Table 3. Effect of soil management and grass species used in a killed-sod planting system on trunk cross-sectional area of young peach trees.

Treatment	Trunk cross-sectional area[z] (cm^2)			
	1985	1986	1987	1988
Kentucky 31	6.1 bc	22.4 a	46.4 a	60.8 a
Falcon fescue	5.9 bc	24.2 a	50.2 a	64.4 a
Orchardgrass	7.5 ab	25.2 a	52.9 a	69.5 a
Perennial ryegrass	8.3 a	25.6 a	52.4 a	66.9 a
Kentucky bluegrass	6.6 bc	24.9 a	49.9 a	64.9 a
Bare soil–cultivated	5.1 cd	16.1 b	34.9 b	49.5 b
Bare soil—herbicide	4.5 d	15.6 b	35.1 b	48.4 b

[z]Mean separation within columns by Duncan's multiple range test (P = 0.05, n = 15).

Table 4. Effect of soil management and grass species used in a killed-sod planting system on leaf N concentration of young peach trees.

Treatment	Leaf N concn[z] (% dry wt)	
	1985	1986
K-31	3.53 a	3.30 a
Falcon fescue	3.32 a	3.27 a
Orchardgrass	3.50 a	3.33 a
Perennial ryegrass	3.40 a	3.35 a
Kentucky bluegrass	3.64 a	3.30 a
Bare soil–cultivated	3.06 b	2.99 b
Bare soil—herbicide	2.85 b	2.85 b

'Mean separation within columns by Duncan's multiple range test (P = 0.05, n = 15).

resulted in greater growth than the bare soil treatments through the third growing season.

It was not until the 4th year that the canopy width and tree height of those trees raised in bare soil equaled those raised in killed sod. TCA of trees grown in killed sod was greater at the end of 4 years than the TCA of trees grown in the bare soil treatments.

Leaf N levels were significantly higher during the first and second growing seasons in all the killed-sod treatments than in the bare soil treatments (Table 4). There were no differences between management systems after the second growing season (range 2.63–2.76 in 1987 and 3.21-3.44 in 1988). These results are similar to those in our previous studies with killed sod (Welker and Glenn, 1988). There were no differences in leaf N content among grass species treatments.

K-31 was used exclusively in our previous studies (Glenn and Welker, 1989a, 1989b; Welker and Glenn, 1988) investigating the attributes of a killed-sod planting system. This study showed that K-31 was not unique in its ability to improve peach tree growth when used to develop a killed-sod mulch. All of the grasses used in this study resulted in greater growth of the young peach trees than the conventional bare soil system, although K-31 resulted in the least growth response of the grasses tested.

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Influence of Aluminum and Manganese on Rabbiteye Blueberries

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Abstract. **A sand culture study arranged in a *3 × 3* factorial was used to determine the influence of Al and Mn levels on leaf nutrient content and plant growth of 'Tifblue' rabbiteye blueberry *(Vaccinium ashei* Reade). Aluminum fertilization increased leaf Al content but did not affect plant vigor, leaf dry weight, or chlorosis. Manganese fertilization resulted in increased Mn in the leaves and a decrease in all growth parameters measured. The Al × Mn interactions were significant for Mn concentration in the leaves and vigor ratings. At the highest Mn fertilization rate, increasing Al fertilization had a synergistic influence on leaf Mn. Plant vigor at the highest Mn rate was lowest when no Al fertilizer was added. Increasing Al fertilization resulted in better plant vigor in plants grown with a high rate of Mn fertilization.**

Rabbiteye blueberries are acidophilic plants that can accumulate high levels of Mn and Al (Korcak, 1988; Spiers, 1984). In field conditions, leaf levels of Al and Mn in *V. angustifolium* Ait. and *V. myrtilloides* Michx. were up to 110 and 1500 $mg \cdot kg^{-1}$ respectively (Trevett et al., 1968). Field-grown highbush blueberries (V. *corymbosum* L.) had high levels of leaf Al (445 $mg \cdot kg^{-1}$) and Mn (183 $mg \cdot kg^{-1}$) (Ballinger and Goldston, 1967). There was no evidence of reduced growth at these Al and Mn levels.

Aluminum in large amounts is toxic to plants and any stimulator effects of Al on the growth of *Vaccinium* and other calcifugous plants may be due to indirect effects associated with lowering soil pH (Pratt, 1973). Peterson et al. (1987) indicated high leaf Al levels (up to 317 $mg \cdot kg^{-1}$) associated with aluminum sulfate fertilization may cause poor growth in rabbiteye blueberries. Excess Al and Mn induced visible Mg deficiency and reduced leaf Mg and Ca in norway spruce *(Picea abies* L.) seedlings (Hecht-Buchholz et al., 1987); however, no visible toxicity symptoms were observed in several blueberry species treated with high levels of Al and Mn (Korcak, 1988). In the same study, 'Tifblue' rabbiteye blueberry exhibited less growth under high (1.7 mM) Mn and best growth with intermediate (0.072 mM) Mn fertilization. The objective of this study was to determine main and interactive effects of Al and Mn fertilization on 'Tifblue' rabbiteye blueberry.

