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Project Summary

Demonstration of Irrigation Return Flow Water Quality Control in the Mesilla Valley, New Mexico

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The general objective of this project was to demonstrate the effect of alternative water management practices on the quality of drainage return flow and soil salinity in the Mesilla Valley in southern New Mexico. The project area consisted of a 4-acre test site and a 450-acre demonstration site. The feasibility of irrigating at or near 100 percent irrigation efficiency with water of medium salinity (1200 ppm), while maintaining optimum crop yield over many years, was demonstrated on the 4-acre test site at the New Mexico State University Plant Science Farm. At the 450-acre Demonstration Farm, a combination of present-day irrigation technology showed how, through modern water management, return flow quality and quantity can be improved. In addition, an economic analysis was performed to determine the economic feasibility of the water management practices demonstrated. The economic analyses were made based on the assumption that valley-wide implementation of demonstrated water management practices would result in reduced return flows and salinity at levels found in the demonstration area.

Irrigation efficiency and irrigation interval had a significant effect on chloride concentration of saturation extracts of samples taken from the rooting depth of surface irrigated plots. In addition, there were significant increases in the salt content of the soil irrigated for five years with a trickle system, but the trickle plots yielded six percent more lint cotton on 25 percent less water than did the surface irrigated plots with essentially no difference in lint quality.

The results of this study indicated that by using irrigation scheduling, farm irrigation efficiency can be increased by 13 to 23 percent. However, field irrigation efficiency was found to vary from 80 percent down to 35 percent regardless of type of crop or field size. Trickle-irrigation of a 1.3 hectare pecan orchard resulted in irrigation efficiencies near 100 percent with apparent above average yields.

Economic analysis of proposed alternative water management systems for the Mesilla Valley indicated that irrigation scheduling service (ISS) reduced irrigation water use by 17 to 24 percent while net returns to land risk increased by 5 to 9 percent. A combination of ISS and sprinkler-irrigation of vegetable crops for seed germination resulted in the highest net returns to land and risk with only minor savings in irrigation water use. ISS and trickle-irrigation management practices only added marginal water savings when compared with ISS, but net returns would be reduced drastically.

ISS could reduce irrigation return flows to the Rio Grande from 30 to 36 percent and the salt load to the river by

38,000 to 42,000 tons annually. ISS plus sprinkler could reduce irrigation return flows by an additional 4 to 5 percent and the salt load by an additional 4,000 to 5,000 tons annually. ISS and trickle-irrigation could reduce return flows 7 to 16 percent below the ISS alternative and the salt load in the river by 9,000 to 23,000 tons annually.

This Project Summary was developed by EPA's Robert S. Kerr Environmental Research Laboratory, Ada, OK, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The quality of irrigation return flow represents a major problem in the western United States. The water of the Upper Rio Grande has been reported as a classic example of water quality degradation due to irrigation. Mineral pollution is the most serious problem in the Upper Rio Grande Basin. The problem is serious because the basin is approaching, or has approached, conditions of full development and utilization of the available water resources. There is a progressive increase in the concentration of total dissolved solids and the percent sodium from the upper to the lower sampling stations in the Upper Rio Grande Basin. The large increase in dissolved solids in the river along the irrigated areas is, to a large extent, due to the concentrating effect of irrigation.

Almost all of the valley land in the Upper Rio Grande Basin has a high water table. Where irrigation exists, drainage canals divert water from the "near-surface aquifers" into the Rio Grande. In the Mesilla Valley, as in many other areas, high equilibrium salinity concentrations are known to exist in the near-surface aquifer. The key to achieving a reduction in salt loading is to lower the groundwater levels. The most effective means for lowering groundwater levels is to reduce the source of groundwater flows, which can be accomplished by reducing seepage losses through lining canals and laterals, or by reducing deep percolation losses resulting from excessive irrigation by improved on-farm water management practices.

