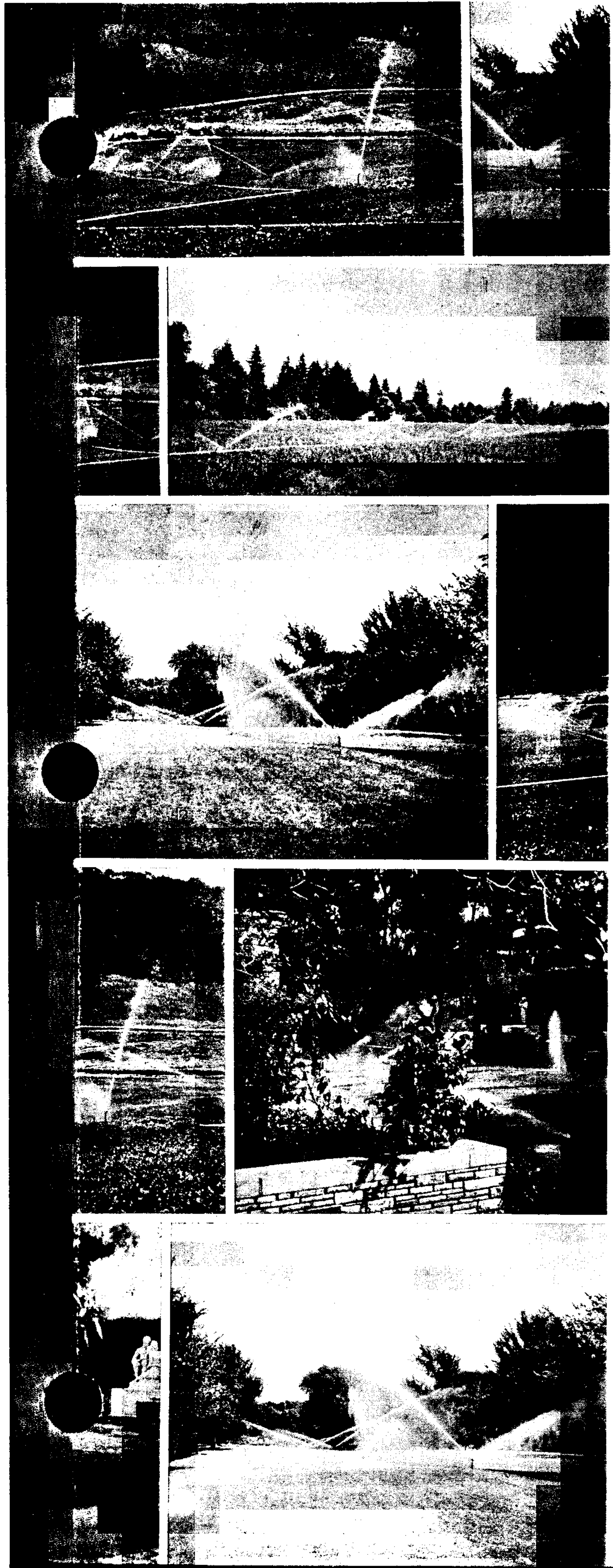

Sprinkler Irrigation Association

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A METHOD FOR MEASURING WATER INTAKE RATE INTO SOIL FOR SPRINKLER DESIGN [1/]

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"Determination of safe intake rates for soils is one of the most important considerations in planning a sprinkler irrigation system," is a quotation from the Sprinkler Irrigation Association reference book "Sprinkler Irrigation" (4) which points out the problem that equipment and procedures described in this paper were designed to solve.

The sprinkler system designer in the past has had to estimate the intake rate from soil texture, observation of other systems operating in the nearby area, or if these two sources of information were not available, the intake rate was a guess.

This past procedure for determining the safe intake rate for system design often resulted in sprinkler systems that do not fit the soil intake rate characteristics. The selection of an intake rate too low for a soil resulted in longer operating time and excess equipment. If the intake rate selection was too high for the soil, the result would be water standing on the surface of the soil and runoff from the area being irrigated. In a well designed sprinkler system the water is not applied faster than the soil will absorb it (1).

The intake rate of a soil is not a fixed value. It varies from a relatively high rate during the first few minutes of water application for a soil near the wilting point to a much lower, very slowly decreasing value as the soil moisture exceeds field capacity. Figure 1 shows a typical intake rate variation versus time of water application curve for one soil.

