DISTRIBUTION RATES AND PATTERNS FROM PLASTIC SUBIRRIGATION PIPE*

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INTRODUCTION

Better irrigation methods are required to conserve our limited water resources for increased crop production. Interest has recently been renewed in subirrigation methods as a means of saving moisture.

The usual subirrigation methods that depend on high water tables to supply moisture to growing crops have proved unsuitable in arid and semiarid regions where salinity problems develop with rising water tables (3). These techniques are limited to very specific soils with low soluble salt contents and an impervious subsoil so that the depth of the water table can be controlled.

A recent method described by Zetsche (4) and Busch (2) uses buried pressurized plastic pipes to supply water to the soil. The distribution of soil moisture depends on its unsaturated movement within the soil profile without raising the water table. This technique shows promise in overcoming the salinity problems associated with other subirrigation methods. Additional advantages of this method include a greater water use efficiency and the reduction in the operational labor.

This paper reports the results of a study conducted at the Experimental Farm, Swift Current, to determine pressure changes in plastic pipes, water delivery rates from a subsurface water distribution system and to evaluate the technique of subirrigation under local conditions.

MATERIALS AND METHODS

Laboratory Tests

Laboratory tests were conducted to determine water discharge rates at different pressures from holes of two sizes in ½-inch (I.D. 0.622 inches) plastic pipe. The pressure decreases along the perforated pipe were measured and used to calculate the maximum length of laterals.

A test box, 48 feet long, was divided into compartments one foot square, each equipped with a ¾-inch copper overflow tube (figure 1). A 48-foot, nominal ½-inch polyethylene pipe (wall thickness 0.077 inches) was placed lengthwise on the cross partitions. Holes of 1/16-inch diameter were drilled at 12-inch centers for the first test. The holes were enlarged to 3/32-inch diameter for the second test. The test pipe was connected to a water supply and pressure gauges were attached to both ends of the test pipe. Water discharged in the horizontal direction from the holes in the pipe wall.

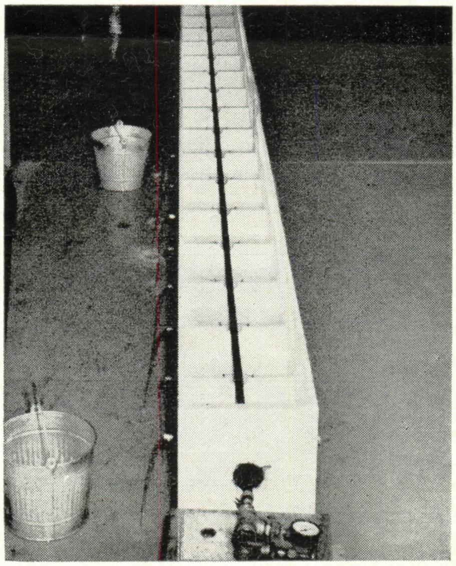

Figure 1. Test box showing partitions, pipe and the pressure gauge at the inlet end of the pipe.

Field Tests

A field experiment was conducted under a crested wheatgrass stand growing on sandy loam soil to measure water movement from the pipes to and within the soil. Eight 50-foot laterals were spaced 40, 50, 50, 50, 60, 70 and 80 inches apart in trenches 6 inches wide and 16 inches deep. Because the water application rate was

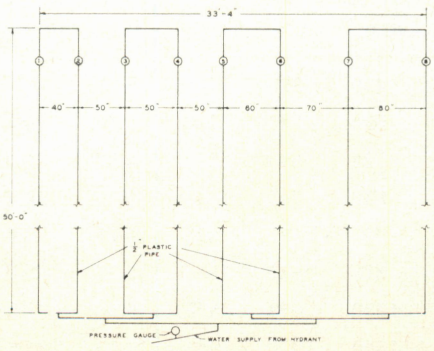

Figure 2. Plan of the field subirrigation layout.

calculated for the 50-inch spacing, this spacing was triplicated (figure 2). Individual laterals were connected at both ends in a manner used by Zetsche (4) to equalize the water pressure throughout the system. Before placing, holes of 1/16-inch diameter were drilled through the pipe, creating double holes at 24 inch centers. Double holes were used in field tests to eliminate any possibility of asymmetrical water distribution with respect to a lateral line which could have resulted from 12-inch spaced staggered holes. Horizontal positioning of drilled holes was maintained by stakes and clamps. The plastic pipes were then covered with two inches of coarse sand before backfilling. A pressure gauge on the inlet pipe and a domestic water meter in the supply line were included in the system. A vertical grid of approximately one foot was established across the laterals for soil sampling purposes. Two subirrigations were applied at a rate calculated to supply three inches of water where the laterals were spaced 50 inches apart. This resulted in a greater application rate at narrow spacings and less at wider spacings because the water discharged at a uniform rate from each lateral line. The average rate of field application was about 1 ½ inches per hour. Prior to the test, soil samples for moisture content and electrical conductivity were taken with a small tube sampler. Before the test the soil was very dry, approaching the wilting point. Twenty-four hours after each subirrigiation the soil was again sampled for moisture determination. The first line of sampling holes was located two feet from the inlet end at right angles to the laterals. The second line was located 10 feet further towards the center to exclude the effect of the soil disturbance caused by gravimetric samplings. Soil moisture contents were calculated and the distribution pattern across the lateral lines was marked on a section diagram (figure 3). Soil salinity changes will be assessed after several seasons of subirrigation and were not included in this paper.

