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Project No. 88-N1 - Water Infiltration and Orchard Floor Management

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Objectives: (1) Evaluate the five different orchard floor vegetation management practices (treatments) for differences in infiltration from initial water intake through a steady state penetration rate. (2) Evaluate changes in water infiltration rate by treatment throughout the irrigation season. (3) Recommend management practices which may include changes in irrigation method, use of water, and application of soil amendments for each vegetation management system.

Interpretive Summary:

Water penetration problems can result in reduced yield, tree vigor and nut quality due to water stress from inadequate irrigation, inadequate leaching of soil salts, and inadequate movement into the crop root zone of surface-applied fertilizers and soil amendments. A water penetration problem can also cause excessive runoff of applied waters, and water-logging which can be directly related to increased susceptibility to insect pests and diseases. Almond orchard floor vegetation management practices are one of the major cultural practices which can mitigate or accentuate a water infiltration problem. The effect of these practices on water infiltration rates should be evaluated.

After four years of imposed treatments, five orchard floor management systems were evaluated: resident vegetation; Blando brome grass; 'Salina' strawberry clover; complete residual chemical control of the orchard floor vegetation; and chemical mowing. This last strategy uses a post emergence herbicide at low rates throughout the season to retard vegetation growth. The herbicide is then utilized to eliminate the resident vegetation by harvest time. All treatments were replicated four times. To determine insitu water infiltration characteristics of the soil for each treatment, a portable, rainfall simulator-type infiltrometer was developed. The infiltrometer operates on a 12-volt DC power supply. Water application rate is adjusted by a computer-controlled, peristaltic pump. The application rate is adjustable from 0.06 to 4.5 inches per hour at any time during its operation. Rate selection through pump control, data acquisition and storage is made by a portable, laptop computer.

Data collected in each plot was fit to an infiltration equation proposed by Horton using non-linear regression (Figure 1). This infiltration equation is integrated to obtain accumulated infiltrated volumes (Figure 2). Infiltration rate can be evaluated using various infiltration parameters including initial (maximum) rate, rate of decline, steady state or accumulative infiltration rate after some "set time." The most beneficial parameter to orchardists would be the steady state or the sustained infiltration rate and accumulative infiltrated water after a "set time".

Significant differences in water infiltration characteristics were found between orchard floor management systems. In general the cover crop treatments (resident vegetation, clover and brome) were significantly higher in both infiltrated volume after 120 minutes and steady state infiltration than in the chemical mowing and residual

herbicide treatments (Tables 2 and 3). A total of 1.3 inches of additional water volume was infiltrated over a 120 minute irrigation period in the brome versus the residual chemical treatments (Figure 2).

This study was performed in August, 1988. Early season infiltration characteristics will be determined in 1989 and compared with these late season results.

Experimental Procedure:

Portable Infiltrometer. A portable, drop-forming rainfall simulator-type infiltrometer was designed for use in measuring water infiltration characteristics of field soils. The development of this device was supported by the Kearney Foundation for Soil Science. The device can be handled by a single person and is small enough to easily fit in a pickup truck. All power is supplied by a 12-volt DC lead acid battery power source. Since 120V 60Hz sinewave power is required, an invertor is used which provides frequency control of $\pm$ 0.5Hz.

The structural component is a rectangular steel frame, supported by two 25 cm diameter pneumatic wheels and two steel support legs. The wheels and legs are adjustable to provide leveling. Carried under this frame on a linear motion track is a water distribution device (rack) made of 25 mm schedule 40 PVC pipe. The rack has ten 1-meter length lines each 11.1 cm apart. Each of the lines have 50 equally spaced syringe adapters to which 0.18 to 0.38 mm inside diameter hypodermic needles can be attached. In alternate lines, the needles are staggered by 1/2 the needle spacing. In total, 500 outlets cover one square meter area. The rack is moved back and forth the distance of two line spacings (22.2 cm) to insure maximum droplet distribution uniformity. Control of this motion is by a digital linear actuator controlled by a separate logic device.

Water is pumped through a 200 mesh filter to minimize clogging which has been a problem with other similar devices of this type. Water is pumped to the rack by a peristaltic pump which contains onboard logic to control pump speed from 60-600 rpm. The pump controller communicates with the external laptop computer through a RS232C serial interface. The pump responds to commands issued from the laptop computer to apply the desired precipitation rate. Rates are selected based on visual observations to maintain near "Incipient Ponding Conditions" for the term of the experiment.