Many factors influence the shape of the intake rate-time of water application curve. Musgrave (3) sums up the major factors as being:

(a) Surface condition and amount of protection against the impact of rain.
(b) Internal characteristics of the soil mass, including pore size,

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1/ Contribution from the Southwest and Northwest Branches, Soil and Water Conservation Research Division, Agricultural Research Service, USDA, in cooperation with the Nevada Agricultural Experiment Station and the Idaho Agricultural Experiment Station.

This paper was co-authored by Rhys Tovey and Claude H. Pair, Research Engineer (Irrigation), Northwest Branch, Soil and Water Conservation Research Division, USDA-ARS, Boise, Idaho

depth or thickness of the permeable portion, degree of swelling of clay and colloids, content of organic matter, and degree of saturation.

(c) The moisture content and degree of saturation.
(d) The duration of application of water.
(e) The season of year and temperature of soil and water.

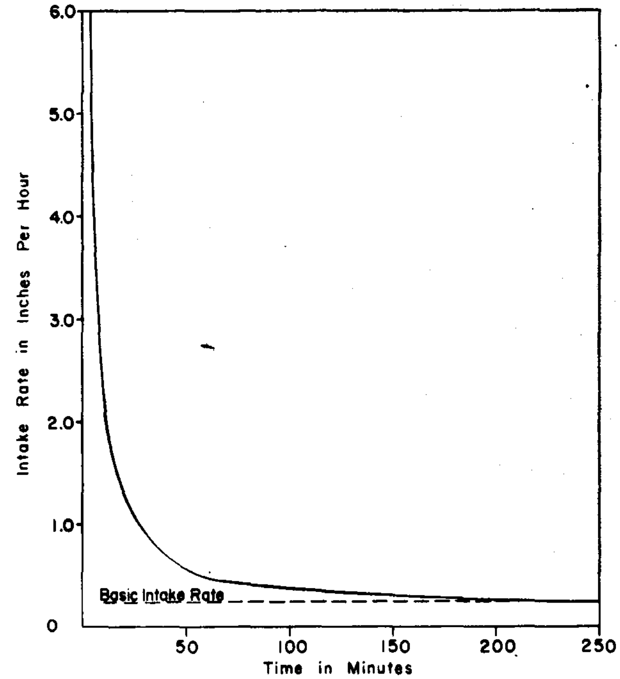

Figure 1. Example of Typical Intake Rate Curve

The agricultural irrigation system designer assumes the system operator will apply the amount of water that will bring the soil moisture in the crop root zone up to field capacity. Sometimes additional water will be applied if leaching is needed to reduce harmful salts.

The basic intake rate that is given for many soils in most sprinkler design handbooks has been determined by cylinder infiltrometers. These rates are those measured for the various soils when they are between field capacity and saturation. In a similar manner, determination of an intake rate for a soil is this moisture range by using methods that have the characteristics of water application by sprinklers, will give an intake rate measurement that will be safe to use in sprinkler system design.

Equipment

The portable sprinkler-intake rate measuring equipment is an improved model of the portable sprinkler evaluation device developed by the Agricultural Research Service at Reno, Nevada and described in "Irrigation Engineering and Maintenance" magazine (5).

The equipment consists of a trailer-mounted water recirculating unit with a sprinkler head operating inside a circular shield, (Figure 2) 60 rain gages, 100 milliliter graduate, and recording forms.

