# IMPROVING IRRIGATION in Eastern Oregon

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# To Begin With . . .

Developing new irrigation land generally presents some soil and irrigation management problems. Certain problems emerged on the Owyhee Project shortly after irrigation was initiated in 1935. Among these were high water use, low irrigation efficiency, low water intake rates, excessive surface runoff, and scattered nonproductive "slick spots." Similar problems exist on other irrigation projects.

These problems were studied as a cooperative State-Federal research program beginning in 1946 and ending in 1953, except for observations and certain final tests made in 1954. Main results of the experimental plot research have been published in Oregon Agricultural Experiment Station Technical Bulletins 22 and 23. Results of farm field trials from 1950 to 1953 are presented in this publication. Recommendations for handling soil and furrow irrigation problems in this and other areas also are reported.

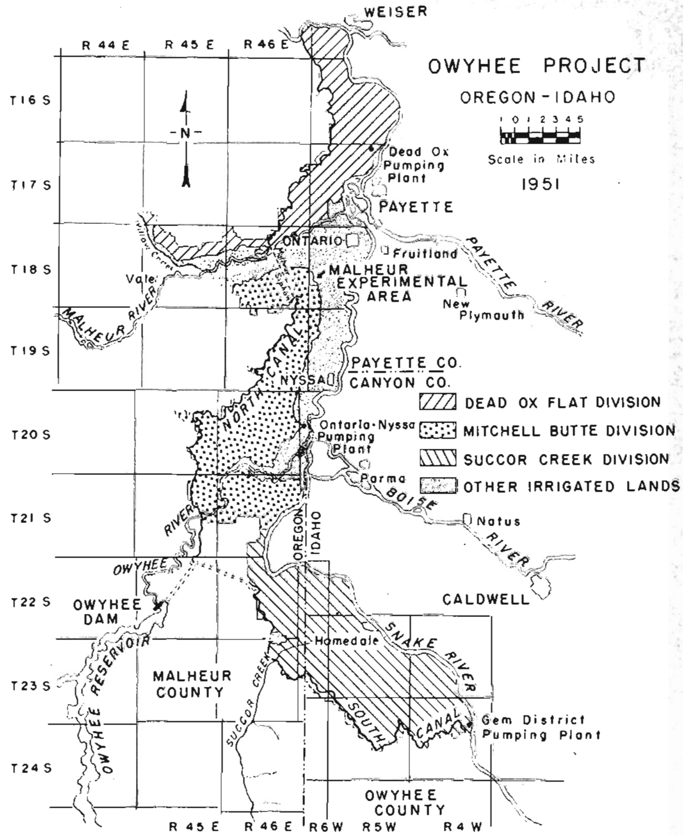



**Figure 1. Map of Owyhee Project area.**

# The Owyhee Project Area

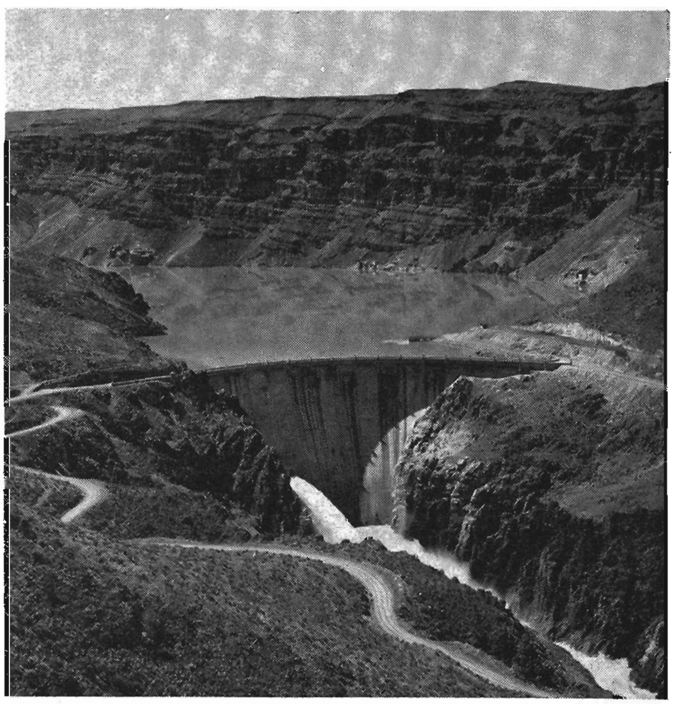


**Figure 2. Owyhee Dam, which provides irrigation water for the Owyhee Project area.**

A map of the Owyhee Irrigation Project is shown above. The area includes approximately 155,000 acres; 102,000 are irrigable. In 1953, approximately half the irrigated land was used for hay, pasture, and forage crops, a fourth for cereals, a tenth for vegetable and truck crops, a tenth for sugar beets, 3 per cent for seed crops, 1 per cent for fruit, and 1 per cent miscellaneous crops. These figures do not include the area on the map labeled "other irrigated lands."

A large part of the land lies on valley slopes and higher benches where shallow soils are the rule. In the northern half of the project, soils are dotted with numerous irregularly spaced "slick spots." The soils become progressively deeper and have less cemented substrata (hardpan) as their location approaches the valley floor. It is the upland soils on which irrigation management has been difficult.

