of herbicide the second year after clearing, followed by spot treatment of individual sprouts for three years, was necessary to control brush regrowth.

Selected annual and perennial grasses, seeded after brush clearing, provided excellent soil erosion control (once established). Bur clover and rose clover were quick to germinate and can be used alone or together, under conditions of rainfall or irrigation.

Birdsfoot trefoil seeded with the annual grasses helped to provide excellent vegetative cover where slopes were irrigated. The perennial grasses became well established and can be seeded as a mixture or alone. Clover included with perennial grasses gave added soil protection the first year.

From the list of grasses and ground covers commonly used for lawns, four grasses have shown favorable characteristics which make them adaptable to hillside planting: Newport Kentucky bluegrass, St. Augustinegrass, Bermudagrass RC-140, and sheep's fescue. All four provided a thick sod without mowing, stayed green, produced vegetative growth between three and eight inches high, and competed against native herbaceous invaders. These grasses required only monthly irrigation after establishment to survive in the local climate. The ground cover Lippia performed equally as well. A preplant weed-control program with calcium cyanamide proved beneficial.

Certain slow-burning species can protect the soil from erosion and provide ornamental characteristics when they are given only minimum maintenance. All species tested appear to be very drought tolerant and with few exceptions provide erosion protection within a reasonable period of time.

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INFLUENCE OF

ON THE

CITRUS

This experiment was conducted in a greenhouse to study the influence of five irrigation and three soil-oxygen levels on the uptake of 12 nutrients in citrus seedlings. Different irrigation treatments used in this experiment significantly decreased the total amounts of nitrogen, chloride, sodium, zinc, copper, and iron in the whole seedling, while dry weights of seedlings—and the total amounts of phosphorus, potassium, calcium, magnesium, manganese, and boron—were not affected. A decrease of the soil-oxygen supply to seedling roots decreased the amounts of all elements except sodium, which was increased.

TABLE 1. INFLUENCE OF IRRIGATION ON THE AMOUNTS OF NUTRIENTS PER CITRUS SEEDLING

Nutrient*	Control (A)	Water table (B)	Saturated every 4 days (C)	Saturated 3 times per month (D)	Saturated 2 times (E)	C.V.†
Dry wgt/g	5.42	4.81	4.77	4.75	5.18	15
N	62.00 b	53.00 ab	52.00 a	50.00 a	57.00 ab	15
Cl	12.00 a	14.00 b	13.00 ab	13.00 ab	14.00 b	18
Na	2.00 a	2.00 a	4.00 b	9.00 c	4.00 b	26
Zn	0.11 b	0.08 a	0.08 a	0.08 a	0.09 a	14
Cu	0.03 b	0.02 a	0.02 a	0.01 a	0.02 a	28
Fe	2.89 c	1.28 a	1.78 b	1.59 ab	2.42 c	22

* All nutrient weight differences were significant at the 1% level and expressed in mg.

† C.V. is coefficient of variability, expressed in per cent. Mean values are different only if they do not have a letter in common.

An adequate amount of oxygen in the root zone is necessary to maintain plant respiration. The diffusion of oxygen in soils is determined to a large extent by the soil pore-space arrangement and the degree to which these pores are filled with water. This paper presents data on the influence of five irrigation levels and three soil-oxygen treatments (in a factorial setup) on the amounts of nutrients taken up per seedling.

Six-week-old citrus seedlings were transplanted into Ramona sandy loam in 1-liter glass cylinders painted on the outside. An unpainted vertical strip 1 cm wide was covered with black tape, which

IRRIGATION AND SOIL OXYGEN NUTRIENT CONTENT OF SEEDLINGS

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TABLE 2. INFLUENCE OF SOIL OXYGEN ON THE AMOUNT OF NUTRIENT IN CITRUS SEEDLING

