This is to certify that the

dissertation entitled

THE RESPONSE OF FRUIT TREES TO
ORCHARD FLOOR MANAGEMENT

presented by

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has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Horticulture

Major professor

Date July 2, 1990

THE RESPONSE OF FRUIT TREES TO ORCHARD FLOOR MANAGEMENT

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Horticulture

1990

ABSTRACT

THE RESPONSE OF FRUIT TREES TO ORCHARD FLOOR MANAGEMENT

By

Michael Lee Parker

The effect of orchard floor management on fruit tree growth was evaluated over a three year period. Apple [Malus domestica Borkh. cv. Empire/MM111] and cherry [Prunus cerasus L. cv. Montmorency/Mahaleb] trees were grown in two sods with 6 different vegetation-free treatments ranging in area from 0 to 7.4 m^2. The treatments, established and maintained with herbicide, that provided the greatest amount of vegetation-free area resulted in the greatest shoot length and trunk cross-sectional area (TCA) in 1987 and 1988. A vegetation-free strip of 3.7 m^2 in the tree row avoided the reduction in tree growth associated with vegetative covers. The smaller vegetation-free areas had lower mass soil moisture. Soil moisture may be a key factor limiting tree growth in minimal vegetation-free area treatments.

Twelve orchard floor treatments were evaluated on peach [Prunus persica L. Batsch. cv. Redhaven/Halford] tree growth. A significant difference in TCA area occurred only in mid-1986. Differences in shoot length were present only at the end of the 1987 season. Significant differences in leaf nitrogen were detected in 1987 and 1988, however all were greater than recommeneded levels of 3.1% for Michigan conditions.

Soil moisture levels were greater in the herbicide and clean cultivated treatments in May and June, 1987.

Peach tree root distribution was evaluated for six orchard floor treatments. Treatments providing 37 m^2 of vegetation-free area, either with herbicides or cultivation, had the greatest root numbers 1.2 and 1.9 m from the tree in the alleyway. 'Kentucky 31' tall fescue and alfalfa vegetative covers had fewer tree roots in the soil-profile, both vertically and horizontally, than the vegetation-free treatments. Kentucky bluegrass and fine fescue did not result in as great a reduction in tree root numbers as the tall fescue.

DEDICATION

To my wife, Laurie, and my parents, Gordon and Ellen, and family for their continual prayer, support and encouragement. I would also like to thank the Almighty God, the source of all knowledge and wisdom, for the grace given to finish this dissertation.

ACKNOWLEDGEMENTS

I would like to express my appreciation to Dr. Jerome Hull, Jr. for the opportunity to pursue this advanced degree. I would also like to thank Dr. Hull for his instruction and guidance during my degree program. The time spent in the field implementing and maintaining research plots reinforced much of my education for which I am grateful.

I would also like to express my gratitude to Drs. Ron Perry and James Flore for their assistance with labor and equipment during this investigation. Dr. Perry's assistance with methods and techniques used during this investigation were much appreciated.

I would also like to thank Drs. Jim Flore, Eric Hanson, Ron Perry, Alan Putnam, Paul Rieke and Alvin Smucker for serving on my guidance committee. Their input and assistance in planning the research and in reviewing the papers was appreciated.

I would also like to express my appreciation to fellow graduate students for their friendship, assistance and many interesting discussions.

Appreciation must also be given to the crew at the Clarksville Horticultural Experiment Station for their assistance with the field work.

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LITERATURE REVIEW

Orchard floor management has made a transition from clean cultivation to clean cultivation plus cover crops to permanent vegetative covers during the 20th century (Partridge, 1937; Partridge and Toenjes, 1937). In Michigan, Toenjes et al. (1956) stated that the transition from clean cultivation to vegetative covers had occurred during a 25 year period. However, the transition involved many different systems utilizing cultivation, vegetation and herbicides incorporated together in varying combinations.

Clean cultivation utilized frequent mechanical tillage to maintain a vegetation-free orchard. Elimination of the vegetation which could compete with tree growth for soil moisture and nutrients was the greatest advantage (Breggar and Musser, 1939). Controlling all vegetation on the orchard floor was frequently practiced to modify the orchard microclimate and provide frost/freeze protection for the fruit crop. Hamer (1975) reported temperatures 3°C warmer just above bare soil compared to just above a heavy vegetative cover. In North Carolina, no differences in the canopy temperature of peach trees occurred between treatments of bare ground, total sod or herbicide strips for frost protection (Meager and Meyer, 1990) .

Clean cultivation promoted erosion on sloping sites and resulted in lower soil structure. Decreased soil structure and reduced infiltration associated with clean cultivation also contributed to soil erosion

(Partridge, 1937; Li et al., 1942; Aldefer and Shaulis, 1942; Anthony et al., 1948). To alleviate the detrimental affects, cover-cropping was implemented. Cover-cropping involved planting various vegetative covers, such as wheat, rye, sorghum, etc., in the cultivated soil, once a year or several times during a year. Cover-cropping frequently did not significantly reduce erosion or improve soil structure compared to clean cultivation (Partridge, 1937; Proebsting, 1937; Shaulis and Merkle, 1939; Alderfer and Shaulis, 1942).

The disadvantages of clean cultivation and cover-cropping were numerous and frequently documented. In orchard systems maintained for many years, the negative aspects of clean cultivation offset the advantages (Partridge, 1937). The advantages of clean cultivation most commonly cited were increased soil moisture, increased tree size, increased fruit size and ease of maintenance. An extensive survey by Shaulis and Merkle (1939) involving 26 orchards in 15 counties in Pennsylvania studied the long term effect of orchard floor management. Clean cultivated orchards had lower soil organic carbon levels of 20,390 kgs/ha and cover-cropped orchards were only slightly greater with 24,200 kgs/ha compared to orchards with vegetative covers with 34,100 kgs/ha. Total soil nitrogen and porosity were also much lower in cultivated and cover-cropped orchards compared to orchards with a vegetative cover. Decreased soil porosity, measured by soil volume weight also occurred in soils continually clean cultivated or cover-cropped, compared to soils with permanent vegetative covers. Other disadvantages reported for clean cultivation, compared to soils with vegetative covers, included increased soil erosion on sloping sites, reduced soil organic matter, poorer soil structure and lower total soil nitrogen (Judkins and Wander, 1945; Goode and White, 1958).

Li et al. (1942) and Anthony et al. (1948) reported optimal soil structure, measured by mechanical analysis of aggregate stability and probable permeability, in the top 8 cm under a bluegrass sod. Alfalfa sod had the most stable soil structure at the 8 to 16 cm depth because of deep rooting. Clean cultivated plots had the least stable soil structure at all soil depths measured. Li et al. (1942) and Anthony et al. (1948) reported on a three-year study in which a bluegrass sod had a 0.05% rainfall runoff with 26 kgs per ha of soil erosion, compared to 4.6% and 9,370 kgs per ha, respectively, for a plot clean cultivated with a fall and spring cover crop. Greater soil structure, measured by decreased bulk density, increased aggregate stability and pore size, was reported in vegetative treatments compared to clean cultivation (Welker and Glenn, 1988).

Clean cultivated soils were originally thought to have a greater soil moisture holding capacity and less moisture loss than vegetative covers. This was true initially but was detrimental to soil moisture infiltration for the long term. Kenworthy (1953) compared soil moisture under clean cultivation and sod covers for 2 years and 25 years. Treatments maintained for two years had greater soil moisture under clean cultivation than a fescue sod. However, treatments established for 25 years had greater soil moisture in a bluegrass sod than in a clean cultivated soil. He attributed the soil moisture reduction in the cultivated soil to reduced soil structure.

Partridge and Toenjes (1937) stated clean cultivation decreased soil moisture infiltration, compared to soils with vegetative covers resulting from decreased soil porosity. Anthony et al. (1948) reported that the soil moisture in the surface 15 cm at the base of a 2-3 percent slope under clean cultivation would contain 225 MT more water per ha than the soil at the top of the slope. Little soil moisture difference between the top and bottom of a slope was reported for the same situation with a vegetative cover. The authors concluded that the reduced water content at the top of the clean cultivated slope resulted from reduced soil permeability and decreased infiltration. Li et al. (1942) found a higher infiltration rate in a bluegrass sod than in alfalfa sod, and much lower infiltration in clean cultivation. Twenty-four hours after a rainfall, the clean cultivated plots had 1 to 8% less soil moisture in the surface 39 cm than the bluegrass or alfalfa sod. Glenn and Welker (1989a) demonstrated greater infiltration rates for both killed and mowed sod compared to clean cultivation. The killed sod was obtained by establishing a tall fescue sod for one-year and then treating the entire area with herbicide to kill the sod without disrupting the sod cover.

Decreased soil organic carbon content also reduced soil moisture infiltration. Container grown apple trees grown in soils without organic matter required a 2.5 greater time period for surface water to penetrate into the soil compared to soils with rye organic matter (Shaulis and Merkle, 1939).

Clean cultivation equipment frequently destroyed tree roots close to the soil surface. Cockroft and Wallbrink (1966) reported root densities in the surface 18 cm of the soil to be 210 in cultivated soil and 553 in soil maintained vegetation-free with herbicide. Cultivation equipment also frequently damaged tree trunks and the loose cultivated soil impeded heavy equipment movement under saturated soil moisture conditions (Toenjes et al., 1956; Daniel and Hardcastle, 1972).

<u>Vegetative Covers</u>

Permanent vegetative covers gradually replaced clean cultivation in many commercial orchards. A major concern with using vegetative covers was their effect on tree growth resulting from competition for soil moisture and/or nutrients (Kenworthy and Gilligan, 1949; Baxter and Newman, 1971; Lord and Vlach, 1973; Goode and Hyrycz, 1976; Shribbs and Skroch, 1986a).

Vegetative covers differ in competition posed to tree growth. Partridge (1937) listed 6 factors to consider in selecting an orchard cover to control erosion in Michigan including two to minimize competition for moisture and nitrogen. The first was that the vegetative cover should be shallow rooted to minimize the competition with tree growth for moisture. The second was that all vegetative covers should be mixtures and contain a legume with "nitrogen-gathering capacity" to minimize nitrogen competition. Vegetative cover mixtures recommended included Canadian and Kentucky bluegrass, fescue, orchardgrass, red top, smooth brome and timothy. Shribbs and Skroch (1986a) evaluated nine different vegetative covers and reported a wide range in apple tree growth.

Vegetative covers eliminated many disadvantages associated with clean cultivation, but had the potential to reduce tree growth. Shribbs et al. (1986) evaluated the effect of Kentucky bluegrass, Korean lespedeza, orchardgrass or red sorrel on apple seedling growth under greenhouse conditions. Treatments of orchardgrass and red sorrel resulted in smaller trees than the bluegrass or lespedeza treatments.

The differences in tree growth were inversely dependent on the vegetative biomass of the ground cover, the greater the vegetative biomass the smaller the tree growth.

Alfalfa and bluegrass sods that were disked every 3-4 years reduced the growth of young apple trees up to 4 years of age compared to cover-cropped orchards (Anthony et al., 1948). In Ireland, apple trees grown in timothy grass and clover with a 1 m^2 vegetation-free area had smaller trunk diameters than trees maintained completely vegetation-free with herbicides (Robinson and O'Kennedy, 1978). Tree growth and fruit yield were reduced in the vegetative treatment over the duration of the 8-year study. Stinchcombe and Stott (1983) reported significantly larger apple tree trunk diameters in treatments maintained totally vegetation-free compared to treatments of total grass, clover, or vegetative covers with a herbicide strip. Trees in total grass had the smallest stem diameter. Six years after removal of the grass with a herbicide, the trees in total grass were still the smallest.

Shribbs and Skroch (1986a) obtained larger apple trunk diameter for trees in vegetation-free areas, either by herbicide or cultivation, than in orchardgrass or tall fescue. Trees grown in tall fescue had smaller trunk diameters than trees grown in bluegrass, wheat or red sorrel. And the trees grown in nimblewill, red sorrel or blackberry covers had greater trunk diameters than trees grown in legume, tall broadleaf weeds, Kentucky bluegrass, orchardgrass or tall fescue. Baxter and Newman (1971) in Australia, obtained greater apple trunk diameter and shoot length in vegetative covers of volunteer weeds with a 1.3 m herbicide strip or totally vegetation-free compared to trees in complete vegetation. In this four-year-study, applications of 200 kgs of nitrogen per ha did not overcome the inhibition of growth associated with the sods.

Peach trees grown in mowed tall fescue sod produced smaller trunk diameters than trees maintained in vegetation-free soil, either with herbicides or cultivation (Welker and Glenn, 1988). The trees in the mowed sod had the least shoot length, trunk cross-sectional area (TCA), tree height and canopy width at the end of the three-year study. In Canada, Layne and Tan (1988) evaluated clean cultivation and permanent creeping red fescue strips with and without irrigation on peach tree growth for five years. The permanent fescue strip treatment with trickle irrigation was reported as the best treatment and permanent fescue strips without irrigation the worst treatment for tree growth and yield.