Two-year-old 'Tifblue' plants were potted in 1 l-liter containers of water-washed sand during February 1987. This study was conducted in a fiberglass shade house (20% shade) under natural daylength and temperatures. Plants were grown for 1 month without fertilization, then from 15 Mar. until 15 May were fertilized uniformly with a complete nutrient solution and then pruned to a height of ≈ 10 cm.

Beginning 15 June 1987, previously described nutrient solutions (Spiers, 1978) with differential Al and Mn concentrations were applied to the pots 5 days a week. Nitrogen was supplied as $(NH_4)_2SO_4$ and solution pH was adjusted to 5.5 ± 0.2 with H_2SO_4. All pots were leached with tap water followed by demineralized water twice weekly. Fertilizer treatments were: all combinations of Al (0, 3.7, and 37mM) and Mn levels (0, 1.8, and 18 mM) supplied as $Al(OH)_3$ and $MnCl_4H_2O$, respectively. The 3 x 3 factorial experiment was arranged in a randomized complete-block design with single plants as experimental units and five replications. On 23 Sept. 1987, plants were visually rated for vigor (0 = dead, 5 = most vigorous) and chlorosis (1 = most chlorosis, 5 = no symptoms). Leaf numbers 4, 5, and 6 from the terminal of several branches were collected, dried (60 C), finely ground, and analyzed by atomic absorption spectrophotometry (Mn) or colorimetry (Al) (Chapman and Pratt, 1978). Total growth (dry-weight basis) was determined by harvesting the new growth

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Table 1. Influence of Al and Mn fertilization levels on plant characteristics and elemental leaf content of 'Tifblue' rabbiteye blueberry.

Element and concn (mM)		Vigor[z]	Chlorosis[y]	New growth dry wt (g)	Leaf concn ($mg \cdot kg^{-1}$) Al	Mn
Al						
0		4.5	4.2	52	51	609
3.7		4.9	4.6	55	58	763
37.0		4.7	3.8	55	63	971
Significance–linear		NS	NS	NS	*	NS
Mn						
0		5.0	4.8	58	55	70
1.8		4.9	4.6	56	58	401
18.0		4.3	3.2	48	60	1872
Significance—linear		**	**	*	NS	**
Interaction		**	NS	NS	NS	*
Mn	Al					
0	0.0	5.0				74
0	3.7	5.0				61
0	37.0	5.0				75
1.8	0.0	5.0				423
1.8	3.7	5.0				389
1.8	37.0	4.7				491
18.0	0.0	3.6				1330
18.0	3.7	4.8				1893
18.0	37.0	4.7				2448

[z]5 = highest vigor.
[y]5 = no chlorosis.
NS,*,**Nonsignificant or Significant at P = 0.05 or 0.01, respectively. There were no significant quadratic effects.

(growth after pruning) and adding this to the weight of the leaf samples collected for analysis.

The Al × Mn interactions were significant for leaf Mn concentration and plant vigor ratings (Table 1). At the 0 and 1.8 mM levels of Mn fertilization, Al fertilization had no influence on Mn in the leaves. With 18 mM Mn fertilization rate, increasing Al fertilization had a synergistic influence on leaf Mn. Plants treated with the highest levels of both Al and Mn had an average of 2448 $mg \cdot kg^{-1}$ Mn in their leaves. Plant vigor was greatest at the two lower levels of Mn fertilization. At the highest level of Mn fertilization, however, plant vigor was lowest when no Al fertilizer was added. Increasing Al fertilization resulted in better plant vigor under the high rate of Mn fertilization.

Increasing Al fertilization levels resulted in a linear increase in leaf concentrations of Al but had no independent significant effects on Mn leaf content, vigor, or new growth (Table 1). From 0 to 37 mM Al fertilization, there was an increase of only 12 mg Al/kg in the leaves. There was a negative (r^2 = – 0.331, P = 0.05) relationship between leaf Al concentration and new growth of plants, but this was independent of Al fertilization levels. Korcak (1988) found similar results using lower (0.015 mM) Al fertilization levels.

Manganese fertilization influenced all characteristics measured, except Al concentration in the leaves (Table 1). As Mn fertilization levels increased from 0 to 18 mM, there was a linear increase in leaf Mn content from 70 $mg \cdot kg^{-1}$ to 1872 $mg \cdot kg^{-1}$. Both Mn fertilization levels and resulting Mn leaf concentrations were negatively correlated with all plant growth measurements. More Mn fertilization (and Mn in leaves) resulted in less plant vigor, more chlorosis, and less new growth. Some of this effect may be due to an increase in the anion (Cl-) associated with Mn fertilization, since most Al-Cl species usually are more toxic than Al-SO_4 species, but the use of $(NH_4)_2SO_4$ as a N source and H_2SO_4 to control solution pH would tend to buffer these effects.

Within the limits of this study, high levels of Mn fertilization and corresponding leaf Mn content resulted in decreased plant growth in rabbiteye blueberries. The determined effects of high levels of Mn appear to be reduced by Al fertilization.

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