Irrigation and Drainage Letter

Agricultural Extension Service **University of California**

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LARRY BOOHER'S RETURN DELAYED

Larry Booher planned to be back on the job August 15. Just before terminating his sabbatical leave in Rome, he suffered a perforated abdominal ulcer. After receiving two blood transfusions he made good recovery and is returning to Davis.

ALL GLUED HOMEMADE TENSIOMETER

The "missing link" has been found by Herb Paul and one of his cooperators: It is a piece of plastic tubing connecting the sight glass with the plastic tee eliminating the need for filler material. See attached information.

ROOT GROWTH IN RELATION TO SOIL MOISTURE

Luke Werenfels discusses his research carried out during his sabbatical leave. Root growth of apple trees was studied and related to soil moisture and seasonal effects. See attached sheets.

WATER PENETRATION UNDER DIFFERENT SOIL SURFACE MANAGEMENT PRACTICES

Philip Hamaker, a visiting student from Holland, did a careful job of evaluating well-replicated soil surface management experiments on the Nickels property in Colusa County. See attached information.

TRANSPIRATION RETARDANT INVESTIGATIONS

Dr. Hagan discusses the research carried out on two approaches to reduce transpiration: Plastic sprays which form a film covering the stomates of the leaves and reflectants, which by reflecting part of the solar radiation reduce the energy available for evaporation from the leaf surface. Note attached information.

RATE OF ADVANCE METHOD FOR DETERMINATION OF INTAKE CHARACTERISTICS OF BORDERS AND FURROWS

This method which was developed at Utah State University is discussed in detail because it offers many advantages over the cylinder infiltrometer method, the main one being the elimination of variability inherent with infiltrometers. Note attached information.

COMING EVENTS

November 2-4, 1966 - National Meeting of the Irrigation and Drainage Division of the ASCE, Star Dust Hotel, Las Vegas, Nevada.

November 13-18, 1966 - Annual Convention National Reclamation Association, Albuquerque, New Mexico.

January 24-25, 1967 - California Irrigation Institute, Hotel El Rancho, Sacramento, California

Werenfels - Booher - Houston - Marsh

CO-OPERATIVE EXTENSION WORK IN AGRICULTURE AND HOME ECONOMICS, U. S. Department of Agriculture and University of California co-operating

DRAINAGE STUDY OF SOLANO IRRIGATION DISTRICT

A graduate student made the above study of the effect of imported irrigation water on rise in water tables. Copies are available through the Davis office.

CANAL WATER TEMPERATURE STUDIES

Dick Schade reports on the studies and the effect on soil temperatures in orchards.
See attached pages.

THE ALL GLUED HOMEMADE TENSIOMETER

Finally we have a homemade tensiometer which can be assembled of parts that all fit snugly. The "missing link" in Chet Hemstreet's design (Irrigation & Drainage Letter, January 1965) was the connection of the Plexiglass sight glass with the plastic tee. Previously, resin was used to fill the gap between the two. Now a cooperator of Herb Paul in San Joaquin County found that P.V.C. 2110 Schedule Pipe, Type II high impact, Schedule A fits snuggly over the sight glass and into the plastic tee. This pipe has an O.D. of 0.84" and an I.D. of 0.74".

San Joaquin Sulfur Company, a farmer's supply house at Lodi, assembles the top -- Plastic tee + brass bushing + gage + P.V.C. 2110, Schedule A sleeve + sight glass + stopper -- and sells it to the growers at a nominal fee. The grower chooses the length of the plastic pipe to suit his need. All he then does is to glue the ceramic cup on and glue the pipe into the tee.

Herb prepared a 1-sheet handout containing the diagram of Hemstreet's design on one side and a list of the local suppliers on the other. This has been very successful. As a consequence a large number of tensiometers were made up by growers. With the new improvement, Herb is experiencing practically no leaky tensiometers any more.

ROOT GROWTH IN RELATION TO SOIL MOISTURE

During my sabbatical leave, I had an opportunity to work on root growth of an apple root stock in relation to soil moisture. The major part of the work was carried out in a greenhouse having removable sides. These protected the plants from rain but otherwise offered climatic conditions typical for a humid temperate zone climate (Federal Horticulture Experiment Station at Wadenswil, Switzerland).