One and two-year-old peach trees grown in fine sandy loam soil with a 4.9 m wide herbicide strip down the tree row and a 2.5 m wide vegetation strip between rows resulted in equal or larger trunk diameters than trees grown in mechanically tilled soil in Georgia (Daniel and Hardcastle, 1972). However, tree growth under the same management systems in a clay loam soil exhibited no treatment differences. Weller et al. (1985) grew one and two-year-old peach trees in bermudagrass densities ranging from 0 to 100% and observed reduced tree growth at bermudagrass densities greater than 50%. An inversely proportional linear growth response for shoot and root growth was reported for bermudagrass density. Peach trees grown in mowed sod had smaller trunk diameter than trees in herbicide, cultivation or hay mulch treatments at the end of a 6-year study (Lord and Vlach, 1973).

To minimize the competition of the vegetative cover on tree growth many management strategies have been incorporated into orchard floor management. Chemical herbicides to control vegetation proved valuable in orchard floor management (Hogue and Neilsen, 1987).

Ries et al. (1962) evaluated simazine for control of vegetation around apple and peach trees. Simazine treated plots resulted in increased peach tree shoot growth and foliar nitrogen levels compared to clean cultivation. The apple trees had greater foliar nitrogen and longer shoot length when maintained vegetation-free with simazine than trees grown in vegetative treatments. Baxter and Newman (1971) also reported greater apple leaf nitrogen in vegetation-free treatments mainatained with simazine. However, Lord and Vlach (1973) reported no differences in apple and peach leaf nitrogen content for trees grown in the field in simazine-treated soil compared to clean cultivation.

The growth reduction associated with vegetative covers was also minimized by total herbicide treated areas. Robinson and O'Kennedy (1978) produced apple trees with greater trunk diameter when all vegetation was controlled with herbicide compared to trees in total cultivation. Treating the entire orchard floor with herbicide to control all vegetation did not facilitate traffic movement, erosion control or organic matter production to maintain soil structure and did not gain widespread acceptance.

Baxter and Newman (1971) recommended the implementation of a vegetative alley and herbicide strip down the tree row for both economic benefit as well as for ease of orchard maintenance, especially in nonirrigated orchards. Shribbs and Skroch (1986a) reported a herbicide strip to be the standard orchard floor management practice in new orchards. A vegetation-free zone around the tree with a vegetative alley between tree rows minimized competition to tree growth while maintaining soil structure and supporting orchard traffic in the vegetative alley. Lord and Vlach (1973) listed other advantages of herbicide vegetation control over clean cultivation to include a smooth drive alley to minimize fruit bruising, control of vegetation near the tree trunk and no damage to tree roots.

Herbicide strips down the tree row has proven beneficial, but the desired size of the vegetation-free area for optimal tree growth has not been determined. Welker and Glenn (1985, 1989) obtained a 78% increase in peach tree trunk diameter by increasing a vegetation-free square from a 0.36 m^2 to 13 m^2 the first year. Trunk cross-sectional area increased with increasing vegetation-free area from 0.36 m^2 to 13.0 m^2 for all four years of the study. Peach trees grown 3 years in complete sod had smaller trunk diameters than trees grown in sod killed with herbicide before planting, cultivation or total herbicide treatments (Welker and Glenn, 1988). Trees grown in sod killed with herbicide had the greatest trunk diameter. Daniel et al. (1972) grew peach trees in a 4.9 m herbicide strip and obtained larger trunk diameters compared to trees grown in complete cultivation or cultivated strips 3.7 or 7.4 m wide. Increased weed competition and root pruning were indicated to be responsible for reduced tree growth.

Vegetative covers may compete with trees for soil nutrients. Goode and Hyrycz (1976) grew apple trees in cultivation or ryegrass, with and without nitrogen, and reported trees grown in sods without nitrogen resulted in yellow leaves and reduced tree root growth. Shribbs and Skroch (1986b) found lower leaf and twig nitrogen levels in two-year-old apple trees grown in vigorous vegetative covers, such as tall fescue and tall broadleafs compared to less vigorous covers such as nimblewill, blackberry, or vegetation-free plots. They calculated a positive correlation between apple leaf nitrogen and tree growth and suggested competition for nitrogen was a major factor in reduced tree growth.

Stinchcombe and Stott (1983) reported lower leaf nitrogen for apple trees grown for three years in complete grass compared to trees grown in clover, complete vegetation-free or grass with herbicide strip treatments, with respective foliar nitrogen of 1.8%, 2.4%, 2.6%, and 2.4%. Baxter and Newman (1971) reported that apple trees grown for four years in sod treatments had a leaf nitrogen of 2.35% compared to the vegetation-free treatments with foliar nitrogen ranging from 2.69 to 2.75%. The vegetative covers were reported to be the first to utilize applied nitrogen thus limiting nitrogen available for tree growth. Apple leaf nitrogen levels were higher in the legume and blackberry treatments, with 2.45% and 2.35% respectively, than treatments of tall broadleaf weeds, orchardgrass, or tall fescue, 2.14%, 1.83%, and 1.85% respectively (Shribbs and Skroch, 1986b). Significant differences in leaf P, K, Ca and Mg occurred but only leaf N and Ca were deficient, with leaf Ca deficient in all treatments. Nitrogen was concluded to be the a major factor limiting tree growth under vegetative covers.

Vegetative covers also affect the foliar nutrient status of peach. Welker and Glenn (1985) reported foliar nitrogen and copper levels were greater for one-year-old peach trees grown in larger vegetation-free squares. Peach leaf nitrogen was positively correlated to the size of the vegetation-free area ranging from 0.4-13 m^2, while leaf Mg and Zn were negatively correlated. Trees grown in mowed sod had the lowest leaf nitrogen after three years compared to vegetation-free treatments (Welker and Glenn, 1988). Leaf nitrogen was lower in mowed sod treatments compared to herbicide, cultivation or hay mulch treatments for six-year-old peach trees and they concluded that the orchard management systems limiting tree growth may affect available nutrient availability as well as soil moisture (Lord and Vlach, 1973).

Vegetative covers differ in quantity and depth of soil moisture utilization. Goode (1955) evaluated three grasses and reported perennial ryegrass depleted soil moisture the most, timothy was intermediate and the least depletion under the meadow grass. Perennial ryegrass rooted 15 cm deeper than timothy and 46 cm deeper than the meadow grass. Reduced apple tree growth in these vegetative covers resulted from competition for moisture. Toenjes et al. (1956) also reported differences in moisture utilization by different sods. Bluegrass, timothy, chewings fescue and redtop treatments had greater soil moisture in the top 61 cm compared to treatments of clover or alfalfa. Soil moisture under the alfalfa and clover at the 102 cm depth, the lowest depth measured, was 3-4 times lower than the moisture under the Kentucky bluegrass, timothy, chewings fescue or redtop Baxter and Newman (1971) reported vegetative covers of volunteer weeds resulted in lower soil moisture in an apple orchard than vegetation-free treatments maintained with herbicides.

Interference

The reduction in tree growth associated with vegetative covers, compared to vegetation-free treatments, suggests interference. Interference was defined as the effect on plant growth of one plant induced by another (Radosevich and Holt, 1984), and can either promote or inhibit plant growth. The mechanisms by which interference may affect plant growth are numerous. Two probable effects of inhibitory interference are competition and allelopathy. Competition for nutrients and water would be a direct effect of interference as discussed earlier. Allelopathy, the inhibition of growth of one plant due to toxic substances released from another (Putnam and Tang, 1986) would be an indirect effect, in contrast to direct effects such as moisture or nitrogen. Some plants which have been identified as secreting toxic compounds are Canadian thistle, oats, rye, sorghum, yellow nutsedge, walnut, wheat or quackgrass (Putnam, 1983).

Grapes grown in a greenhouse with rye plant leachates resulted in smaller plants than grapes grown in clean cultivated soil where moisture and nutrients were not limiting (Cubbon, 1925). Overland's (1966) work revealed the inhibitory response of leachates from barley seeds and roots on plant growth. The inhibitory response was plant specific with the greatest growth inhibition on chickweed and no growth inhibition on wheat. An alkaloid was isolated from the root leachates that would inhibit growth as did the root leachates.

Residues of barley, oats, rye, sorghum or wheat have been reported to result in reduced weed biomass in field and greenhouse vegetable plantings (Putnam and DeFrank, 1983; Barnes and Putnam, 1983; Putnam et al., 1983). However, some of the smaller-seeded vegetables, such as lettuce and tomato, which are planted shallow, were also adversely affected by the plant residues.

Allelopathic interactions have also been investigated in perennial cropping systems. Cover crops of rye, sorghum or wheat planted in the fall and killed with herbicide in the spring resulted in greater apple and cherry tree trunk diameter and shoot length compared to a mowed fescue cover (Putnam et al., 1983). The presence of the crop residues provided 60 days of weed control without inhibiting tree growth. Weller et al. (1985) reported that reduced peach tree growth in bermudagrass could not be accounted for by nutrient deficiencies and suggested that there was possibly an allelopathic interaction. Fales and Wakefield (1981) reported the growth inhibition of the branches and top of a woody plant, forsythia, when leachates from the roots of Kentucky bluegrass, perennial ryegrass or red fescue were applied to the soil of forsythia cuttings. Dry weight root production of the forsythia was also reduced by application of leachates from perennial ryegrass or red fescue.

Root Growth

Atkinson's (1980) review of root systems revealed limited studies of the effects of orchard floor management on perennial root systems. Cowart (1938) studied the root distribution of young peach trees in sandy loam/sandy clay loam. After the first year of growth, trees had an average rooting depth and lateral spread from the trunk of 92 cm. Over 82% of the total root system was within 31 cm of the tree trunk through the soil profile. The greatest root weight occurred at the 15-31 cm depth, with the greatest root densities at the 31-46 cm depth. After the second year, roots were found to a depth of 1.4 m with a 1.8 m lateral spread from the trunk. Over 67% of the tree roots were within 31 lateral centimeters of the trunk with the greatest root numbers at the 15-31 cm depth. Roots less than 2 mm diameter were estimated to comprise 18% of the tree's total root system. Clean cultivation may have altered tree root numbers in the top 15 centimeters.

Atkinson and White (1976) compared complete grass cover, complete elimination of vegetation with herbicide, and a 1.5 m herbicide strip on root growth of 5-year-old apple trees. Tree root number and weight increased with increased vegetation-free area. Complete grass cover had the fewest tree roots and lowest root weight, 50 and 156 g respectively. Total control of vegetation with herbicide resulted in the most roots and greatest root weight, 97 and 219 g respectively. Complete grass cover had fewer roots in the top 7 cm of the soil with more roots at the 7-15 cm depth than the other treatments. Atkinson et al. (1977) reported 10-year-old apple trees under herbicide strip management had greater root densities in the herbicide strip than in the vegetative alley. Tree roots under the vegetative alley were deeper than those in the herbicide strip.

Cockroft and Wallbrink (1966) evaluated peach and pear tree rooting under four orchard floor management systems. Cultivation to a depth of 8 cm prevented rooting in the surface 8 cm, all other treatments had rooting in the surface 8 cm. The greatest root weight was at the 46 cm depth. In peach, bare surface or straw mulch treatments resulted in greater root length, concentration, and weight than cultivation or white clover treatments. They concluded that orchard floor management did not promote deeper rooting but affected surface rooting.

Glenn and Welker (1989b) investigated the effect of tall fescue grass on peach root growth in a greenhouse. Comparing bare soil with tall fescue, planted 50 cm from the trees, they reported no decrease in root growth greater than 1 mm under the tall fescue. The tall fescue did result in decreased root length of roots less than 1 mm diameter, both under the tall fescue and in the 50 cm vegetation-free zone between the tree and the tall fescue.

Irrigation also affected tree root distribution. Cripps (1971) reported that non-irrigated apple trees rooted to depths greater than 90 cm while the majority of roots of irrigated trees were above 45 cm. In South Africa, apples irrigated every 7 days had greater rooting percentage in the surface 60 cm of the soil while trees irrigated every 58 days resulted in deeper rooting with major rooting occuring in the surface 110 cm (Beukes, 1984). In Australia, peaches irrigated every 3 to 4 days had greater root concentrations in the surface soil, measured by mm of root length per cubic centimeter, than trees irrigated every 12-16 days (Richards and Cockroft, 1975). Layne et al. (1986) reported that irrigation increased peach root numbers in the surface 30 cm of the soil which increased with irrigation frequency. Non-irrigated trees had 18% of the roots in the surface 30 cm of the soil compared to 42% for trees irrigated each week.

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SECTION I

THE EFFECT OF ORCHARD FLOOR MANAGEMENT ON APPLE AND CHERRY TREE GROWTH AND MOISTURE UTILIZATION

ABSTRACT

The effect of six orchard floor management treatments on tree growth were evaluated for apple (*Malus domestica* Borkh. cv. Empire/MM111) and cherry (*Prunus cerasus* L. cv. Montmorency/Mahaleb). Vegetation-free areas ranging from 0.0 to 7.44 m^2 were applied around the tree and evaluated in both tall fescue and hard fescue sods. A vegetation-free zone around the tree resulted in greater trunk cross-sectional area (TCA) in all three years for apple but only in the second and third year for cherry in both grass covers compared to no vegetation-free zone. The greater vegetation-free areas resulted in greater tree growth. Amount of vegetation-free area was positively correlated to shoot length and trunk diameter in both grass covers and was significant for apple in the second and third growing season and for cherry in the third growing season. Vegetation-free area was related to mass soil moisture content in the tree row. Treatments providing 0-1.49 m^2 vegetation-free area, the smallest vegetation-free zones, had less soil moisture than the larger vegetation-free strip treatments. Increased tree growth was directly related to increased vegetation-free area with greater soil moisture levels.

