19th ANNUAL ALMOND RESEARCH CONFERENCE
December 3, 1991

Project No. 91-N4 - Prediction of Successful Amelioration of Water Infiltration Problems in Almond Orchards

Project Leader: Terry L. Prichard, Water Management Specialist
University of California
420 S. Wilson Way, Stockton, CA 95205
(209) 468-2085

Cooperating Personnel: Wesley Asai, Ken Fuson

Objectives: (1) Evaluate a number of soil series in which almonds are grown as to their tendency to crust and impede water infiltration. (2) Develop guidelines as to the likelihood of success when using cover crops in ameliorating the effects of crusting in various soil types.

Interpretive Summary:

Chemical composition and soil mineralogy often influence the tendency of soils to form infiltration-limiting surface crusts. Additionally, agricultural practices such as cultivation, irrigation and the presence of cover crops, have been shown to affect soil surface crust formation. However, the success of remedial amendments (both physical and chemical) is largely unknown.

A method was developed to rate field soils as to their tendency to form surface crusts and diminish water infiltration. Eight soils, varying in texture and location within the Sacramento and San Joaquin Valleys of California (Table 1), were investigated to determine the effect of crusting on water infiltration and potential remediation practices. Emphasis was placed on soils with historically observed reductions in infiltration rates, reportedly due to soil surface crusting. All sites (except for Linden) were located in orchards.

Table 1. Soil types used in infiltration studies.

Site	Soil Type	Texture
Ceres	Hanford	sandy loam
Merced	Delhi	sandy loam
Cortez	San Joaquin	sandy loam
Linden	Wyman	loam
Hamilton City	Wyo	silty clay loam
Crows Landing	Carbona	clay loam
Durham	Vina	silty clay loam
Farmington	Hollenbeck	silty clay

Water infiltration characteristics of each treatment were determined once all treatments were at equal moisture content. Irrigation waters available for use on many of the soils evaluated are often low salinity (less than 0.1 dS/m), which contribute to reductions in infiltration rates. To eliminate this bias, a standard water, typical of surface irrigation waters in the San Joaquin Valley of California, was used in all tests (Table 2). The use of this water contributed to higher infiltration rates than experienced using the native waters.

Table 2. Chemical constituents of water used in infiltration studies

pH	EC dS/m	Ca + Mg meq/L	Na meq/L	Cl meq/L	HCO_3 meq/L	SAR
7.65	0.69	2.6	4.3	1.0	7.0	1.8

Water infiltration characteristics of these field soils were determined using a portable, microcomputer-controlled, drop-forming infiltrometer as described in the Kearney Foundation Second-year Annual Report (Prichard, et al. 86-1). Water infiltration measurements were made by operating the infiltrometer at an initial rate (5 inches per hour) until ponding at the soil surface was noticed. The application rate was then incrementally decreased maintain "incipient ponding" conditions for the term of the experiment (120-240 minutes). The final or steady state infiltration was commonly less than 0.2 inch per hour.

In each case where differences exist, the crusted infiltration rate was reduced when compared to the disturbed treatment (Table 3). Infiltration characteristics of the soil in each treatment were compared to determine the mechanism(s) and relative effect of the soil physical and chemical properties on infiltration reduction. Particle size analysis, clay mineralogy, organic matter, amorphous Al and Fe, salinity, exchangeable cations, aggregate stability and soil pH were determined at each site (Table 2).

Table 3. Initial and final infiltration rates and the cumulative depth of infiltrated water after 240 minutes of irrigation

Soil Type	Treatment	Initial in/hr	Final in/hr	Infiltrated Water 240 minutes (in)
Hanford	crusted	4.86 a*	0.51 a	2.59 a
	disturbed	4.31 a	0.72 a	3.53 b
	polymer	4.83 a	0.56 a	2.78 b
Delhi	crusted	4.61 a	0.60 a	3.09 a
	disturbed	4.67 a	0.71 a	3.88 b
	polymer	4.65 a	0.66 a	3.30 b
San Joaquin	crusted	5.65 a	0.39 a	2.48 a
	disturbed	5.37 a	0.80 b	4.11 b
Wyman	crusted	5.19 a	0.38 a	3.97 a
	disturbed	5.06 a	0.56 b	4.60 b
	polymer	4.73 a	0.50 b	2.46 b
Wyo	crusted	4.76 a	0.53 a	2.80 a
	disturbed	5.25 b	0.48 a	3.31 a
Carbona	crusted	5.62 a	1.06 a	5.12 a
	disturbed	7.73 b	0.27 b	6.95 b
Vina	crusted	4.60 a	0.89 a	6.23 a
	disturbed	12.48 b	1.11 a	8.83 b
Hollenbeck	crusted	4.79 a	1.38 a	6.21 a
	disturbed	5.90 b	1.39 a	8.51 b

