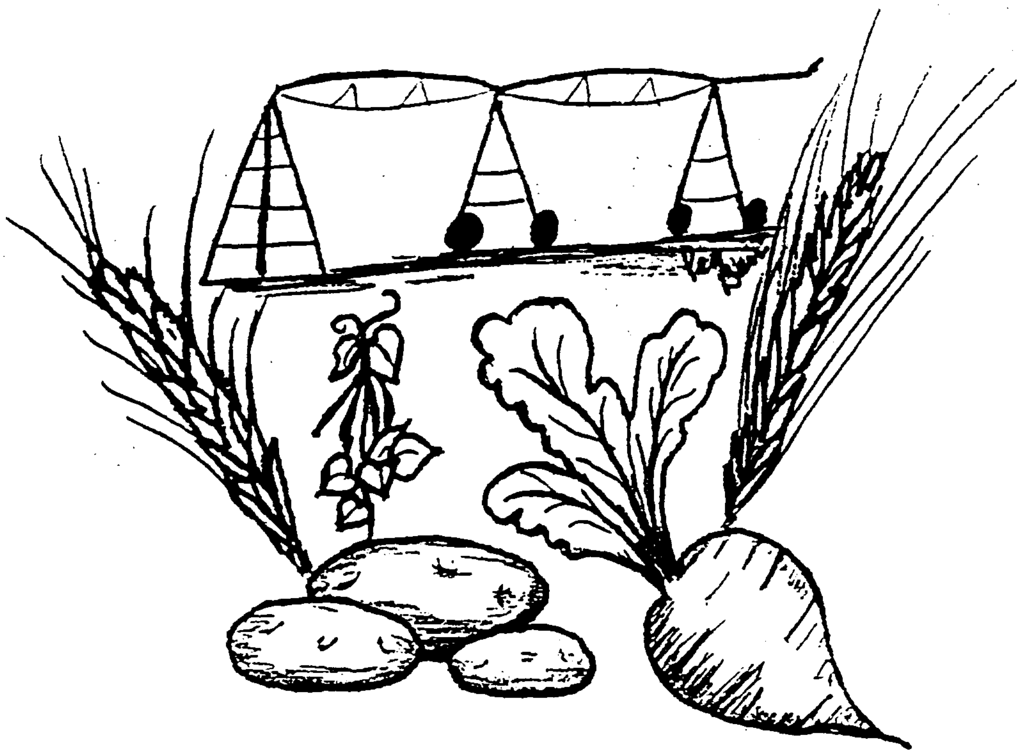
Sojka, R.E. 1996. Management options for control of irrigation-induced erosion. p. 95-103. Vol. 28. In: Proc. of the Winter Commodity Schools, Univ. of Idaho Coop. Ext. System.

MASTER COPY

Proceedings of the WINTER COMMODITY SCHOOLS - 1996



University of Idaho
Cooperative Extension System

IN COOPERATION WITH
Idaho Barley Commission
Idaho Bean Commission
Idaho Irrigation Equipment Commission
Idaho Potato Commission
Idaho Wheat Commission
Idaho Sugarbeet Growers Association

Volume 28

1996 ANNUAL IDAHO WINTER COMMODITY SCHOOLS

FOREWORD

This publication represents presentations made at the various commodity schools sponsored by the University of Idaho during the months of January and February, 1995. Winter commodity schools are given annually to present up-to-date research and other pertinent information of benefit to Idaho agriculture. Each of the commodity schools are coordinated by University of Idaho. College of Agriculture faculty. Presentations are made by University faculty, USDA-ARS faculty, other state and federal agencies, industry representatives and producers.

REGISTERED COMPOUNDS ARE LEGAL ONLY FOR THE PRESENT PRODUCT REGISTRATION USES. SUBSEQUENT REGISTRATIONS MAY BE ALTERED OR RETRACTED. ANY USER OR PROMOTER OF THESE RECOMMENDATIONS IS LIABLE TO THE EXTENT THAT ALL REGISTRATIONS MUST BE CURRENT AND VIABLE.