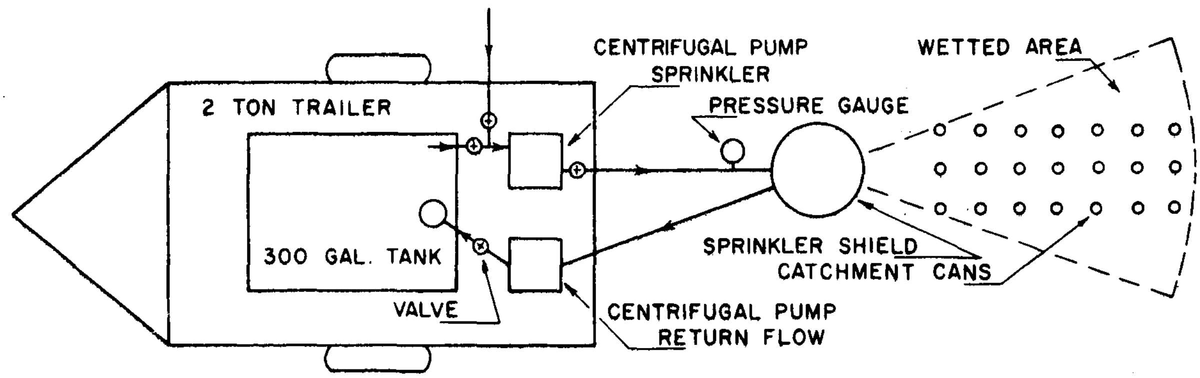

Figure 2. Layout of Equipment for Measuring Soil Intake Rate

The trailer-mounted water recirculation system consists of the following: a 2-ton capacity trailer, a 300-gallon water supply tank, two self-priming centrifugal pumps (one with sufficient capacity to deliver at least 100 gpm. at 50 psi. to the sprinkler nozzles, and the other capable of returning all excess water from the shield to the supply tank), flexible intake and discharge hose for both pumps, a pressure gage and four control valves. The screened intake hose and valve arrangement for the main pump make it possible to operate the sprinkler directly from irrigation canals or ditches, or it can be used to fill the water supply tank.

The portable irrigation sprinkler evaluation device described in "Irrigation Engineering and Maintenance" (5) is adequate for measuring the basic intake rates of medium and fine-textured soils. A larger shield (Figure 3) was constructed and the higher capacity pump installed to obtain a wider range of water application rates for measuring the intake rate of coarse-textured soils. A medium pressure sprinkler was modified to hold 5 sets of nozzles (Figure 4). The modified sprinkler operates