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

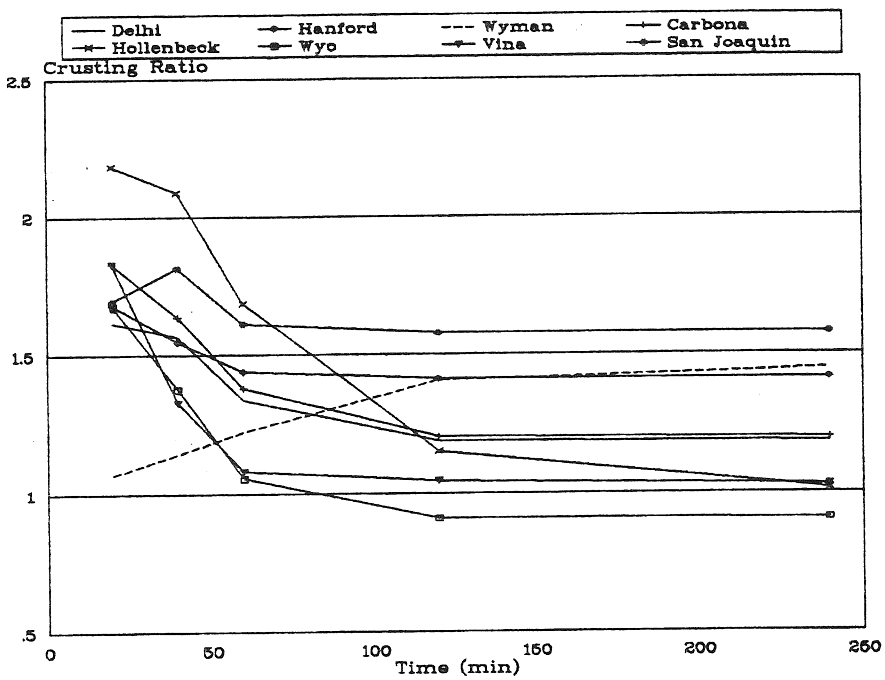
Table 4. Physical and chemical properties of soils at seven sites
(0.0 - 1.0 inch unless indicated)

Soil Property	Soils						
	Hanford	Delhi	Wyman	Wyo	Carbona	Vina	Hollen-beck
Organic Matter (%)	3.34	1.99	4.85	3.79	2.13	3.67	4.13
Organic Carbon (%)	1.94	1.16	2.82	2.20	1.24	2.13	2.40
Aggregate Stability (%) 0 - 1 in	76.1	24.7	14.3	60.2	23.6	52.3	60.9
Aggregate Stability (%) 0 -6 in	24.7	20.1	17.4	69.3	33.9	15.1	41.3
CBD Fe (%)	0.38	0.41	1.68	0.91	1.25	2.07	0.98
CBD Al (%)	0.03	0.03	0.10	0.08	0.11	0.19	0.09
CEC (cmol/Kg)	6.16	5.18	13.22	17.67	20.59	33.81	23.75
pH	8.08	7.88	7.53	7.71	7.44	4.99	6.95
Exchangeable cations (cmol/Kg)							
K	0.57	0.00	1.04	0.49	0.49	0.53	1.56
Na	0.10	0.11	0.18	0.28	0.73	0.11	0.23
Ca	8.26	8.72	15.08	10.59	8.33	13.41	10.96
Mg	1.70	2.53	5.03	5.15	5.67	7.11	5.15
sum base	10.63	11.35	21.33	16.50	15.22	21.16	17.90
1:1 Soil Extract (mg/L)							
EC (dS/m)	1060	810	380	380	281	417	349
Ca	2791	1667	851	579	1495	1240	645
Mg	1628	1730	543	502	121	1010	401
K	1181	520	329	110	104	93	460
Na	219	298	338	699	1226	256	452
Cl	210	212	289	924	1464	72	408
NO_3	1200	2216	998	835	640	2464	1679
PO_4	98	41	22	18	24	0	32
SO_4	182	150	221	316	256	1113	183
HCO_3	8367	4841	1706	561	1922	87	519
Sand (%)	76.8	76.8	35.0	12.5	29.2	5.0	15.0
Silt (%)	17.2	12.8	41.8	59.9	36.8	55.8	44.4
Clay (%)	6.0	10.4	23.2	27.6	34.0	39.2	40.6
Mica*	4	4	1	3	0	0	2
Vermiculite*	3	3	0	1	1	0	2
Smectite*	1	1	1	2	1	3	0
Kaolinite*	2	2	1	1	2	1	1