INTRODUCTION

Orchard floor management changed during the 20th century from clean cultivation to grass covers (Partridge, 1937; Partridge and Toenjes, 1937) and herbicide strips in the tree row (Lord and Vlach, 1973; Atkinson and White, 1976a). The combination of cover-cropping and clean cultivation for a portion of the growing season followed by one or two cover crops for the rest of the year, had little benefit over clean cultivation in controlling soil erosion (Partridge, 1937; Shaulis and Merkle, 1939).

Clean cultivation resulted in reduced soil structure stability compared to grass, clover or alfalfa covers (Li et al., 1942; Anthony et al., 1948; Welker and Glenn, 1988). Shaulis and Merkle (1939) reported that clean cultivation, year-round or with cover crops, decreased soil structure. Clean cultivation resulted in decreased water infiltration rates compared to alfalfa, clover or grass covers (Partridge and Toenjes, 1937; Anthony et al., 1948; Glenn and Welker, 1989). Bluegrass sod had a greater infiltration rate than alfalfa sod and both were much greater than clean cultivation (Li et al., 1942). Decreased soil structure stability and water infiltration promoted soil erosion (Partridge, 1937; Li et al., 1942; Anthony et al., 1948). Equipment used to clean cultivate frequently damaged tree trunks and shallow tree roots and the tilled soil impeded traffic ability under high soil moisture conditions.

Apple trees grown in alfalfa or bluegrass had reduced tree growth (Anthony et al., 1948). Apple trees grown in grass, broadleaf weeds or legumes had smaller trunk diameters than trees maintained vegetation-free with herbicides or cultivation (Robinson and O'Kennedy, 1978;

Stinchcombe and Stott, 1983; Shribbs and Skroch, 1986a). Shribbs and Skroch (1986a) evaluated the effect of nine vegetative covers, including grasses, broadleafs, or legumes on apple tree growth and reported a differential growth response. Welker and Glenn (1988) reported that peach trees grown in mowed sod had smaller trunk diameters than trees maintained vegetation-free with herbicides or cultivation.

Differential utilization of soil moisture, both in depth and degree, occurred between grass species and legumes (Toenjes et al., 1956; Goode, 1955). Goode and Hyrycz (1976) concluded that grass species differentially compete with trees for soil nitrogen and/or soil moisture.

Vegetative covers also affected the nitrogen composition of apple and peach leaves (Neilsen et al., 1984; Welker and Glenn, 1985; Shribbs and Skroch, 1986b). Peach in tall fescue had reduced foliar nitrogen levels with the smaller vegetation-free areas around the tree (Welker and Glenn, 1985). Apple trees grown in complete grass had lower leaf nitrogen than trees grown under varying vegetation-free areas (Neilson et al., 1984). Shribbs and Skroch (1986b) concluded that competition for nitrogen may be a major factor in reduced tree growth in vegetative covers.

Shribbs and Skroch (1986a) reported herbicide-treated tree rows with grass alleys to be the standard orchard floor management practice in new orchards. A vegetation-free zone in the tree row with a vegetative alley between tree rows minimized competition to tree growth while maintaining soil structure in the alley. Welker and Glenn (1985, 1989) observed that increasing the vegetation-free area around peach trees, ranging from 0.36 to 13 m^2, resulted in larger trunk diameters.

Daniel and Hardcastle (1972) reported that peach trees grown in a 4.9 m herbicide strip had larger trunk diameters than trees grown in total cultivatiuon or cultivated strips 3.7 and 7.4 m wide. Herbicide strips in the tree row with vegetative alleys offer several advantages over total herbicide systems such as reduced soil erosion and equipment support under saturated soil conditions (Atkinson and White, 1976b).

Herbicides have been applied to control vegetation around fruit trees but little information has been reported as to desired area or configuration of the vegetation-free zone. This study was to determine the effect of different vegetation-free areas on apple and cherry tree growth and soil moisture.

METHODS

This research was conducted on a Riddles sandy loam soil at the Michigan State University Clarksville Horticultural Experiment Station in western Michigan. Two sods, Reliant hard fescue [*Festuca ovina* ssp. duriuscula (L.) Koch.] and Kentucky 31 tall fescue (*Festuca arundinacea* Schreb.) were compared. The hard fescue was sown at 200 kg/ha and the tall fescue at 305 kg/ha.

The sods were sown in September, 1985 in adjacent plantings and each was subdivided into 6.1 m square plots. Empire/MM111 apple (*Malus domestica* Borkh.) and Montmorency/Mahaleb tart cherry (*Prunus cerasus* L.) trees were planted in May, 1986. Apple and cherry trees were alternated in a tree row through the middle of each plot with an apple and cherry tree in each plot. Trees were spaced 2 m apart in each plot and 3.7 m apart between adjacent plots in the row with 6.1 m between rows. Apple trees were headed at 76 cm at planting and trained as central leader trees. Cherry trees were not headed at planting but all lateral branches were removed and trees were trained to a modified central leader system.

Six treatments were established in both grass covers to provide varying amounts of vegetation-free area around the trees as follows:

Treatment	Vegetation-free Area m^2
1. Complete Sod	0.00
2. 61 cm herbicide square	0.36
3. 122 cm herbicide square	1.49
4. 122 cm wide herbicide strip	3.72
5. 183 cm wide herbicide strip	5.58
6. 244 cm wide herbicide strip	7.44

The vegetation-free areas were applied symmetrically around the trees in the patterns described above. The strip treatments were continuous between the apple and cherry tree and vegetation-free area was calculated based on half the distance to the adjacent tree. Treatments were initiated three weeks after tree planting. Gramoxone (1,1'-dimethyl-4-4'-bypyridinium ion), a contact herbicide, was applied with a hand sprayer at 1.1 kg/ha with 0.1% X-77 surfactant at approximately 30 day intervals during the growing season to maintain the vegetation-free areas. The experimental design was a randomized complete block with 6 replications.

Trunk diameter, terminal shoot length and soil moisture were measured during the growing seasons. Trunk diameter was measured 38 cm above the graft union using electronic calipers. Two perpendicular measurements were averaged and trunk cross-sectional area (TCA) calculated. Shoot length was measured from the base of the current season's growth to the shoot apex for the primary scaffolds.

Soil moisture was monitored by Bouyoucos soil moisture blocks (Bouyoucos and Mick, 1940) with a Bouyoucos moisture meter (both from Beckman Instruments, Inc., Cedar Grove, NJ). Before installation the blocks were soaked in water. Those measuring saturation were then air dried to confirm the blocks registered a full range. Blocks that did not register both extremes were discarded. Blocks were placed in the tree row, 61 cm from the tree, at depths of 15, 30 and 45 cm.

Soil moisture calibration curves, relating mass soil moisture to electrical resistance from the Bouyoucos moisture meter, for the Riddles sandy loam were determined in the laboratory (Appendix 1-M). Soil samples were taken from the field at 15 cm, the A horizon, and at 30 and 45 cm depths, the B horizon. The Bouyoucos moisture measurements were converted to mass soil moisture content, total mass of water in soil divided by soil oven dry weight, using the soil moisture calibration curves. The soil moisture range for the 15 cm depth was 7.7%-19.5% and 10.1%-17.3% for the 30 and 45 cm depth. Field capacity for the A horizon soil was approximately 21% and approximately 18% for the B horizon soil.

Both 1987 and 1988 were very dry during the growing season (Fig. 1) for Michigan. Plots were irrigated on June 4 and July 30 in 1987 and on May 20, June 27 and July 29 in 1988. Approximately 13 cm of water per unit area was applied saturating the soil to a minimum depth of 46 cm to saturate all the moisture blocks.

Data were compared by analysis of variance and mean separation determined by Duncan's multiple range test at the 5% significance level.

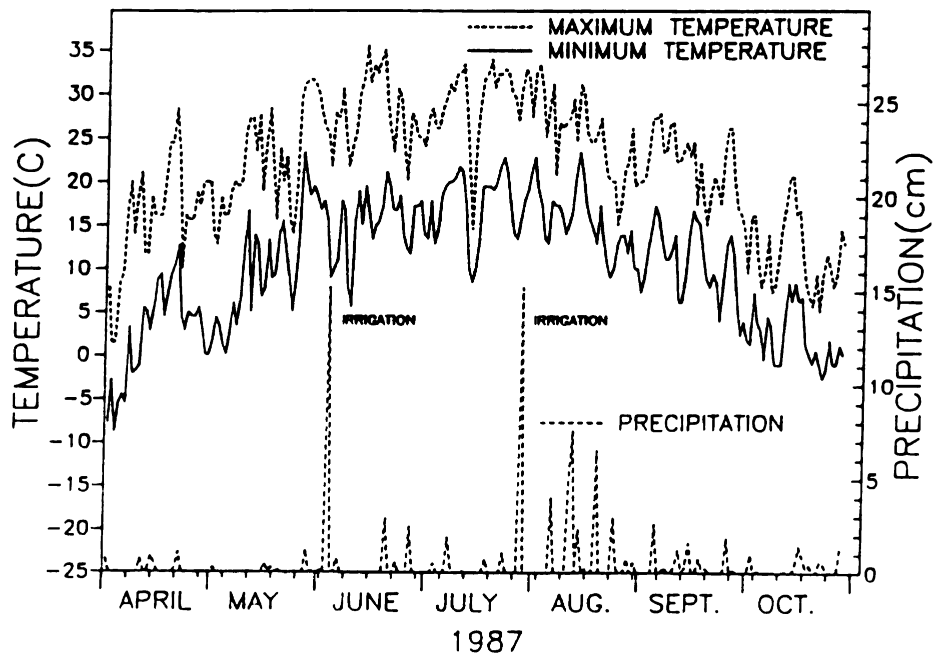
RESULTS

Apple Tree Response

Growth Response--Hard Fescue

There were no significant treatment differences in shoot length in 1986 or 1988 (Table 1). In 1987, shoot length was significantly less

Figure 1: Daily maximum and minimum temperature, daily precipitation and applied irrigation for 1987 and 1988 for the Clarksville Horticultural Experiment Station. Data presented for April through October each season.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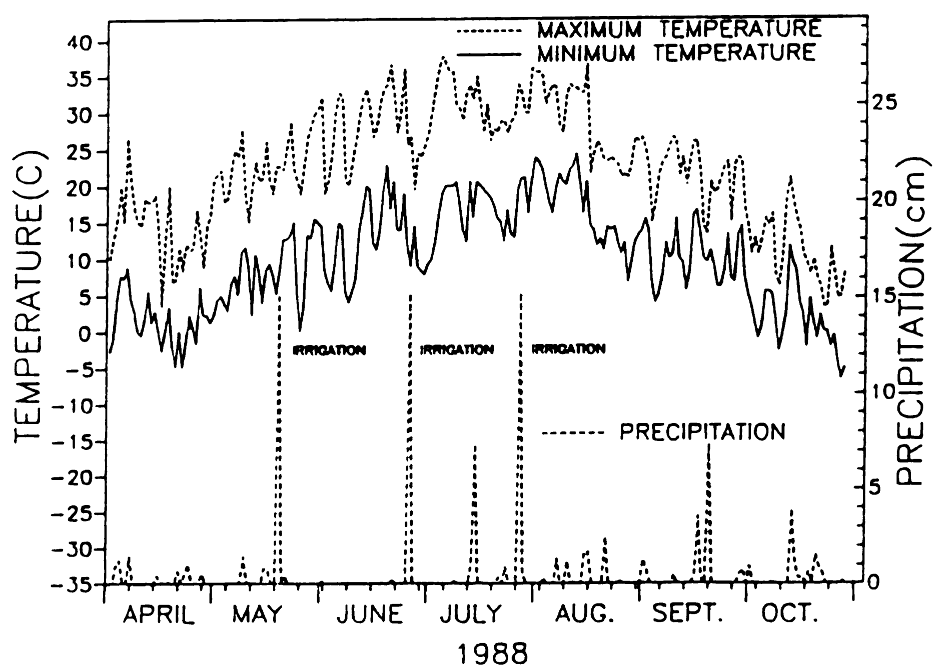
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Table 1: The effect of vegetation-free area around apple trees in Reliant hard fescue sod on shoot length and trunk cross-sectional area (TCA).[z]

TREATMENT	AVERAGE SHOOT LENGTH (cm)			AVERAGE TCA (cm^2)		
	11/5/86	9/25/87	9/15/88	10/30/86	9/25/87	9/15/88
Complete Sod	48.3 a	64.5 d	83.8 a	1.85 b	4.38 d	9.95 d
61 cm Square	56.9 a	76.0 c	84.7 a	2.22 a	5.61 c	12.65 c
122 cm Square	55.6 a	80.4 bc	85.1 a	2.51 a	6.92 b	16.28 b
122 cm Strip	58.1 a	88.4 ab	85.0 a	2.37 a	7.40 ab	17.55 b
183 cm Strip	55.7 a	82.7 abc	84.5 a	2.48 a	6.97 b	17.15 b
244 cm Strip	60.4 a	89.7 a	86.6 a	2.55 a	8.14 a	20.14 a

[z] Treatment means separated within columns by Duncan's multiple range test (P=0.05).

for trees in complete sod than all other treatments. The trees in the 61 cm square had less shoot growth than the trees in the 122 or 244 cm strip treatments.