# Water Use High

In planning irrigation facilities for the Owyhee Project, engineers calculated that a farm delivery of 3.2 acre-feet of water per acre would be adequate. A summary of water use for the Owyhee Project by years is shown in figure 3. Shown also are the irrigation requirements by years based on the Blaney-Criddle formula, which takes into account the effect of climate for the particular year and the acreage of various kinds of crops. The difference between water delivered and the water requirement represents losses.

# Water Losses High

On any irrigation project there are unavoidable losses of water. There also are some avoidable losses. In the research trials an effort was made to determine how much water was lost, where the losses occurred, and how they could be reduced.

### How much water is lost?

Comparing the water delivered with the estimated water required in figure 3, you will note that only 39 per cent of the water delivered to the farm headgates was needed for crop production. The remaining 61 per cent was lost. Some additional water also was lost by evaporation and seepage from the distribution canals above farm headgates. These losses, however, were not included in this study. They would be in addition to the figures reported here.

From 1950 to 1953, 16 measurements of irrigation efficiency were made on farm fields. The average was 54 per cent. This means that 54 per cent of the water delivered to the farm field was stored in the root zone where the plants could get it. The remaining 46 per cent was lost. Operators on the farms studied were better than average, as indicated by the higher efficiency they obtained compared to the project average.

### How do losses occur?

Between 1941 and 1953, 32 separate measurements of runoff from farm fields were compared to the amount of water applied. The average runoff was 31 per cent of the water applied, accounting for about two-thirds of the total loss. In some cases this runoff water can be picked up and reused on the next field, but in many cases it enters drainage ditches and is lost as far as the farm and the project are concerned.

**Runoff**

Some water percolates below the root zone where plants cannot get it. Eventually this water seeps down through the soil mantle to the water table. Measurements on 16 fields showed that deep percolation losses average 15 per cent of the water applied. Because of a rela-

