MEASUREMENT OF FURROW INFILTRATION RATES MADE EASY[1]

D. E. MILLER AND W. W. RASMUSSEN[2]

Abstract

An irrigation system was developed for infiltration studies that utilized overflow controls to maintain nearly constant inflow into irrigation furrows. Furrow outflow was measured with HS flumes equipped with water-level recorders. Data were easily and rapidly converted to infiltration rates and cumulative infiltration by a computer.

Additional Index Words: **infiltrometer, plot irrigation, cumulative intake.**

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MANY DIFFERENT techniques have been used to measure infiltration rates in irrigation furrows. Doneen and Henderson (1953) used cylinder infiltrometers, and Bondurant (1957) blocked off a 30-cm length of test furrow. These approaches have three disadvantages in that a very small part of a furrow length is involved in the measurement, water is not flowing in the furrow, and there is possible disturbance of the soil during infiltrometer installation. Shull (1961) used a bypass furrow infiltrometer in which infiltration was measured in a small furrow segment. This has the same disadvantages as the ring infiltrometer, except that the whole furrow is being irrigated while the infiltrometer is in use.

Williams et al. (1957) measured the rate of inflow at the head of the furrow and the outflow at the bottom with the difference taken as a measure of infiltration rate. Shockley et al. (1959) detailed how to make such measurements with calibrated containers at the top and bottom of a furrow. Small trapezoidal flumes have been used to measure flow rates in individual furrows (Chamberlain, 1952). These procedures are satisfactory for a few measurements, but labor demands are excessive for a large number of furrows, or for repeated measurements and several irrigations. Mech (1960) used HS flumes equipped with water level recorders to measure inflow and outflow rates for individual plots. A continuous record of each irrigation was obtained, but the reduction of the data to infiltration rates and cumulative intake was tedious. Nance and Lambert (1968) developed a recirculating plot infiltrometer in which runoff from a furrow was returned to a supply tank. The water level in the supply tank, traced with a water-level recorder, showed the cumulative infiltration at any given time. This system worked well but was adapted to a small number of relatively small plots.

Rasmussen[3] developed a plot irrigation system that utilized overflowing controls to maintain near constant heads. This system worked well with large studies and was used by Miller and Aarstad (1971) together with a rapid, reliable means of processing data.

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[2]Soil Scientists, SEA, Federal Research, USDA, Prosser, Washington and Kimberly, Idaho.

[3]Rasmussen, W. W. Unpublished information on file at the Snake River Conser. Res. Cnt., Kinberly, Idaho.

Flow Control and Measurement

An inflow control unit, like that developed by Rasmussen, is shown in Fig. 1, and the field installation used by Miller and Aarstad shown in Fig. 2. The overflow control was made from an 80-liter steel barrel and the overflow catchment from the bottom of a 115-liter steel barrel. The latter unit was supported by blocks or firm soil to maintain the overflow surface level. Water was delivered to each control through aluminum pipes joined with reinforced rubber tubing under a head of at least 60-cm above the overflow surface. Water flowed under constant head to each furrow through a horizontal 10-cm aluminum pipe with drilled orifices on the underside to give the desired flow rate. Orifices of several sizes were made around the pipe, and those not used during an irrigation were sealed with rubber stoppers. Inflow rates could be changed easily during an irrigation by rotating the pipe and changing stoppers. To apply different rates of inflow to furrows in adjacent plots, the pipe was cut into appropriate lengths and joined with rubber tubing. This allowed desired orifices to be selected independently for each plot. The pipe was maintained horizontal with wood or cement block supports under each joint or at about 3-m intervals. A single overflow unit was used satisfactorily to service 50 to 60 furrows covering 30 to 50 m.

The unit in Fig. 1 maintained a water head of 56 cm at the orifice with negligible fluctuation (61- and 28-cm heads also have been used satisfactorily). Flow rates per furrow were varied from about 3 to 12 liters/min, requiring orifices from 0.56 to 1.03 cm in diam. with the 56-cm head. During an irrigation, the flow from an individual orifice was essentially constant and the variation in flow rate among orifices along a length of pipe was less than ±3% of the average flow of all orifices. Trash was prevented from entering the horizontal distribution pipe by a plastic screen placed in the overflow barrel.

The study by Miller and Aarstad (1971) involved about 1.5 ha with 12 control units each irrigating 17 to 20 furrows, 76 cm apart and 60 m long. Irrigation of all plots could be started within 15 to 30 min. No further attention was required, except occasional inspection for plugged holes. Inasmuch as the flow rate into each furrow varied slightly with hole smoothness and inaccuracies in leveling the pipe, actual flow rates were measured with a 4-liter can and a stop watch. In this study plots were six furrows wide. The outflows from the four center furrows of each plot were combined and measured with an HS flume (18 cm deep) equipped with a water-level recorder (Fig. 2).