Trees grown in complete sod had smaller TCA than all other treatments at the conclusion of each growing season. In 1987, trees in the 244 cm strip had significantly greater TCA than all other treatments except trees in the the 122 cm strip. Trees in the completes sod had significantly less TCA than all other treatments and trees in the 61 cm square had less TCA than all other vegetation-free treatments. The 244 cm strip treatment yielded trees with the greatest TCA in 1988. Trees in the 122 cm square, 122 cm strip, and 183 cm strip treatments had greater TCA than the trees in the 61 cm square.

Growth Response--Tall Fescue

The three strip treatments had significantly greater shoot length than trees in the complete sod or the 61 cm square treatments all three years (Table 2). The 122 cm square treatment did not differ from the complete sod or 61 cm square treatments in 1986 but was significantly less than the 122 cm or 244 cm strip treatments. In 1987, the 122 cm square treatment had less shoot growth than the 183 cm strip treatment but greater than the complete sod or 61 cm square treatment.

TCA at the end of the 1986 season in complete sod was significantly less than all treatments except the 61 cm square (Table 2). The 61 cm square had less TCA than the 122 or 244 cm strip treatments. In 1987 and 1988, the complete sod and 61 cm square treatments had significantly less TCA than all other treatments. In 1988, the 244 cm strip treatment resulted in the greatest TCA but did not significantly differ from the 183 cm strip treatment.

Table 2: The effect of vegetation-free area around apple trees in Kentucky 31 tall fescue sod on shoot length and trunk cross-sectional area (TCA).[z]

	AVERAGE SHOOT LENGTH (cm)			AVERAGE TCA (cm^2)		
TREATMENT	11/5/86	9/25/87	9/15/88	10/30/86	9/25/87	9/15/88
Complete Sod	33.8 c	38.5 c	68.0 b	1.41 c	2.94 b	6.35 d
61 cm Square	38.8 c	45.4 c	63.8 b	1.60 bc	3.18 b	7.02 d
122 cm Square	41.0 bc	70.4 b	79.3 a	2.03 ab	6.83 a	13.59 c
122 cm Strip	51.1 a	78.3 ab	77.8 a	2.36 a	6.92 a	15.91 bc
183 cm Strip	49.2 ab	85.3 a	81.2 a	2.01 ab	7.23 a	17.70 ab
244 cm Strip	51.4 a	82.1 ab	84.6 a	2.11 a	7.62 a	18.97 a

[z] Treatment means separated within columns by Duncan's multiple range test (P=0.05).

Cherry Tree Response

Growth Response--Hard Fescue

The shoot length of cherry trees grown in hard fescue did not differ the first growing season, 1986 (Table 3). In 1987, trees in complete sod had significantly less shoot growth than all other treatments. Shoot length in 1988 was significantly less in the complete sod or 61 cm square than in the 244 cm strip treatment.

Cherry TCA did not differ significantly between treatments in 1986 (Table 3). In 1987 and 1988, complete sod had the smallest TCA.

Growth Response--Tall Fescue

Shoot length of cherry trees in tall fescue did not differ between treatments in 1986 (Table 4). In 1987, trees grown in complete sod or the 61 cm square treatments had significantly less shoot length than all other treatments. The 122 cm strip treatment had significantly less shoot length than the 183 cm strip. The complete sod treatment also had significantly less shoot length in 1988 than all treatments except the 61 cm square. The 61 cm square had less shoot growth than the 122 or 183 cm strip treatments.

The TCA of cherry trees grown in tall fescue did not differ significantly in 1986 (Table 4). In 1987 and 1988, trees in complete sod or the 61 cm square treatments had significantly smaller TCA than all other treatments.

Relative growth rates (RGR) for apple and cherry trunk diameter for 1987 and 1988 also differed significantly (data not shown). The complete sod and 61 cm square treatments had the lowest RGR.

Table 3: The effect of vegetation-free area around cherry trees in Reliant hard fescue sod on shoot length and trunk cross-sectional area (TCA).[z]

TREATMENT	AVERAGE SHOOT LENGTH (cm)			AVERAGE TCA (cm^2)		
	11/5/86	9/25/87	9/15/88	10/30/86	9/25/87	9/15/88
Complete Sod	35.7 a	39.3 b	54.7 b	1.57 a	3.70 c	7.47 c
61 cm Square	33.5 a	52.5 a	55.4 b	2.07 a	5.41 b	13.74 b
122 cm Square	38.4 a	61.2 a	61.5 ab	2.25 a	6.54 ab	14.43 b
122 cm Strip	34.2 a	65.7 a	71.7 ab	2.36 a	7.12 a	18.16 a
183 cm Strip	29.2 a	57.8 a	63.7 ab	1.73 a	5.28 b	14.37 b
244 cm Strip	30.5 a	62.0 a	77.2 a	1.87 a	6.22 ab	16.84 ab

[z] Treatment means separated within columns by Duncan's multiple range test (P=0.05).

Table 4: The effect of vegetation-free area around cherry trees in Kentucky 31 tall fescue sod on shoot length and trunk cross-sectional area (TCA).[z]

	AVERAGE SHOOT LENGTH (cm)			AVERAGE TCA (cm^2)		
TREATMENT	11/5/86	9/25/87	9/15/88	10/30/86	9/25/87	9/15/88
Complete Sod	26.7 a	20.2 c	33.9 c	1.37 a	2.01 b	3.95 b
61 cm Square	31.2 a	18.7 c	50.8 bc	1.51 a	2.15 b	4.64 b
122 cm Square	31.3 a	52.4 ab	65.0 ab	1.59 a	4.01 a	10.82 a
122 cm Strip	30.0 a	41.5 b	70.4 a	1.43 a	4.36 a	12.01 a
183 cm Strip	28.1 a	63.7 a	71.3 a	1.56 a	5.18 a	14.47 a
244 cm Strip	30.1 a	58.3 ab	64.6 ab	1.51 a	4.63 a	13.71 a

[z] Treatment means separated within columns by Duncan's multiple range test (P=0.05).

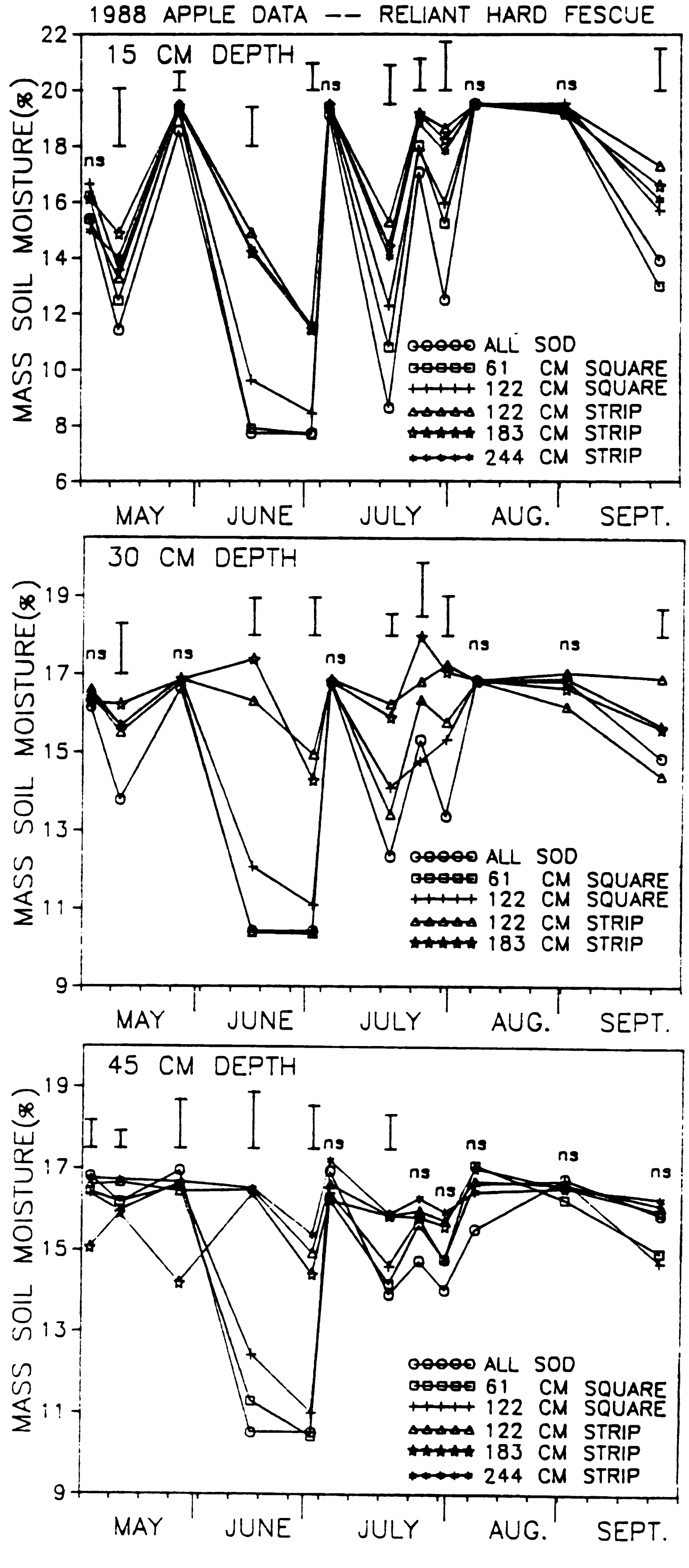
Apple Soil Moisture

Hard Fescue

Soil moisture differed between treatments at the 15 cm depth in mid-May, 1988 (Fig. 2). Complete sod had significantly less soil moisture than the 183 or 244 cm strip treatments. Trees were irrigated May 20 and by May 27, soil moisture for complete sod was significantly less than all other treatments. Soil moisture in the 61 cm square or complete sod treatments were significantly less than all treatments in mid-June at the lowest level the blocks would register. The 122 cm square had significantly less soil moisture than the strip treatments. On June 27, the strip treatments had greater soil moisture than all other treatments. Irrigation on June 27 saturated the soil. By mid-July, the complete sod treatment had the lowest soil moisture followed by the 61 cm square which was followed by the 122 cm square treatment, all significantly less than the strip treatments. These treatment differences continued, even with 8 cm of rain in mid-July, until irrigation on July 29. Significant differences were next measured September 16 when the complete sod or the 122 square treatments again had significantly less soil moisture than all other treatments.

Data for the 30 cm and 45 cm depth (Fig. 2) reveal moisture fluctuations somewhat similar to those at the 15 cm depth. The strip treatments usually had greater soil moisture content than the complete sod, 61 cm square and 122 cm square treatments. However, at the 45 cm depth, the decrease in soil moisture was not as great as at the 30 cm depth. Significant differences were not detected after mid-July at the 45 cm depth, but at the 30 cm depth differences occurred in mid-

Figure 2: The effect of six vegetation-free area around apple trees in Reliant hard fescue on the 1988 percent mass soil moisture content in the tree row. Vertical bars represent LSD ($P<0.05$) when significant treatment differences were present, ns = no significant difference.


1988 APPLE DATA -- RELIANT HARD FESCUE
15 CM DEPTH
MASS SOIL MOISTURE(%)
ns
ALL SOD
61 CM SQUARE
122 CM SQUARE
122 CM STRIP
183 CM STRIP
244 CM STRIP
MAY
JUNE
JULY
AUG.
SEPT.
30 CM DEPTH
45 CM DEPTH

September. Soil moisture at the 30 cm depth is not reported for the 244 cm square treatment because the moisture blocks did not function.