The U.S. Senate Select Committee (1961) and a U.S. Water Resources Council Study (1968) reports estimated that the Upper Rio Grande and Pecos Basins were the shortest on water in relation to projected future demands of any basin in the continental United States. The Water Resources Council study identified the major problems as water deficiencies, groundwater storage depletion, and poor water quality because of mineral pollution. The past 15-year average inflow to Elephant Butte Reservoir is only about 65 to 70 percent of the long-term average inflow. Thus, a program for reduction of mineral pollution loading is urgently needed in order to protect existing water uses from mineral quality degradation during low-flow periods, and to prevent the serious restriction of future basin-wide economic development.

Conclusions

Field Plot Demonstration

In 1976 and 1977 irrigation treatment (efficiency and irrigation interval) had a significant effect on the electrical conductivity (EC) and chloride concentration of saturation extracts of samples taken from the rooting depth in the surface-irrigation plots. EC_e and chloride concentrations were significantly higher for the plots irrigated near 100 percent efficiency. However, irrigation treatments did not have a significant effect on EC_e and chloride concentration of soil below 150 cm, indicating that improving irrigation efficiency has no immediate effect on the quality of percolation water.

Based on the chloride concentrations of soil water percolating below the root zone in the surface-irrigated plots, leaching fractions of 0.14, 0.11 and 0.09 were obtained for the planned 80, 90 and 100 percent efficiency treatments, respectively.

Surface-irrigation treatments had no significant effect on cotton yield at the five percent level of probability during 1972 through 1977. However, yields decreased with increased irrigation efficiency, except in the 50 percent depletion (two weeks irrigation interval) treatment. For the conditions of the experiment, less frequent irrigations with some leaching provided the highest cotton yields.

There was a significant increase in the salt content of the soil irrigated for five years with a trickle system, especially in the 30 to 130 cm depth range. The salinity increase was 25 percent for the plots irrigated at 0.2 bar and 100 percent for the plots receiving 25 percent less water than the 0.2 bar treatment.

Salt contents were significantly higher in the soil between the trickle lines than below the trickle lines to a depth of 50 cm. Below 50 cm, there were no significant differences in salt content below or between the trickle lines.

Averaged over five years and all treatment, the trickle-irrigated plots yielded six percent more lint cotton than the surface-irrigated plots, with no difference in line quality. An average of 35 percent more water (irrigation and rain) was applied to the surface-irrigated plots than to the trickle-irrigated plots.

There was a strong inverse correlation between flow of water in the Del Rio Drain and its quality. The average EC of the water in the Del Rio Drain from 1972 to 1978 was very close to the average EC of the water from 1921 to 1936, indicating a near equilibrium of the valley along the Del Rio Drain.

Demonstration Farm

Using irrigation scheduling on the 450-acre Demonstration Farm, the yearly irrigation efficiency was 63 percent, a 13 to 23 percent increase over the 40 to 50 percent irrigation efficiency considered normal for the Mesilla Valley.

The results show that the overall irrigation efficiency of the Demonstration Farm (63 percent) was above average with irrigation scheduling, although large variations from field to field were noted ranging from 80 percent to 35 percent. Field irrigation efficiencies did not correlate with the type of crop being grown or field size.

The canals at the measurement sites had very low seepage losses. In the main canal, the maximum loss per 1000 meters of canal ranged from 3 percent down to 0.2 percent, depending upon the flow in the canal. Seepage losses from the farm ditches measured were 1.1 to 5.6 percent of the total applied water over the growing season.

Trickle-irrigation of the pecan orchard resulted in irrigation efficiencies of nearly 100 percent. Additional measurements are necessary to determine if any detrimental effects would occur from salt accumulation due to the continued use of trickle-irrigation with efficiencies approaching 100 percent.

There was a negative correlation between groundwater height on the Demonstration Farm and a drain flow

increase through the farm during 1977. During 1975 and 1976, drain flow measurements at two locations did not show a statistical increase or decrease in the flow through the Demonstration Farm. Consequently, changes in drain flow did not correlate to changes in groundwater height. Short-term changes in flow rates during the growing season may be influenced more by the amount of excess surface water being returned into the drains than by the height of the groundwater table.

