

RESPONSE OF PEACH SEEDLINGS TO WATER STRESS AND SATURATION CONDITIONS¹

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Abstract. Effects of 3 watering regimes on photosynthesis and carbohydrate levels of peach leaves (*Prunus persica* (L.) Batsch) were studied. Unfavorable soil moisture conditions induced leaf wilting, lowered photosynthetic rates, and increased stomatal diffusive resistance. Non-structural carbohydrate increased in leaves grown under water stress conditions, but slightly decreased in leaves grown under soil moisture saturation.

Plant growth and yield are controlled directly by water supply. A deficit of water may reduce rate of growth, impair metabolic processes, and induce premature abscission of plant organs. On the other hand, high available soil moisture and low atmospheric stress are often accompanied by vigorous vegetative growth and soft succulent fruit containing comparatively low soluble solids (15). Optimum soil moisture, coupled with other optimum growing conditions, normally results in satisfactory growth, development and quality of the crop. However, the optimum level of available soil moisture for each crop is not a fixed value but depends on many other factors which influence the general behavior of the plant.

Irrigation to increase yield and influence fruit quality has been a general practice in many crop production regimes. Increases in peach yield and fruit size as a result of supplemental irrigation during the growing season have been reported in many peach-producing states (2, 15, 19). The peach industry in Florida has been growing steadily since the introduction of many low-chilling cultivars. The total acreage in Florida is approaching 6,000 acres, located mainly in the Central and Northern portions of the state. Many of the soil used for peach production in Florida is Astatula fine sand which is characterized by low water holding capacity. Irrigation, particularly in later stages of fruit development from pit-hardening throughout the final swell stage, is beneficial to the trees and is economically feasible. The purpose of this research was to study the response of peach seedlings to water stress and soil saturation conditions under short term growth in the greenhouse.

Materials and Methods

Twelve, uniform, 6-month-old peach seedlings (*Prunus persica* (L.) Batsch) were planted in 15-cm pots in flatwood soil (Kanapha fine sand). The plants received 3 water regimes. Water stress was induced in the first group, by withholding irrigation water until soil suction reached 0.7 bar and irrigation then was applied to restore soil moisture to the field capacity (0.05 bar). Irrigation was scheduled in the second group, when soil water suction reached 0.15 bar. Apparent moisture saturation was maintained continuously

in the third group, by irrigation using capillary rise from a water table that was maintained at 9 cm below the soil surface. Plants received complete nutrient solution once every week and a 16-h photoperiod at a radiation intensity of 200 μ E/m²/sec (400-700nm). Temp was maintained at 32°C during the day and 25°C during the night. The experiment was terminated after 6 weeks. Total chlorophyll and photosynthesis were determined as described by Basiouny and Biggs (3). Stomatal diffusive resistance (SDR) measurements were made on fully exposed leaves by using an automatic diffusive resistance meter (Lambda Instrument Corp., Lincoln, Nebraska) as described by Allen and Cohen (1). Data are presented as the reciprocal of the average conductivity. Stomatal density and aperture were measured microscopically from an imprint on an acrylic film painted on the lower surface of the leaves (8). Total non-structural carbohydrate (TNC) in the leaves was determined by the procedure of Nelson using the modified copper reagent of Somogyi (18) and data were expressed in percent of dry weight.

Results and Discussion

Plant morphology

Water stress (0.7 bar) treatment resulted in general wilting and retarded leaf development. Some leaf abscission occurred particularly near the end of the experiment. This abscission may have been due to an increase in endogenous abscisic acid level (4, 5) resulting from moisture deficit or an interference with other leaf metabolic processes. Inadequate water supply induced early flowering; however, these premature flowers were weak and abscised shortly after they appeared. Leaf characteristics of plants grown under continuous saturation were distinct from those grown under water stress. Under the former conditions, although the leaves appeared somewhat turgid, chlorosis accompanied by noticeable marginal yellowing was observed 6 days after initiation of the experiments and continued through the termination. Premature leaf senescence and death occurred more frequently in plants growing under water saturation than in plants under water stress. This may have been due to root injury resulting in a reduction of root absorption capacity and the formation of phytotoxic compounds (10).

Effects of soil moisture on stomatal diffusive resistance

Peach seedlings grown in moisture saturated substrate had significantly higher stomatal diffusive resistances than those grown under conditions of water stress and adequate soil moisture (Table 1). SDR of peach leaves grown with inadequate soil moisture were significantly higher than those obtained from seedlings irrigated at 0.15 bar (approximate field capacity). These higher values indicated stomatal closure in response to low leaf water potential. Unfavorable soil moisture conditions (water stress and water saturation) appeared to have caused a substantial decrease in the capacity of the roots to absorb and conduct water. Soil water potential was simply not enough for the roots to absorb water in the former case but root damage could have resulted from anaerobic conditions, and high concn of CO₂ in the latter case.