In many of the presentations, references are made to commercial products to meet specific problems or conditions. The University of Idaho accepts responsibility only for generic names of products and is not promoting one product over another.

The contribution of each speaker and cooperation and assistance of the program planning committee members, commodity commissions, grower organizations, commercial exhibitors, sponsors of refreshment breaks and others who assisted with the schools is gratefully acknowledged. Appreciation and thanks is extended to Kristi Copeland, typist, for compiling the reports into this publication. We hope you will find the material in the winter commodity school proceedings useful to your operation.

INTERPRETING RESULTS AND STATISTICAL ANALYSIS:
In a test area, it is impossible to conduct perfect tests because soil, fertility, moisture and other environmental factors vary. Therefore, small differences in results may have no meaning. To help interpret data, statistical techniques have been applied. Such techniques require repeating whole sets of varieties or treatments several times (replication). Results of many data analyses are shown with the least significant differences (LSD). Unless results differ by more than the LSD amount, little confidence can be placed in the importance of variety or treatment differences.

Commodity Editors:

Larry D. Robertson
John Ojala
Bob Vodraska
Brad King
Terry Tindall
Robert Romanko
John Gallian

Larry D. Robertson
Larry D. Robertson
Managing Editor

John Ojala
John Ojala
Managing Editor

MANAGEMENT OPTIONS FOR CONTROL OF IRRIGATION-INDUCED EROSION

R.E. Sojka

THE SEVERITY OF IRRIGATION-INDUCED EROSION

Irrigation-induced erosion is a threat both to the sustainability of irrigated agriculture and to global food security. Arid zone soils are usually low in organic matter and poorly aggregated, with thin, easily eroded A horizons. Carter (1993) demonstrated that, once eroded, yield potentials of PNW soils are severely reduced (Table 1). Furthermore, furrow irrigation, used on much of the world's irrigated land, is an inherently erosive process.

Table 1. Percent maximum yield of Portneuf soil having the entire A horizon removed (from Carter, 1993).

Crop	% Max. Yield without A horizon
Wheat	51
Sweet corn	52
Alfalfa	67
Dry Bean	60
Barley	68
Sugarbeet	79

Water advancing down a dry furrow instantaneously hydrates dry soil, destroying soil structure, and increasing its susceptibility to the erosive forces of the irrigation stream. Furrow irrigation-induced erosion in the PNW commonly removes 2-20 tons per acre of soil per year, with much of the erosion (3-8x the field averaged rate) occurring near the upper end of fields near furrow inlets (Berg and Carter, 1980; Kemper et al., 1985; Fornstrom and Borelli, 1984, Trout, 1996a,b). Over 22 tons per acre of soil loss has been measured for a single 24 hr irrigation (Mech, 1959). The magnitude of this problem is better appreciated when one recognizes that typical soil loss tolerance values for these soils are around 5 tons per acre per year. Thus, in the 90-100 years that PNW furrow irrigation has been practiced, many fields have little or no topsoil remaining on the upper one-third of the field. Furthermore, the topsoil remaining on lower field portions is mixed with subsoil washed off upper field reaches and deposited at the lower end.

The negative impacts of soil loss are numerous (Carter, 1990). The B horizons of most arid zone soils have poor chemical and physical properties. They easily crust, seal, and compact, and

Presented at the Idaho Potato School on January 25, 1996.

often have phosphorous and micronutrient deficiencies, which collectively impair emergence, fertility, rooting, absorption of water and nutrients, and yields. As yield potential decreases, input costs increase, while the probability of response from inputs declines. Thus, production-cost increases while yield and profit decline.