The effect of irrigation scheduling on drain flow quantity was not detectable. However, irrigation scheduling at the Demonstration Farm increased the irrigation efficiency by approximately 13 percent.

Salinity of the drain water showed a negative correlation with flow, decreasing as drain flow increased in all years. Groundwater quality at the sampling points on the Demonstration Farm indicated an increase in nitrate content and a decrease in total salinity with depth below the water table.

Economic Analysis

For the three water supply periods (1967, 1973, and 1976) significant quantities of groundwater could have been saved (17 to 24 percent) while the returns to land and risk could have been increased by 4.8 to 9.2 percent by the incorporation of irrigation scheduling service (ISS). Irrigation return flows could have been reduced by 30 to 36 percent and the salt load on the Rio Grande reduced 38,000 to 43,000 tons with the implementation of ISS.

The combination of ISS and sprinkler-irrigation for vegetable crop seed germination could add an additional reduction of two to three percent in irrigation water savings. Net returns to irrigated agriculture would be expected to decrease below that expected for ISS in two of the three water supply periods by 1.4 to 3.1 percent and only increase by about 0.4 percent in above average surface water supply period. Irrigation return flows would decrease by an additional four to five percent and the salt load on the Rio Grande only be reduced by 4,000 to 5,000 tons annually.

The combination of ISS and trickle-irrigation for orchards could significantly reduce surface water use (6 to 15 percent) with increases in groundwater (0.4 to 9 percent) above the ISS alternative. However, significant decreases in net returns would be encountered. Irrigation return flows would decrease by 7 to 16 percent below the ISS alternative which translates to 9,000 to 23,000 tons of salt to the Rio Grande annually.

A combination of ISS, sprinkler- and trickle-irrigation management practices would reduce surface supplied irrigation water use by 6 to 16 percent and groundwater use by 16 to 18 percent below that of current irrigation practices. The impact on net returns would vary from a reduction of nine percent to an increase of about one percent annually. The reduction in irrigation return flows could be 40 to 50 percent and the salt load on the Rio Grande reduced 50,000 to 70,000 tons annually.

Recommendations

1. For maximum benefit of water supplies in the Mesilla Valley, farm irrigation systems should be designed for minimum leaching.
2. Increased efforts are needed to better define the actual water use of crops in the Mesilla Valley, in particular of pecan orchards.
3. Trickle-irrigation, though not economical at present, can be used to maintain or improve yields of cotton with 25 percent less water. Demonstration projects on the use of trickle-irrigation for vegetable production in the Mesilla Valley are recommended. Trickle systems may be economically justified for quality and marketing considerations.
4. Increased efforts are needed to further encourage the utilization of irrigation scheduling service and sprinkler-irrigation of vegetable crops for seed germination in the Mesilla Valley.
5. A combination of irrigation systems should be investigated for seed germination, i.e. trickle or sprinkler and flood.
6. Equipment to measure applied water to each field should be incorporated in farm irrigation systems to improve field irrigation efficiencies.
7. Continued monitoring of the salinity in the soil beneath the field sites where irrigation scheduling is practiced would help to determine the long-range effect of increased efficiency on salinity buildup.
8. Future studies should be directed toward predicting the long-term effects on the salt load in the Rio Grande resulting from improvements in irrigation efficiency in the irrigated areas along the Rio Grande in New Mexico, and taking into account continued use of groundwater as well as increased urban and industrial developments.
9. A detailed study of the hydrology of the Mesilla Valley should be undertaken to determine the effect of mixing on the quality of groundwater.

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The complete report, entitled "Demonstration of Irrigation Return Flow Water Quality Control in the Mesilla Valley, New Mexico," (Order No. PB-82-255 316; Cost: $15.00, subject to change) will be available only from:
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