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Response of Jojoba Seedlings to Waterlogged Root Environments[1]

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Abstract. **Although few seedlings of jojoba [*Simmondsia chinensis* (Link) C. K. Schneid] developed foliar symptoms when their roots were waterlogged at 23°C for 42 days, root systems of all plants were irreversibly damaged. At 33°, symptoms developed more rapidly, but again all plants died when treatments were prolonged to obtain foliar effects on a high proportion of plants. The limit of survival at 33° was when about 50% of the seedlings expressed symptoms. Jojoba is intermediate in sensitivity to waterlogging based upon direct comparisons with walnut (very sensitive) and pear (very tolerant).**

Much attention has been given recently to the potential production of jojoba for commercial purposes. Jojoba seeds contain a high-quality liquid wax that may be used for many purposes (4). The horticultural knowledge of jojoba has recently been reviewed (4, 10). Jojoba is drought-tolerant (1, 2) and salinity-tolerant (2, 9). Plants favor hot climates and are reported to grow faster at soil temperatures of 33°C than at lower ones (6).

Irrigation is recommended for establishment and production in climates having irregular distribution of rainfall (4, 5, 10). Attempts are being made to grow jojoba in northern California where rainfall can exceed 80 cm. Production with irrigation or in regions of relatively high rainfall increases the likelihood of saturated soils. The combination of soil saturation and high temperature is particularly damaging to some plants (3, 8).

Jojoba plants are generally thought to be intolerant of excessive soil moisture. Jojoba is reported to do poorly in heavy soils (5). Overwatering young seedlings can be disastrous to their survival (10). However, Reyes et al. (6) reported no mortality even though growth was drastically reduced when 1.5% 0_2 was supplied to the soil surface for 6 months. This suggests greater tolerance than generally believed to low oxygen stress which occurs in waterlogged soils. Thus, it was of interest to measure the response of jojoba plants to waterlogged conditions.

Jojoba seedlings were grown in pasteurized fine sandy loam-fir bark (1:1, v/v) in milk cartons (0.95 1) in a greenhouse. When 3 to 7 months old and about 30 cm in height, waterlogging treatments were initiated using procedures previously described (3). Tap water was maintained about 2.5 cm above the root media. Root temperature was controlled at either 23 or 33°C in a water bath. Air temperature was regulated only within broad limits from about 10 to 16° at night and from 22 to 32° during the day.

In some cases, similarly grown seedlings of 'Winter Nelis' pear (*Pyrus communis* L.) and/or northern California black walnut [*Juglans hindsii* (Jeps.) Jeps.] were treated at the same time with the jojobas. The number of plants in each treatment differed with the experiment. When symptoms appeared on the shoots, roots were drained and plants were held for further observation in the greenhouse. Wilting, chlorosis, and epinasty or necrosis of leaves was used as an indicator of irreversible root damage (3, 8). Because of the difficulty in detecting leaf symptoms with jojoba, some treatments were terminated and all plants were drained when about 50% of those in a given group showed symptoms.

The first waterlogging treatment consisted of 10 plants each of jojoba, walnut, and pear at a root temperature of 23°C. All 10 walnut seedlings expressed symptoms of waterlogging and were removed by the 11th day. Pear seedlings were removed when the treatment was terminated after 42 days. Their only change was a progressive development of red color in leaves after about 2 weeks of flooding. Responses were as expected for walnut (3) and pear (7). Only 2 jojoba plants appeared abnormal during 42 days of treatment. One was removed on the 15th day, and the other was removed after 34 days. Their appearance was only suggestive of the usual symptoms of waterlogging. Leaves were slightly paler than the normal grey-green color and appeared to be somewhat dry. The almost sessile leaves, especially the more succulent ones at the upper 2 to 3 nodes, drooped slightly. Neither the color change nor drooping were as pronounced as chlorosis or epinastic curvature typical of many other plants' response to waterlogging.

On the 42nd day of waterlogging, the remaining 8 jojoba seedlings were drained and held for observation. The roots of the 2 plants removed earlier were examined at this time. Roots were not discolored, but tissues external to the xylem sloughed off readily when gently rubbed. Roots of nontreated plants appeared the same, but tissues would not slough off. Leaves of 1 of the 2 plants were brown and dry; those of the other were dull grey-green. The former plant was considered dead; the later irreversibly damaged.

Walnut and wingnut (3) and *Prunus* (P. B. Catlin, unpublished) will recover if removed from a waterlogging treatment before exhibiting foliar symptoms. This was not the case with jojoba. Plants were examined 6 weeks after they were drained and all root systems were dead, based on sloughing of external tissues. Leaves had become either brown and dry or a very dull green.

The treatment at 23°C indicated that jojobas were considerably more sensitive than pears to waterlogging, but it could not be established if jojoba was more tolerant than walnut because of the lack of leaf symptoms where irreversible root damage had occurred.

Plants develop more severe symptoms and are more quickly affected by waterlogging as root temperatures increase (3, 8). Thus, to clarify the response of jojoba, 4 additional groups of plants were treated at root temperatures of 33°C. Twenty and 10 pear seedlings were included in the first 2 trials.

Of the first 2 trials at 33°C, the first plants showed symptoms and were drained on the 8th and 10th days of treatment, respectively. Symptoms were as described above. Times at which certain proportions of each group expressed symptoms are given in Table 1.

Table 1. Times at which percentages of each group of jojoba seedlings expressed foliar symptoms to waterlogging at 33°C and the status of plants 6 weeks after they were drained.