Eroded soil deposits in the lower reaches of fields, and in drains, return-flow ditches, lakes, streams or rivers. Even when a significant amount of this sediment is captured in the lower reaches of the field or in containment ponds, redistribution onto the field is required. The societal costs of these losses include reduced net on-farm returns and reduced production, with resultant upward pressure on commodity pricing; higher cost of canal maintenance, river dredging, and algal control; riparian habitat degradation and biodiversity reduction; water contamination; impairment of fisheries and recreational resources; reservoir capacity reduction; and accelerated hydro-electric generator wear (Sojka and Lentz, 1995). Many of these expenses and losses are long range costs and are neglected in cost benefit analyses for supporting conservation practices.

Irrigation-induced erosion per se has been a recent research focus. Research on this topic only began appearing with any frequency in the 1970's, after establishment of the Kimberly, Idaho, ARS research group (1964). To date the Kimberly location has published over 100 related research papers.

SOIL CONSERVATION PRACTICES FOR IRRIGATED AGRICULTURE

Most of the initial impetus for soil conservation in irrigated agriculture was protection of riparian areas receiving irrigation return flows. This led to an early strategy focused mainly on sediment settling basins in return flow systems. Subsequently, efforts concentrated on the prevention of soil loss from the farm. A parallel goal of both of these containment strategies was to return captured sediment to the eroded sites on farm land. Current research emphasis represents a shift from engineering practices toward development of soil, water and crop management practices that are aimed at halting all soil movement, thereby retaining soil in place, eliminating subsequent soil handling or transport.

Because each farm is unique, a given sediment containment practice may not be equally suited to all situations. Farmers determine which practice or practices suit their situation. Ultimately, erosion abatement practices that are used are more valuable than practices that are not used, regardless of the relative potential effectiveness of a given practice. Enforcement of clean water standards may eventually demand that return flows leaving a farm meet specified water quality standards. These standards may be voluntary standards or may be tied to potent financial incentives or disincentives.

Below is a brief summary of some of the more important conservation practices that have been developed for irrigated agriculture. They differ in ease of adoption, effectiveness, and cost of implementation, but offer a range of options to suit most situations. These practices and related factors have been discussed in greater detail in several recent publications (Carter, 1990; Carter et al., 1993; Sojka and Carter, 1994).

Sediment Retention Basins: Sediment ponds can be large, perhaps 1/4 acre, servicing a 40-60 acre field, or small "mini-basins" that temporarily pond runoff for only 6-12 furrows. The basins reduce flow rates and briefly retain water, allowing deposition of suspended particulates and reducing desorption of phosphorous. Retention basin effectiveness depends on sediment load, inflow rates, retention time, and texture of suspended particulates. About 2/3 of solids can be removed from return flows, but only about 1/3 of the suspended clay and total P (Brown et al., 1981). Clay, where most adsorbed P resides is slow to sink to the pond floor. Thus, the practice is more effective for medium textured soils, than for clayey soils.

Buried-pipe Erosion Control Systems: Buried drain pipes with vertical inlet risers allow Furrow irrigation tail water to pond at the bottom of fields until the water level initiates drainage into the riser. These systems promote sediment retention much as ponds do, and are often an adjunct to mini-basins. The method is best suited to elimination of concave field ends. Effectiveness is near 90% while concavities or basins are filling, but drops to pond efficiencies once depressions are filled (Carter and Berg, 1983).

Vegetative Filter Strips: Cereal, grass, or alfalfa strips (10-20 feet wide) sown along the lower ends of furrow irrigated row crop fields reduce sediment in runoff 40-60%, provided furrows are not cut through the filter strip area. Harvested filter strips yield 30-50% below normal for the strip crop (Carter et al. 1993).

Twin row and Close Row Planting: Planting corn as close as possible to both sides of an irrigated furrow to form twin row spacings halved field sediment loss in two years of observation (Sojka et al., 1992). Results for single but narrower than normal row spacings were more variable but showed promise for corn, sugarbeet and field beans. The effect results from a combination of factors including soil binding by roots in close proximity to the flow, introduction of plant litter into the furrow stream, and (with narrow rows only) systematic increase in furrow numbers (and hence wetted perimeter), thus reducing the irrigation set duration needed to deliver equivalent quantities of water. This reduces the runoff stream size and runoff period relative to the total inflow.

