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CULTURAL INFLUENCES ON IRRIGATION DRAINAGE WATER

by

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## INTRODUCTION

Environmental improvement has recently gained a front row seat in the arena of national priorities. In most cases, however, the cause of environmental deterioration must be determined before improvements can be made. Such is the case of water quality. The quality of water in many rivers, canals and drainageways is indeed in need of improvement, but improvements in water quality cannot be efficiently brought about until the source or sources of pollutants can be identified.

According to Viets (12), the usual approach to the study of water quality is to assign certain inputs of constituents to certain industries and municipal sewage plants and charge the remaining input by difference to agriculture. Agricultural input in this case could possibly contain animal wastes flushed from feedlots, pastures or fields; nutrients washed from dead vegetation; leachate from rural (or suburban) septic tanks; eroded soil; and, of course, fertilizer materials in solution or adsorbed to eroded sediment. One can readily see that possible agricultural sources of pollution are difficult to identify.

The quality of irrigation drainage water is of special interest in the western states where many acres of cropland are irrigated. Sylvester and Seabloom (11) found that irrigation return flows had an important influence on the water quality of the Yakima River in Washington. Johnson *et al*. (7) reported on the tile drain effluents analyzed in the San Joaquin Valley. They found the highest concentrations of nitrogen where heavy applications of nitrogen fertilizers were made. Naylor *et al*. (9) have pointed out that the overall nitrogen application efficiency is related to the water application efficiency. The effect of irrigation drainage waters on water quality has been discussed by several others (1, 2, 4).

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Agricultural Engineers and Soil Scientists from the University of Idaho joined in a cooperative effort to study what effects irrigated agriculture might have on water quality in the Boise Valley in southwestern Idaho. The Boise Valley was selected as a research site for several reasons. There was little information available concerning the quantity and quality of the area's irrigation drainage water. Gravity irrigation systems, which are operated at various efficiencies, are used to apply water throughout most of the study area. Water table depths tend to be quite shallow throughout most of the valley. Also, the quality of water in the Boise Valley is of importance to both the established agriculture and the rapidly expanding population of the area.

The research effort was initiated in 1970 and was planned to obtain pertinent information concerning the quality of irrigation drainage water. In 1970, a total of 79 sites in the Boise Valley were sampled to determine constituent concentrations in irrigation headwaters, surface drainage and subsurface drainage. As pointed out by Fitzsimmons et al. (5), flow measurements were needed in conjunction with the sampling in order to determine the amounts of various constituents transported by the water. In 1971, a 60.5-acre tract was extensively monitored during the months of June, July and August to determine the amounts and movements of water and constituents during the peak irrigation season. The farmer of the tract applied commercial fertilizer by plowing down, by side dressing and by metering it into the irrigation water. Crops grown in the intensive study area in 1971 were 33.5 acres of onions and 27 acres of sugar beets.

## METHODS AND PROCEDURES

Measurements were made to determine a water balance for the 60.5-acre study area. All surface flows entering the study area were measured over Cipolletti weirs and surface drainage was measured through a Parshall flume. Stage recorders were used in conjunction with all measuring devices in order to provide a continuous record of all surface flow rates entering and leaving the farm. Penman's equation was used in a computer program developed by Davis (3) to compute the daily evapotranspiration from each of the two crops. Relative humidity and continuous temperature measurements were made at the study area, and other necessary meteorological data needed for computing evapotranspiration were obtained from nearby U. S. Weather Service stations located at Boise, Caldwell and Kuna. The flow and evapotranspiration data were used to compute the amounts of drainage water leaving the study area. The surface drainage was measured directly, and the subsurface drainage was computed from a water balance for the area.

Amounts of constituents present in the water were determined from samples collected from headwaters, surface drainage and subsurface drainage. The surface flow samples were taken from the open ditches where water was flowing. The subsurface water was sampled using five piezometers located 12 feet below the ground surface in the study area. The frequency of sample collection depended on several factors such as changes in flow rates and the addition of commercial fertilizer to the water. During periods of rapidly changing flow rates and/or nutrient concentrations, surface flow samples were taken as frequently as every hour, whereas groundwater samples were usually taken at 10-day intervals. The samples were quick-frozen and stored until they could be transported to the laboratory for analysis.