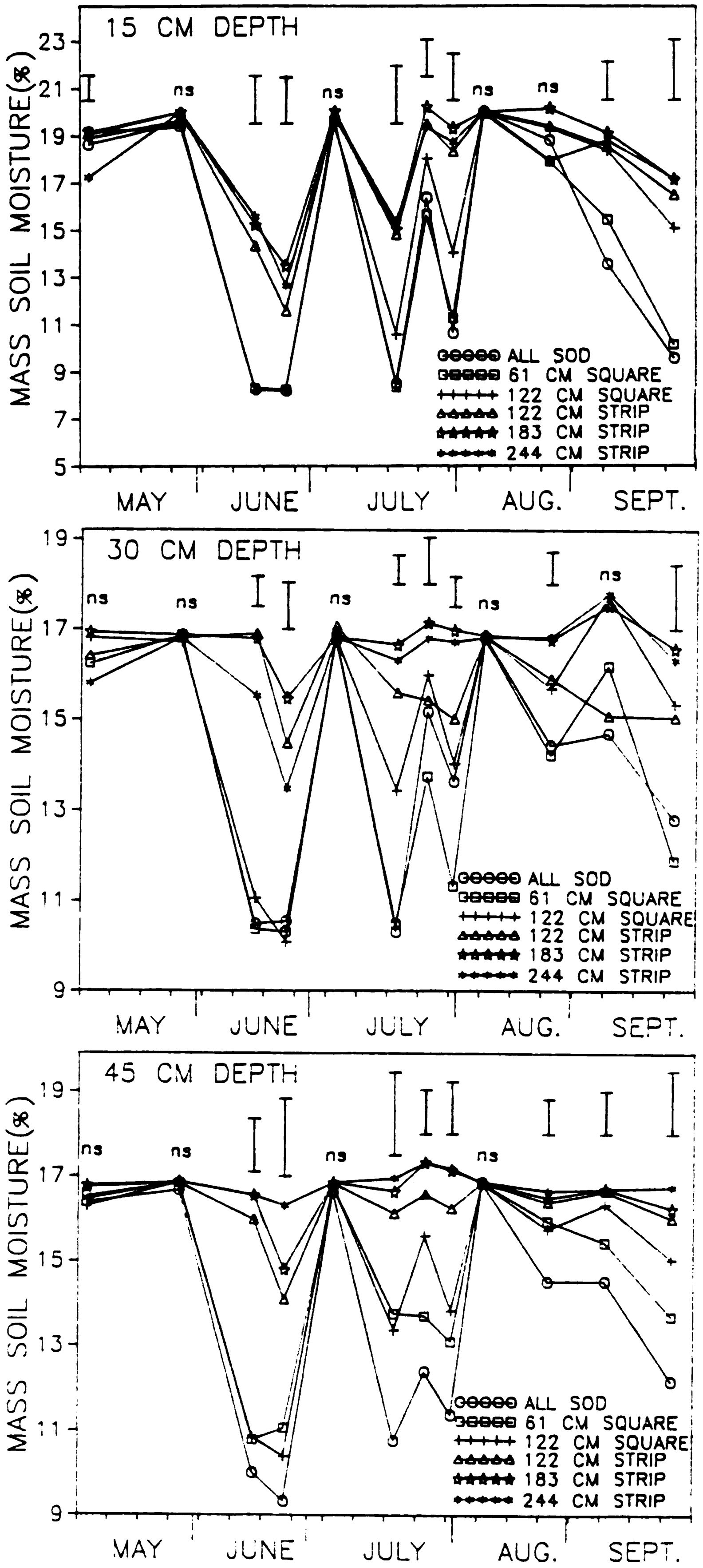
Tall Fescue

Significant treatment differences were recorded June 13 at the 15 cm depth when the three strip treatments had significantly greater soil moisture content than all other treatments (Fig. 3). The moisture blocks in the complete sod, 61 cm square and 122 cm strip treatments were at their lowest registering limit. The complete sod or 61 cm square treatments had recorded this limit by June 6. Soil moisture decreased rapidly following irrigation on June 27, and by July 15, the strip treatments again had significantly greater soil moisture than all other treatments. After irrigation on July 29, significant treatment differences were measured twice in September when the complete sod or 61 cm square treatments had significantly less soil moisture than all other treatments.

Soil moisture content at the 30 and 45 cm depths was more variable than at the 15 cm depth for some treatments. At the 30 cm depth, the complete sod, 61 cm square and 122 cm square treatments had the lowest soil moisture content during 1988. On July 15, the 183 cm or 244 cm strip treatments had significantly greater soil moisture than the 122 cm strip. The complete sod or 61 cm square treatments had significantly less soil moisture than the other treatments at the lowest limit of the blocks. A 7 cm rainfall occurred July 16. On July 28, the 183 cm or 244 cm strip treatments had significantly greater soil moisture than all other treatments with the the 61 cm square having the least. Significant differences occurred August 19 when the 183 or 244 cm strip treatments again had significantly greater soil moisture than all other

Figure 3: The effect of vegetation-free area around apple trees in Kentucky 31 tall fescue on the 1988 percent mass soil moisture content in the tree row. Vertical bars represent LSD ($P<0.05$) when significant treatment differences were present, ns = no significant difference.

1988 APPLE DATA -- KENTUCKY 31 TALL FESCUE



treatments and the complete sod or 61 cm square treatments had significantly less than the other treatments. In September, significant differences occurred and the strip treatments again had greater soil moisture than the complete sod or 61 cm square treatments.

At the 45 cm depth (Fig. 3), when significant differences were measured, the greatest soil moisture usually occurred in the strip treatments with the lowest in the complete sod or 61 cm square. However, soil moisture in the 122 cm square treatment was frequently less than that in the strip treatments, but generally greater than in the complete sod or 61 cm square treatments.

Cherry Soil Moisture

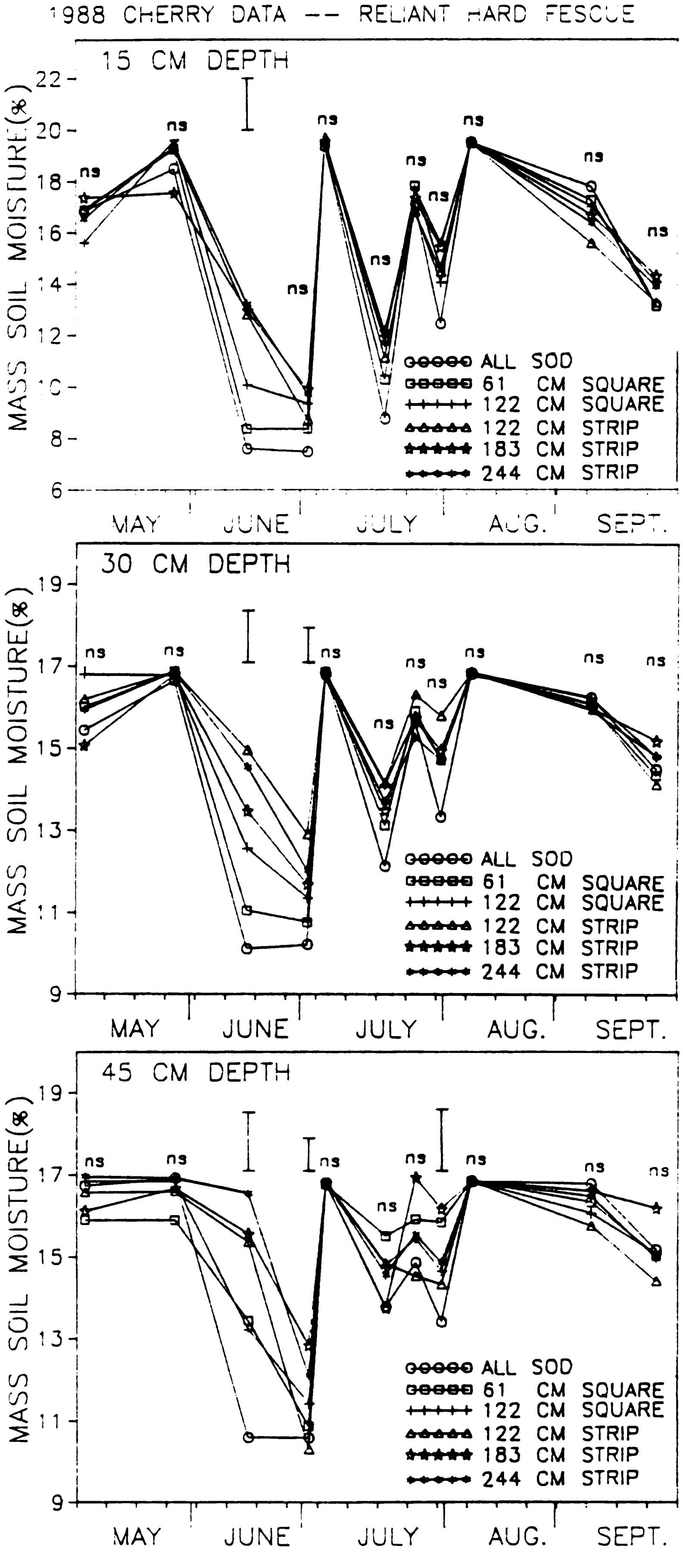
Hard Fescue

Significant soil moisture differences occurred less often for the cherry trees. At the 15 cm depth, differences occurred only in June (Fig. 4). The three strip treatments had significantly greater soil moisture than the other treatments on June 13. After irrigation June 27, no significant treatment differences were recorded for the remainder of the season.

The complete sod treatment had significantly less soil moisture at the 30 cm depth than all other treatments except the 61 cm square on June 13 and 27, registering the lowest limit of the blocks. The strip treatments contained the greatest soil moisture with intermediate soil moisture levels in the 122 cm square treatment. After irrigation on June 27, no treatment differences were detected for the rest of the season.

Significant differences in soil moisture at the 45 cm depth occurred June 13. The complete sod treatment had the lowest soil

Figure 4: The effect of vegetation-free area around cherry trees in Reliant hard fescue on the 1988 percent mass soil moisture content in the tree row. Vertical bars represent LSD ($P<0.05$) when significant treatment differences were present, ns = no significant difference.


1988 CHERRY DATA -- RELIANT HARD FESCUE
15 CM DEPTH
30 CM DEPTH
45 CM DEPTH
MASS SOIL MOISTURE(%)
ns
ALL SOD
61 CM SQUARE
122 CM SQUARE
122 CM STRIP
183 CM STRIP
244 CM STRIP
MAY
JUNE
JULY
AUG.
SEPT.

moisture content (the lowest limit the blocks could register) and the strip treatments the greatest. By June 27, the 183 cm or 244 cm strip treatments had greater soil moisture than the complete sod, 61 cm square and 122 cm strip treatments, which recorded the lowest limit of the blocks. After irrigation June 27, treatment differences occurred only on July 28. The 183 cm strip had greater soil moisture than the complete sod or 122 cm strip treatments.

Tall Fescue

Soil moisture for cherry trees in the tall fescue at the 15 cm depth was significantly greater in the three strip treatments in June (Fig. 5) than the other treatments. After irrigation June 27, significant treatment differences occurred July 28 when the 183 cm strip treatment had significantly greater soil moisture than the complete sod or 61 cm square treatments. After irrigation July 29, no differences occurred until September 16 when the 122 cm square, 183 cm strip or 244 cm strip treatments had significantly greater soil moisture than all other treatments.

The strip treatments also had significantly greater soil moisture in June at the 30 and 45 cm depths. After irrigation June 27, significant treatment differences occurred July 15. Soil moisture varied during July but generally, the greater vegetation-free areas had the greater soil moisture.

Linear correlations between vegetation-free area and shoot length or trunk diameter were highly (P=0.01) significant all three years for apple trunk diameter in hard fescue (Table 5). Correlations between vegetation-free area and shoot length were significant (P=0.05) in 1986 and highly significant in 1987. Highly significant correlations were

Figure 5: The effect of vegetation-free area around cherry trees in Kentucky 31 tall fescue on the 1988 percent mass soil moisture content in the tree row. Vertical bars represent LSD ($P<0.05$) when significant treatment differences were present, ns = no significant difference.

1988 CHERRY DATA -- KENTUCKY 31 TALL FESCUE

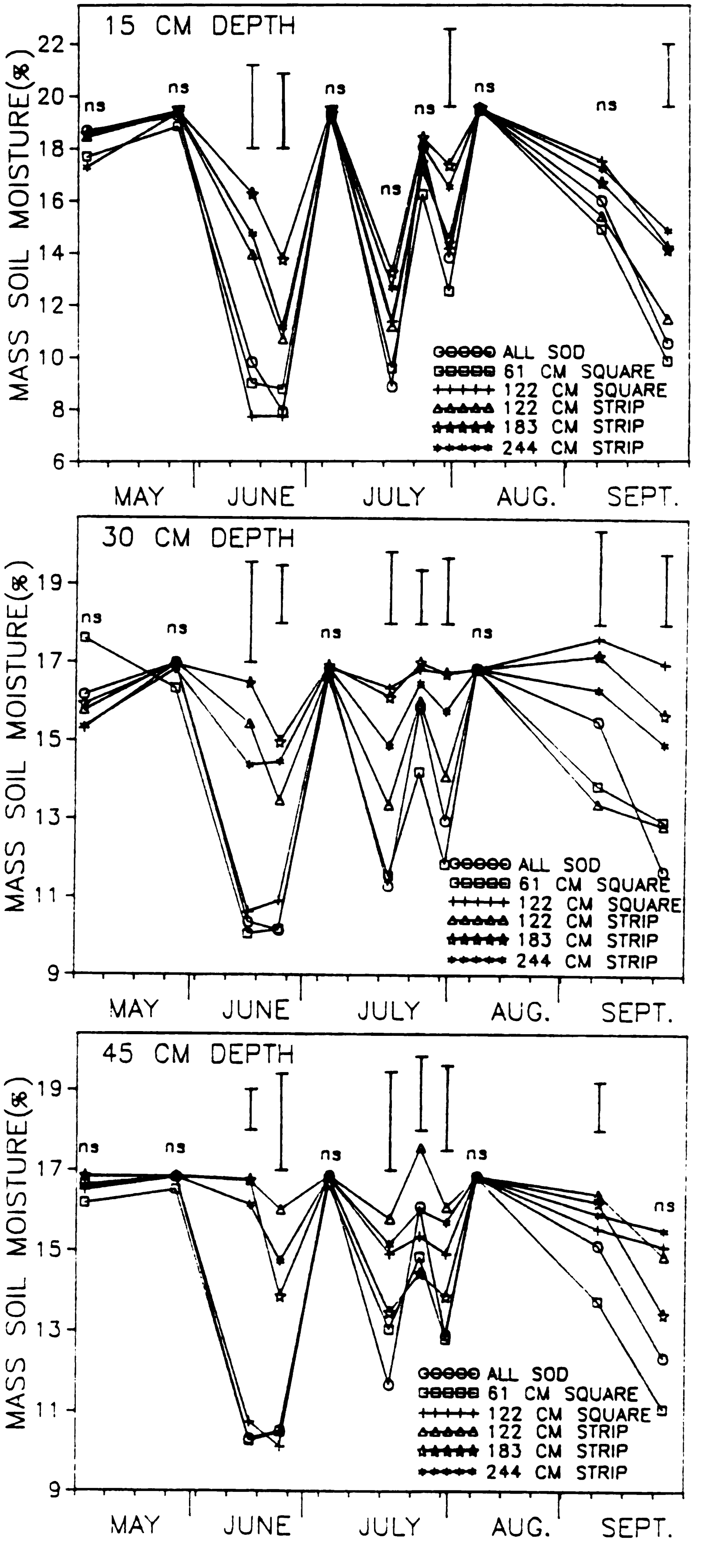


Table 5: Linear regression equations and correlation coefficients (r) for vegetation-free area around apple and cherry trees to trunk diameter or shoot length, in hard and tall fescue for 1986, 1987 and 1988.[z]