**Deep percolation**

**Figure 3. Water Deliveries Exceed Calculated Need.**

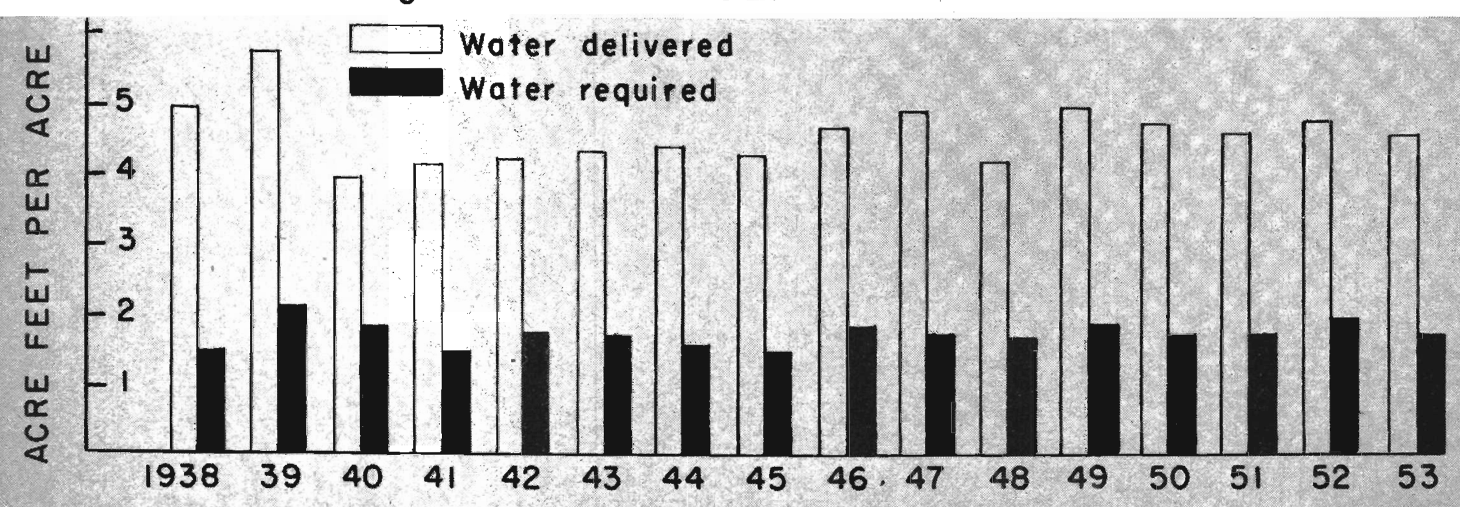
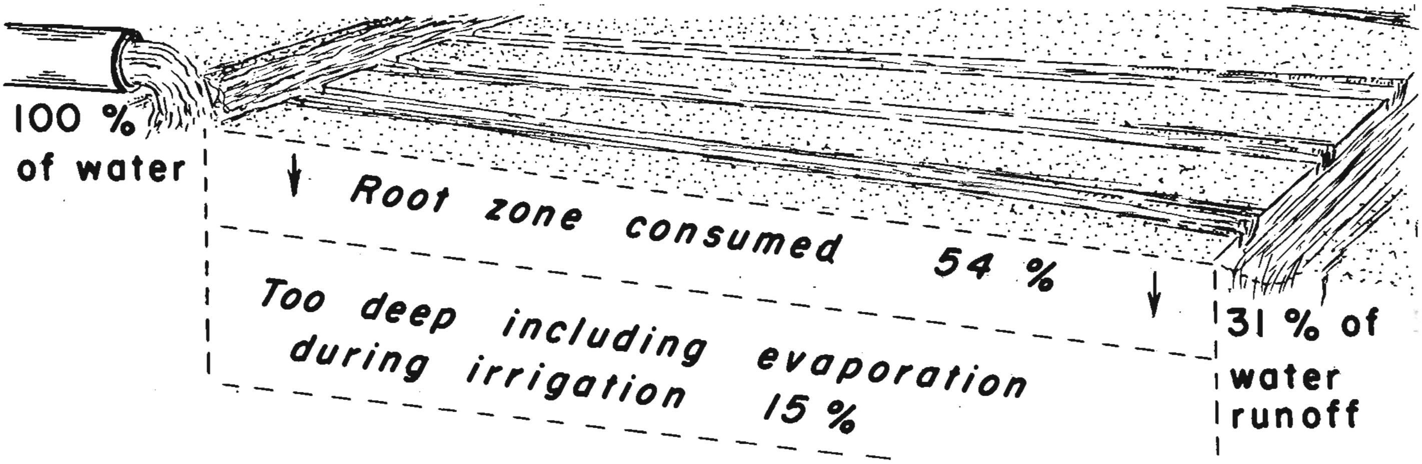


Figure 4. How Irrigation Water Is Lost.




tively low amount of salt in water from the Owyhee reservoir, the leaching requirement for salinity control need not exceed 5 per cent of water entering the soil.

In addition to water loss from deep percolation, the figures include evaporation from the surface of the water on the field and the wetted soil surface during an irrigation. (Do not confuse with evaporation between irrigations, which is part of consumptive use explained below.) Evaporation and deep percolation together account for about one-third the total loss.