Tailwater Reuse: Retention ponds can be inexpensively enhanced to recirculate sediment-laden water into the furrow irrigation water supply. This does not halt or slow erosion per se, but largely automates replacement of sediment onto the fields from which they came. Advantages include maximizing water supply efficiency and 100% on farm sediment retention (Carter et al, 1993). Capital and energy cost and accelerated pump wear are disadvantages. There is also mingling of disease inoculum, weed seed, and chemicals, although these occur where return flows are reused anyway. On a larger scale, however, many surface irrigation districts have been engineered and are operated with an assumption of return flows making part of the irrigation supply for large portions of the district. Elimination of all return flows could dry up some reaches of existing systems or require modification of primary canal capacity to provide water to farms on lower reaches of the delivery system if some water is not routed through return flow systems.

Improved Water Management: Improved inflow/outflow management, stream size monitoring (post-advance flow reduction), field leveling, alternate furrow irrigation, infiltration measurement (soil water budget monitoring) and irrigation scheduling (furrow or sprinkler), can all improve water use efficiencies. These changes could reduce water application and hence, runoff amounts, reducing erosion as a side benefit (Trout et al., 1994).

Furrow Mulching: Use of plant residue or living mulches in irrigation furrows can be very effective at halting erosion. Permanent furrow sodding halted nearly 100% of erosion (Cary, 1986) without adverse yield effects in barley, wheat, beans and corn. The technique required a special furrow cutter to maintain established furrows. Straw or other manageable residues can be selectively placed in furrows producing 52-71% sediment loss reduction (Miller et al., 1987; Aarstad and Miller, 1981; Brown, 1985; Brown and Kemper, 1987). Drawbacks of these techniques include large increases in advance times and infiltration rates, and the addition of field operations for establishment and/or maintenance of the mulches. Mulching can occur at inconvenient times for crop managers, or cause problems during cultivation. Straw also sometimes moves in furrow streams, damming furrows and causing water to flow over rows into adjacent furrows.

Whey Application: Some irrigated areas are near dairy processing plants. For many processors disposal of acid cottage cheese whey is a problem. Soil-applied acid whey accelerates remediation of exposed lime subsoils and conserves nutrients, using an agricultural byproduct. If combined with straw application, whey can reduce furrow irrigation-induced erosion as much as 98 % and increase infiltration over 20 % (Robbins and Lehrsch, 1992; Brown and Robbins, 1995; Lehrsch and Robbins, 1994). The disadvantages of this approach are the cost and inconvenience of bulk hauling and field application of the whey. Usually processors, who often need land application sites, will provide whey at not cost.

Polyacrylamide-Treated Irrigation Water: Treating advancing furrow irrigation water (only) with 10 ppm polyacrylamide (PAM) has reduced sediment loss in runoff 85-99% while increasing infiltration 15% (Lentz et al., 1992; Lentz and Sojka, 1994; Sojka and Lentz, 1993, 1994). This translates to about 1 kg/ha of PAM used per treated irrigation. PAM, an industrial flocculent