		Time in treatment (days)			Seedling status 6 wk after last plant drained[z]			
		Proportion of seedlings with symptoms			No. plants with symptoms		No. plants without symptoms	
Trial	No. jojoba seedlings	20%	50%	80%	Live	Dead	Live	Dead
1	10	9	14	22	0	8	0	2
2	20	11	13	23	0	16	0	4
3	20	6	10[y]	---	2	11	6	1
4	40	7	10	---	2	18	15	5

[z]Plants drained when symptoms appeared or for plants without symptoms in trials 1 and 2 drained on days 22 and 23, respectively, in trials 3 and 4 drained on day 10.
[y]65% of plants with symptoms.

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As expected, plants were affected more rapidly at 33° than at 23°. Symptoms developed on 80% of the plants by the 22nd or 23rd day. All jojobas, even those without symptoms, died. Again, irreversible damage to roots preceded expression of damage in shoots.

Of the 20 pear seedlings in trial 1, only 4 expressed leaf symptoms between the 18th and 37th day of waterlogging. Plants without symptoms were drained on the 37th day. Four of these died, but 12 had produced many new white roots when examined 6 weeks later. Of the 10 pear seedlings in trial two, 7 developed foliar symptoms between the 12th and 34th days. Two of these were alive when examined 6 weeks after being drained. The 3 plants without symptoms had retained their leaves and produced new roots.

All pears had considerable root damage, but some had not reached the irreversible point. When damage progresses slowly, it is not surprising that a few plants with symptoms survive and a few symptomless plants do not. This variability points to the fact that foliar symptoms are not always a precise indicator of the extent of root damage.

The greater tolerance of pear than jojoba to waterlogging found at 23°C was confirmed at 33°; however, a better estimate of the response of jojobas was desired. To further test jojoba and the application of the technique, 2 additional trials, 3 and 4, were waterlogged at 33°. Plants were drained when symptoms appeared; 20% of the plants expressed symptoms by 6 and 7 days and the 50% level was reached or exceeded (group 3 had 65%) on the 10th day (Table 1). All remaining plants were then drained. Of the 27 symptomless plants in trials 3 and 4, 21 survived (Table 1) and a few of these had resumed root and shoot growth 6 weeks later.

Irreversible damage again occurred with some jojoba plants before any waterlogging symptoms developed. This was indicated by the 6 apparent survivors that died after being drained. With all 4 trials at 33°C there was a considerable time lag between root damage and expression in the shoot.

The techniques used here have been employed to screen and select plants with increased tolerance to waterlogging (3), and results with pear indicate applicability to this species as well. Jojoba populations can also be screened for more tolerant individuals with slight modification of the usual technique. Removal of plants from treatment when about 50% expressed foliar symptoms revealed the limit of survival for the population.

Jojobas are less tolerant to waterlogging than pear but considerably more tolerant than walnut. Walnuts would have reached 100% mortality at 33°C (3) by the time 20% of the jojobas expressed symptoms. The extreme waterlogging sensitivity sometimes attributed to jojoba appears unwarranted. Lack of mortality of jojoba plants under very low supplies (1.5%) of oxygen to the soil above roots (6) supports this conclusion.

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Response of Mites and Leafminers to Trickle Irrigation Rates in Spray Chrysanthemum Production[1]

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Abstract. **The numbers of twospotted spider mites (*Tetranychus urticae* Koch) per unit of leaf area on 'Manatee Yellow Iceberg' chrysanthemum (*Chrysanthemum* X *morifolium* Ramat.) grown with 13.6, 20.3, 27.1, 33.9, or 40.7 cm of water during the crop cycle were inversely related to amounts of water provided on both of 2 sampling dates. The numbers of mites per leaf were inversely related to amounts of water provided on the first of the 2 sampling dates. There was no significant response of leafmine densities with various amounts of water provided.**

The physiological status of host plants grown under various conditions has been shown to affect mite densities (4). However, the effects of water-stressed agricultural crops on plant-feeding mites is not clear. Gould (2) found that the twospotted spider mite (*Tetranychus urticae* Koch) did not survive well on cultivars of bitter cucumber (*Cucumis sativus* L.) produced with low water regimes and proposed that the water-stressed plant increased the concentration of cucurbitacin-c, a plant substance detrimental to mites. Conversely, Chandler et al. (1) found that populations of the carmine mite [*T. cinnabarinus* (Boisduval)] and the Banks grass mite [*Oligonychus pratensis* (Banks)] were more dense on a crop not containing cucurbitacin-c, field corn (*Zea mays* L.) produced under conditions of low soil moisture (200 cb), than populations were when moisture was maintained at higher levels ($\leq$ 50 cb). The purpose of this study was to evaluate the impact of conservative water management practices on mite and leafminer management in chrysanthemum.

Plots of 'Manatee Yellow Iceberg' chrysanthemums (0.9 × 3.7 m) were grown in a fiberglass, sawtooth greenhouse with 13.6, 20.3, 27.1, 33.9, or 40.7 cm of water delivered during the crop cycle by trickle irrigation. Precipitation and ground water were excluded from the production area. Irrigation treatments were replicated 6 times in randomized complete blocks. Rooted cuttings were set on Feb. 13, 1980. Plants were harvested on May 12; the effect of irrigation rates on cut flower production is presented elsewhere (3). Methomyl (Lannate 90SP) in-

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