**Evaporation**

### How can these losses be reduced?

To reduce water losses, know your soil's water storage capacity as well as the expected rate of use. Where published soil surveys exist, water storage capacities are available. Where there is no survey, this information may be obtained in some cases from your county agent, or by sending a properly taken sample to the OSC soil testing laboratory. Water storage for two major soils on the Owyhee Project is shown in table 1. Figures are averages from several fields which may vary individually as much as ½ inch per foot depth. To use these figures in the field you must know the active rooting depth of your crop.

**Know your soil's water storage capacity**

Consumptive use is the seasonal amount of water used by plants and evaporated from the adjacent soil surface. Average consumptive use of several crops as determined in these studies is shown in table 2. The difference between crops is caused mainly by different length and time of growth period. Inches of water consumptively used in a day is known as the rate of use. This rate is useful for determining how much of the stored water has been used since the previous irrigation. Rates of water use for several crops are shown in figure

**Know expected rate of use**

Table 1. Average Available Water Two Malheur County Soils Can Store

| Soils | 1st foot | 2d foot | 3d foot | 4th foot |
|---|---|---|---|---|
| | *Inches* | *Inches* | *Inches* | *Inches* |
| Very fine sandy loam. Hardpan and extreme nodulation 18″ to 24″ below surface. Hardpan 8″ to 16″ thick. Common in Mitchell Butte division | 2.3 | 2.2 | 2.8 | 2.6 |
| Silt loam surface over heavy clay subsoil 10″ to 18″ below surface. Common in Dead Ox Flat division | 2.3 | 1.7 | 2.6 | 2.7 |

**Table 2. Seasonal Water Requirements of Some Crops in the Ontario Area**

| Crop | Water use |
|---|---|
| | *Inches* |
| Wheat | 26 |
| Barley | 18 |
| Alfalfa | 35 |
| Red clover | 31 |
| Pasture | 35 |
| Corn | 23 |

5. From these data and knowledge of your soil's water storage capacity, you can estimate the required frequency of irrigation.

*Example 1.* Let's say you are raising alfalfa on the first soil of table 1, with the hardpan stopping roots at the 24-inch depth. It was irrigated July 1. When will it need irrigating again? The 2 feet of soil store 4.5 inches of available moisture. From figure 5 you find that alfalfa will use about .32 inches per day during the first 10 days of July for a total of 3.2 inches. The next 3 days will have an average "rate of use" of about .36 inches per day for a total of 1.08 inches. By July 13, 4.28 inches will have been used. Irrigation of about 4 inches should start July 11 or 12 on those parts of the field irrigated July 1.

*Example 2.* Let's say you are raising barley on silt loam soil as described in table 1 and irrigated June 10. Storage of available moisture after irrigating is 4 inches in the top 2 feet and 1.3 inches in the 24- to 30-inch layer, for a total of 5.3 inches. On June 20 a soil examination with an auger shows root activity and moisture extraction to a depth of 30 inches. Average "rate of use" June 10 to June 20 is .23 inches per day from figure 5 for a total of 2.3 inches. Average "rate of use" June 20 to 25 is .28 inches per day for a total of 1.4 inches. Average "rate of use" June 25 to June 30 is 0.32 inches per day for a total of 1.6 inches. By June 30, 2.3 plus 1.4 plus 1.6 equals 5.3 inches so that all the available water will have been used. About 4.5 inches should be applied starting on June 26 or 27.

Of the 16 irrigations on farm fields where irrigation efficiency was measured, 13 could have used a shorter irrigating time. Once the root zone was filled all the additional water added was lost through runoff, deep percolation, or evaporation. The average length of one setting of water on these 16 fields was 52 hours. If each irrigation had been stopped when the root zone was filled, an average of

