WHEN WATER AND SOIL WON'T MIX

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Some potato growers are having serious problems getting sufficient water into their soils to maintain a high moisture level during high water use periods. This is not a new problem, but one which has been recognized as severe on some of the newer irrigation developments.

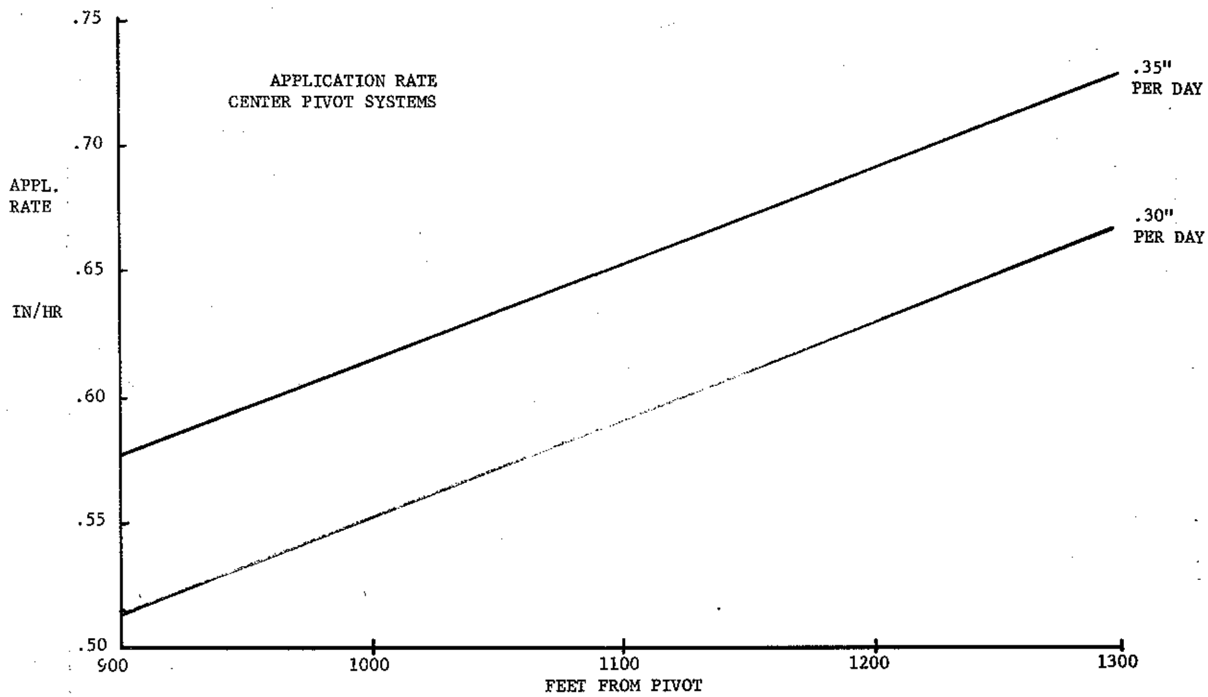
We have been aware of the problem on surface irrigation soils for many years. The author, in asking for research assistance concerning low intake rates in a letter written in 1961 to the Department of Agronomy, suggested three possible causes:

1. siltation occurring in the bottom of the furrow;
2. algae formation occurring with frequent irrigations;
3. defloculation due to certain salts being leached.

In this same letter it was asked, "Would it be better to withhold irrigations until the furrow bottoms are dry and ruptured?" "Would the addition of gypsum or wetting agents to the water help even though the problem might be due to siltation?"

Many of the newer irrigation developments are utilizing center pivot sprinkler systems. On high silt and clay soils, serious runoff and erosion has occurred. Most of these systems have been developed in the mid-West where, in general, high water use rates are not required. Also, deeper rooted crops are usually grown and sufficient moisture can be stored with low application rates as irrigation supplements summer rainfall.

In central and eastern Washington, evaporative demands are as much as .35 to .4 inches of water per day. Where shallow rooted crops such as potatoes are grown there is very little margin for safety, and often these same amounts or more must be added each day. If irrigations are every two or three days, .75 to 1.2 inches must be applied at each irrigation. The following figure shows the rate of application for various lengths of center pivot systems at two application rates. When water is applied faster than the soil's ability to absorb it, runoff will occur. When runoff occurs, erosion often becomes a problem.

