Managing vegetative and reproductive growth and controlling tree size are priorities for sustainable, productive peach orchards. Tree size can be maintained by pruning above-ground shoots, but new shoots can grow vigorously from buds that were correlatively inhibited before pruning. Annual pruning is a significant expense, and the numerous cuts may provide entry for disease (Hayden and Emerson, 1975).

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Key words: Peaches, pruning, grass competition, root growth, abscisic acid, water stress.

Abstract. Peach [(Prunus persica (L.) Batsch., ‘Rutgers Redleaf’) trees were grown for two seasons in a greenhouse with three pruning treatments (none, shoot tips removed, and half the shoots removed) and three grass treatments (no grass competition; perennial ryegrass, Lolium perenne L., ‘Linn’; and tall fescue, Festuca arundinacea Schreb, ‘Kentucky 31’). Competing grass reduced shoot growth, leaf area, and weight of fine roots in shallow soil, but did not affect the growth response to pruning. Regrowth from pruned trees was such that the shoots : root ratio was restored to that of unpruned trees. Leaf water potential, stomatal conductance, and photosynthesis had decreased markedly by 48 hours after irrigation ceased in trees without competition (larger trees) and to a similar level by 96 hours in trees with competition (smaller trees). Apparently, the reduced leaf area of peach trees grown with grass competition delayed water stress. Leaf abscisic acid levels were not directly affected by grass competition but increased as leaf water potential decreased. Grass competition modified morphology and reduced tree size, but did not affect shoot growth following pruning.
Results and Discussion

Grass competition reduced peach shoot and root dry weight but did not alter the shoot : root dry-weight ratio (S/R) (Table 1). Fescue and ryegrass reduced shoot and root weights similarly. Generally, pruning did not reduce dry weights or S/R. Following heavy or light pruning, regrowth of shoots occurred until a S/R similar to nonpruned trees was achieved. Heavily pruned trees had about twice the new shoot growth of nonpruned trees. No interaction occurred between competition and pruning in terms of shoot growth (Table 2). Grass competition effectively reduced the size of trees, but the relative effects of competition were similar regardless of the level of pruning. Thus, regrowth following pruning appeared to be determined by the severity of pruning and tree size rather than by grass competition.

Total root weight of trees was reduced by grass competition, but only roots in the 0–30 cm depth were affected (Tables 1 and 3). Roots <1 mm in diameter were reduced by more than 40% by fescue and ryegrass. Below the 30-cm soil depth, grass root weight decreased, and peach root weight was not affected by grass competition (Table 3). Nearly all components of shoot growth, including leaf number, weight, and area and stem width were reduced by grass competition (Table 2 and data not shown).

Thus, grass appeared to interfere with fine root development of peach trees at shallow depths. This may have resulted in reduced water and nutrient capture and reduced shoot growth.

Correlation analysis supported results from analysis of variance. Peach shoot and root dry weights were negatively correlated with grass shoot dry weight (\( r = -0.85^{**} \) and \(-0.58^{**} \), respectively) and with grass root dry weight (\( r = -0.74^{**} \) and \(-0.59^{**} \), respectively). Only weights of peach roots <1 mm in diameter in the 0–30 cm soil depth were correlated with grass root dry weight (\( r = -0.48^{**} \)).

When irrigation ceased, increases in leaf ABA lagged behind decreases in leaf water potential and stomatal conductance (Figs. 1 and 2). For example, leaf water potential and

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Table 1. Effects of pruning intensity and competition with grasses on dry weight (g) of peach shoots, roots, and shoot : root ratio (S/R).