Reduction of Data

Flumes were individually calibrated over a flow range of from 0 to about 23 liters/min. Variation among flumes was

Table 1—Example of table sent to computer center for conversion to infiltration rates. Table continued through complete irrigation of 24 plots.

Experiment 1—Location data
Irrigation 3—Date
Year 1

Equation $Y = 0.0033z + 0.1780z^4$

Plot no.	Treatment. replication	Inflow constant	Value of z at indicated hour 1	2	4	6	8	10	12
		cm/hr	cm						
1	4.2	0.518	0.0	0.40	0.60	0.70	0.80	0.82	0.85
2	1.2	0.505	0.72	1.00	1.12	1.15	1.18	1.18	1.18
3	5.2	0.508	0.0	0.60	0.90	0.98	1.00	1.00	1.00
4	2.2	0.513	0.0	0.0	0.0	0.38	0.44	0.48	0.52
5	3.2	0.505	0.0	0.0	1.00	1.07	1.07	1.07	1.07

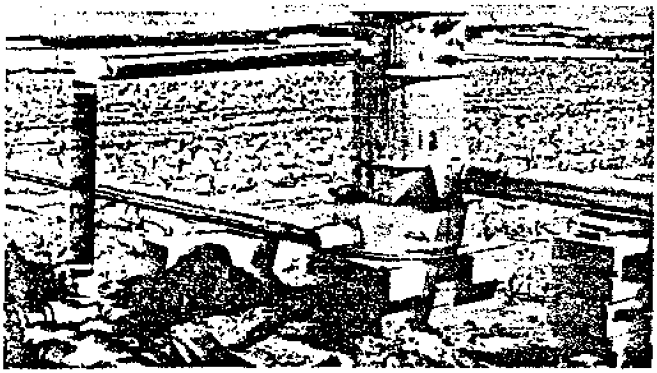

Fig. 1—Overflow control unit to regulate inflow rates into irrigation furrows. The 10-cm aluminum pipe is level and has an orifice above each furrow.

so small that a single calibration curve was used. The calibration curve was combined with the water-level recorder gear ratio, recorder chart width, and field plot size to give an equation

$$Y = 0.0033z + 0.1780z^2$$

where Y is the flume discharge in centimeters per hour and z is the distance in centimeters from the base line to the outflow trace on the recorder chart (Fig. 3). With the inflow rate known and constant, the infiltration rate at any time was obtained by the difference.

Reduction and summarization of the data were simplified by utilizing the computer center at Washington State Univ. They were supplied with a table for each irrigation (Table 1), listing the inflow rate to each plot and the distance z at selected time intervals. For the study involved, data were given for 2-hour intervals during the first 24 hours, and at 6-hour intervals thereafter. The table was coded to give replication and treatment number. The computer center returned a tabulation of infiltration rates and cumulative infiltration at the selected times, together with an analysis of variance for each table. The reduction of data thus amounted to measuring distances on the recorder chart at selected times, completing the table, and mailing it to the computer center. A complete irrigation record of 30 to 40 plots could be prepared in about 3 to 4 hours.

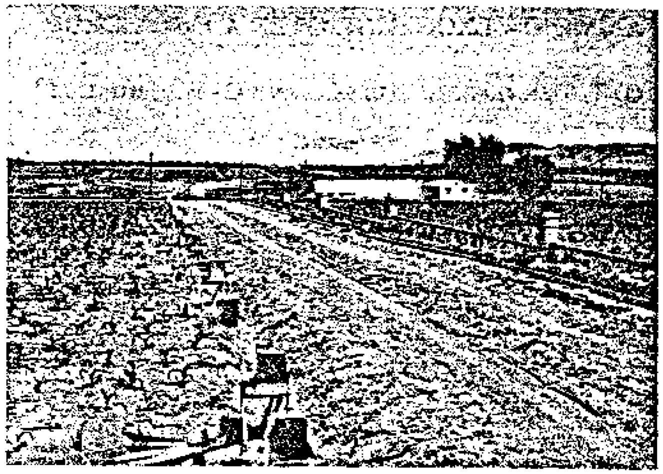

Fig. 2—General view of furrow infiltraton rate measuring equipment. The HS flumes measure outflow from the lefthand set of plots. The overflow units control inflow to the righthand set of plots.

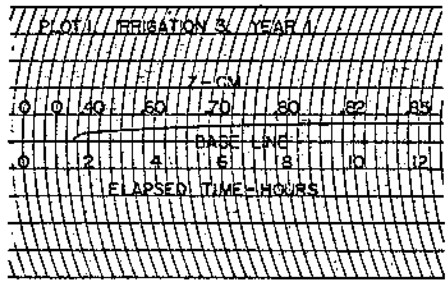

Fig. 3—Example of water level recorder chart and corresponding values of z for equation $Y = 0.0033z + 0.1780z^2$. Data are from Plot 1 and correspond to treatment 4, replication 2 in Table 1.

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