Nutrient*	Soil Oxygen Partial Pressures in Flowing Gas (mm. Hg)			
	152	13	0.3	C.V.†
Dry wgt/g	6.61 c	4.61 b	3.73 a	15
N	74.00 b	51.00 a	40.00 a	14
P	6.00 c	4.00 b	3.00 a	16
K	93.00 c	58.00 b	45.00 a	16
Ca	68.00 b	46.00 a	42.00 a	17
Mg	11.00 b	7.00 o	6.00 a	15
Cl	20.00 c	11.00 b	8.00 a	18
No	3.00 a	4.00 a	6.00 b	26
Zn	0.13 b	0.07 a	0.07 a	14
Cu	0.04 b	0.02 a	0.02 o	28
Mn	0.76 c	0.47 a	0.58 b	19
8	0.22 c	0.13 b	0.10 a	15
Fe	2.93 b	1.41 a	1.64 a	22

* All nutrient and dry weight differences were significant at the 1% level. Nutrients are expressed in mg per seedling.

† C.V. is coefficient of variobility, expressed in per cent. Mean values are different only if they do not have a letter in common.

was then uncovered for root observations during the experiment. The irrigation and soil-oxygen treatments were applied after the seedling roots reached the bottom of the cylinder.

Irrigation treatments were as follows: (A) control—the soils were watered to only 15% average moisture content; (B) a water table was maintained halfway up the soil column; (C) the entire soil column was saturated for a few minutes every four days; (D) the entire soil column was kept saturated for an 8-hour period three times a month; and (E) same as treatment (D), except that the soil column was saturated twice a month (15 and 30 days after treatment).

Aeration treatments were conducted by flowing oxygen-nitrogen mixtures of 152, 10–13, and 0.3 mm Hg partial oxygen pressures over the soil surface. These three soil-oxygen treatments (normal, low, and very low) were imposed upon five irrigation treatments, each replicated four times with single-plant plots. The experiment continued for a period of 35 days in the greenhouse, during which the day temperatures were maintained at about 24°C. The mean daylength for the test period was 11 hours and 40 minutes. The seedlings were then harvested, washed, dried, ground, and analyzed for the 12 nutrients.

Irrigation Effects

The data (table 1) show that total amounts of nitrogen, chloride, sodium, zinc, copper, and iron per seedling were decreased by irrigation treatments. Amounts of phosphorus, potassium, calcium, magnesium, manganese, and boron were not affected. The effect on nutrient uptake may be either direct or indirect. Research has shown that in "wet" soils, oxygen becomes a limiting factor in nutrient uptake, translocation, and distribution within the plant. In treatment D, where the entire soil column was saturated three times, for an 8-hour period, the plants contained significantly higher amounts of sodium per plant than did those irrigated according to treatment E, where the entire soil column was saturated only twice, for an 8-hour period. Thus, certain irrigation practices may contribute to sodium toxicity problems in plants sensitive to salt accumulation—even though the soil is not particularly high in sodium.

Oxygen effects

A decreasing soil-oxygen level lowered the dry weight of plants. Dry weight of tops was not affected as drastically by the low and very low soil-oxygen supplies as was the dry weight of roots, when compared with the normal level (table 2). The total amounts of all nutrients in plants were decreased, except for sodium, which was increased along with the decreasing soil-oxygen supply. These data are in accord with other findings that adequate oxygen supply to the roots plays a very important role in nutrient uptake, translocation, and distribution of nutrients.

Interaction between the irrigation and oxygen treatments had a significant effect on the total amount of sodium per plant. The amount of sodium per plant decreased in wet soils, and increased in dry soils, as the soil-oxygen supply was decreased. When a normal supply of soil oxygen was present, the various irrigation treatments did not influence the amount of sodium per plant. However, when the soil-oxygen supply to the roots was reduced from normal to low or very low, and when the entire soil column was saturated three times a month for an 8-hour period, the amount of sodium increased in the plant. Results obtained in this experiment indicate that irrigation practices and the amount of soil-oxygen supplied to the plant are very important factors in controlling sodium toxicity in citrus seedlings, particularly in soils containing higher amounts of sodium.

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