Leaves from seedlings grown under both water stress and saturation showed changes in stomatal aperture and density

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from those of leaves receiving proper moisture (Table 1). Almost all stomata from the former were closed while those from the latter were open. This observation was expected, since stomatal aperture is influenced by the immediate aerial environmental conditions and by internal factors, such as water status of the plant (9). Water stress induced approximately 35% reduction in stomatal density. This was interpreted as resulting from plant adaptation to water deficit condition. It has been reported that the number of stomata per unit area varies according to the prevailing environmental conditions (9, 17). It was suspected that the lack of a significant difference between stomatal density of leaves grown with excess and adequate soil moisture could have been caused primarily by variation in stomatal number in each leaf.

Table 1. Effect of various soil moisture regimes on stomatal behavior of peach leaves.*

Treatment	Stomatal diffusive resistance [†] (sec/cm)	Stomatal density [‡] (cm ²)
Water stress	7.671 b	24 b
Field capacity	1.728 c	37 a
Water saturation	31.006 a	30 a

*Values in column followed by the same letter are not significantly different at 0.05% level as determined by Duncan's multiple range test.

[†]Each value is an average of 10 replications.

[‡]Each value is an average of 6 replications.

Effect of soil moisture on photosynthetic activity and chlorophyll content

Photosynthetic rates decreased significantly in leaves grown under water stress (Table 2), corroborating previous reports (11, 12, 14). Inadequate water supply resulted in a 28% reduction in CO₂ fixation rate compared to that of leaves receiving optimum amounts of water. A decrease in leaf water potential may have caused stomata closure and decreased CO₂ flux into the leaf. Drought stress may however, have affected carbon metabolism in tissue by altering the amount of carbon flow through competing pathways e.g. amino acid synthesis (13). CO₂ fixation in leaves receiving excessive soil moisture (soil water saturation) was significantly lower, approximately 58%, than in leaves receiving adequate soil moisture. This coincided with a previous report (16). The reason for a greater inhibition of CO₂ fixation in plants under water saturation than in water-stressed plants was not clearly understood, despite the fact that water saturation may induce water stress. Reduction in photosynthetic activities was parallel to increases in stomatal resistance observed under water stress and saturation regimes. Evidence has been presented that factors influencing synthesis and metabolism of glycolic acid, an intermediate

Table 2. Effect of various soil moisture regimes on photosynthesis rates, chlorophyll and carbohydrate content of peach leaves.*

	Total chl. (mg/g f. Wt.)	Photosynthesis (mg Co ₂ /dm ² /hr-1)(% dry matter)	Carbohydrate content.
Water stress	1.891 a	22.37 b	18.7 a
Field capacity	2.312 a	30.94 a	14.9 b
Water saturation	1.493 b	13.25 c	13.1 b

*Values in column followed by the same letter are not significantly different at 0.05% level as determined by Duncan's multiple range test. Each value is an average of 3 replications.

in carbohydrate metabolism, are closely related to stomatal aperture (7, 13).

Chlorophyll content of water-saturated-grown leaves was significantly lower than that of leaves grown under stress and adequate soil moisture. This was mainly due to destruction or inhibition of chlorophyll synthesis in the leaves which resulted from water saturation conditions. Limited drought conditions (water stress) induced a slight reduction in chlorophyll content.

Effects of soil moisture on carbohydrate content

Non-structural carbohydrate levels were significantly higher in peach leaves grown under water stress than in leaves supplied with adequate water (Table 2). This agreed with previous reports (12, 13, 14). It is interesting to note an inverse relationship between photosynthesis and carbohydrate content in leaf tissue grown under inadequate soil moisture. Limited soil water induced both impairment of photosynthesis and apparently did not favor breakdown and translocation of organic compounds from the leaves. There is ample evidence for reduction in photosynthate translocation in plants under moderate or severe water stress (6, 9). The buildup of carbohydrate under water stress was probably due to a greater reduction in translocation and utilization than in production of photosynthate.

Carbohydrate contents of leaves from the soil water saturation treatment were slightly reduced, although this reduction was not significantly different from that observed in leaves receiving adequate water supply. Water saturation may also induce water stress conditions in the plant, however, leaves grown with excessive water remained turgid. An explanation for carbohydrate reduction in this case was that turgid leaves were able to carry on respiration which depleted carbohydrate level in the leaves. This was not countered by carbohydrate production, as leaves were unable to photosynthesize efficiently, a situation resulting in general reduction of carbohydrate levels.