* Clay Legend:
0 = None
1 = Trace
2 = Minor
3 = Moderate
4 = Major

Crusting ratio, a comparative method, is a ratio of disturbed to disturbed-crusted infiltration characteristics. It can be determined from either rates or cumulative infiltrated water at sometime as the irrigation proceeds. This ratio can be viewed as the susceptibility or tendency of soils to form depositional surface crusts and impede water infiltration. Unfortunately, this ratio is not constant, changing over time. Figure 1 shows crusting ratio calculated using infiltration rates as a function of time. Soils with higher clay content (Vina, Wyo and Hollenbeck) are initially affected by the formed crust having ratios exceeding 1.5. By 240 minutes, however, they are little affected. The "sandier" texture soils (San Joaquin, Hanford) are affected more uniformly over time by the crusted surface resulting in nearly a 50% reduction in infiltration rate in three soils.

Figure 1. Crusting ratio calculated using infiltration rates as a function of time for eight soils.



Summary

The infiltration characteristics of eight field soils were measured under three conditions: (1) undisturbed, (2) disturbed, and (3) disturbed-crusted. Three soils were evaluated with the water containing a non-ionic guar polymer, gypsum and surface-applied gypsum at three sites. The effect of cover crops was also evaluated. Soil chemical and physical characteristics were measured on seven of the eight soils.

Different methods of evaluating treatment infiltration characteristics are presented: 240 minutes cumulative infiltrated water and initial and steady state infiltration rates. Significant differences were found to exist between disturbed and disturbed-crusted soil surfaces in seven of the eight soils when compared by cumulative infiltrated water at 240 minutes. Initial and steady state are not well correlated to the presence of a crust across all soils but seem to be within groups of > or < 27 percent clay. Those with > 27 percent clay have initial rates, which are significantly different and steady state generally not significant. In general, the opposite is true of the < 27 percent clay soils examined.

A ratio of disturbed to crusted infiltration rates (crusting ratio) provides insight to the relative effects of surface crusting. When viewed over time, the infiltration rate of the "clayier" soils (> 27 percent) have a ratio of 1.5 to 2.2 early in the irrigation. The ratio declines to near 1.0 over a 240-minute period. This phenomenon may be a result of additional factors reducing the infiltration rate in the disturbed treatment to near that of the crusted treatment. The most likely cause is that after the top inch of disturbed soil becomes fully wetted, the infiltration characteristics of the undisturbed soil become dominant. The sub-surface characteristics are similar in the two treatments. The crusting ratio of the "sandier" soils (< 27 percent clay) (in contrast to the "clayier" soils) does not improve as the irrigation proceeds, maintaining approximately a 1.4 ratio. The surface crust effects remain as the dominant factor influencing infiltration rate.

When considering a normal 12-36 hour irrigation, it is apparent from this work that the "clayier" soils are not significantly impacted from depositional crusts. Initially the infiltration rate of the disturbed surface is higher than that of the crusted surface, but by 120 minutes, the infiltration rate of the lower undisturbed soil becomes dominant. The "sandier" soils are affected for the term of the tests. The practical implication of this is that soil surface manipulation of these soils to disrupt a depositional crust may significantly increase infiltrated water over the term of an irrigation.

The non-ionic polymer applied in the evaluation water at 15 ppm did not result in increased cumulative infiltration over the disturbed surface. It is speculated that over the term of the measurements, the infiltrometer did not form a depositional crust, which was mitigated by the polymer. The remedial practice of gypsum applied on the surface and contained in the irrigation water was investigated in most of these soils, although has not been fully analyzed at this time.