Laboratory analyses included those for nitrate-nitrogen, total phosphorous and total solids. To prevent changes in nutrient forms, the samples were kept frozen until just before the analyses were started. The methods used in making the analyses were essentially the same as those given in APHA Standard Methods (10) and EPA (8). Nitrate-nitrogen was determined by the phenoldisulphonic acid method after removal of any chlorides with silver nitrate. The samples were filtered through 0.45 millipore filters and digested with sulphuric acid and ammonium persulfate for total phosphorous. The phosphorous was determined colorimetrically in the filtrate and digestion mixture by the amino-naphthol-sulfonic acid method. Total solids were determined by weighing the residue after drying a sample for 24 hours at $110^{\circ}$ C. All analyses reported the constituent concentrations in parts per million (ppm) by weight.

The flow, evapotranspiration and chemical analysis data were combined and analyzed for the 1971 study area to obtain a water balance and a mass balance for the different constituents. A digital computer was used for the data analysis and output. Two-hour increments were used in sorting and presenting data so that the effects of various practices could be evaluated during periods of rapidly changing flow and/or concentrations. The data from the two-hour time increments were summed to give totals for the duration of the study period. This summing process proved to be a satisfactory and accurate method of integration for both water volumes and constituent masses.

## RESULTS AND DISCUSSION

Data obtained from the 1971 study indicate that the quantity and quality of surface and subsurface drainage from the monitored tract were different for the two crops grown on the tract. The differences in quantity and quality may be attributed almost entirely to the differences in the cultural practices associated with each crop.

Surface flow data from an irrigation set on onions are plotted in Figures 1 through 4. The set covered a period from 7:00 A.M., June 24, to 7:00 A.M., June 25, and nitrogen fertilizer was added to the water during the first part of the set. The set illustrated typifies all irrigation sets throughout the study period as the irrigator was quite meticulous and consistent with his irrigation practices.

The flow data plotted in Figure 1 form a hydrograph for the irrigation set. As can be seen, the headwater flow rate was essentially constant for the duration of the set. After a time lag that occurred while the water was advancing across the field, the surface runoff

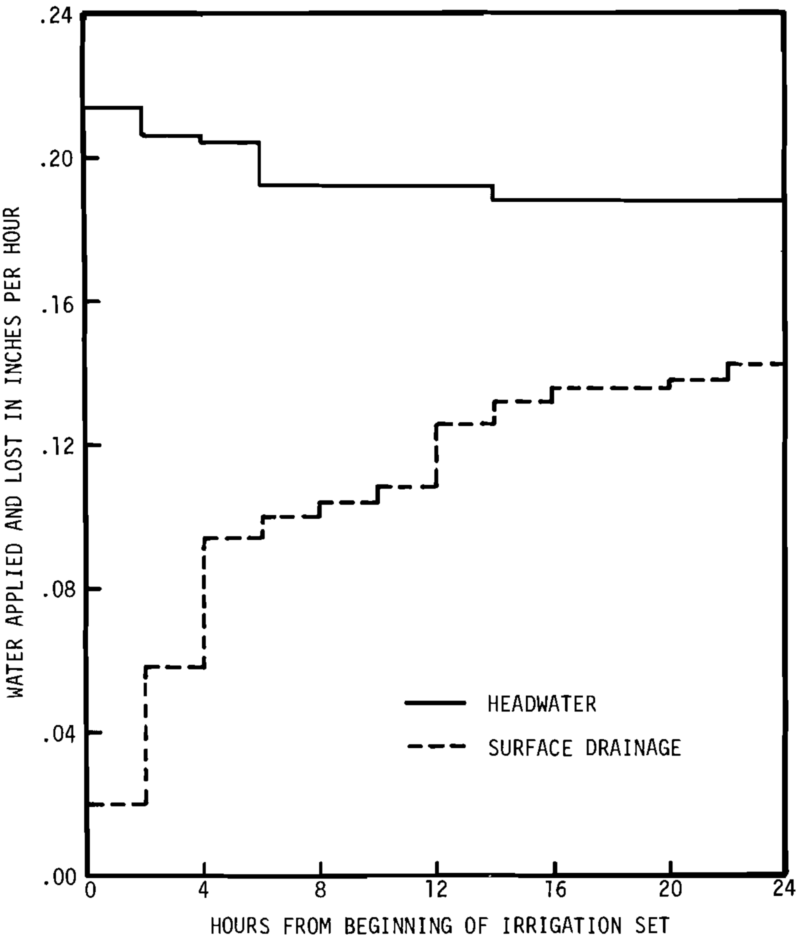


Figure 1. Water applied and lost to surface drainage during an irrigation set

rate increased until it reached a nearly constant value near the end of the set. The shape of the surface runoff curve is influenced by several factors including size of irrigation stream, slope of the field, tillage practices, crop grown and soil type. The area between the curves represents the net volume of water applied to the field during the set.