I worked with mist-propagated, rooted cuttings of the East Malling Root stock type VII, which I planted in wafer like containers holding about 16 gallons of soil each. The dimensions were 39 inches x 39 inches x 2.35 inches. Thus a medium was created in which the root could extend in two dimensions unhindered over a long period of time. The two large sides of the containers were made out of glass, for observation. Twenty-four of these containers were suspended on rails on a frame structure and covered with black plastic. For observation, the containers could be rolled apart thus permitting access. In between observations, the containers could be rolled together in order to create a compact arrangement. The containers were filled with a loam soil to which Pearlite was added in order to increase the porosity.

The four treatments consisted of differential irrigation schedules with enough water added during each irrigation to bring the whole soil profile back to field capacity, with as little drainage as possible. Salt build up was prevented by irrigating with distilled water. Nitrogen was added to the soil at the start of the experiment only. Treatment A was irrigated when the tension at the 8 inch depth reached 20 centibars; treatment B when it reached 40 centibars; treatment C when it reached 80 centibars; and treatment D was unirrigated. After planting, two irrigations were given to all the treatments. The treatment limits imposed resulted in 18, 5, 3 and 0 irrigations respectively.

Measurements of root and shoot growth were made at weekly intervals throughout the growing season. The number of growing roots, the length of new growth, and the rate of suberization were recorded. When the lateral limits of the container were reached, by the first roots, the vertical and lateral spread of the root system was measured in all the containers. At the end of the experiment, all the tree parts were harvested and the dry matter determined.

Some of the more pertinent results are the following:

1. Seasonal Periodicity in Growth

Greatest rate of root growth occurred at the end of August, greatest rate of shoot growth at the beginning of July.

Six root growth maxima interspersed by six root growth minima gave root growth an undulating appearance. The maxima followed each other at an interval ranging from 2-4 weeks. Each maxima was preceded from 2-10 days by an air temperature maximum. Shoot growth maxima on the other hand coincided with air temperature maxima early in the season.

It seems that during air temperature maxima, which under the climatic conditions of Wadenswil also reflect daily sunshine duration maxima, carbohydrate synthesis is at a maximum and shoot growth benefitted directly. During the ensuing drop in temperature, translocation of sugars to roots is at a maximum, setting off a new flush of root growth. Soil temperature had a direct effect on root growth only when it became limiting, which was at the end of the experiment.

2. Soil Moisture

The number of growing roots increased sharply after an irrigation. The increase was detectable in less than 7 days. Response in shoot growth occurred from 7 to 14 days following an irrigation.

There was no difference between mean length of new root growth with the different treatments.

3. Patterns of Root Growth

Significantly greater horizontal spread occurred in the wet treatments. Differences in depth penetration were not significant.

4. Dry Matter of Tree Parts

All plant components decreased in gramm dry matter in the direction from the wet to the dry treatments. This decrease was most pronounced with shoots and leaves and least with the stem and the roots. This brings about the well known relationship of a relative increase in dry matter of roots over shoots of plants being under moisture stress. Surprisingly, the stems (previous year's growth) in the dry treatments also increased percentagewise.

Wilt symptoms were not apparent in any of the treatments. The plants of the drier treatments just adopted a xerophytic growth habitat by reducing their leaf size and their shoot growth.

5. Root Hair Growth

An experiment was set up with small plexiglass containers which permitted direct observation of root hair under a low power binocular microscope. Under conditions of high transpirational stress and high soil moisture stress, a daily fluctuation in

root hair growth was observed. During the night, root hairs grew more than during the day. This fluctuation disappeared when the plants were put in a water-saturated atmosphere.

WATER PENETRATION UNDER DIFFERENT SOIL SURFACE MANAGEMENT PRACTICES

An experiment was established on the Nickels property in Colusa County in the fall of 1964. The Nickel's property was turned into the Nickel's Soils Laboratory by the will of the late Leslie J. Nickels. He left his estate for the purpose of creating a research facility which would permit finding answers to soil and water management problems of Colusa County. A trust was created which is administered by the Department of Soils and Plant Nutrition of the University of California, Davis. A graduate student, Philip Hamaker, was engaged to evaluate, among other things, a soil management experiment. Tom Aldrich provided generous assistance.