| Source of variation | Main effect of: | Peach | Grass | Peach plus grass |
|---------------------|----------------|-------|-------|----------------|
|                     |                | Shoot (S) | Root (R) | S/R | Shoot (S) | Root (R) | S/R | Shoot (S) | Root (R) | S/R |
| Competition         | None           | 353 a   | 254 a  | 1.4 | 0  | 0  | --- | 353 | 254 | 1.4 |
|                     | Fescue         | 134 b   | 172 b  | 0.8 | 168 | 77 | 2.2 | 301 | 249 | 1.2 |
|                     | Ryegrass       | 162 b   | 193 b  | 0.9 | 143 | 50 | 2.9 | 296 | 243 | 1.2 |
| Level of pruning    | None           | 251     | 200    | 1.2 | 160 | 86 | 1.9 | 411 | 286 | 1.4 |
|                     | Light          | 206     | 202    | 1.0 | 159 | 66 | 2.4 | 365 | 268 | 1.4 |
|                     | Heavy          | 192     | 217    | 0.9 | 153 | 57 | 2.7 | 346 | 274 | 1.3 |

#### Table 2. Effects of pruning intensity and competition with grasses on morphological traits of potted peach trees.

| Main effect of: | Annual shoot growth (cm) | Trunk diam (mm) | Total leaf area (m²) | Specific leaf area (cm²·g⁻¹) | Amb leaf area (cm²) | Ratio of leaf area to xylem diam (cm²·mm⁻³) |
|-----------------|---------------------------|-----------------|----------------------|-------------------------------|---------------------|-----------------------------------------------|
|                 | 1996 | 1997 | | | | | |
| Competition     | None | 303 a | 488 a | 19 a | 1.4 a | 159 a | 12.5 a | 815 a |
|                 | Fescue | 184 b | 158 b | 15 b | 0.39 c | 150 a | 7.2 b | 305 c |
| Level of Pruning | None | 163 b | 234 b | 15 b | 0.57 b | 150 a | 8.5 b | 477 b |
|                 | Light | 183 b | 274 ab | 17 a | 0.74 a | 146 a | 8.3 a | 483 a |
|                 | Heavy | 319 a | 359 a | 15 a | 0.87 a | 158 a | 10.4 a | 566 a |

#### Table 3. Effects of pruning intensity and competition with grasses on belowground weight (g) distribution of potted peach trees at two soil depths and of competing grass.

| Main effect of: | Peach | Grass |
|-----------------|-------|-------|
|                 | 0 to 30 cm depth | 30 to 60 cm depth | Leaves | Root depth (cm) | 0 to 30 | 30 to 60 |
|                 | Root diam (mm) | Root diam (mm) | | | | |
| Competition     | None | 29 a | 40 a | 110 a | 47 a | 18 a | 0 a | 98 a | 69 a | 8 a |
|                 | Fescue | 14 b | 25 b | 84 b | 46 a | 18 a | 70 a | 98 a | 48 b | 4 b |
| Level of Pruning | None | 17 b | 29 b | 91 ab | 42 a | 15 a | 44 b | 100 a | 48 a | 4 b |
|                 | Light | 25 a | 33 a | 92 a | 36 a | 0 a | 40 a | 61 a | 51 a | 5 a |
|                 | Heavy | 17 a | 32 a | 90 a | 44 a | 18 a | 40 a | 67 a | 40 a | 4 a |

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3Mean separation within columns and main effects by Ryan–Einot–Gabriel–Welch multiple range test (\( P \leq 0.05 \)).
4Zero values of no competition were excluded from the ANOVA of grass shoot, root, and S/R.

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7Total leaf area divided by total leaf weight per tree.
stomatal conductance of trees without competition decreased markedly between 24 and 48 h, but leaf ABA did not markedly increase until 48 to 72 h. Leaf ABA was correlated with transpiration \( r = -0.18 \) but not with leaf water potential \( r = -0.10 \); nonsignificant at \( P \leq 0.05 \). Transpiration was correlated with leaf water potential \( r = -0.72 \). While increases in xylem-derived ABA may occur because of drought stress (Davies and Zhang, 1991), the large increase of ABA in leaves in this experiment was not an early event in peach-tree response to water stress. However, the small increase in ABA from 24 to 48 h may have been physiologically significant.