	Correlation Coefficients(r)	
	Hard Fescue	Tall Fescue
Apple Data		
1986--Trunk Diameter	Y=16.44 + 0.2395X r=0.506 **	Y=14.45 + 0.342X r=0.457 **
1987--Trunk Diameter	Y=26.10 + 0.8488X r=0.693 **	Y=21.92 + 1.493X r=0.722 **
1988--Trunk Diameter	Y=39.32 + 1.5923X r=0.798 **	Y=31.69 + 2.725X r=0.850 **
1986--Shoot Length	Y=52.95 + 0.90X r=0.341 *	Y=37.32 + 2.227X r=0.614 **
1987--Shoot Length	Y=72.53 + 2.50X r=0.646 **	Y=48.77 + 5.771X r=0.771 **
1988--Shoot Length	Y=84.23 + 0.229X r=0.111 ns	Y=68.60 + 2.314X r=0.640 **
Cherry Data		
1986--Trunk Diameter	Y=15.72 - 0.006X r=0.007 ns	Y=13.62 + 0.034X r=0.069 ns
1987--Trunk Diameter	Y=25.30 + 0.446X r=0.307 ns	Y=17.69 + 1.150X r=0.665 **
1988--Trunk Diameter	Y=39.08 + 0.995X r=0.365 *	Y=26.43 + 2.531X r=0.723 **
1986--Shoot Length	Y=36.15 - 0.836X r=0.272 ns	Y=29.55 + 0.002X r=0.001 ns
1987--Shoot Length	Y=50.27 + 1.984X r=0.433 **	Y=25.19 + 5.446X r=0.631 **
1988--Shoot Length	Y=55.93 + 2.618X r=0.465 **	Y=48.85 + 3.380X r=0.505 **

[z] ns, *, ** Not significant ($P>0.05$) or significantly different at $P<0.05$ and $P<0.01$, respectively.

calculated for apples in tall fescue all three years for trunk diameter and shoot length.

Cherry trees in hard fescue had highly significant correlations between vegetation-free area and shoot length in 1987 and 1988 and significant correlations with trunk diameter in 1988. Cherry trees in tall fescue had highly significant correlations between vegetation-free area and both shoot length or trunk diameter in 1987 and 1988.

For apple and cherry trees in hard fescue, linear correlations between increased shoot length and soil moisture for the month of June were calculated with a ten day lag between soil moisture level and increased tree growth. Correlations for soil moisture versus increased shoot length were R^2=0.49** for apple and R^2=0.38** for cherry, both highly significant.

DISCUSSION

Reliant hard fescue is a relatively short, fine leafed, slow growing, shallow rooted sod that exhibits slow growth when moisture is limiting. Kentucky 31 tall fescue is a relatively tall, coarse, deep rooted grass that grows well all season, even in periods of moderately limiting moisture (Biran et al., 1981).

Vegetation-free area around the apple trees in tall fescue resulted in greater shoot length and TCA all three years than trees in the complete sod. However, trees in hard fescue exhibited no differences in shoot length in 1986 and 1988 but TCA significantly differed all three years. Vegetation-free area was significantly correlated to apple trunk diameter and shoot length in both sod covers all three years except for shoot length in hard fescue for 1988. This indicates that both sod covers were competing or interfering with the growth of the apple trees all three years.

The lack of significant differences in cherry tree growth or correlations with shoot length and trunk diameter the first year did not indicate that vegetation-free area does not affect cherry tree growth. The cultural management of the cherry trees along with the growth characteristics of cherry may have resulted in no measurable treatment differences. Cherry trees do not grow as rapidly as apple trees, therefore the cherry trees were not affected as severly as the apple and significant treatment differences were not measured in the first year. Cherry trees also set terminal bud and do not break vegetative buds as apples do within a growing season. However, in the 1987 and 1988 seasons, tree growth was adversely affected by both grass covers and this effect was partially alleviated with vegetation-free area. This indicates that vegetation-free area does affect cherry tree growth which was not measured during the first growing season.

In this study, the strip treatments provivded the greatest vegetation-free area. Apple and cherry trees produced greater shoot length and TCA with increased vegetation-free zones. Welker and Glenn (1989) also reported that peach TCA in tall fescue was proportional to the size of the vegetation-free area around the tree which ranged from 0.36 to 13.0 m^2.

Apple and cherry trees grown in tall fescue had less shoot length and TCA than trees grown in hard fescue. For the three years, apple shoot length in complete sod averaged 40% less in the tall fescue compared to the hard fescue and TCA averaged 51% less in the tall fescue. Cherry shoot length in complete sod averaged 61% less in the covers were competing or interfering with the growth of the apple trees all three years.

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Apple and cherry trees grown in tall fescue had less shoot length and TCA than trees grown in hard fescue. For the three years, apple shoot length in complete sod averaged 40% less in the tall fescue compared to the hard fescue and TCA averaged 51% less in the tall fescue. Cherry shoot length in complete sod averaged 61% less in the tall fescue than hard fescue and TCA averaged 74% less. There were also TCA differences in the two grass covers between the trees in the 61 cm square compared to the treatments with greater vegetation-free area. For example, both in 1987 and 1988 there were no statistical differences in TCA between the complete sod and the 61 cm square treatments for both apple and cherry in tall fescue, however in hard fescue there were significant differences. The tall fescue sod was so competitive that the 61 cm square vegetation-free zone did not result in increased TCA as occurred in the hard fescue. Shribbs and Skroch (1986a) reportd differential growth of apple trees grown in various vegative covers. They reported that tall fescue resulted in reduced shoot length and trunk diameter when compared to vegetative covers such as Kentucky bluegrass or nimblewill.

Treatments that provided greater vegetation-free area had higher soil moisture. When soil moisture differences occurred the complete sod or 61 cm square treatments had the lowest soil moisture in 1988. In June, at the lowest levels of soil moisture these two treatments were not recording the actual level of soil moisture as they had already reached the lowest limit of the blocks. In mid to late June, soil moisture decreased for all treatments but the rate and degree of decrease was greater for treatments with the least vegetation-free area. After irrigation saturated the soil, the same soil moisture reduction pattern occurred but not as rapidly or to the same degree.

Treatments providing smaller vegetation-free area had less available soil moisture, less shoot length and TCA. Apparently, utilization of soil moisture by the grass in competition with the tree resulted in reduced tree growth. These data suggest that soil moisture under vegetative covers is a key factor affecting tree growth.

Welker and Glenn (1985, 1989) reported vegetation-free area for peach trees resulted in increased tree growth and increased yield during the first four years. Maximum apple and cherry tree growth during 3 years, the length of our study, occurred where a 7.4 m^2 vegetation-free area was maintained around the trees. However, cherry tree TCA in the tall fescue with a 7.4 m^2 vegetation-free area was 23% less the TCA of trees in the hard fescue. The minimum size of the vegetation-free area increased between the first year and the third year. TCA, an indicator of tree growth, suggests that the 122 cm strip treatment was sufficient vegetation-free area for optimum tree growth in both grass covers the first year, but a 244 cm strip was necessary for greatest tree growth in the third year for both grass covers. As the tree's root system expands laterally the vegetation-free area must also increase for optimum tree growth. In another study we found tall fescue greatly reduced peach rooting-both outside and in the vegetation-free zone. This indicates competition and a need for an increased vegetation-free zone as the tree grows.

Tree growth was differentially affected by two grass covers providing differing degrees of competition. For either sod, a vegetation-free area was essential for maximum tree growth. However, the tall fescue did compete more with tree growth and resulted in less tree growth than hard fescue when less than 3.7 m^2 of vegetation-free area was maintained in apples and 7.4 m^2 in cherry, especially in the third year. This indicates that when very vigorous vegetative covers are present in an orchard that a larger vegetation-free area is required for optimal tree growth. This difference in tree growth between the two grass covers indicates selection of an orchard floor cover is an important orchard management consideration before tree establishment.

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SECTION II

THE RESPONSE OF PEACH TREES TO ORCHARD FLOOR MANAGEMENT

ABSTRACT

Twelve orchard floor management treatments were evaluated for their effect on peach (*Prunus persica* L. Batsch cv. Redhaven/Halford) tree growth from 1986 through 1988. Trunk cross-sectional area did not differ significantly between treatments. In 1987, trees produced the greatest shoot length in the complete herbicide, Kentucky bluegrass or chewings fescue treatments and the least in clover or alfalfa. Treatments resulted in differences in peach leaf nitrogen in 1987 and 1988 but did not differ in shoot cold hardiness following the 1987 growing season or fruit yield in 1988. Peach trees in the vegetation-free treatments had greater leaf fresh weight, dry weight and leaf area than trees in the vegetative covers in 1988. Herbicide or clean cultivation treatments had greater soil moisture in May and June, 1987.

INTRODUCTION

Michigan peach growers utilize clean cultivation with cover crops or vegetative alleys with a cultivated or herbicide strip in the tree row. Vegetative covers have different growth habits and pose varying degrees of competition with peach tree growth. The reduction in tree growth has been attributed to competition for nitrogen (Shribbs and Skroch, 1986a), moisture (Kenworthy and Gilligan, 1949) or both (Lord and Vlach, 1973; Goode and Hyrycz, 1976).

Apple trees grown in grass covers had smaller trunk diameters than trees grown vegetation-free or with herbicide strips (Baxter and Newman, 1971; Stinchcombe and Stott, 1983). When all vegetative competition was eliminated around apple trees the trunk diameter was larger than the trunk diameter of trees grown in grass with a 1 m^2 herbicide treated area or complete mechanical cultivation (Robinson and O'Kennedy, 1978).

A 78% increase in peach tree trunk diameter resulted when the vegetation-free area around trees in tall fescue increased from 0.6 m^2 to 3.6 m^2 (Welker and Glenn, 1985). Peach trees grown in complete vegetation had smaller trunk diameters compared to trees with partial or total elimination of the grass cover (Welker and Glenn, 1988; Lord and Vlach, 1973; Daniel and Hardcastle, 1972). Weed competition resulted in reduced tree growth (Daniel et al., 1972).

Apple trees grown in Kentucky bluegrass had greater tree trunk diameter than trees grown in tall fescue (Shribbs and Skroch, 1986a). Larger trunk diameters were also reported for trees grown in nimblewill, red sorrel or blackberry covers than in legumes, tall broadleaf weeds, Kentucky bluegrass, orchardgrass or tall fescue.

Vigorous vegetative covers of tall fescue, orchardgrass, or tall broadleaf weeds resulted in lower apple leaf nitrogen than less competitive covers (Shribbs and Skroch, 1986b). Apple trees grown in complete grass for the first three years had lower leaf nitrogen each year than trees grown in clover or herbicide strips (Stinchcombe and Stott, 1983). Apple trees grown in total grass or broadleaf weeds had lower leaf nitrogen than trees in herbicide strips measuring 1.3 m wide and 9.8 m long (Baxter and Newman, 1971). Shribbs and Skroch (1986b) concluded that vegetative covers limited apple tree growth by competing for nitrogen. Mowed sod resulted in lower peach leaf nitrogen than treatments eliminating or reducing the proximity of the vegetative cover to the tree (Lord and Vlach, 1973; Welker and Glenn, 1985; Welker and Glenn, 1988). Peach leaf nitrogen was positively correlated to the size of the vegetation-free area while leaf Mg and Zn were negatively correlated (Welker and Glenn, 1985).

Vegetative covers resulted in differentially reduced soil moisture and reduced tree growth as a result of competition for soil moisture (Goode, 1955). Toenjes et al. (1956) found clover or alfalfa depleted soil moisture to a greater depth than bluegrass, timothy, redtop or chewings fescue. Goode (1955) reported perennial ryegrass had less soil moisture than timothy which had less soil moisture than annual meadow grass.

Toenjes et al. (1956) advised Michigan fruit growers to utilize shallow rooted vegetative covers that posed little competition to tree growth. Vegetative covers have various growth characteristics which may differentially influence tree growth. Selecting and managing orchard floor covers to minimize competition with tree growth is beneficial. This research evaluated the effect of 12 different orchard covers on peach tree growth and soil moisture.