Orchard Floor Vegetation Management Site. An experimental site near Ceres, California, was established in almonds to evaluate the effects of orchard floor management systems on trees' soil water use economics and pest interactions. This study was supported by the UC IPM Program from 1983-1987.

In 1984, the cover crops (Blando bromegrass and "Salina" strawberry clover) were established to compare with native vegetation, solid residual herbicide, and chemical mowing treatments. Each treatment consisted of four replicates. The orchards were maintained using standard, good horticultural practices with no added fertilizer or irrigation to compensate for any specific management system. All treatments were strip-sprayed with residual herbicides. Centers of cover crops were mechanically mowed each year at approximately 30-day intervals during the growth season. The site was irrigated by a solid set sprinkler system designed to apply 0.12 inches per hour precipitation rate. Difficulty in infiltrating irrigation water in some vegetation management systems was visually noticeable by season's end.

Results

The infiltrometer was tested for uniformity of application under zero wind conditions by using a 103 mm diameter catch can placed within each of the 72 sub-zones of the application area. The infiltrometer was run at a constant rate for a fixed period of time. Application rates varied from 1.6 to 101.6 mm per hour using 0.18 inside diameter needles. Water caught in the can was measured volumetrically. Data were compared using Christiansen's Coefficient of Uniformity (CCU). At all rates, CCU values exceeded 86 percent (Table 1). The lowest values were obtained from the highest rates. The Coefficient of Variation (CV) between catch cans was less than 16.2 for all rates. The poorest CV of 14.3 and 16.2 occurred at 1.6 mm h^{-1}, respectively (Table 1). The variation at the low rates is attributed to minor unleveling of the rack. At the high rates, squirting occurred which distorted the normal gravitational dripping effect. Larger needles reduced the CV at the higher rates. Unfortunately, larger needles also increased the CV at the low rates.

Table 1.
Infiltrometer performance using 0.18 cm inside diameter needles at various rates of application.

Rate (mm h^{-1})	Time (hrs)	Mean Depth of Applied Water (mm)	Coeff. of Variation (%)	Christiansen's Coeff. of Uniformity (%)
1.6	8	12.8	14.3	89
5.1	6	30.6	12.6	90
50.8	2	101.6	9.0	93
101.6	1	101.6	16.2	86

The infiltrometer was used to determine the infiltration rate curve of Hanford fine sandy loam soil (coarse, loamy, mixed non-acid thermic typic Xerorthents) near Ceres, California. The infiltrometer was allowed to operate from a beginning rate of 114 mm h^{-1} until "incipient ponding" occurred. The rate was then decreased in small decrements to maintain this condition over the term of the experiment. Data collected in each plot were fit using non-linear regression to an infiltration equation (Figure 1) proposed by Horton (1935):

$$f = f_c + (f_o - f_c)e^{-kt}$$

where:

- f = infiltration rate at some time
- k = constant representing the rate of decrease in f capacity
- f_c = final equilibrium or steady state rate
- f_o = initial infiltration rate

The infiltration equation is integrated to obtain accumulated infiltrated water volumes (Figure 2). Infiltration capabilities can be evaluated using various infiltration parameters including initial (maximum) rate, rate of decline, steady state rate, or accumulative infiltration after some "set time." The most beneficial parameter to orchardists and design engineers would be steady state, or the sustained infiltration rate, and accumulative infiltrated water volumes after a "set time."

Significant differences in water infiltration characteristics were found between orchard floor management systems. In general, the cover crop treatments (resident vegetation, clover and brome) were significantly higher in both infiltrated volume after 120 minutes and steady state infiltration than in the chemical mowing and residual herbicide treatments (Tables 2 and 3). A total of 33 mm of additional water volume was infiltrated over a 120 minute irrigation period in the brome versus the residual chemical treatments (Figure 2).

Discussion

This work has been conducted on a sandy loam soil known to be affected by surface aggregate in stability resulting in crusting. Crusting limits the movement of irrigation water into the soil profile resulting in ponding of waters on the surface. These problems can result in reduced yield, tree vigor and nut quality reduction due to water stress from inadequate irrigation, inadequate leaching of soil salts, and inadequate movement into the crop root zone of surface-applied fertilizers and soil amendments. A water penetration problem can also cause excessive runoff of applied waters, and water-logging which can be directly related to increased susceptibility to pests and diseases.