The one-set data for total phosphorous and total solids are shown in Figures 2 and 3. The headwater data presented in both figures show that the rate of application of both constituents remained essentially constant for the duration of the set. The amounts of total phosphorous and total solids lost in surface drainage were greatest as surface drainage began and then declined rather sharply. The plots for total phosphorous and total solids lost in surface drainage indicate a fair correlation between the two. This fact was pointed out by Fitzsimmons et al. (5) for the 1970 survey data from the same area.

The effect of applying nitrogen fertilizer in the irrigation water is shown in Figure 4. As can be seen, the nitrate application rate was much greater during the 4-hour period of fertilizer application than during the remainder of the set when only background rates of nitrogen were applied. A significant amount of nitrate-nitrogen was present in surface runoff three hours after the beginning of the set. The greatest amount appeared at about the 5-hour time with a sharp decrease following. The irrigator could have lessened the amounts of nitrate lost in the surface drainage had he stopped the application at an earlier time in the set.

Total water volume values associated with each crop are displayed in Figure 5. As can be seen, more water was applied to and lost from the onions than the sugar beets even though the evapotranspiration requirement for onions was slightly less than the requirement for sugar beets. The differences are a result of different cultural practices associated with each crop. Onions, a rather shallow rooted crop compared with sugar beets, were planted in 28-inch beds, 4 rows to a bed, with an irrigation furrow between adjacent beds. The irrigator used 24-hour irrigation sets so that the beds would be completely wetted on the surface at the center of the bed at the end of each irrigation. The sugar beets were planted in 24-inch rows and were irrigated every other row with sets ranging from 6 to 12 hours in duration. Percentages of the gross applied water that went to evapotranspiration, surface drainage, and subsurface drainage for each crop are listed in Table 1.

TABLE 1. Percentages of total gross applied water to evapotranspiration, surface drainage and subsurface drainage.

| | Sugar Beets (%) | Onions (%) |
|---|---|---|
| To evapotranspiration | 62.9 | 48.7 |
| To surface drainage | 32.2 | 40.4 |
| To subsurface drainage | 3.5 | 18.2 |