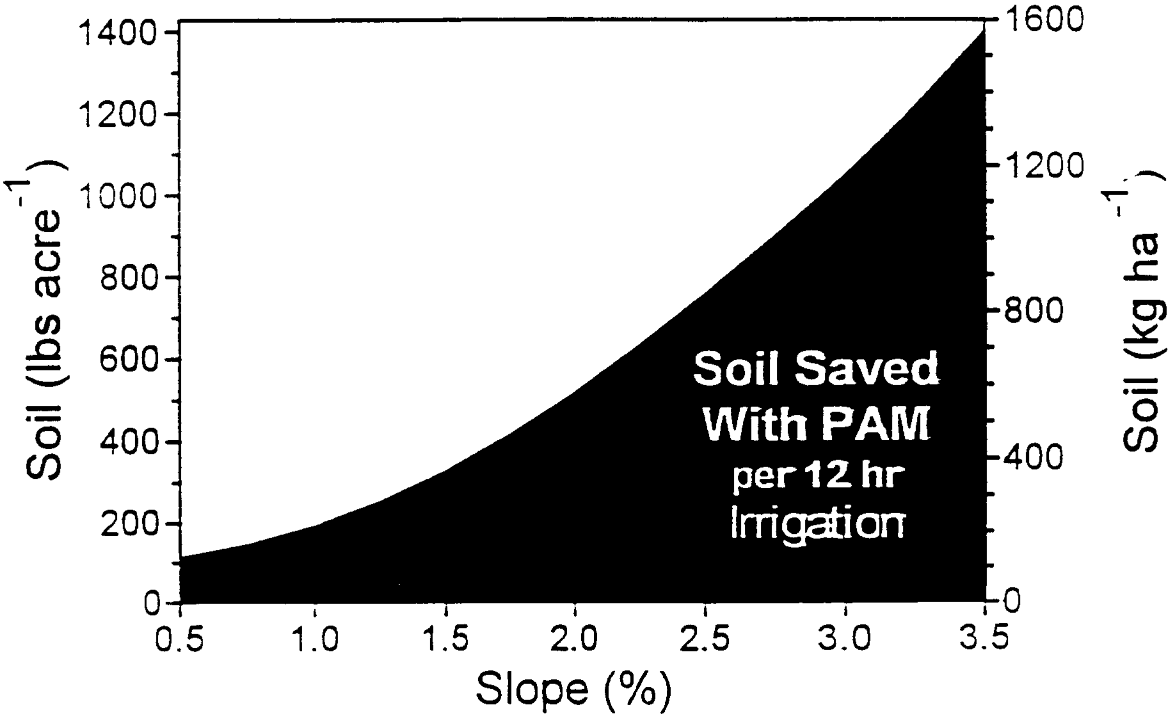


Figure 1 The effect of 10 ppm polyacrylamide in advancing furrow irrigation water (only) on soil lost in tailwater for the entire 12 hr duration of irrigation.

used for food processing and water treatment, is now marketed extensively for erosion control. Results have been highly consistent on a wide range of soils and conditions, showing high effectiveness, low cost, and lack of major effects on other farming practices (Fig. 1). With 10ppm PAM, initial water inflows can be more than doubled (then cut back once water has advanced across the field), virtually without erosion. This permits greater field infiltration uniformity. Ongoing PAM research by conservationists and manufacturers are rapidly providing better materials and more effective user protocols. Interest has also arisen for use of PAM with sprinkler irrigation.

Water Quality: In recent field research at Kimberly, ID elevated sodium adsorption ratio (SAR) in furrow irrigation water, especially at low electrical conductivity (EC) increased the erosivity of the furrow stream (Lentz et al., 1993, 1996). Sediment in runoff more than doubled when SAR 12 EC 0.5 dS m^{-1} water was used, compared to SAR 0.7 EC 2.0 dS m^{-1} water (Fig. 2). Sediment loss increased 1.5 times, compared to Snake River water (SAR 0.7 EC 0.5 dS m^{-1}). Many farms have multiple water sources (e.g. well and canal water) of varying quality. It behooves farmers to use less erosive water on steeper or more erosive ground, and/or to blend waters, where feasible, to reduce erosion hazard. These results demonstrate that process-driven erosion models must consider water quality effects. They also underscore the need to know what water quality is used in erosion simulators for valid data interpretation.