This problem of water penetration has been attributed to a number of probable factors and conditions. Small infiltration rates in surface soils are reported in coarse as well as fine textured soils. Some of the probable causes are crusting due to impact of rain and sprinkler drops, low electrolyte/high sodium irrigation waters, swelling and dispersion of soil colloids, soil particle orientation, and compaction from farm machinery and cultural practices.

It has been shown that the appropriate use of a vegetation management system (cover crops) is beneficial to soils which tend to crust. Future work should be directed towards evaluation of the major types of soil series which almonds are grown in order to predict the magnitude of benefit from the presence or absence of cover crops.

There were three objectives of this study. The first objective has been achieved. Significant differences in steady state and accumulative water infiltration were found when comparing different orchard floor management techniques in August and September of 1988. The second objective is to compare these results to early season findings. This work will be conducted in May, 1989. The third objective (recommended management practices for each orchard floor system) necessarily requires the completion of the first two objectives.

Publications

Prichard, T.L., A. Perez, and G.J. Hoffman. ***Evaluation of a portable rainfall simulator-type infiltrometer.*** 1989 Proceedings of Pacific Region Meeting, American Society of Agricultural Engineers

Prichard, T.L, A. Perez, G.J. Hoffman, and W.K. Asai. ***Determination of water infiltration characteristics of soil under various vegetation management systems using a portable rainfall simulator-type infiltrometer.*** 1989 Proceedings of Plant Soil Conference, American Society of Agronomy.

Table 2.

Infiltration Rate at 120 minutes (inches/hour)

clover	0.74	a*
resident vegetation	0.57	ab
brome	0.57	ab
chemical mowing	0.41	bc
residual herbicide	0.30	c

Table 3.

Accumulated Infiltration After 120 minutes (inches)

brome	2.57	a*
clover	2.49	a
resident vegetation	2.16	a
chemical mowing	1.54	b
residual herbicide	1.28	b

* Common letters among means within rows denote no significant difference at $p \leq 0.05$.

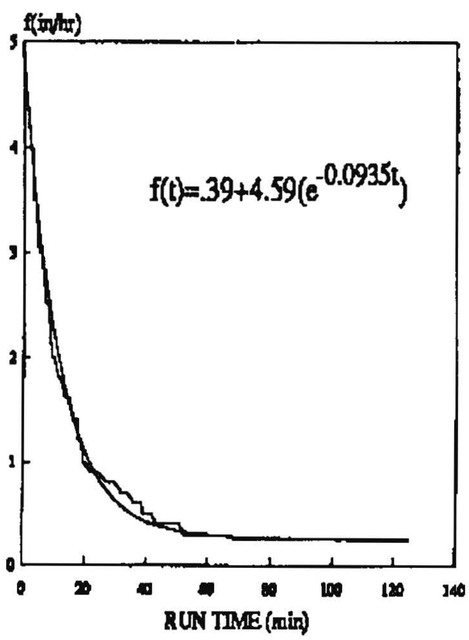

Fig. 1 . A graphical representation of the field data and calculated non-linear regression (smooth curve).

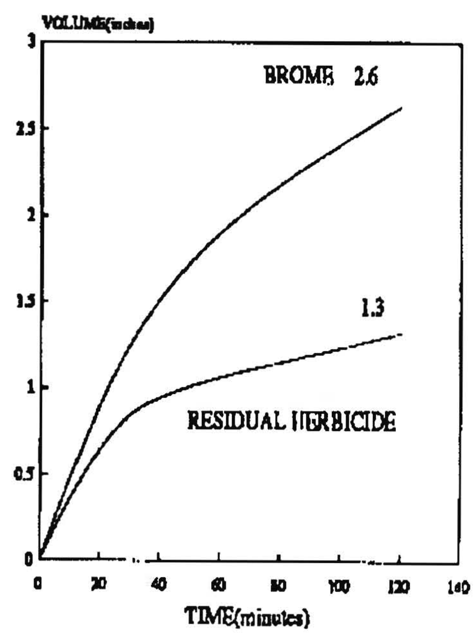

Fig. 2. Accumulated infiltrated volume (inches) for brome and and residual herbicide in a 120 minute period.