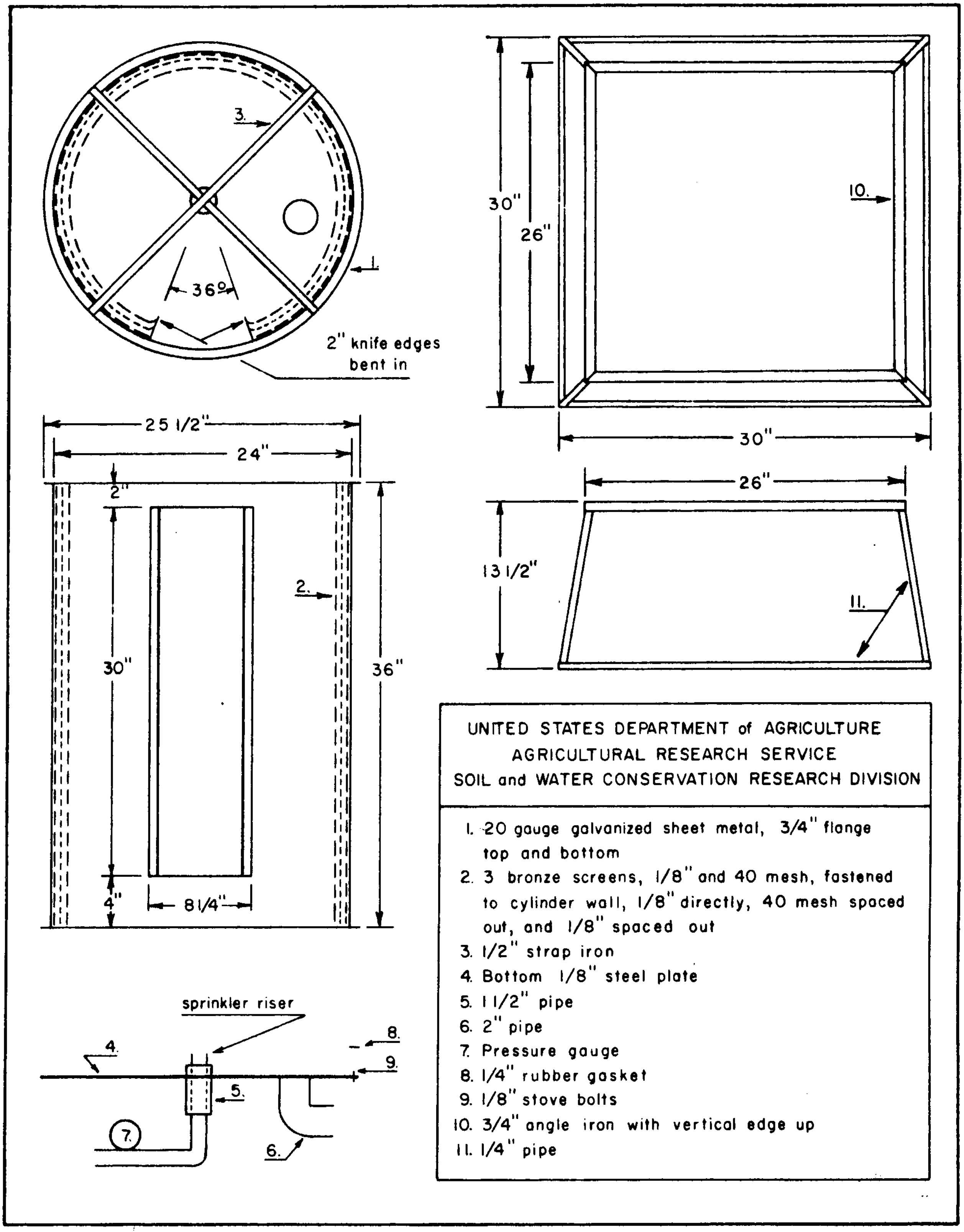

Figure 3. Revised specifications for sprinkler shield and stand.

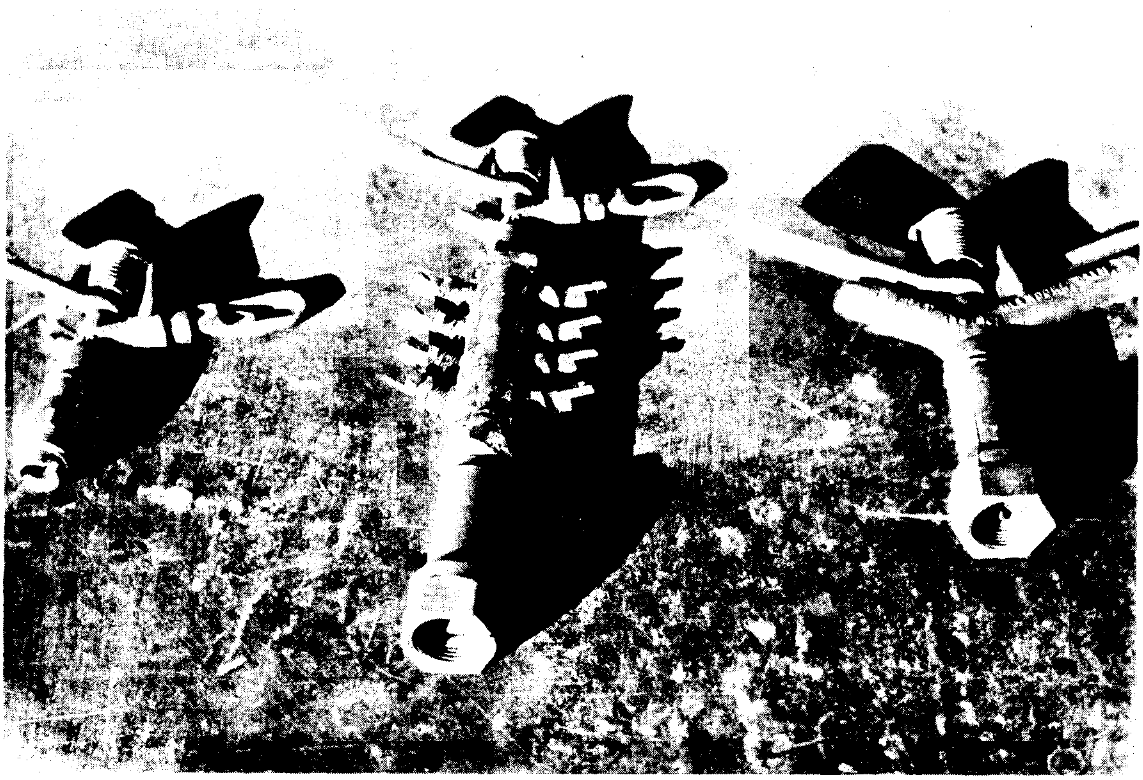

Figure 4 - Picture of modified sprinkler (center).

satisfactorily and by using a combination of various nozzle sizes and pump discharge it is possible to obtain the water application rate desired.