**Reduce time of irrigation**

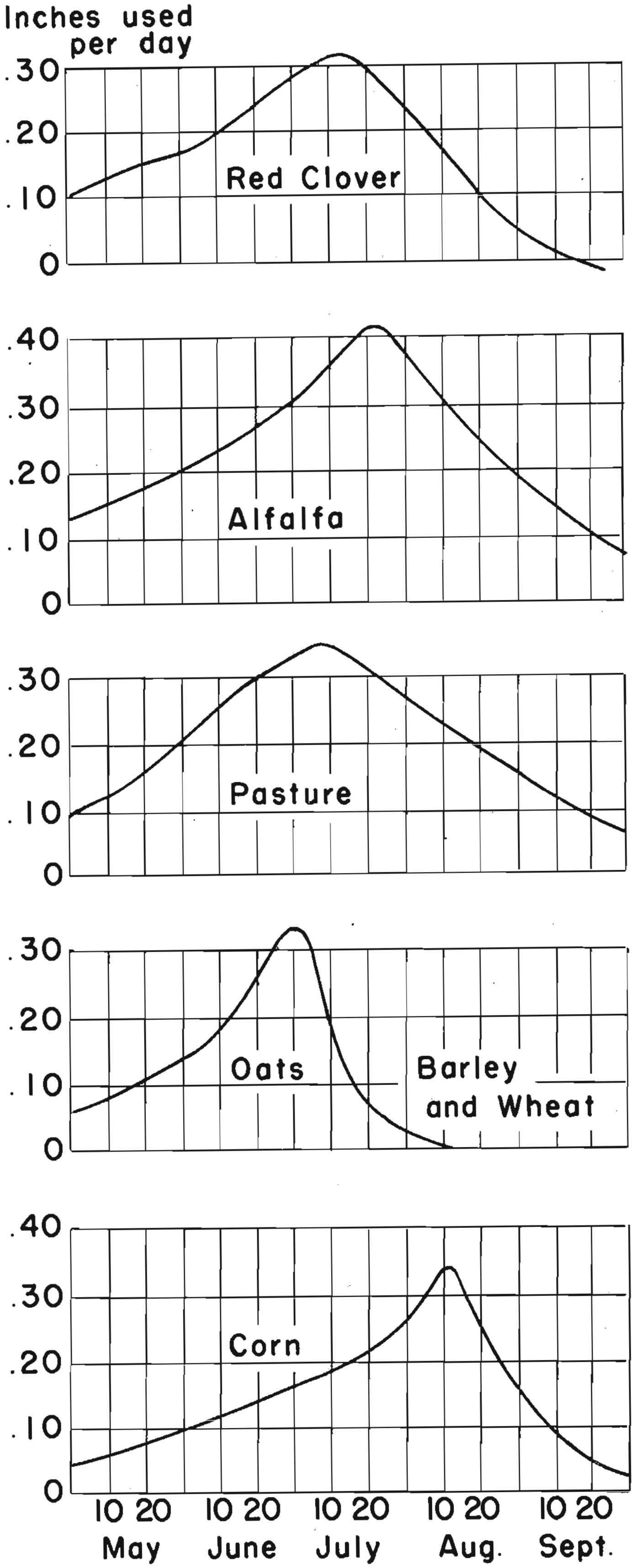



**Figure 5. Rate of water used depends on temperature and stage of growth.**

only 41 hours would have been required. You can find when the root zone is wet by using a soil auger at various times during the irrigation.

**Reduce water in each furrow**

Amount of flow was larger than necessary on the farm fields measured, even at the start of the irrigation. The quantity of water in each corrugation for efficient irrigation should be enough to reach the end of the run in about one-fourth the total time that water is applied. If more water than this is applied, runoff loss is higher than need be and excessive erosion often occurs. If a smaller quantity is applied, deep percolation loss at the upper end of the run may become excessive.

Runoff loss could have been reduced on almost every field measured if the irrigator had decreased the amount of water in each furrow just as soon as it reached the end of the run. While this practice requires more labor, it saves much of the runoff loss. Controls such as siphon tubes, gated spiles, or gated pipe make it easier to reduce runoff losses. See figure 6.

**Level the land**

Any high spot on a field may prolong an irrigation unnecessarily. By the time the high spot has received sufficient water, the rest of the field has absorbed too much. Water can be distributed much more uniformly on smooth fields.

**Increase intake rate**

Early studies showed that much of the soil on the Owyhee Project had abnormally low water intake rates. These contributed to high water losses. Because of their importance, the next section reports methods of improving intake rates.