Conclusion

The data presented in this report showed that limited drought as well as soil saturation induced reduction in plant growth, leaf chlorosis and considerable decline in the ability of the plants to carry on photosynthesis. The data also suggested that, assuming other cultural conditions are optimal, frequent irrigation of sandy soils—that is soil moisture suction is maintained in the range of 0.05 to 0.15 bars during the growing season—would result in normal function of leaf stomata, high efficiency of CO₂ fixation and consequently higher yield.

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EVALUATION OF HERBICIDES FOR AVOCADO GROVES¹

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Abstract. Several herbicide combinations were evaluated for control of lantana, coral vine, balsam apple and various grasses in mature avocado groves. Lantana was controlled by treatments which included glyphosate, or a combination treatment of bromacil, diuron and paraquat. All herbicides gave good to excellent control of balsam apple; however, treatments with glyphosate and 2,4-D were more effective when combined with soil residual herbicides. Most herbicide treatments gave good to excellent control of grass species, except 2,4-D and simazine. One treatment containing bromacil and diuron produced mild phytotoxic symptoms on a few older avocado leaves.

A wide variety of annual and perennial weeds infest avocado (*Persea americana* Miller) groves in the shallow, calcareous soils of south Florida. Among the worst weed problems are woody perennials such as lantana (*Lantana camara* L.) which has a rapid regrowth capability under the Homestead subtropical conditions. Due to their ability to recover quickly, mowing or nonlethal concn of contact herbicides only have a temporary effect in suppressing their growth.

Several herbicides have been evaluated for controlling weeds in avocado groves. Spot treatments of 2,4-D have proven effective in controlling annual and perennial broadleaf weeds (1, 2). Monuron and diuron control annual weeds at rates which do not damage established trees (1, 2, 4, 5, 8, 9). Avocados tolerate atrazine and simazine at rates which control most annual broadleaf weeds (1, 2, 4, 5). Bromacil and terbacil have effectively controlled weeds particularly grasses, but often produce persistent phytotoxic symptoms on avocado foliage (3, 5). Paraquat is one of the

few contact herbicides registered for use in avocados (5, 6). Glyphosate, a relatively new herbicide, is a non-selective, broad spectrum, systemic compound which shows considerable promise in the control of deep rooted perennials or stoloniferous grasses in orchard crops, including avocados. Injury has occurred, however, to some fruit trees when this herbicide contacts foliage or green trunks (7).

The purpose of this study was to evaluate several combinations of herbicides for efficacy in controlling annual and perennial weeds without damage to established avocado trees.

Materials and Methods

Experiments were conducted in two commercial groves growing on Rockdale soil at two locations. Grove 1 consisted of 10 year old 'Simmonds' and 'Pollock' trees infested with a dense stand of lantana and balsam apple (*Momordica charantia* L.). Large crabgrass (*Digitaria sanguinalis* L.), guineagrass (*Panicum maximum* Jacq.) and natalgrass (*Rhynchehytrum repens* (Willd.) C. E. Hubb) were also present in the test area. Single tree plot ground area was 3.5 by 6 m (11.5 x 19.5 ft) and treatments were randomized in a complete block design with 5 replications. The test area was mowed June 5-7, 1973 and 4 weeks later the initial herbicide treatments were applied to vigorously growing weeds 20-25 cm (8-10 in) high.

Grove 2 consisted of seedling trees over 15 years old with a severe infestation of coral vine (*Antignon leptopus* Hook & Arn.). Single tree treatment plots measuring 3.5 by 4.5 m (11.5 x 14.5 ft) were randomized in a complete block design with 4 replications. The test area was mowed July 5, 1973 and 2 weeks later the initial herbicide treatments were applied to vigorously growing coral vine 10-45 cm (4-18 in) high.

For the purpose of identifying the season of application of each herbicide the "timing" is shown as follows: ES = early summer (applications made July, 1973 and June, 1974), MS = mid summer (application made Aug., 1973), W = winter (application made Dec., 1973-Jan., 1974).

Herbicides were applied using a CO_2 pressurized hand sprayer with a boom containing 4 nozzles that gave a spray swath 1.8 m (6 ft) wide. The spray volume was 325 l/ha (34.5 gal/acre) and the spraying pressure was 2.5 kg/cm² (33 psi). A blend of phytobland oil plus surfactant was added to all spray mixtures at a rate of 5 l/ha (0.5 gal/acre) except those containing 2,4-D. In 1973 the early and

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