The treatments were:

A. Cultivation, i.e. discing to control the growth of a volunteer winter cover crop; discing, cultipacking and rolling to achieve a smooth surface for harvesting operations.

B. Clipping, i.e. mowing to control the growth of the winter cover crop until growth ceased, without working under or removing the mulch.

C. Spraying, i.e. controlling the growth of annual weeds with chemicals.

Each treatment covered an area included by 4 trees and was repeated 9 times resulting in a total of 27 plots. The layout was a randomized complete block. Each plot was evaluated by four 18-inch diameter single ring infiltrometers. Thus a total of 108 infiltrometers were run. They were placed at the drip line of each tree. Infiltration measurements were made in January of 1965 and in February of 1966. Accumulative inches of water infiltrated in 60 minutes were compared.

The results are shown in the table below.

	Accumulative intake in inches	
	1965	1966
cultivated	1.76	2.96
chopped	1.71	3.11
sprayed	1.36	2.26

The difference between years was probably due to lower soil moisture at the time of the test in 1966. Treatment differences were not significant in 1965, but in 1966 the spray treatment showed significantly slower penetration than the other two treatments. This is in accordance with the work we did with Dr. Proebsting. (California Agriculture, May, 1963). Hamaker attributed the lack in difference between cultivating and chopping to the time of the year the infiltration tests were run. Then the disced plots had a lot of weed growth too.

We should be careful in not drawing the wrong conclusions from this and condemn spray cultivation.

In situations where we have a traffic pan or a disc pan, the improvement in subsurface structure of the soil most likely more than offsets the deterioration in surface structure than offsets the deterioration in surface structure (surface sealing) due to spraying. This might not show up in short term infiltration experiments but would be reflected in a greater basic intake rate. However, in some instances, surface sealing is a problem and must be overcome by applying organic or inorganic mulches on the surface of the ground, or by light discing.

TRANSPIRATION RETARDANT INVESTIGATIONS

Less than 1% of the water absorbed by plant roots is retained within the plant, and a considerably smaller percentage is contained in the harvested crop. Water use by plants actually constitutes the least efficient step in the processes of water storage, conveyance, irrigation, and conversion to harvested crops.

This project seeks to increase utilizable water supplies by reducing water losses from crop plants and ornamentals and also from watershed vegetation, if sufficiently inexpensive transpiration retardants can be developed. Transpiration retardants possibly could also increase crop production by reducing water stress during critical growth stages; preventing flower, fruit and leaf drop under stress conditions; and maximizing size and turgor of fruits and vegetables prior to harvest. Retardants may also reduce salt injury to crops and ornamentals, possibly permitting satisfactory production with irrigation water of relatively poor quality.

Two approaches are under study: (1) spraying leaves with plastic emulsions to form a film with a low permeability to water vapor but with a relatively large permeability to carbon dioxide and oxygen and (2) covering leaves with highly reflective materials to reduce heat energy available for transpiration. These studies are being conducted by a group led by Dr. Robert M. Hagan, professor of Water Science at Davis.

To be a satisfactory transpiration retardant of the film forming type, a material must be found which is relatively impermeable to water vapor while quite permeable to carbon dioxide and oxygen. In addition, the material must be nonphytotoxic and be capable of forming a good film which is flexible and resistant to breakdown in sunlight or to decomposition by micro-organisms. A number of plastic emulsions have been checked, but no suitable material yet has been found. Cooperation has been established with several chemical companies to encourage development of improved materials. Principal problems involve the obtaining of a plastic with desired differential permeabilities to water vapor and to carbon dioxide and oxygen, and one which will be non-toxic and form an acceptable film.

Available materials are being studied in the laboratory and in both the greenhouse and field. In the laboratory, simultaneous measurements are being made on transpiration and photosynthesis using single leaves under carefully controlled conditions. The materials so far studied tend to reduce both transpiration and photosynthesis. In some cases, a reduction in photosynthetic rate may be acceptable if the retardant causes a sufficient reduction in water use rate or leads to other beneficial effects.

Another problem with present materials is the rapid loss in effectiveness. The cause of this is under study.

The application of a reflective material similar to whitewash or kaolinite to leaf surfaces may reduce significantly the amount of solar radiation absorbed by the leaf, mainly in the visible part of the spectrum. This results in reduced transpiration. The reflected material may also reduce photosynthesis under conditions of low light intensity. However, excessive water use occurs primarily under conditions of high

light intensity where the reflection of heat energy may increase the net photosynthesis. The application of too thick a layer of reflective material can also block stomatal openings causing a reduction in photosynthetic processes.