METHODS

This research was conducted at the Michigan State University Clarksville Horticultural Experiment Station in western Michigan. The soil was a Riddles sandy loam soil (moderately well drained, typic Hapludalfs, fine-loamy, mixed, mesic). The vegetative covers were sown in September, 1985 in 6.1 m square plots. Three peach trees [*Prunus persica* (L.) Batsch cv. Redhaven/Halford] were planted April, 1986 in a tree row in the middle of each plot. Trees were spaced 2 m apart in the row and 6.2 m between rows. Trees were trained to an open center with 3 scaffolds per tree. The 12 orchard floor management treatments were:

1. Herbicide--Maintained vegetation-free with herbicide
2. Clean cultivation--Maintained vegetation-free with cultivation
3. Park Kentucky bluegrass (*Poa pratensis* L.)
   Seeded at 100 kg/ha.
4. Manhattan II perennial ryegrass (*Lolium perenne* L.)
   Seeded at 317 kg/ha.
5. Reliant hard fescue (*Festuca ovina* ssp. *duriuscula* (L.) Koch.)
   Seeded at 199 kg/ha.
6. Wintergreen chewings fescue (*Festuca rubra* L.)
   Seeded at 199 kg/ha.
7. 30% Manhattan II perennial ryegrass + 70% Park Kentucky bluegrass (PR+KB), by weight
   Seeded at 95 kg/ha and 70 kg/ha, respectively.
8. 80% Manhattan II perennial ryegrass + 20% Wintergreen chewings fescue (PR+CF), by weight
   Seeded at 254 kg/ha and 40 kg/ha, respectively.
9. Smooth bromegrass (*Bromus inermis* Leyss.)
   Seeded at 26 kg/ha.
10. White Dutch clover (*Trifolium repens* L.)
    Seeded at 11 kg/ha.
11. Peak alfalfa (*Medicago sativa* L.)
    Seeded at 22 kg/ha.
12. Kentucky 31 tall fescue (*Festuca arundinacea* Schreb.)
    Seeded at 305 kg/ha.

Gramoxone (1,1'-dimethyl-4-4'-bypyridinium ion), a contact herbicide was applied by hand sprayer at 1.1 kg/ha with 0.1% X-77 surfactant at approximately 30 day intervals during each growing season to establish and maintain the herbicide treatment and a 1.22 m wide vegetation-free strip in the tree row of the vegetative treatments. The clean cultivation treatment was rototilled to a depth of 8 cm at 30-40 day intervals during each growing season to control vegetation.

The experimental design was a randomized complete block with four replications. Data were collected from the middle tree in each plot.

Trees were fertilized annually in the spring with 57 grams of nitrogen (N) per year of tree age, applied as urea or ammonium nitrate. Fertilizer was banded around the perimeter of the tree. Twenty three (23) kgs of N per hectare, were also broadcast annually, either as urea or ammonium nitrate, over the orchard floor of all treatments.

Trunk diameter was measured 25.5 cm above the soil surface. Two perpendicular measurements were taken, averaged, and trunk cross-sectional area (TCA) calculated. Terminal shoot length of the three main scaffolds was measured from the base of the current season's growth to the shoot apex and then averaged.

Soil moisture was monitored with Bouyoucos soil moisture blocks (Bouyoucos and Mick, 1940) and a Bouyoucos moisture meter (both from Beckman Instruments, Inc., Cedar Grove, NJ) through July of 1987. Thereafter, soil moisture measurements were recorded with a Campbell 10X datalogger (Campbell Scientific, Inc., Logan, UT) as electrical resistance. Bouyoucos blocks were tested before installation by soaking in water for saturation and then air dried to verify the blocks registered a full range.

The blocks were saturated and placed at depths of 15, 30 and 45 cm at three locations. Blocks were placed in the tree row beneath the herbicide strip 61 cm from the tree trunk, and 61 or 155 cm from the trunk perpendicular to the tree row. The location in the alley 61 cm from the tree was at the interface of the herbicide strip and alleyway treatments. Many blocks did not function in 1988 and those soil moisture data are not presented.

Soil moisture calibration curves (Appendices I-M and II-K), relating mass soil moisture to Bouyoucos meter readings and electrical resistance from the datalogger, were determined in the laboratory. Soil samples were collected from the field at the 15 cm depth, the A horizon, and the 30 and 45 cm depth, the B horizon. The Bouyoucos meter measurements and electrical resistance values were converted to mass soil moisture content, total mass of water in soil divided by soil oven dry weight, using the soil moisture calibration curves. The soil moisture range for the 15 cm depth for the Bouyoucos meter was 7.7-19.5% and 14.6-19.5% for the datalogger. At the 30 and 45 cm depths the moisture ranged from 9.9-17.3% for the Bouyoucos moisture meter and 13.9-16.8% for the datalogger. Field capacity for the A horizon soil was approximately 21% and 18% for the B horizon soil.

Twenty leaves were sampled from each tree twice in 1987 and on four dates in 1988 to determine leaf nutrient content. Leaves were collected from the mid section of the current seasons growth, dried at 60 C and ground in a Wiley mill to pass through a 40 mesh screen and digested in sulfuric acid (H_2SO_4) with potassium sulfate (K_2SO_4) and selenium (Se) as catalysts. Total ammonium (NH_4) concentrations were determined with a Quik-chem flow analyzer (Lachat Instruments, Mequon, WI) using the Kjeldahl method. In 1987, leaf samples were dry ashed and diluted in LiCl and Al, Zn, Fe, B, P, Cu, Mn, Mg, Ca, K content determined by Plasma Spectral Analysis.

Peach shoot cold hardiness was determined after the 1987 growing season using the method described by Howell and Weiser (1970). Four shoots from each tree, 16 per treatment, were collected approximately 1.5 m above the ground on the east side of the tree. Cold hardiness was expressed as T50 values, the temperature at which 50% of the shoots had cambial and phloem browning (Bittenbender and Howell, 1974).

Relative cropping was evaluated July 5, 1988 by removing six shoots of various length from each guard tree, 48 per treatment, measuring shoot length, and determining fruit number and fruit weight. Fruit were then hand thinned to a spacing of approximately 20 cm. Yield in 1988, involved harvesting all of the fruit in two harvests, a result of extremely warm harvest weather.

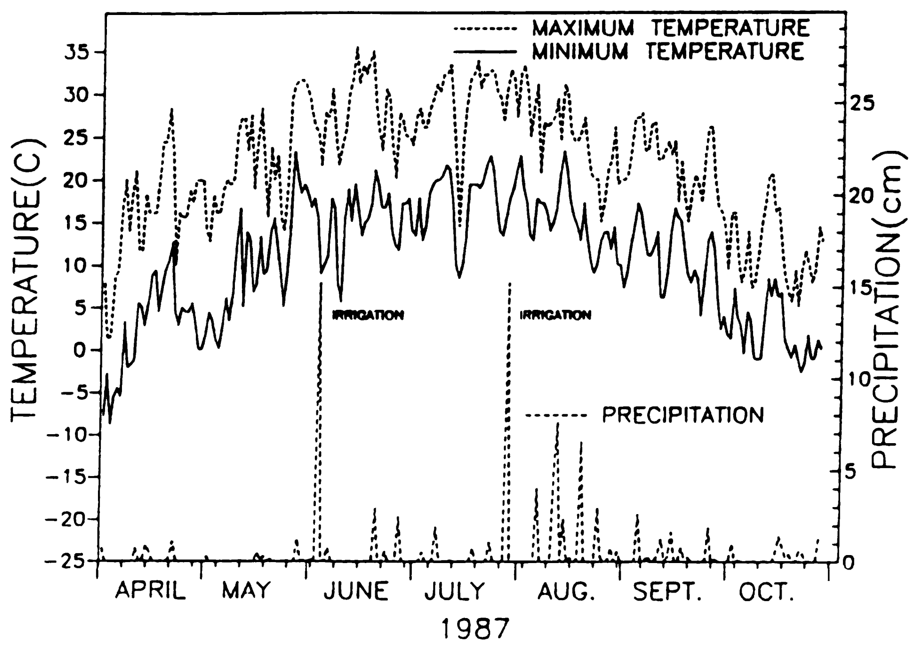
Leaf net photosynthesis was measured on 2 fully expanded leaves per tree with a portable ADC photosynthetic unit, Model LCA-2 (Analytical Development Co., Hoddesdon, England). Leaf photosynthetic rates were calculated using the computer program developed by Moon and Flore (1986).

Leaf size, fresh weight, dry weight and area were measured in October, 1988. Twelve leaves that were located 8 to 10 leaves below the shoot apex, were collected from each tree. Leaf area was measured using a Delta-T area meter (Cambridge, England).

The 1987 and 1988 growing seasons were very dry for Michigan (Fig. 1). Plots were irrigated June 4 and July 30 in 1987 and May 20, June 27 and July 29 in 1988. Approximately 13 cm of water per unit area was applied at each date to saturate the soil to a minimum depth of 46 cm to saturate all the moisture blocks.

The vegetative covers were mown to a height of 8 cm approximately 3 times during each growing season. Prior to mowing, the height of the vegetative covers was measured. Two-930 cm^2 area samples of each

Figure 1: Daily maximum and minimum temperature, daily precipitation and applied irrigation for 1987 and 1988 for the Clarksville Horticultural Experiment Station. Data presented for April through October each season.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APRIL
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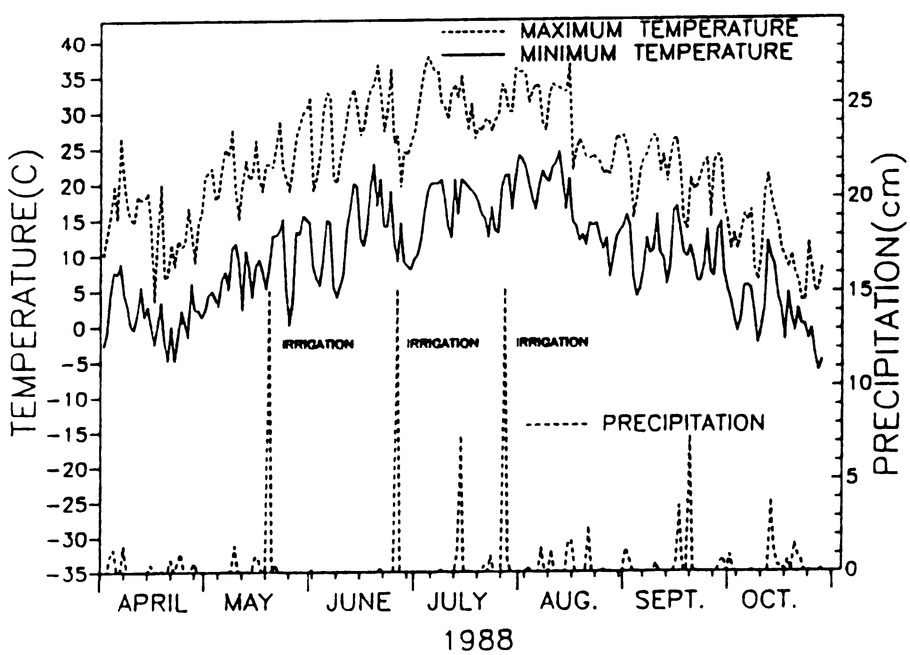
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OCT.
1988

vegetative cover were collected from opposite sides of the tree for fresh and dry weight determinations.

Data were analyzed by analysis of variance. Mean separation was determined by Duncan's multiple range test at the 5% significance level with a significant F test at the 5% level.

RESULTS

No significant differences in TCA occurred between treatments during this study (Table 1). Significant differences in shoot length occurred only in 1987. The herbicide, clean cultivation, Kentucky bluegrass, or chewings fescue treatments had significantly greater shoot length than the clover or alfalfa treatments. The herbicide, Kentucky bluegrass, and chewings fescue treatments had significantly greater shoot length than all treatments except the clean cultivation or PR+CF.

Soil moisture measurements in the tree row, under the herbicide strip, in 1987 indicated herbicide, Kentucky bluegrass, bromegrass, and tall fescue treatments had significantly greater soil moisture, May 13 at the 15 cm depth, than clover (Table 2). Irrigation June 4 and July 30 saturated the soil. On August 7, treatments of herbicide, chewings fescue, PR+CF, bromegrass and clover had significantly greater soil moisture than the alfalfa treatment. On September 8, all treatments except the Kentucky bluegrass or PR+KB had greater soil moisture than clean cultivation. The Kentucky bluegrass, chewings fescue, PR+CF, clover, and alfalfa treatments had significantly greater soil moisture on September 29 than the vegetation-free treatments. On October 6, all treatments except tall fescue had significantly greater soil moisture than the vegetation-free treatments or perennial ryegrass.

Table 1: The effect of orchard floor management on peach trunk cross-sectional area (TCA) and shoot length.[z]

TREATMENT	AVERAGE TCA (cm^2)			AVERAGE SHOOT LENGTH (cm)		
	10/30/86	9/25/87	9/15/88	11/5/86	9/24/87	10/20/88
Herbicide	6.08 a	25.30 a	43.74 a	73.0 a	145.3 a	118.5 a
Clean Cult.	4.88 a	21.53 a	38.36 a	67.8 a	134.9 ab	106.2 a
Kentucky Blue.	5.58 a	20.69 a	38.72 a	70.6 a	140.7 a	127.2 a
Perennial Rye.	4.79 a	18.60 a	32.34 a	58.9 a	117.4 bc	107.6 a
Hard Fescue	4.95 a	19.71 a	37.69 a	67.7 a	115.9 bc	102.0 a
Chewings Fescue	4.52 a	18.93 a	35.91 a	61.0 a	145.2 a	115.3 a
PR+KB	4.75 a	19.37 a	33.67 a	73.5 a	116.3 bc	106.2 a
PR+CF	4.71 a	18.83 a	33.36 a	66.7 a	123.9 abc	100.9 a
Bromegrass	5.48 a	20.47 a	34.13 a	70.7 a	116.2 bc	105.3 a
Clover	4.21 a	18.31 a	33.11 a	61.8 a	110.2 c	109.8 a
Alfalfa	5.17 a	19.06 a	36.28 a	74.3 a	112.1 c	121.7 a
Tall Fescue	5.17 a	17.60 a	29.66 a	75.1 a	113.6 bc	101.8 a

[z] Treatment means separated by Duncan's multiple range test ($P=0.05$) with significant F test at 5% level.