The circular shield is designed to allow a revolving head sprinkler to operate normally inside the shield. This is accomplished by placing various-sized brass screens inside the 24" diameter shield to dissipate the energy of the water jet from the sprinkler nozzle and allow the water to run down the sides of the shield. The shield is made from 20 gauge galvanized sheet metal.

An opening in the side of the shield and the installation of knife-edge deflectors at the edge of this opening allows the water jet from the sprinkler nozzles to spray on an arc of the field as it would in a normally operating sprinkler system. The arc of the field wetted from the opening in the shield is about one-eighth of a circle. The remainder of the water from the sprinkler is retained inside the shield and recirculated back to the tank on the trailer.

Method

The site on which the intake rate measurements are to be made is selected from typical soils in the field for which a sprinkler system is being designed. If soils vary over the field or farm, several intake rate measurements will have to be made. Soil profile characteristics should be determined at each measurement site. Depths of various soil layers, textures, initial soil moisture content of the soil, and any other special items such as plow pans, lime layers, etc. should be noted. These data will be useful for future soil correlation.

The equipment should be set up with the shield opening in position so that the operating sprinkler will cover the site selected for the intake rate measurements. It is preferable to set up the apparatus with the sprinkler jet going in the same direction as the prevailing wind.

If the soil at the site is not at field capacity, the sprinkler and a lawn soaker hose is used to irrigate the area and bring the soil up to field capacity before making the measurement.

After the soil has exceeded field capacity, three rows of pattern catch-cans are spaced at 5-foot intervals out from the sprinkler shield in the center of the wetted arc to determine the application rate. Figure 2 shows the layout of the equipment and pattern catch cans when in operating position.

The sprinkler is started and run for at least one hour. Water application is observed and notes made concerning whether the water is being applied too fast, too slow, or at just the right rate. Water is being applied too fast if it is standing on the soil surface when the sprinkler jet reaches the same point after a complete revolution of the sprinkler. If the water is soaking into the soil before the sprinkler jet has completed a rotation the intake rate of the soil is higher than the application rate. The maximum application rate is when the water being applied to the area just disappears from the surface as the sprinkler jet returns to apply more water to the same spot.

The sprinkler equipment is shut down after all areas have been observed and the soil reaction to the various rates of water application noted. Finally, the amount of water in the various cans is measured using a 100-ml. graduate and calculations are made to determine the application rate in each section of the test area. See Figure 5 which is a form used to record and calculate the optimum sprinkler design soil intake rate.

Results and Discussion

A number of field tests were run during the 1962 irrigation season in the irrigated area near Boise, Idaho. Water intake rates for sprinkler design were determined in conjunction with cylinder infiltrometer rates measured by S.C.S. personnel. The results, given in Table 1, show that the design intake rate for sprinklers is lower than the cylinder

SOIL INTAKE RATE FOR IRRIGATION SPRINKLER DESIGN

Date 8/8/62

Farm JIM MUNROE Location S-12, T-5-S, R-2-E OWYHEE COUNTY, IDAHO

Soil Type GARRETT SILT LOAM - G+ 1M4 Crop ALFALFA

Cropping History

Sprinkler Nozzle Size 3/16 X 7/32 Pressure 70 PSI

Test Started 1:48 PM Test Ended 2:48 PM

TEST DATA

Distance	Row 1		Row 2		Row 3		Average		Observed Intake Rate		
ft	cc	in.	cc	in.	cc	in	cc	in.	under	adequate	over
0	—	—	—	—	—	—	—	—	—	—	—
5	106	0.53	121	0.60	117	0.58	115	0.57			✓
10	81	0.40	88	0.44	85	0.42	85	0.42			✓
15	58	0.29	62	0.31	60	0.30	60	0.30			✓
20	54	0.27	57	0.28	57	0.28	56	0.28			✓
25	58	0.29	56	0.28	55	0.28	56	0.28			✓
30	58	0.29	59	0.30	57	0.28	58	0.29			✓
35	58	0.29	56	0.28	52	0.26	55	0.28		✓	
40	52	0.26	51	0.26	51	0.26	51	0.26		✓	
45	44	0.22	41	0.20	39	0.20	41	0.21	✓		
50	33	0.16	31	0.16	31	0.16	32	0.16	✓		
55	29	0.14	31	0.16	30	0.15	30	0.15	✓		
60	26	0.13	26	0.13	27	0.14	26	0.13	✓		
65	25	0.12	25	0.12	23	0.12	24	0.12	✓		
70	21	0.10	20	0.10	19	0.10	20	0.10	✓		
75	17	0.08	17	0.08	17	0.08	17	0.08	✓		
80	8	0.04	8	0.04	6	0.03	7	0.04	✓		