The use of transpiration retardants to achieve water economy and, in some cases, more favorable plant growth is extremely promising in principle. However, no satisfactory material has yet been developed of the plastic emulsion type. Use of inexpensive materials as leaf reflectants may have promise under conditions of very high light intensity.

Further progress reports will be supplied later.

RATE OF ADVANCE METHOD FOR DETERMINATION OF INTAKE CHARACTERISTICS OF FURROWS AND BORDERS

Several years ago, a group led by J. Christiansen developed this rate of advance method at Utah State University, Logan, Utah. They checked it against cylinder infiltrometer tests and obtained good to perfect agreement. In California, Herb Paul checked it for furrows and I did the same for borders and found good agreement also.

As there are no complicated or laborious measurements to be taken, the rate of advance method lends itself very well to evaluating soil, crop and water managements effects on water penetration. Three prerequisites are necessary.

1. Constant inflow.
2. Uniform grade of the land down border or furrow.
3. Predominance of one soil type down furrow or border.

These prerequisites frequently can be met in California.

Although it is not necessary to know its derivation in order to apply the method, it is included here for those who like to know the why in addition to knowing the how. The basic idea is that the higher the intake the slower the water will advance. Making use of the law of the conservation of mass, one can say that the water infiltrated at any time t is equal to the water turned into the furrow or border in time t minus the water remaining on the surface at time t. For simplicity's sake we divide our terms by the area and arrive at the average depth of water infiltrated, which is equal to the depth applied minus the depth remaining on the surface

Thus

$$Da\ SL = Q \cdot t - AL \text{ or dividing by the area } S \cdot L \qquad (1)$$

$$Da = \frac{Q \cdot t}{S \cdot L} - Ds = \frac{q \cdot t}{L} - Ds \qquad (2)$$

where:

L = Length of furrow or border strip wetted in time t
Q = Rate of flow entering the furrow or strip assumed constant
S = Spacing of furrows or borders

$q = \frac{Q}{S}$ = Rate of flow per unit width

t = time

Da = Average depth of water that has entered the soil as it flows down a furrow or border strip on a uniform grade in time t.

Ds = Equivalent average depth of water on the surface

Almost all the data obtained from cylinder infiltrometers and other methods show that infiltration rate can be expressed by the formula

$$I = K \cdot t^{n} \tag{3}$$

where

I = The intake rate at any time t

K = A constant representing the instantaneous intake rate at time t = 1

n = Exponent which is always negative with values between 0 and -1

D = Accumulative depth of water that has entered the soil in an infiltrometer in time t

The formula for accumulative intake is obtained by integration of formula (3).

$$D = \int_{o}^{t} I \, dt = \int_{o}^{t} K \cdot t^{n} \, dt = \frac{K \cdot t^{n+1}}{n+1} \tag{4}$$

When plotted on log log scale paper, equations 3 and 4 become straight lines. The intercept with the x-axis at time = 1 then is the K value for equation (3), and the $\frac{K}{n+1}$ value for equation (4) respectively. The slope of the line then yields the n value (equation 3) or n+1 value (equation 4).

To obtain the term average depth infiltrated over the border at time t we have to integrate the equation for accumulative intake from time 0 to time t, and divide by t. This we may visualize as follows. Let us assume the water advanced for 10 minutes. At the turnout, the intake opportunity time would have been 10 minutes and at the waterfront 0 minutes. Therefore, we have to integrate the infiltration equation from 0-10 minutes in order to get the total depth infiltrated. To get the average we divide by the time, that is by 10.

$$Da = \frac{1}{t} \int_{o}^{t} D \, dt = \frac{1}{t} \int_{o}^{t} \frac{K \cdot t^{n+1}}{n+1} \, dt = \frac{1}{t} \, \frac{K \cdot t^{n+2}}{(n+1)(n+2)} = \frac{K \cdot t^{n+1}}{(n+1)(n+2)} \tag{5}$$