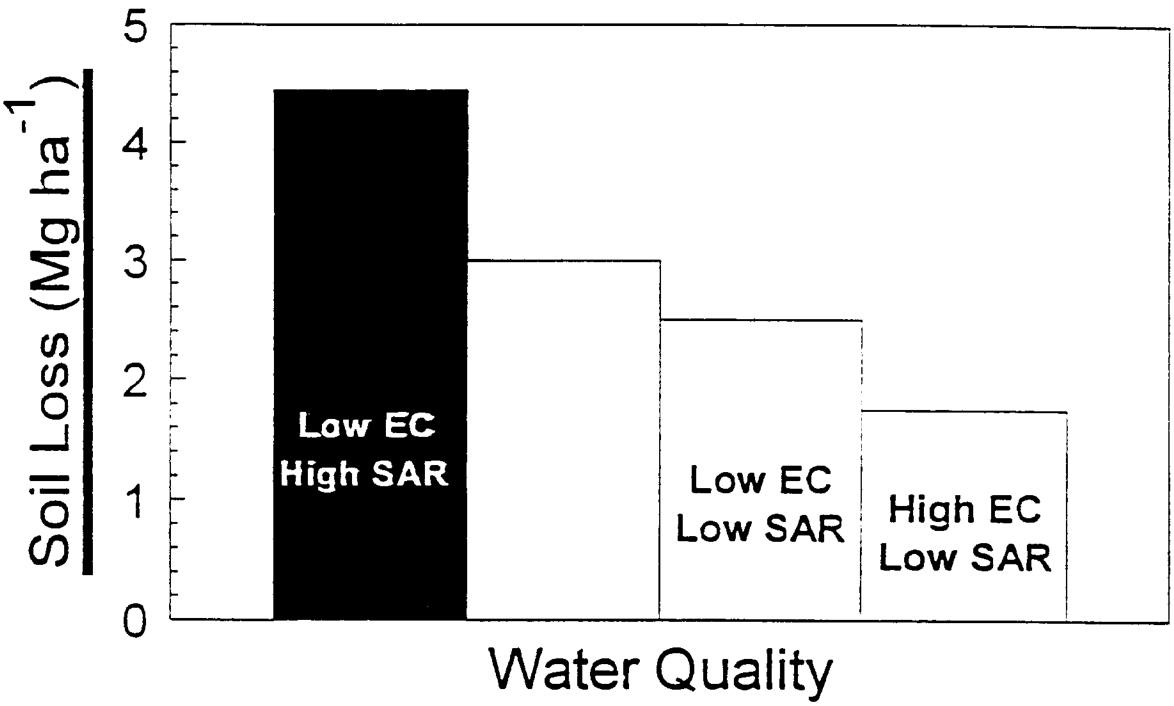


Figure 2 The effect of four water qualities on soil lost in tailwater from irrigation furrows (Lentz et al., 1993, 1996).

Conservation Tillage: Field-wide erosion reductions of over 90 %, reduced production costs, and, some yield increases have been noted for a range of conservation tillage and no-till cropping systems under furrow irrigation (Carter and Berg, 1991; Sojka and Carter; 1994). Once established, these systems can provide long range, cost-effective erosion elimination. A disadvantage of this approach is reluctance by many farmers to adopt such all-encompassing changes to their operations. Furrow irrigation needs reasonably uniform and unobstructed furrows for consistent and timely water advance. This sometimes is a problem in residue-intensive systems. Under sprinkler irrigation, conservation tillage can be implemented much as in rainfed systems.

Zone-subsoiling: Because most of the world's irrigated soils have been in production for less than 100 years, compaction has only recently been recognized as a potential problem. Compaction deteriorates soil structure and impedes infiltration. Both impair crop production and contribute to runoff and erosion. Zone-subsoiling improved yield and grade of furrow irrigated potatoes and increased infiltration up to 14% while reducing soil loss in runoff up to 64% (Sojka, et al., 1993a, 1993b). Zone-subsoiling can be used with either furrow or sprinkler irrigation.

Reservoir Tillage: Creating small pits between crop rows (called reservoir tillage, dammer diking or basin tillage) helps prevent or reduce runoff. This technique is suitable both to dryland farming and to sprinkler irrigation, but not to furrow irrigation. Sprinklers used on irregular sloping fields, especially the outer reaches of center pivots where application rates are high, can induce excessive runoff and erosion. Reservoir tillage has eliminated about 90 % of these sprinkler-related runoff and erosion losses (Kincaid et al., 1990).