RESULTS AND DISCUSSION

Laboratory Test

Water discharge from round holes was controlled by their size and the pressure in the pipe. The standard orifice equation (1) for discharge rate is:

$$Q = CdA \sqrt{2\ gh} \qquad 1$$

where Q = volume of water in cm^3

Cd = orifice discharge coefficient

A = area of orifice in cm^2

g = acceleration due to gravity in cm/sec^2

h = pressure head in cm

The average discharge from the line during the laboratory test was used for calculating the coefficient of discharge. Test results (table I) showed that sufficient pressure control along the pipe could be achieved only if the holes were relatively small in relation to the pipe diameter. The test with 1/16-inch diameter holes in the pipe showed approximately 20 percent reduction in the water pressure at the down stream end of the 48 foot long pipe. In contrast the pressure decrease was 75-80 percent at the far end of the pipe when 3/32-inch diameter holes were tested. It was concluded from these tests that 3/32-inch diameter holes were too large at 12-inch spacings to achieve any uniformity of water distribution along the 48-foot lateral. As the smaller 1/16-inch diameter holes in the test pipe resulted in a better water and pressure distribution, that design was chosen for field tests.

Field Tests

Field tests provided data for calculating *in situ* discharge rates from the pipe and indicated the water distribution pattern in the soil. At 19 psi pressure the calculated discharge rates in the soil were 280 and 339 cubic centimeters per minue per hole for the first and second application respectively. These corresponded to 38 and 48 percent of the amount measured in the test box. The rate during the second application was higher which seemed to indicate that the previous irrigation had pushed sand particles away from the discharge holes, providing more space for the water to escape. The moisture content of the soil prior to second irrigation was higher which could have influenced the absorption rate.

The 16-inch depth for subirrigation lines as suggested by Zetsche (4) was satisfactory. Irrigation water moved upwards close to the soil surface by capillary forces but no changes in the colour of the soil usually associated with increased moisture were observed at the surface, nor were any soil moisture increases detected by gravimetric samplings near the soil surface.

Subirrigation at lateral spacings up to and including 60 inches was sufficient to increase soil moisture supply in the first four feet of the soil profile, except at the immediate soil surface (figure 3). After the first application of water a dry area in the soil profile existed between 60 inch spaced laterals. This uneven distribution was caused by the light application of water rather than too wide a spacing. The top two inches of soil remained dry as observed visually and confirmed by soil samplings. Crested wheatgrass stand exhibited drought symptoms where soil moisture was shown to be low by soil samplings. The moisture distribution pattern at 70 and 80 inch spacings was uneven throughout the entire length of the test area and the grass showed discoloration and restricted growth. Subirrigation that maintains a low moisture content near the soil surface may be useful for weed and evaporation control. Salinization control may also result from the use of such an irrigation method.

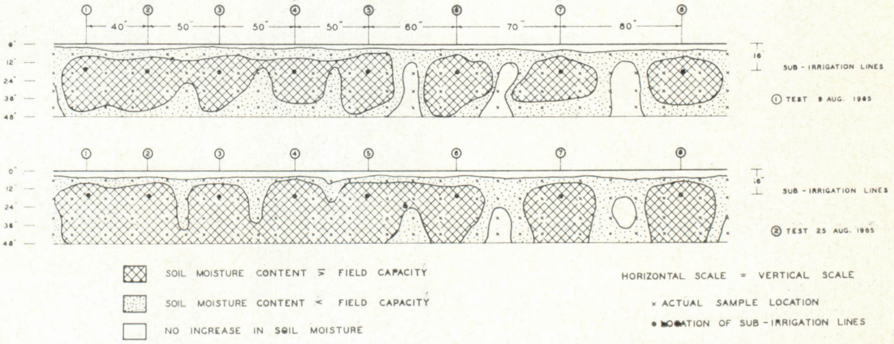

Figure 3. Soil moisture distribution from subirrigation lines.

TABLE I. WATER DISCHARGE RATES, PRESSURE CHANGES AND CALCULATED Cd VALUES WITH 1/16 AND 3/32-INCH DIAMETER HOLES AT 12-INCH SPACINGS IN HALF-INCH NOMINAL PLASTIC PIPE

Water inlet pressure in psi	Diameter of holes	Discharge rate in ml/minute from openings in pipe at following distances from the inlet end: 1 ft.	10 ft.	20 ft.	30 ft.	40 ft.	47 ft.	Average dis-charge ml/min.	Calc-ulated Cd value	Water pressure at the far end as % of inlet pressure
10	1/16"	650	600	510	450	430	390	505	0.42	60.0
20	"	920	880	750	680	630	580	740	0.40	80.0
30	"	1120	1070	875	750	725	680	870	0.37	76.5
40	"	1340	1270	1150	885	830	765	1040	0.39	80.0
10	3/32"	1340	1140	1050	830	530	385	894	0.42	5.0
20	"	1905	1815	1515	1155	870	625	1314	0.37	20.0
30	"	2375	2065	1825	1545	1230	860	1650	0.38	23.0
40	"	2800	2570	2140	1740	1460	1070	1963	0.39	25.0

SUMMARY AND CONCLUSIONS

Laboratory tests with half-inch plastic pipe showed that water discharge rates from the 48-foot long test pipe were more uniform with 1/16-inch diameter holes than from 3/32-inch diameter holes both spaced at 12-inch centers. Longer lateral lines were possible with smaller diameter holes in the pipe wall.

Field test showed satisfactory moisture distribution in the top four feet of soil profile from perforated plastic pipes placed at 16-inch depth. Lateral spacings up to and including 60 inches were close enough to cause a general soil moisture increase in a sandy loam soil below a crested wheatgrass stand. No soil moisture increase was observed in the top two inches of the soil profile.

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