Substituting the value of Da from equation 5 in equation 2 we have

$$Da = \frac{K \cdot t^{n+1}}{(n+1)(n+2)} = \frac{q \cdot t}{L} - Ds \tag{6}$$

Ds can be either measured or determined graphically. In border irrigation it is fairly easy to measure the average depth of the water, in furrows this is more difficult. It is not necessary to measure the depth because there is a graphical method for doing it: $\frac{q \cdot t}{L}$ is plotted versus time on log-log paper. A curve concave upwards results. By trial and error, a value for Ds is found which when subtracted from $\frac{q \cdot t}{L}$ will yield a straight line. This straight line then is a graph of the function

$$\frac{K \cdot t^{n+1}}{(n+1)(n+2)}$$

The intersect of this straight line with the x-axis at time t = 1 is the value of

$$\frac{K}{(n+1)(n+2)}$$

The slope of the line is the value of n+1. This permits figuring the values for K and n and thus the infiltration equations (3) or (4) can be written up.

An example taken from a border irrigation trial shows the procedure. The inflow was 2.24 cfs. Since our units are feet and minutes, we have to change ft^3/sec to ft^3/min. $2.24 \cdot 60 = 134.4$ ft^3/min. The border was 30 ft. wide, so the unit flow is $\frac{134.4}{30} = 4.4$ $ft^3/min/ft$. We then proceed and compute $\frac{q \cdot t}{L}$ from our rate of advance data. For the 100 foot station, for instance, this is $\frac{4.4 \cdot 6}{100} = .264$.

L Feet	t Minutes	$\frac{q \cdot t}{L}$	$\frac{q \cdot t}{L}$ - Ds Ds=.250	$\frac{q \cdot t}{L}$ - Ds Ds=.205	$\frac{q \cdot t}{L}$ - Ds Ds=.220	$\frac{q \cdot t}{L}$ - Ds Ds=.235
0	0					
100	6	.264	.014	.059	.044	.029
200	13	.286	.036	.081	.066	.051
300	20	.294	.044	.089	.074	.059
400	28	.308	.058	.103	.088	.073
500	36	.308	.058	.103	.088	.073
600	45	.330	.080	.125	.110	.095
700	54	.339	.089	.134	.119	.104
800	64	.352	.102	.147	.132	.117
900	73	.357	.107	.152	.137	.122
1000	84	.369	.119	.164	.149	.134

By trial first .250 was subtracted from $\frac{q \cdot t}{L}$ and it yielded a curve concave downward (Fig. 1). Then .205 was tried and it was not enough, because it yielded a curve concave upwards; 0.220 was still not enough but .235 was good because it yielded a straight line.

The crux of the problem is selecting the right Ds. Frequently when using small streams for border irrigation, the water reaches the 50 foot or 100 foot station before the average depth of water on the ground surface has built up. As a result of this, the first points on the $\frac{q \cdot t}{L}$ curve are too low to fit the rest of the curve. And by subtracting a constant Ds a straight line cannot be achieved. In this case, the first two stations have to be left out. This is not a serious problem if long runs including many stations are used.

In our example the intersect at t = 1 is 0.011. The slope of the line (tangent) is 0.565. (see Fig. 1).

Thus

$$\frac{K}{(n+1)(n+2)} = 0.011$$

$$n+1 = 0.565$$

$$\frac{K}{(n+1)} = (n+2) \cdot 0.011 = 1.565 \cdot 0.011 = 0.0172$$

$$K = 0.0172 \cdot (n+1) = 0.0172 \cdot 0.565 = 0.00965$$

$$n = 0.565 - 1 = -0.435$$

We then can write up

$$D_{ft} = \frac{K}{n+1} t^{n+1} = 0.0172 \cdot t^{0.565}$$

or

$$D_{in} = 12.0 \cdot 0.0172 \cdot t^{0.565} = 0.207 \cdot t^{0.565} \qquad (7)$$

and

$$I_{ft/min} = K \cdot t^{n} = 0.00965 \cdot t^{-0.435}$$

or

$$I_{in/hr} = 0.00965 \cdot 12 \cdot 60 \cdot t^{-0.435} = 6.95 \cdot t^{-0.435} \qquad (8)$$

Equations (7) and (8) can easily be plotted on log log paper (see discussion following equation [4]). From this graph the values for intake rate or accumulative intake can be read and used as such or for plotting on linear scale as was done in Fig. 2.