Low-Pressure Wide-Area Spray Emitters: The geometry of center pivot irrigation systems requires very high instantaneous water application rates in the outermost 1/3 of the pivot. The larger the pivot the worse the problem. By using spray booms and special emitters, smaller drop sizes are spread over a larger area. Energy is conserved and runoff and erosion are greatly reduced compared to standard impact head systems (Kincaid et al., 1990).

CONCLUSIONS

Despite great progress in the past twenty five years there is much work left to be done in the area of irrigation-induced erosion. Irrigation-induced erosion is one of the greatest threats to maintaining the sustainability of irrigated agriculture in the Pacific Northwest. There are numerous conservation practices available to farmers. The choices are diverse enough to provide viable conservation alternatives for most irrigated situations capable of reducing erosion by at least 50%. In many instances the cost of erosion control is substantially or completely offset by savings in other farming operations made necessary by erosion, or by improvements in crop yield or quality associated with implementation of the conservation practice.

BIBLIOGRAPHY:

1. Aarstad, J.S., and D.E. Miller. 1981. Effects of small amounts of residue on furrow erosion. Soil Sci. Soc. Am. J. 45:116-118.

2. Berg, R.D., and D.L. Carter. 1980. Furrow erosion and sediment losses on irrigated cropland. J. Soil Water Conserv. 35:367-370.

3. Brown, M.J. 1985. Effect of grain straw and furrow irrigation stream size on soil erosion and infiltration. J. Soil Water Conserv. 40:389-391.

4. Brown, M.J., J.A. Bondurant and C.E. Brockway. 1981. Ponding surface drainage water for sediment and phosphorous removal. Trans. ASAE. 24:1478-1481.

5. Brown, M.J., and W.D. Kemper. 1987. Using straw in steep furrows to reduce soil erosion and increase dry bean yields. J. Soil. Water Conserv. 42:187-191.

6. Brown, M.J., and C.W. Robbins. 1995 (anticipated). Combining cottage cheese whey an straw reduces erosion while increasing infiltration in furrow irrigation. J. Soil Water Conserv. 50:(in press).

7. Carter, D.L. 1990. Soil erosion on irrigated lands. In: Irrigation of Agricultural Crops, Ch. 37, Agronomy 30. pages 1143-1171. B.A. Stewart and D.R. Nielson, eds., Am. Soc. Agronomy, Madison, WI.

8. Carter, D.L. 1993. Furrow erosion lowers soil productivity. J. Irrig. Drain. Eng. ASCE. 119:964-974.

9. Carter, D.L., and R.D. Berg. 1983. A buried pipe system for controlling erosion and sediment loss on irrigated land. Soil Sci. Soc. Am. J. 47:749-752.

10. Carter, D.L., and R.D. Berg. 1991. Crop sequences and conservation tillage to control irrigation furrow erosion and increase farmer income. J. Soil Water Conserv. 46:139-142.

11. Carter, D.L., C.E. Brockway, and K.K. Tanji. 1993. Controlling erosion and sediment loss from furrow-irrigated cropland. J. Irrig. Drain. Eng. ASCE. 119:975-988.

12. Cary, J.W. 1986. Irrigating row crops from sod furrows to reduce erosion. Soil Sci. Soc. Am. J. 50:1299-1302.

13. Fornstrom, K.J., and J. Borelli. 1984. Design and Management procedures for minimizing erosion from furrow irrigated cropland. ASAE Pap. 84-2595. ASAE, St. Joseph, MI.

14. Kemper, W.D., T.J. Trout, M.J. Brown, and R.C. Rosenau. 1985. Furrow erosion and water and soil management. Trans. ASAE 28:1564-1572.

15. Kincaid, D.C., I. McCann, J.R. Busch and M. Hasheminia. 1990. Low pressure center pivot irrigation and reservoir tillage. pp. 54-60. In: Visions of the Future. Proc. 3rd Natl. Symp., Phoenix, AZ, Oct. 28-Nov. 1, 1990, ASAE. St. Joseph, MI.