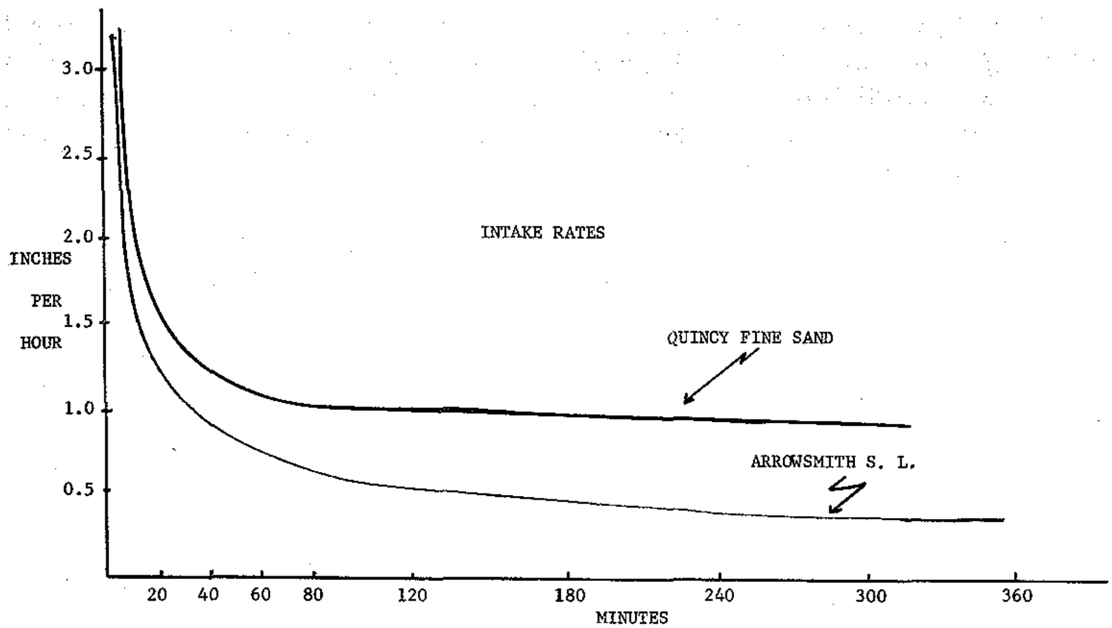


Causes of Low Intake Rates

Texture and structure are the two main terms used to describe the physical characteristics of soil. Texture describes the soil's primary particle size, such as fine (clay), medium (silt), and coarse (sand). Structure describes the effect of the grouping or relationships of these particles to each other, such as massive, block or granular.

For medium and fine textured soils to be in good tilth they must possess a granular structure or be temporarily broken into small aggregates. Coarse textured soils are essentially always in good tilth and are usually found in a single-grained granular state. We gauge the structural quality of a soil by the ability of the soil to retain good tilth during and following irrigation.

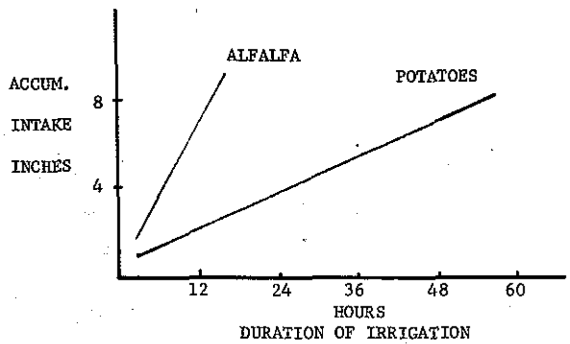
Texture of soil essentially can never be changed. The following figure shows relationships of intake rate to various textures of soil.