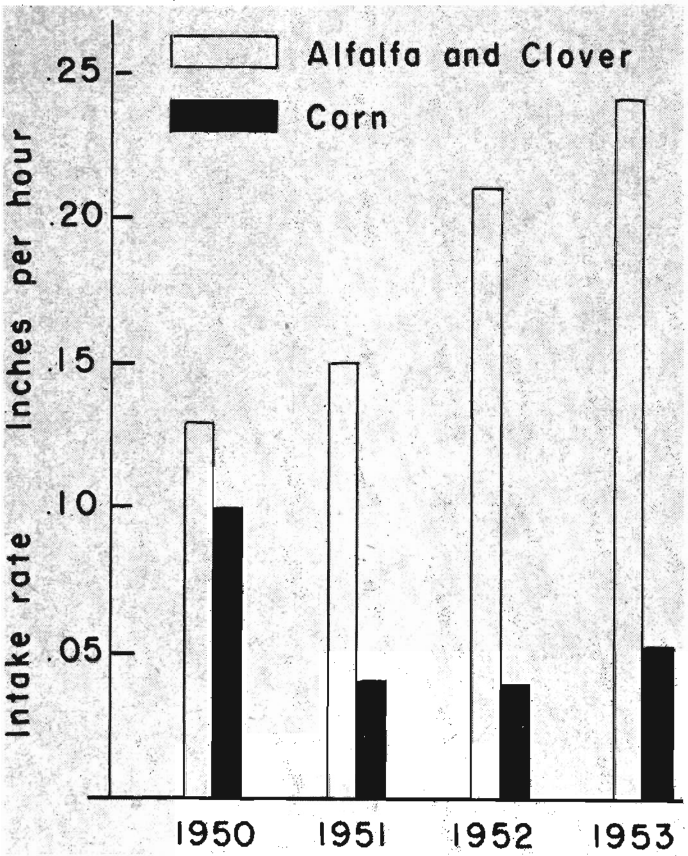
Figure 6. Controls, such as siphon tubes (left) and gated pipe (right), make it easier than shovel control (center) to reduce runoff losses and obtain even distribution.

# Some Soil Intake Rates Low

### Results of low intake rates

Low intake rates mean excessive use of water, increased time required for irrigation, reduced aeration, and insufficient soil wetting. On fields with low intake rates where irrigations are continued for a long period, low irrigation efficiencies result from excessive runoff and evaporation. Field irrigation efficiencies can be higher where intake rates are faster. The time required to apply water can be shortened, thus reducing runoff waste. Low intake rates usually are accompanied by slow cross wetting or "subbing" of the soil between furrows. Many irrigations are prolonged primarily in an attempt to wet the soil between corrugations.

Figure 7. Water Intake Rates Higher for Alfalfa and Clover Than for Corn.




## Ways to improve intake rates

Cropping practices greatly affect intake rates. Close-growing crops—particularly hay and forages—increase intake rates while row crops have an opposite effect. Figure 7 shows the average intake rates for each of 4 years on fields growing alfalfa and clover, compared to those on fields with corn. Close-growing crops cover and protect the soil so the physical condition is maintained and improved. They also contribute more root material and surface residue that open up channels for water infiltration into the surface soil. Another value: lowering the speed of water flow down the corrugations on furrows means more opportunity for water to spread out and be absorbed rather than rushing past.

