, barley, corn, and bean yields are encouraging (Table 1). Sugar beets did not grow well, even though normal fertilizer recommendations were followed. Nitrogen was broadcast on the field before the clean-tilled strips between the furrows were rototilled. An acceptable stand of beet seedlings was obtained, but they grew slowly and soon showed severe N deficiency. An additional N application was made as a band in the bottom of the furrows to a portion of the test area in July. The response was obvious as shown by the first two entries in Table 1, but the yield was still low compared to the better commercial growers in the area. At the end of the season, a trench was dug across several rows of the beets and beans, and the roots were exposed by washing away part of the side of the trench. The beet roots grew preferentially away from the sod furrows and into the clean-tilled area between each beet row (Fig. 3). The pinto bean roots tended to grow preferentially in among the sod roots under the irrigation furrows. The bluegrass roots did not spread laterally into the clean-tilled soil between the rows.

Perhaps the direction of beet root growth was stim-

Fig. 2. Photograph of a bluegrass sod furrow used to irrigate pinto beans. (A) is water in the bluegrass furrow, and (B) the clean tilled strip between bean rows.

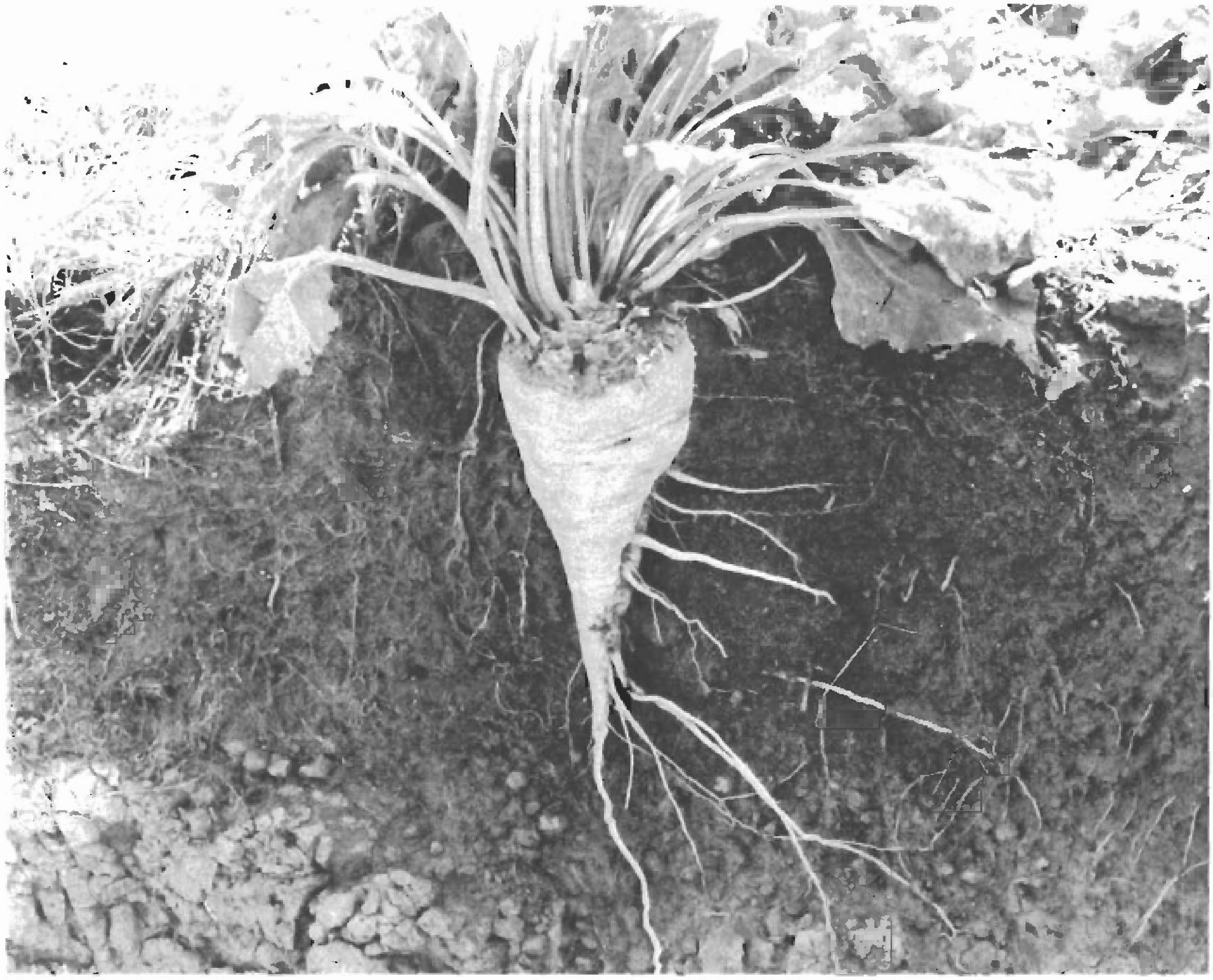

Fig. 3. Photograph of a soil profile washed with water from a high pressure hose to expose the bluegrass roots (left) and beet roots (right).

ulated by N_2 levels in the soil while bean roots were more affected by the water distribution. In any case, the severe N deficiency of the beets must be overcome without adding large amounts of N above that normally required in a clean-tilled field. Banding all of the N in the clean tilled area between the rows might help, or it may be necessary to kill the sod in the furrow at the beginning of the season (Cary et al., 1975, p. 9) and replant it the following autumn. More information is needed on the N cycling around the permanent sod furrows in which the grass is all returned to the soil, but which at the same time, competes with the crop being produced (Starr and DeRoo, 1981). There is the possibility of using a legume rather than grass to stabilize the furrows, but this must be weighed against the increased difficulty of controlling broadleaf weeds in a permanent legume stand.

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