Figure 2 shows three examples of infiltration rates arrived at by infiltrometers and by the rate of advance method showing very good agreement.

We can say that the rate of advance method is very good for arriving at the infiltration rate of soils. Its main advantage over the cylinder infiltrometer method is that it integrates variability in soil structure and permits arriving at the average intake rate of a field. Its disadvantage is that it requires accurate plotting and that it is not always easy to find Ds. With a little practice however, these disadvantages are overcome rather easily.

BORDER #1

FIGURE 1

$\frac{q \cdot t}{L}$ - Ds

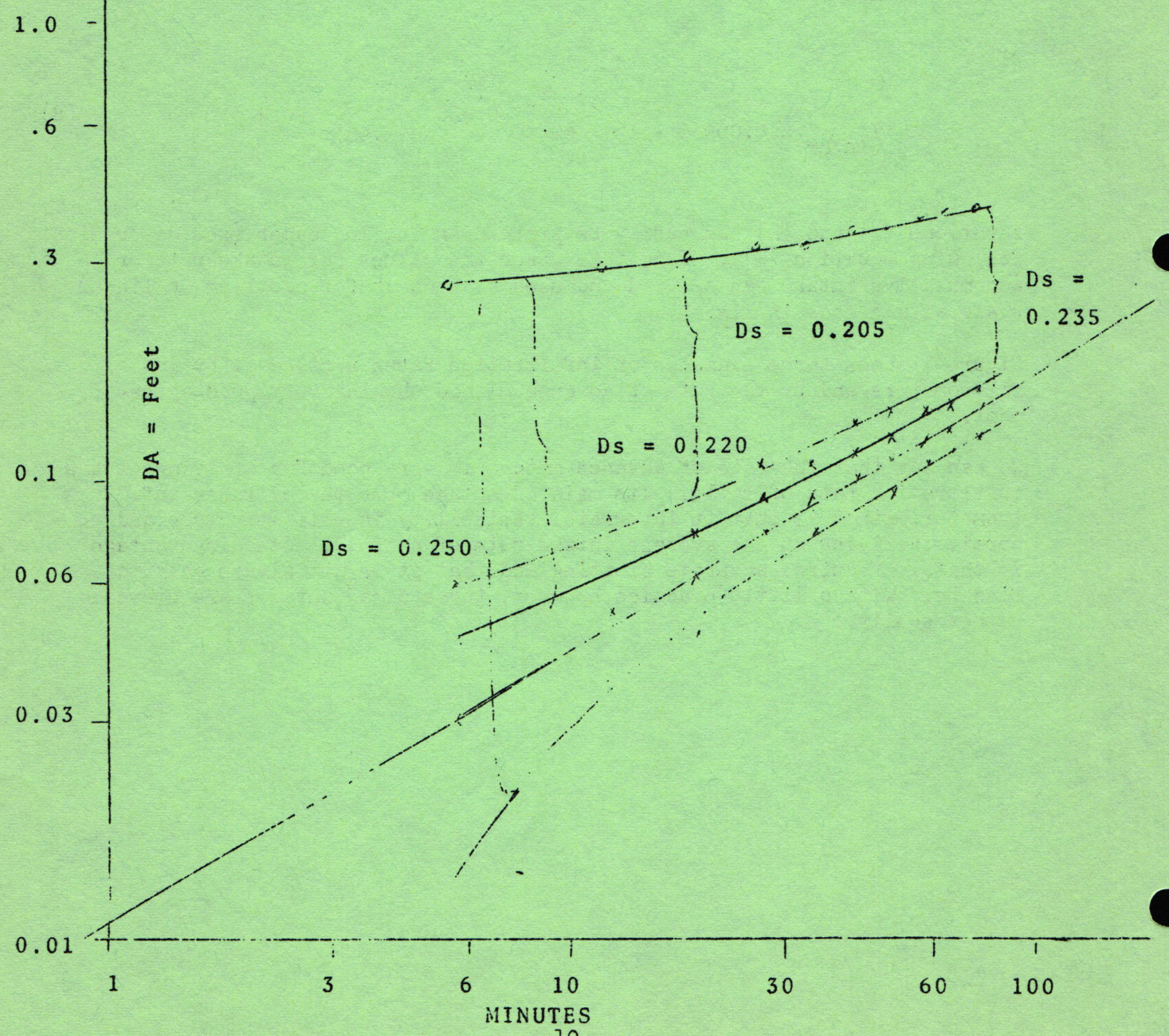
$$D_A = 0.011 = \frac{K}{[n+1][n+2]}$$

$$n+1 = 0.565$$

$$K = 1.565 \times 0.011 = 0.0172$$

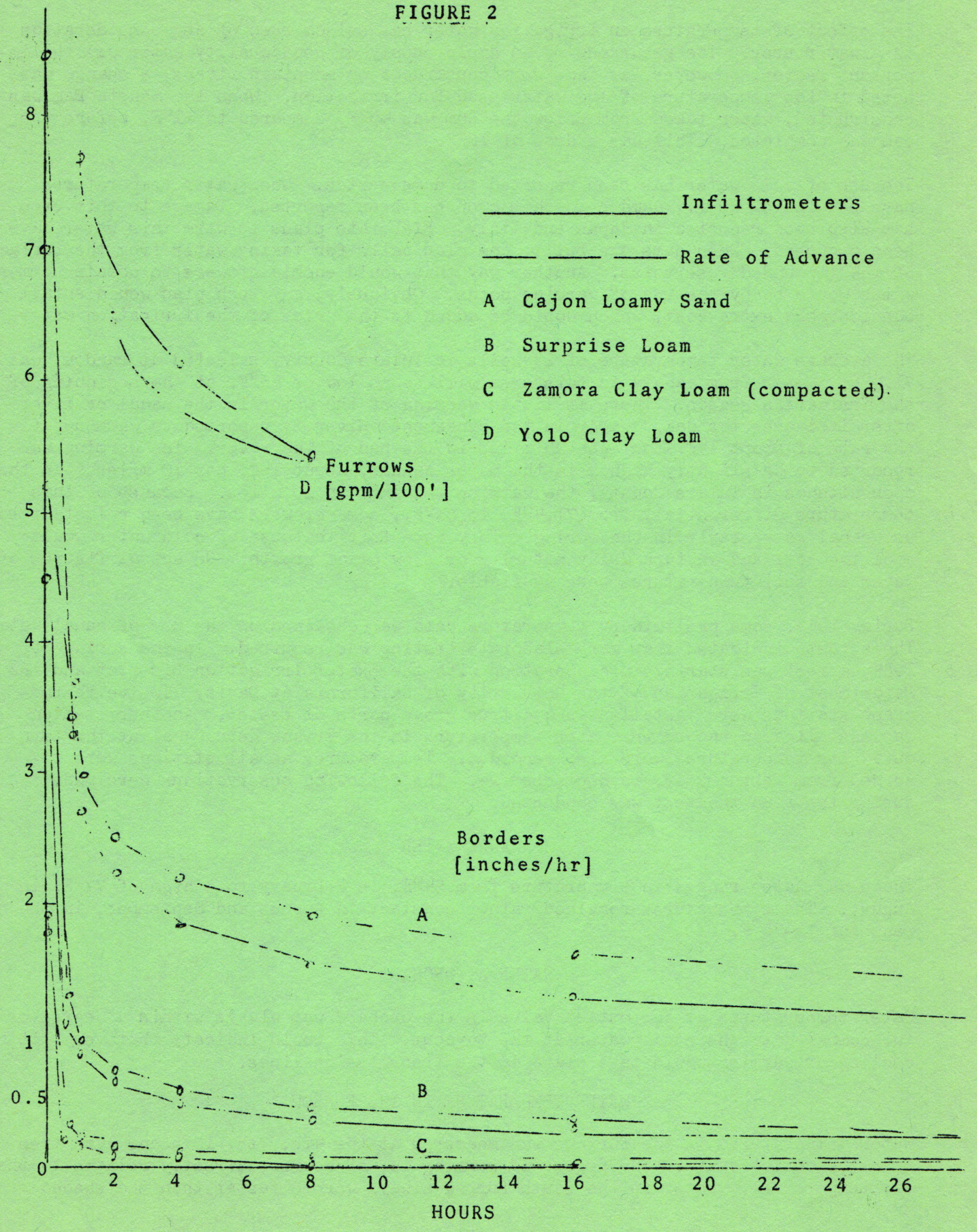
$$D_{ft} = 0.0172 \cdot t^{0.565}$$

$$D_{in} = 0.207 \cdot t^{0.56}$$



INFILTRATION RATES FROM RATE OF ADVANCE & INFILTROMETERS

FIGURE 2



CANAL WATER TEMPERATURE STUDIES

Richard O. Schade, Tulare County Farm Advisor

The effect of temperature on irrigation water has seldom been of any consideration to a water user. The assurance of an ample supply of good quality water was the important factor. However, as dams were construced on mountain rivers, a change was noted in the temperature of the water used for irrigation. When the Shasta Dam was constructed, water taken from below the dam was 45°F. compared to 61°F. before the dam was completed. This was a drop of 16°F.

The use of cold water has been reported to damage rice. When water temperatures have been below 69°F., damage to this crop has been reported. Damage to this crop has also been reported in Japan and Italy. Elaborate plans to warm this water have been proposed. When dams are built, one plan calls for taking water from the surface of the impounded reservoirs. Another way that would enable growers to obtain warmer water would be by the use of warming ponds. Obviously, any such plan would entail considerable extra cost, which would be added to the price of the irrigation water.