Correia et al. (1997) found that peach leaf stomates opened in the morning despite high xylem ABA, and stomate responsiveness to ABA increased during the day. In the current experiment, measurements were taken close to 10:00 AM and stomate sensitivity to ABA may have increased later. After irrigation ceased, leaf water potential and ABA were affected by competition but not by pruning. Trees grown without competition had greater leaf area and leaf-area : xylem-diameter ratio, which may have caused greater water use and stress compared with smaller trees growing with competition (Table 2).

Competition for water very likely occurred between grass and peach trees. Peach leaf water potential 72 h after cessation of irrigation was more negative as grass crown and root dry weight increased (data not shown). However, peach trees appeared to be better competitors for water than grass or to avoid water stress. Even though grass moisture status was not measured, grass leaves wilted before peach leaves. Thus, the combination of a smaller tree size and greater capacity to exploit soil water, possibly from deeper soil layers, may have delayed water stress in peach trees grown with grass competition.

Trees grown without competition were larger than those grown with competition, and stomatal conductance and photosynthesis of the larger trees declined earlier and at a faster rate after irrigation ceased (Table 1, Fig. 2). However, the total root and shoot weight per pot of grass plus peach tree was uniform for all treatments (Table 1). Soil moisture depletion was fastest with trees grown without competition (Fig. 1 C). Trees grown with grass competition from either species had less root weight (Table 1), particularly roots <1 mm in diameter at the 0–30 cm depth where grass roots were abundant (Table 3).

Total leaf area and the ratio of leaf area to xylem diameter were less in trees grown with competition than in those grown without competition (Table 2), and total water demand was probably less in trees grown with grass. Peach trees grown with fescue had less leaf area than those grown with ryegrass (Table 2). This may be associated with greater fescue weight (Table 3). Correlation coefficients between ground cover total dry weight and peach leaf area, xylem diameter, trunk diameter, 1997 stem dry weight, and root dry weight at the 0 to 30 cm depth were \(-0.84, -0.67, -0.48, -0.72, \) and \(-0.63 \), respectively.

Fig. 1. (A) Leaf abscisic acid concentration, (B) leaf water potential, (C) and soil moisture changes following cessation of watering peach trees in the greenhouse. The effects of pruning were non-significant and competition treatments were averaged across pruning treatments. Bars represent one \( \pm \) se.
Previous research suggested that grass may reduce peach tree size by competing for resources (Glenn et al., 1996; Tworkoski et al., 1997). The current experiment indicates that peach trees grown with grass competition may be less susceptible to drought stress because of reduced size, a greater percentage of peach tree root weight below grass roots, and lower leaf-area : xylem-diameter ratio. This altered morphology may have been caused by competition for space, water, or mineral nutrients.

A practical implication of the current work is that shoot regrowth following pruning was determined by the amount of pruning and by overall tree size. Grass competition from fescue or ryegrass reduced the size of peach trees, affecting dry weight of shoots and fine roots in the upper soil. However, grass competition did not cause additional shoot regrowth reduction following pruning and a shoot : root balance was restored that was similar to that of unpruned trees. An additional implication is that peach trees grown with grass competition appeared to be better adapted to survive conditions of limited soil resources because of reduced tree size and altered morphology. When irrigation ceased, grass competition did not accelerate leaf water stress. Leaf ABA concentrations did not increase at a faster rate in trees grown with competition than in those without competition. These findings are based on a model system that increased the chances for competitive interaction between the tree and the grass. In the field, competition may be reduced by spatial avoidance between tree and grass roots. Trees grown with grass competition must be evaluated to determine whether or not similar morphological modifications occur under field soil conditions. The results suggest that grass competition will effectively control young peach tree size and that the differential reduction in shoot regrowth caused by competition was similar across all pruning treatments.

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