**Cropping practices**

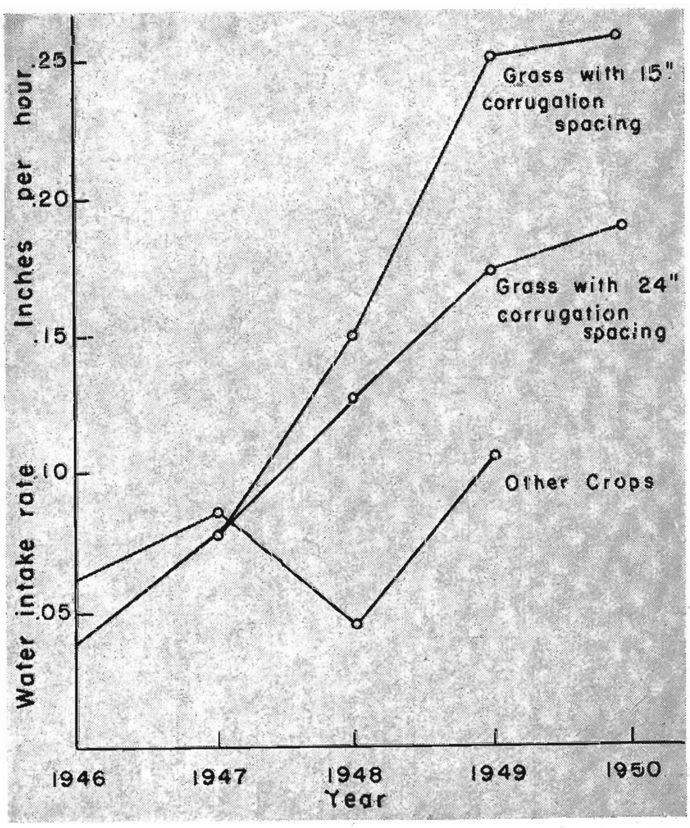
Grass has proved to be the most effective crop for improving the intake rate. This is illustrated in figure 8, indicating that 3 or 4 years are needed to obtain full benefit from the grass crop. How long the improved intake rate would last after plowing up the grass was not determined. "Other crops" indicated in the figure include grain in 1946, Hubam clover in 1947, corn in 1948, and first-year alfalfa in 1949.

Corrugation spacings for "other crops" were 24 inches in 1946 and 1947, 36 inches in 1948, and 20 inches in 1949. Both the crop and the corrugation spacing had important effects on the intake rate. Closer corrugation spacing increases intake rates since more land surface is under water, and the lateral distance across which water must move between corrugations is decreased. This is an effective means of reducing the time required for an irrigation, as indicated in figure 9, thus reducing losses from runoff, evaporation, and percolation. Subsoiling parallel with the corrugations did not permanently increase the water intake rate or crop growth, though it had a noticeable effect on the first irrigation.

**Reduce corrugation spacings**

The combination of grass crop and nar-

Figure 8. Grass and Close Corrugation Spacings Improve Water Intake Rates.



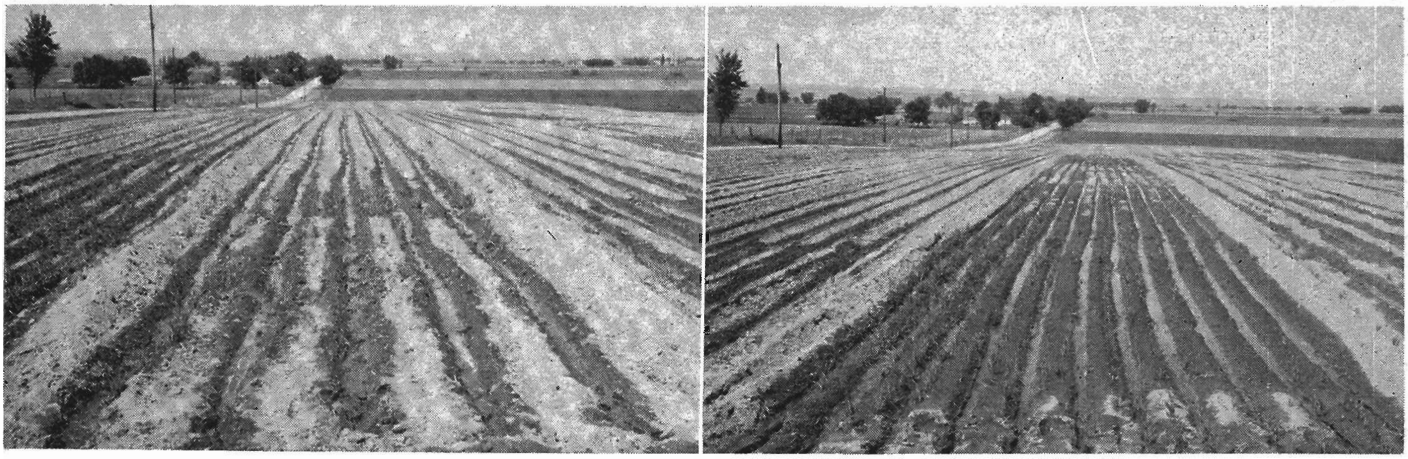


Figure 9. Cross wetting or "subbing" is completed sooner with close corrugation spacings. Left, 24-inch spacings; right, 12-inch spacings. Both fields irrigated the same length of time.