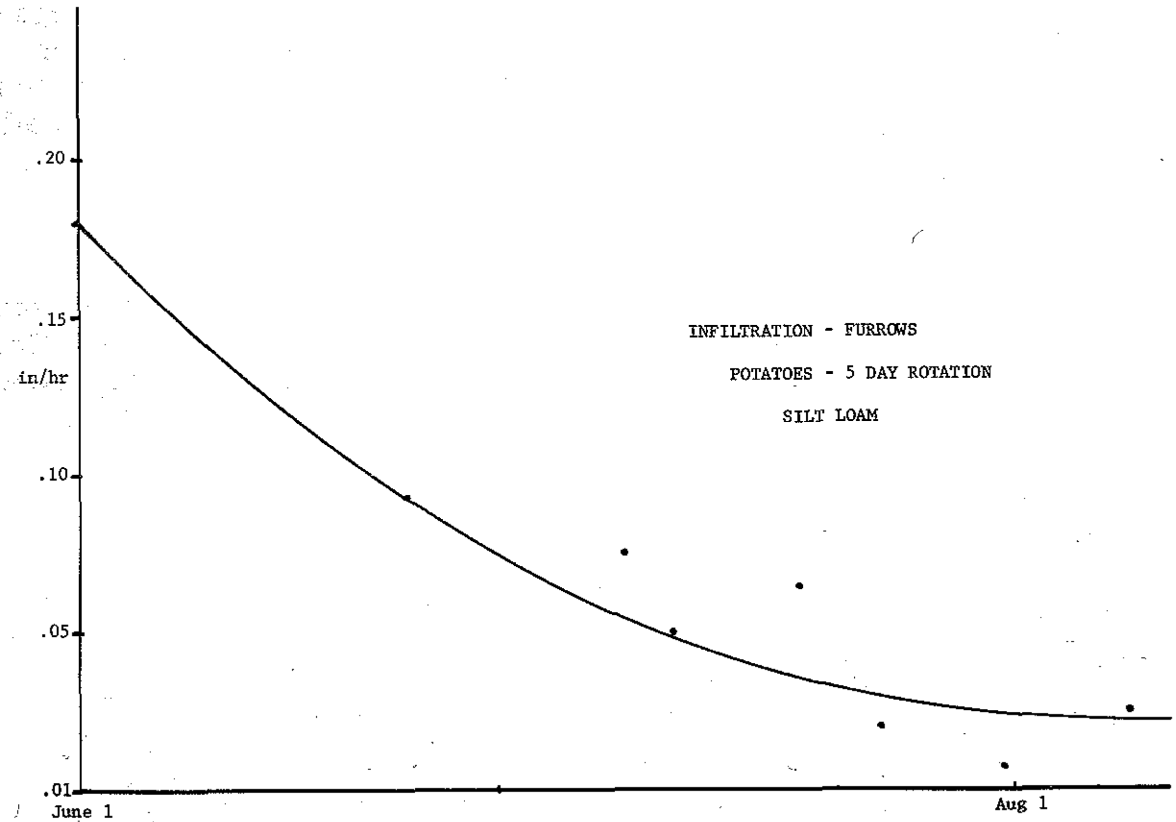
Structure of soil is continually changing due to processes which tend to improve or destroy. Beneficial processes, including microbiological activity, alternate freezing and thawing, alternate wetting and drying (provided rewetting is slow), proper tillage (frequently to the detriment of soil physical conditions just below tillage depth), and possibly the physical incorporation of crop residues; destructive processes include compressive or sheer forces due to traffic load or tillage tending to break down soil structure units and the disruptive action of water or slaking.

Permanent structure is favored by a high proportion of certain cations, sufficient reactive clay for aggregation (but not excessive content), and organic matter in a form which contributes to the bonding together of aggregates. Other bonding agencies, particularly lime and oxides of iron, aluminum, and silicon, also contribute to aggregate formation. Slaking is caused by the almost explosive escape of entrapped air when aggregrate strength is lowered on wetting, and by differential swelling. Slaking action is greatest when dry soil is rapidly inundated--a common condition for surface soil under irrigation. Resistance to slaking depends on the strength of bonding or cementing agents and their resistance to water action.

The type of crop being grown and a cropping sequence in the rotation has an effect on intake rates as shown by the following figure:



Intake rates also vary considerably within a cropping season as shown by the following figure:



Many potato growers in the State of Washington have had experiences in growing potatoes in other states where possibly the low intake rate problem was due to a high concentration of sodium salts in relation to calcium and magnesium. These sodic soils are serious in some parts of eastern Oregon and Idaho, but, in general, these sodic conditions have not caused a major problem in our potato growing areas in Washington. The primary problems of low intake rates under surface irrigation seems to be in the sloughing or slaking creating a thin, unstructured film on the bottom of the furrows under surface irrigation, and an equivalent type of condition due to impact of large falling droplets under sprinkler irrigation.

Possible Solutions

Anything which can be done to maintain or to improve soil aggregation is to be encouraged. Since it is impractical to change texture or incorporate different amounts of silt, clay and sand to maintain the most favorable aggregation, it becomes a problem of managing whatever soil is present.

Surface Irrigation

Incorporation of crop residues into the soil surface seems to be the most practical and economical way to promote higher intake rates. The following tables show the results of research work conducted using straw as the crop residue. Work was done by D. E. Miller, ARS, IAREC, Prosser.

Table 1.

1969 - WSU Roza Unit, Prosser

Infiltration Rates at 24 Hours--Inches per Hour

Irrigation	Control	Annual 3 ton Straw	Annual 6 ton Straw
1 May 29	.103	.183	.260
2 July 23	.096	.166	.190
3 August 23	.110	.150	.167

Table 2.