16. Lehrsch, G.A., and C.W. Robbins. 1994. Cheese whey as an amendment to disturbed lands: effects on soil hydraulic properties. In: Proc. Int. Land Reclamation and Mine Drainage Conf. and Third Int. Conf. on the Abatement of Acidic Drainage, Pittsburgh, PA. Apr. 1994. Vol. 3. USDI Bur. Mines Spec. Publ. SP 06C-94. NTIS, Springfield, VA.

17. Lentz, R.D., I. Shainberg, R.E. Sojka, and D.L. Carter. 1992. Preventing irrigation furrow erosion with small applications of polymers. Soil Sci. Soc. Am. J. 56:1926-1932.

18. Lentz, R.D. and R.E. Sojka. 1994. Field results using polyacrylamide to manage furrow erosion and infiltration. Soil Science. 158:274-282.

19. Lentz, R.D., R.E. Sojka and D.L. Carter. 1996. Furrow irrigation water-quality effects on soil loss and infiltration. Soil Sci. Soc. Am. J. 60:238-245.

20. Mech, S.J. 1959. Soil erosion and its control under furrow irrigation in arid West. Info Bull. 184. USDA/ARS Gov. Print. Office. Washington, DC.

21. Miller, D E., and J.S. Aarstad and R.G. Evans. 1987. Control of furrow erosion with crop residues and surge flow irrigation. Agron. J. 51:421-425.

22. Robbins, C.W., and G.A. Lehrsch. 1992. Effects of acidic cottage cheese whey on chemical and physical properties of a sodic soil. Arid Soil Res. and Rehab. 6:127-134.

23. Sojka, R.E., M.J. Brown and E.C. Kennedy-Ketcheson. 1992. Reducing erosion from surface irrigation by furrow spacing and plant position. Agron. J. 84:668-675.

24. Sojka, R.E. and D.L. Carter. 1994. Constraints on Conservation Tillage Under Dryland and Irrigated Agriculture in the United States Pacific Northwest. Ch. 12. In: M.R. Carter (ed.) Conservation Tillage in Temperate Agroecosystems. Lewis Publishers, Boca Raton.

25. Sojka, R.E., and R.D. Lentz. 1993. Improving water quality of return flows in furrow-irrigated systems using polymer-amended inflows. Proceedings of the SWCS Conference on Agricultural Research to Protect Water Quality, 21-24 Feb., 1993. Minneapolis, Minn, pp. 395-397.

26. Sojka, R.E., and R.D. Lentz. 1994. Polyacrylamide (PAM): A new weapon in the fight against Irrigation-induced erosion. USDA-ARS Soil and Water Management Research Unit, Station Note #01-94.

27. Sojka, R.E., and R.D. Lentz. 1995. Decreasing sedimentation loss from surface irrigation into riparian areas. Proceedings: Northwest Regional Riparian Symposia. Diverse Values: Seeking Common Ground. Idaho Riparian Cooperative. University of Idaho and the Idaho Water Resources Research Institute. 8-9 December, 1994. Boise, ID pages 62-68.

28. Sojka, R.E., D.T. Westermann, M.J. Brown and B.D. Meek. 1993a. Zone-subsoiling effects on infiltration, runoff, erosion, and yields of furrow-irrigated potatoes. Soil & Till. Res. 25:351-368.

29. Sojka, R.E., D.T. Westermann, D.C. Kincaid, I.R. McCann, J.L. Halderson, and M. Thornton. 1993b. Zone-subsoiling effects on potato yield and grade. Am. Pot. J. 70:475-484.

30. Trout, Tom, Dave Carter, and Bob Sojka. 1994. Irrigation-induced soil erosion reduces yields and muddies rivers. Irrigation J. 44:8, 11-12.

31. Trout, T.J. 1996a. Furrow irrigation erosion and sedimentation: on-field distribution. Trans. ASAE (In Press).

32. Trout, T.J. 1996b. Modelling sediment transport in irrigation furrows with WEPP relationships. Trans. ASAE (In Press).