rower corrugation spacings gave the highest intake rate and permitted irrigation with a minimum of water loss.

**Add organic matter**

Turned under Hubam clover improved intake rates slightly. Manure applied two successive years at 20 tons per acre each year on plots where Hubam clover also was turned under increased intake rates somewhat more, but was not as effective as the grass crop.

### Summary of practices for improving intake rates

1. Use steep lands with low intake rates for grass and hay crops as much as possible; hold cultivated row crops to a minimum.
2. Space corrugations as close as practical for the crop and site conditions.
3. Add as much organic matter as possible, using both crop residue and barnyard manure.
4. Avoid overly long irrigations since intake rates decline as time goes on.

Figure 10. Hay and forage crops reduce runoff, compared to row crops. More roots and surface trash from forages also increase water intake rates and reduce erosion hazards on higher benches.

# "Slick Spots" a Problem

## The problem

Irregular areas with poor or no plant growth are scattered throughout many fields. These areas are recognized easily in freshly tilled fields by their gray color, compared to the brown color of the surrounding soil. Water penetration is poor and crops suffer from water shortages during the warmer part of the season, even with frequent irrigations. Subsoils also contained adsorbed sodium which harms sensitive plants.

## How to improve "slick spots"

Sodium must be removed from the clay particles and replaced by calcium to improve the physical condition so water and plant roots can penetrate. Research trials showed the best way to accomplish this change is a combined application of gypsum and manure. Gypsum supplies calcium to replace sodium from the clay,

**Add gypsum and manure**

and manure temporarily improves the physical condition and water penetration. Straw, hay, and crop residues also can be used. Liberal amounts are needed. On trial plots, 50 tons per acre of manure and 16 tons per acre of gypsum were used. These rates aren't too costly because usually there is a relatively small total area of slick spots on any one farm.

Work the gypsum and manure into the surface and plant a crop. A forage

**Plant a crop**

crop is preferred. If residues other than manure are used apply supple-

Figure 11. Irregular, scattered "slick spots" are identified easily, and lower the yield average.

## The cause

The exact sequence of events is uncertain, but under an earlier influence of salts, sodium was adsorbed by the clay particles. The clay particles dispersed and moved downwards in the soil, leaving an ashy gray surface soil of low fertility and forming a clay layer in the subsoil which water and plant roots find difficult to penetrate.

mental nitrogen and phosphorus. One hundred pounds per acre each of N and $P_2O_5$ are suggested initially. If the forage mixture does not contain a legume, additional nitrogen may be needed the second year. If straw is used, nitrogen will be needed both for decomposition of the straw and for crop growth. Watch carefully for nitrogen deficiency, and supply more nitrogen as needed.

**Fertilize adequately**

Frequent irrigation is necessary to wash out replaced sodium. Forage crops hasten the removal of sodium because they require more irrigations per season. Increase in organic matter and improvement in the soil's physical condition also will be more rapid with forage crops.

**Irrigate**

Sulfur and waste sugar beet lime were tried but were not as effective as gypsum. In this soil, the calcium from lime application proved to be less soluble than from gypsum. Sulfur is most effective on calcareous soils. Slick spots in this area are calcareous only in the deeper substrata.

This bulletin reports cooperative research by the Oregon Agricultural Experiment Station; the Bureau of Reclamation, U.S. Department of the Interior; and the Soil and Water Conservation Research Branch of the Agricultural Research Service, U.S. Department of Agriculture. The latter now includes the U.S. Salinity Laboratory and the former Division of Irrigation, Soil Conservation Service, who participated.

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