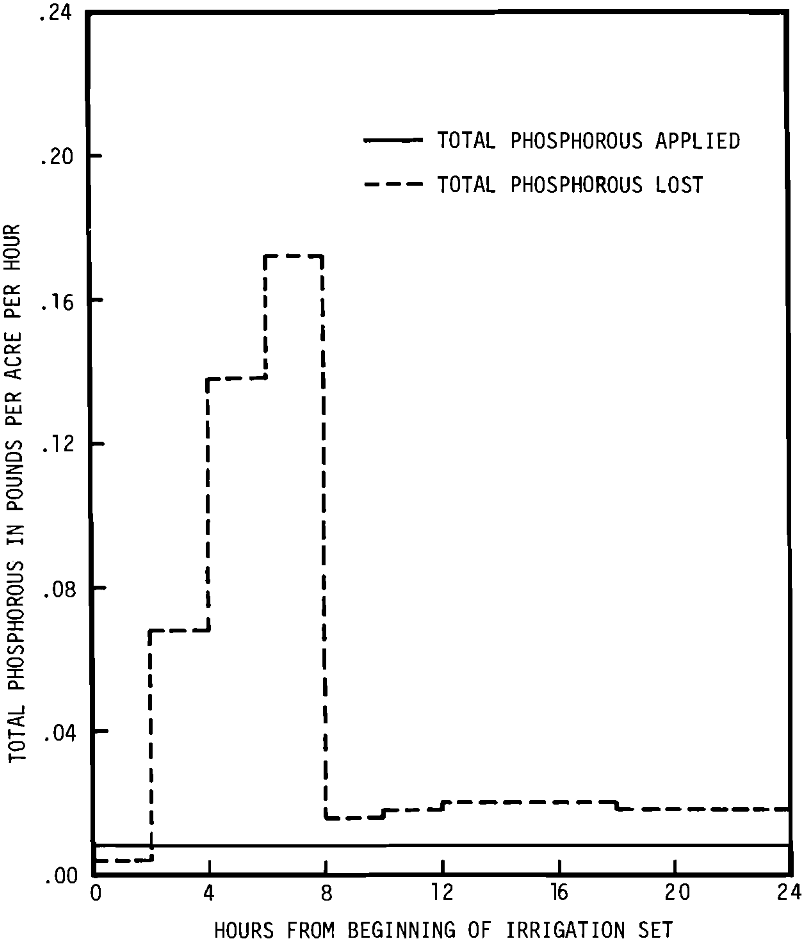


Figure 2. Total phosphorous gained and lost during an irrigation set

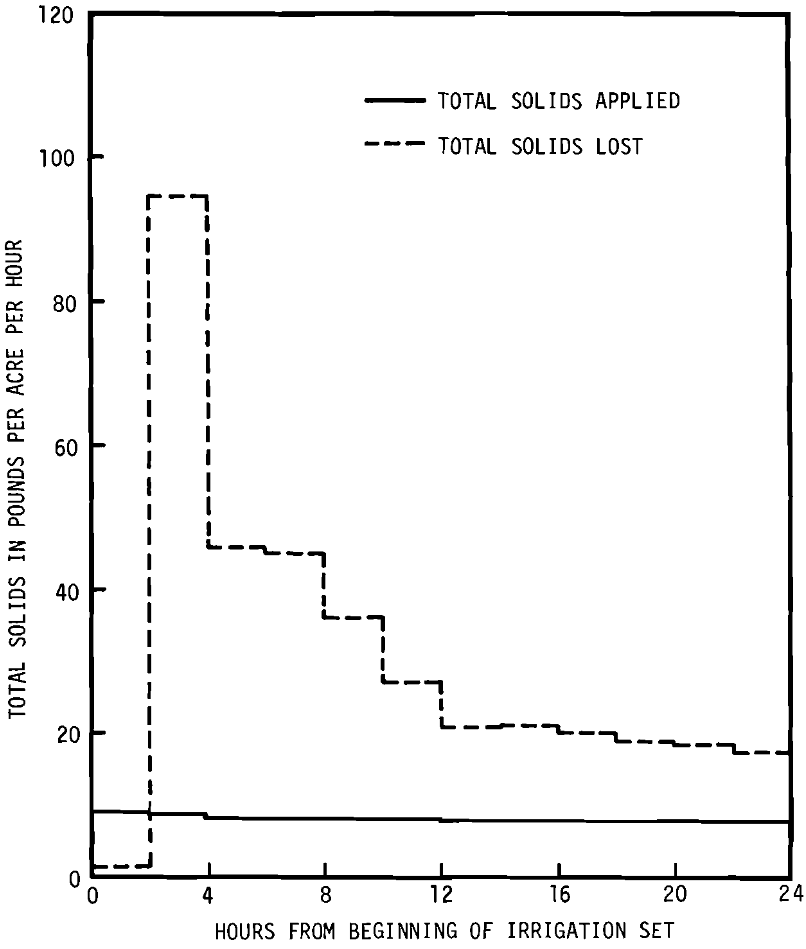


Figure 3. Total solids gained and lost during an irrigation set

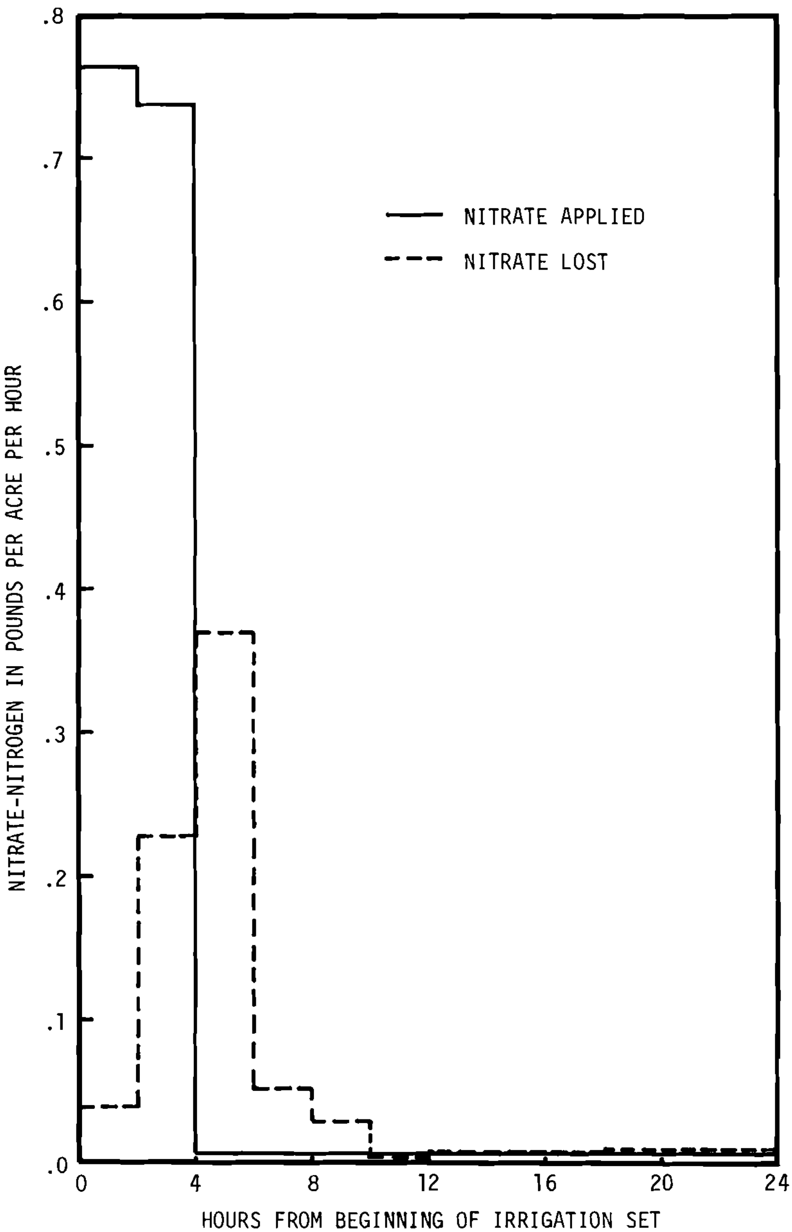


Figure 4. Nitrate-nitrogen applied and lost during an irrigation set

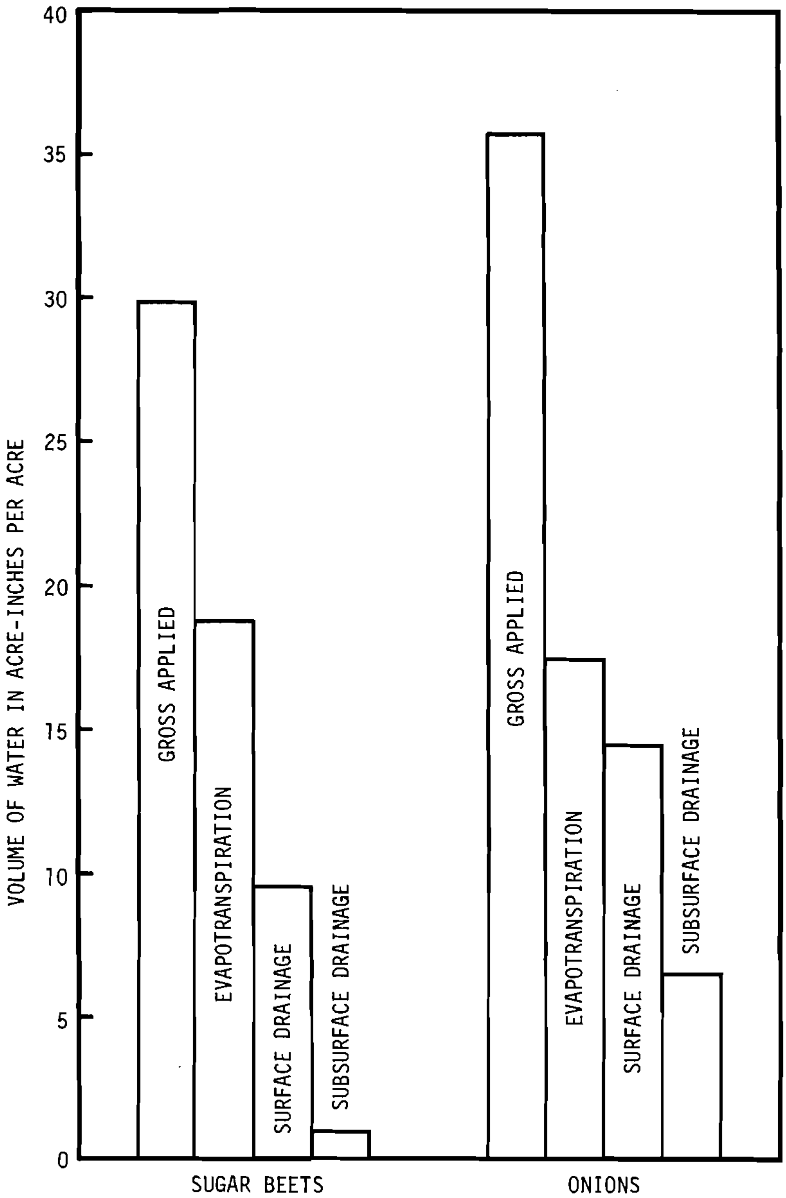


Figure 5. Total volumes of water associated with each crop

The values listed in Table 1 indicate that the irrigation efficiencies were higher for sugar beets than for onions. The percentage of the gross applied water going to evapotranspiration is termed Consumptive Use Efficiency by Israelson and Hansen (5). The Consumptive Use Efficiency should be nearly 100% when irrigating with high quality water. All water applied to the study area had a conductance of less than 0.2 mmhos per cm and negligible sodium. When this efficiency drops the percentage of water lost to drainage increases. The different Consumptive Use Efficiencies of 62.9% for sugar beets and 48.7% for onions also affected the amounts of constituents that were lost in the drainage water from each crop.

TABLE 2. Total constituents gained and lost in surface flows.