The average water temperature of 23 wells in Tulare County, selected at random, was 71.4°F. Water from canals in this area will be as low as 55°F. at the beginning of the irrigation season. There is little warming of the water in the canal or river after it leaves the dam. Water in the Sacramento River is reported to warm up at the rate of about 1°F. for each 25 miles in the bed of the river. The warming was reported to be slightly higher in the major canals, about 1°F. per 10 miles. In the open ditches in Tulare County, the warming was 2°F. in 10 miles. Because of this temperature differential, from 71.4°F. to 55°F., some growers have been reluctant to use canal water early in the spring. They have felt that use of cold water would cool the soil and in turn delay maturity or slow plant growth. No actual figures of water and soil temperatures were available.

During 1963, some preliminary temperature data was obtained on the use of canal water. These tests indicated that more elaborate testing was required. In the spring of 1964, a test was started in cooperation with the Exeter Irrigation District and the Department of Irrigation of the University of California at Davis. Twelve thermograph stations were installed in a citrus grove north of Exeter. Another station was installed to record the water temperature in the Friant Kern Canal at the turnout. Air temperatures were also recorded. Temperatures at all stations were recorded from February 19, to September 24. The following observations were made during the time the test was conducted.

CANAL WATER

The canal water ranged in temperature from 54°F. in February to a high of 77°F. in August. The temperatures remained rather constant in August and September, in the range of 72-75°F.

WATER AT ORCHARD

Water temperatures at the outlet valve in the orchard was always within a degree or two compared to the canal water at the turnout. This would indicate that very little cooling or warming would take place in the transmission lines.