SOIL PROFILE

0 – 24"	24" –
80 % FIELD CAP. FINE SILT	SATURATED LOAM

Design Intake Rate AVERAGE FOR SPRINKLER = 0.26"/HR.

AVERAGE RING INTAKE AT 4 HR. = 0.39"/HR.

AVERAGE RING INTAKE AT 5 HR. = 0.29"/HR.

Figure 5

infiltrometer measurements obtained. The Nyssa silt loam soil had a uniform profile to a depth of 60" but there was a high sand content in the silt loam soil. In contrast the Garbutt silt loam had a uniform profile for 60" but was composed of very fine silt. The Moulten sandy loam had a 4" compacted layer between and 8" and 12" depths.

Table 1. Intake rates for sprinkler design

Soil type	Tests	Sprinkler design rate	Cylinder infiltrometer rate[a]	Crop
	No.	In./hr.	In./hr.	
Clay loam	1	0.18	0.34	Potatoes
Nyssa silt loam	3	0.33	0.71	Alfalfa
Garbutt silt loam	2	0.21	0.26	Alfalfa
Moulten sandy loam	7	0.20	0.24	Sugar beets, corn
Vinson fine sandy loam	2	0.27	0.23	Alfalfa
Loamy sand	1	0.74	-	Poor pasture

The intake rate under sprinkler irrigation should be lowest when measured on bare soils. Water drops from the sprinkler segregate the fine material into a thin compact layer at the soil surface. This was found to be the case by Duley (2) under rainfall conditions on bare soils. Sprinkler irrigation is similar to rainfall.

The equipment and method described could be used to determine the effects of droplet size and impact on soil structure and on the sprinkler design intake rate of a soil.

The method of measurement of intake rates for sprinkler design outlined in this paper should give results that will be safe under all irrigation conditions, because tests are conducted when the soil moisture of the root

a/ Cylinder infiltrometer measurements made by USDA, Soil Conservation Service personnel and is the average rate from five measurements made 4 hours after tests started.

zone is between field capacity and saturation.

For some sprinkler system designs the amount of water replaced by an irrigation may not be sufficient to bring the soil profile to field capacity, and the design intake rate could be higher than the one measured using the methods described in the paper.

Summary

A method for measuring the water intake rate into a soil for sprinkler design has been a need of the designer of sprinkler irrigation systems for many years.

The intake rate measuring equipment developed for sprinkler design purposes consists of a trailer-mounted water recirculating unit which operates a sprinkler inside a circular shield. The shield permits the sprinkler to operate over an eighth of the area normally covered by a sprinkler operating outside the hood.

The intake rate of a soil is a variable quantity as many investigators have found. Intake rate is measured using sprinkler equipment when the soil profile is near field capacity and thus should be approaching the lowest value on the intake rate-time of water application curve.

Intake rate measurement is made by bringing the test area to near field capacity, setting out three rows of pattern catch cans near the center of the area wetted by the sprinkler, and operating the sprinkler for a definite period of time while observing the intake of water in the soil at various places between cans. The area selected for measurement of the rate of application should be that where the water just disappears from the surface when the sprinkler nozzle has completed a revolution. Water caught in the pattern catch cans on either side or in the center of this area is measured, and knowing the time the sprinkler has been applying water, an intake rate can be calculated.

Results of 16 sprinkler-intake rate tests on 6 types of soil in the vicinity of Boise, Idaho are presented. Comparison of the sprinkler-intake rates with cylinder infiltrometer rates on the same sites indicate that the cylinder infiltrometer rates after 4 hours are higher and more variable than those measured by the sprinkler-intake rate measuring device.

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