| Constituent | Crop | Applied in headwater (lb/acre) | Lost in surface drainage (lb/acre) | Net gain or loss (lb/acre) |
|---|---|---|---|---|
| Total P | Sugar beets | 1.12 | 1.45 | -0.33 |
| | Onions | 1.54 | 4.84 | -3.30 |
| Total Solids | Sugar beets | 849.77 | 1804.22 | -954.45 |
| | Onions | 894.01 | 3207.18 | -2313.17 |
| Total Nitrate N | Sugar beets | 4.57 | 1.77 | +2.80 |
| | Onions | 9.31 | 3.96 | +5.35 |
| Nitrate N from background | Sugar beets | 1.43 | 0.90 | +0.53 |
| | Onions | 2.06 | 1.90 | +0.16 |
| Nitrate N from fertilizer | Sugar beets | 3.14 | 0.87 | +2.27 |
| | Onions | 7.25 | 2.06 | +5.19 |

Values shown in Table 2 do indicate that irrigation efficiencies influence the amounts of constituents leaving an irrigated field in the surface drainage. The amounts of total phosphorous applied to each crop were nearly the same. The same was true concerning the total solids applied. However, the amounts of total phosphorous and total solids lost in surface drainage from each crop differed quite markedly as did the percentages of gross applied water lost to surface drainage. Values for nitrate-nitrogen from background also show the effect of different irrigation efficiencies. Approximately 37% of the applied background nitrate was retained on the sugar beets while only 8% was retained on the onions. A greater proportion of nitrate from fertilizer applied in the irrigation water was retained on each crop. Approximately 72% of the fertilizer nitrate applied to both the sugar beets and onions remained on the fields. This fact is due to the care the irrigator used when applying fertilizer in the irrigation water.

The greatest difference in the amounts of constituents lost to drainage from the two crops was the amount of nitrate-nitrogen lost to subsurface drainage as a result of deep percolation. Nitrate moves readily with the water in the soil. The amounts of nitrate lost to subsurface drainage from the sugar beets and onions were 2.156 lb/acre and 15.188 lb/acre respectively. The variation may be attributed mainly to the large difference in the amounts of water that were lost to deep percolation from each crop and also to fertilization practices before and during the irrigation season.

Results from the 1971 study indicate that the irrigator would save more than water by increasing his irrigation efficiencies. He would retain nutrients and soil that are valuable to him as a farmer and at the same time reduce the potential pollution of the water for downstream users.

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