WATER TEMPERATURE IN THE FURROW

Water temperatures in the furrows was measured at the 4th, 7th, 10th and 14th tree from the outlet valve. The degree of warming is, of course, directly related to the air temperature. Water in the south furrow always warmed faster than the shaded

north row, but only by 2 or 3 degrees. This same warming is noted in the morning on the east side of a tree when the furrows run north and south. At air temperatures of 85°F., the water warmed from 69°F. to 77°F. in the 14-tree run. When air temperatures were low, 55°F., no warming of the water was noted. It was obvious that the water temperature is directly affected by air temperature and the amount of shading.

TEMPERATURE IN THE SOIL

Soil temperatures were recorded below the furrow at the 6- and 12-inch level at three locations. The first station was between trees 2 and 3, the second between trees 8 and 9, and the third between trees 15 and 16. Results of these readings show that early in the season, use of canal water actually resulted in a higher average daily soil temperature. This is due to the fact that the water temperature was higher than the minimum temperature of the soil. As the irrigation season progressed, water application results in a lowering of soil temperature in the upper zone. This temperature lowering was in the range of 6-10°F. Within 24 hours after irrigation, the soil temperature returned to values indicated before irrigation. The soil temperature between the furrows was apparently unaffected by the irrigation. In this orchard, only a small portion of the soil mass was affected by the application of cold irrigation water. The total effect on any given parcel of land would depend on many factors such as the soil, crop planted, rooting habit of the crop, length of time irrigated, and many others. Under the conditions reported, it is unlikely that any damage could have been done and even some benefit might be realized early in the season.

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