1969 - WSU Roza Unit, Prosser

Cumulative Intake After 24 Hours--Inches

Irrigation	Control	Annual 3 ton Straw	Annual 6 ton Straw
1 May 29	4.32	6.70	8.11
2 July 23	3.27	4.91	5.44
3 August 23	3.30	4.21	4.42

Any system of irrigation which will prevent erosion and subsequent siltation on the bottom of the furrows should be helpful. The use of small streams and cross-slope irrigation to reduce the gradient are two possibilities. Cultivation after each irrigation to break the crust of silt in the furrow bottom is also effective but often impractical.

Sprinkler Irrigation

Under sprinkler irrigation the same principles apply in that incorporation of crop residues into the soil surface are beneficial, and anything which can be done to reduce the application rate or impact of falling water will be beneficial. Many examples of the beneficial effect of sod cover and trashy fallow can be cited. One report from Wyoming is shown in Table 3.

Table 3.

Simulated Rainfall

	Inches per Hour After 1 Hour
Bare Fallow	0.3
Trashy Fallow	2.26
Grassland	1.20

Solid set irrigation systems (properly designed) come the closest to any type of system to apply light application rates with minimum labor cost. Existing handmove and sideroll wheel systems can be used in the same manner, but extra equipment will probably have to be provided, since the length of irrigation set will have to be prolonged in most cases. With center pivot sprinkler systems, one way of alleviating the problem is to reduce the length of lateral (refer to Figure 1.). In attempting to solve the intake rate problem, many designers and users have suggested speeding the systems to two or more revolutions per day, but with the present types of systems very little is being accomplished since the application rate is the same. The only thing which is changed is the duration of irrigation, as shown in the following example.

Example: What is the application rate 1000' from the center point of a system which applies .35 inch per day.

1. When system completes the circle in 12 hours. Water is on one point for 16.8 minutes and applies .35/2 or .175 inches.

$$\frac{175''}{16.8 \text{ min.}} \text{ as } \frac{x}{60 \text{ min.}} = .62 \text{ in/hr}$$

2. When system completes the circle in 24 hours. Water is on one point 33.6 minutes and applies .35 inch per day.

$$\frac{.35''}{33.6 \text{ min.}} \quad \text{as} \quad \frac{x}{60 \text{ min.}} \quad = \quad .62 \text{ in/hr}$$

The advantage of speeding up would be to take advantage of the initial higher intake rates in the first few minutes of water application. The Ames Company has designed and is demonstrating a different type of center pivot system on the K2H development at Eureka, Washington. This consists of spray type nozzles located every 7 feet on the boom instead of the conventional rotating impact sprinklers. The idea is to reduce the droplet size and the height of fall to reduce the deterioration of the soil surface. In trying to correct for this problem, they have compounded the application rate problem as shown in the following example.

Example at 1250' from pivot point. Measured application .13 of an inch (10 hour rotation) in 95 seconds.

$$\frac{.13''}{95 \text{ sec.}} \quad \text{as} \quad \frac{x}{3600 \text{ sec.}} \quad = \quad 4.94 \text{ inches/hour}$$

The value of this particular piece of equipment will not be known until next season.

To prevent problems caused by compacting by equipment, many growers in the Mid-west have started using minimum tillage practices. Some growers have developed machinery which breaks up and incorporates the previous crop year's aftermath at the same time the present crop is being planted and fertilized. Very little is known on minimum tillage under our conditions, but the following table shows the effects of compaction on intake rates.

Table 4.

Effect on Compaction on Infiltration Rates

Treatment	Bulk Density (3-6 cm depth)	Infiltration Inches/Hour
Light compaction	1.22	2.03
Moderate compaction	1.55	1.09
Heavy compaction	1.64	0.09

This work was conducted by the University of California in 1957. Mid-west growers have also used vertical mulching to a limited extent, but since our problem seemed to be hinged on what happens at the very surface, it is probably more important to incorporate crop residues throughout the surface area rather than in certain bands as is affected by vertical mulching.

Although very little is known about the effects of fall fertilization on crop residues and their subsequent breakdown, here in Washington, a recent release from California indicated they are favoring spring spplication in order to prevent as much straw breakdown as possible. Possibly in our area, where we have colder winter conditions, this may not be significant. Their trials showed a decrease in intake from 1.57 inches per hour to 1.31 when 120 lbs of N was added to barley crop residues. The N was applied in late August and infiltration measurements were made the next July.