Table 2: The effect of orchard floor management on mass soil moisture of peach trees at depths of 15, 30 and 45 cm, 61 cm from the tree in the tree row--1987.[z]

	% MASS SOIL MOISTURE								
	15 cm Depth								
TREATMENT	5/13	5/29	6/18	8/7	8/25	9/8	9/29	10/6	10/20
Herbicide	14.3 ab	13.6	14.0	17.0 a	17.0	17.0 a	15.1 c	15.4 b	14.7
Clean Cultivation	12.0 abc	12.2	13.3	15.5 abc	17.0	14.8 b	15.7 bc	15.7 b	14.6
Kentucky Bluegrass	13.6 ab	12.2	14.3	15.5 abc	16.2	16.1 ab	17.6 a	17.3 a	16.2
Perennial Ryegrass	10.9 bc	11.3	12.9	16.0 abc	17.0	17.0 a	16.7 abc	15.7 b	15.0
Hard Fescue	11.1 bc	11.0	14.0	16.1 abc	18.0	17.9 a	16.8 ab	16.9 a	15.2
Chewings Fescue	13.2 abc	13.6	14.9	16.9 a	18.0	18.0 a	17.7 a	17.2 a	15.9
PR+KB	12.5 abc	11.9	12.7	14.9 bc	16.2	16.2 ab	16.3 abc	16.9 a	15.0
PR+CF	13.2 abc	12.2	13.8	16.6 ab	17.4	18.2 a	17.6 a	17.3 a	16.3
Bromegrass	15.3 a	12.4	14.2	16.7 a	17.8	17.7 a	17.4 ab	17.1 a	15.1
Clover	9.9 c	10.8	13.0	16.8 a	17.2	17.1 a	17.9 a	17.2 a	15.9
Alfalfa	12.9 abc	11.0	10.0	14.7 c	17.0	17.2 a	18.0 a	17.2 a	16.0
Tall Fescue	13.5 ab	12.3	13.0	15.5 abc	17.9	18.0 a	16.3 abc	16.3 ab	15.4
	30 cm Depth								
TREATMENT	5/13	5/29	6/18	8/7	8/25	9/8	9/29	10/6	10/20
Herbicide	14.7	14.3	14.7	15.7	15.8	15.7	14.9	14.7	14.3
Clean Cultivation	14.5	14.2	14.9	15.4	15.4	15.1	14.8	14.7	13.9
Kentucky Bluegrass	14.3	13.5	14.8	15.3	16.1	15.7	15.5	15.7	14.8
Perennial Ryegrass	15.4	14.4	14.8	15.5	16.4	15.9	15.5	15.5	14.8
Hard Fescue	14.7	13.6	15.4	15.4	16.3	15.9	15.6	15.5	14.6
Chewings Fescue	14.7	14.6	15.4	15.9	16.2	16.1	15.7	15.7	14.9
PR+KB	14.3	13.5	14.4	14.5	15.6	15.2	15.2	15.5	14.4
PR+CF	15.7	14.4	14.8	14.7	16.2	15.8	15.1	15.1	14.4
Bromegrass	15.2	13.6	14.5	14.5	16.1	15.9	15.2	15.1	14.2
Clover	12.3	12.8	13.9	15.5	15.8	15.5	15.7	15.7	15.0
Alfalfa	14.0	13.1	12.7	14.6	15.6	15.2	15.6	15.6	14.6
Tall Fescue	14.8	13.6	14.9	14.6	16.1	15.9	15.0	15.1	14.3
	45 cm Depth								
TREATMENT	5/13	5/29	6/18	8/7	8/25	9/8	9/29	10/6	10/20
Herbicide	16.4 a	15.8 a	16.2	15.2	15.0	14.7	14.5	14.4	14.9
Clean Cultivation	16.2 a	16.0 a	16.4	14.7	16.3	15.8	14.8	15.3	14.3
Kentucky Bluegrass	16.4 a	15.6 a	16.0	15.4	16.2	15.9	15.4	15.2	14.6
Perennial Ryegrass	16.7 a	16.6 a	16.6	15.0	16.4	15.9	15.4	16.0	15.5
Hard Fescue	16.7 a	16.5 a	16.4	15.1	15.7	15.6	15.8	15.6	15.0
Chewings Fescue	16.7 a	16.3 a	15.9	15.4	15.8	15.5	15.5	15.0	14.4
PR+KB	16.5 a	16.2 a	16.3	13.9	16.3	15.7	15.0	15.1	14.6
PR+CF	16.8 a	16.5 a	16.2	15.1	15.5	15.2	15.0	15.1	14.8
Bromegrass	16.4 a	14.9 ab	15.8	14.6	16.2	16.1	15.4	14.9	14.7
Clover	14.5 b	13.9 b	14.1	14.8	15.1	15.3	16.0	16.0	15.3
Alfalfa	16.5 a	15.6 a	14.6	14.9	16.4	16.0	15.8	15.5	15.0
Tall Fescue	16.4 a	15.3 ab	15.8	14.7	15.7	15.3	15.3	15.0	14.6

[z] Treatment means separated by Duncan's multiple range test (P=0.05), when treatment differences are indicated by a significant F test at the 5% level.

No significant treatment differences occurred at the 30 cm depth in the tree row in 1987. Significant differences occurred at the 45 cm depth, in the tree row on May 13 and 29. On May 13, the clover had significantly less soil moisture than all treatments and on May 29 clover had less soil moisture than all treatments except bromegrass or tall fescue.

Soil moisture measurements in the alleyway, 61 cm from the tree, were at the interface of the herbicide strip and alleyway treatments (Table 3). At the 15 cm depth, on May 13, the herbicide or chewings fescue treatments had greater soil moisture than the hard fescue or clover treatments. All treatments except the hard fescue, bromegrass, and alfalfa had greater soil moisture than clover. On May 29, the clean cultivation treatment had greater soil moisture than all of the vegetative covers. The herbicide treatment did not differ significantly from the chewings fescue or PR+CF treatments. Significant differences did not occur again until September 8, when all treatments except PR+CF or tall fescue had greater soil moisture than clean cultivation. On September 29 and October 6, Kentucky bluegrass had greater soil moisture than the herbicide, clean cultivation and alfalfa treatments. Clean cultivation had significantly less soil moisture than all other treatments. On October 20, clean cultivation had significantly less soil moisture than all treatments except herbicide, bromegrass, alfalfa and tall fescue. Kentucky bluegrass had greater soil moisture than the herbicide, clean cultivation, alfalfa and tall fescue treatments.

Significant differences in soil moisture at the 30 cm depth, occurred only May 29, when the vegetation-free treatments had greater

Table 3: The effect of orchard floor management on mass soil moisture in the alleyway of peach trees at depths of 15, 30 and 45 cm, 61 cm from the tree--1987.[z]

TREATMENT	5/13	5/29	6/18	8/7	8/25	9/8	9/29	10/6	10/20
	% MASS SOIL MOISTURE								
	15 cm Depth								
Herbicide	13.6 a	12.2 ab	12.4	16.4	18.1	17.7 a	17.0 bc	16.6 bc	15.6 bcd
Clean Cultivation	12.5 ab	13.7 a	12.7	15.4	16.2	14.6 b	14.8 d	14.9 d	14.8 d
Kentucky Bluegrass	12.5 ab	9.4 c	12.6	16.8	18.3	18.4 a	18.3 a	17.9 a	17.4 a
Perennial Ryegrass	12.4 ab	9.1 c	11.2	15.9	17.2	18.1 a	18.0 ab	17.6 abc	17.0 ab
Hard Fescue	10.0 bc	8.6 c	11.9	16.2	17.4	17.4 a	18.0 ab	17.7 ab	17.0 ab
Chewings Fescue	13.7 a	10.7 bc	12.6	17.5	17.7	17.9 a	18.0 ab	17.7 ab	16.4 abc
PR+KB	12.3 ab	8.7 c	12.0	15.7	18.1	18.1 a	18.0 ab	17.5 abc	16.9 ab
PR+CF	12.8 ab	9.5 bc	10.8	16.7	17.6	16.5 ab	18.0 ab	17.6 abc	17.1 ab
Bromegrass	10.4 abc	8.6 c	11.1	16.7	17.3	17.3 a	17.6 abc	17.2 abc	16.0 abcd
Clover	9.0 c	8.9 c	11.0	16.1	17.4	17.4 a	17.9 ab	17.6 abc	16.9 ab
Alfalfa	11.1 abc	9.1 c	9.0	15.0	17.4	17.3 a	16.5 c	16.5 c	15.4 cd
Tall Fescue	12.5 ab	9.2 c	10.9	16.0	16.4	16.4 ab	17.1 abc	17.1 abc	15.7 bcd
	30 cm Depth								
TREATMENT	5/13	5/29	6/18	8/7	8/25	9/8	9/29	10/6	10/20
Herbicide	14.5	13.9 a	14.6	15.2	16.1	15.5	15.2	14.8	14.3
Clean Cultivation	14.5	13.5 a	14.6	15.1	15.9	15.3	15.0	14.9	14.1
Kentucky Bluegrass	14.6	12.0 b	14.1	15.5	16.2	16.2	16.1	15.9	15.7
Perennial Ryegrass	14.9	12.1 b	12.8	15.2	15.0	16.2	16.1	16.0	15.7
Hard Fescue	14.5	11.6 b	14.6	15.5	15.7	15.6	16.0	15.8	15.3
Chewings Fescue	14.5	12.9 ab	14.0	15.8	15.8	15.6	16.2	16.0	15.6
PR+KB	14.1	12.0 b	13.7	15.0	16.1	16.0	15.9	15.8	15.4
PR+CF	15.1	12.0 b	13.1	15.7	16.2	16.2	16.1	15.9	15.6
Bromegrass	13.7	11.6 b	13.8	15.7	16.3	16.1	15.9	15.7	15.1
Clover	12.5	11.5 b	12.5	16.1	15.8	15.7	16.1	16.0	15.4
Alfalfa	14.2	12.0 b	11.8	14.9	16.2	16.0	15.7	15.7	15.2
Tall Fescue	14.9	12.0 b	13.1	15.1	16.2	15.5	15.9	15.8	15.3
	45 cm Depth								
TREATMENT	5/13	5/29	6/18	8/7	8/25	9/8	9/29	10/6	10/20
Herbicide	16.5 a	15.9 a	16.1 a	15.8	15.7	15.2	15.1 ab	14.8 bc	15.6 a
Clean Cultivation	16.4 a	15.6 ab	15.5 a	14.8	16.1	15.5	14.4 b	14.7 c	13.8 b
Kentucky Bluegrass	16.4 a	13.9 cde	14.3 ab	14.5	15.8	15.7	16.2 a	16.2 a	16.0 a
Perennial Ryegrass	16.6 a	14.1 cd	13.5 ab	15.5	15.8	15.1	16.3 a	16.1 a	15.5 a
Hard Fescue	16.5 a	14.6 abc	15.5 a	15.3	16.4	16.3	16.1 a	15.8 ab	15.4 a
Chewings Fescue	16.1 a	14.2 bcd	14.8 ab	15.3	14.5	14.5	16.2 a	16.0 a	15.0 a
PR+KB	16.4 a	13.1 cdef	14.5 ab	15.5	16.4	16.3	16.3 a	16.1 a	15.8 a
PR+CF	16.7 a	13.7 cde	13.6 ab	16.0	16.4	16.4	16.3 a	16.1 a	15.9 a
Bromegrass	16.1 a	13.0 def	14.6 ab	15.3	15.2	15.8	15.9 a	15.5 abc	15.1 a
Clover	14.5 b	11.8 f	12.2 b	14.8	16.6	16.3	15.4 ab	15.7 abc	15.4 a
Alfalfa	16.1 a	12.5 ef	12.4 b	14.9	16.4	16.0	15.6 ab	16.1 a	16.0 a
Tall Fescue	16.4 a	12.8 def	13.8 ab	14.9	15.8	15.8	15.3 ab	16.0 a	15.9 a

[z] Treatment means separated by Duncan's multiple range test(P=0.05), when treatment differences are indicated by a significant F test at the 5% level.

soil moisture than all vegetative covers except chewings fescue. There were no significant treatment differences between the vegetative covers.

At the 45 cm depth, all treatments had greater soil moisture May 13 than clover. On May 29, the vegetation-free treatments had significantly greater soil moisture than all vegetative covers except hard fescue or chewings fescue. Clover or alfalfa had significantly lower soil moisture than the vegetative covers of perennial ryegrass, hard fescue and chewings fescue. Herbicide, clean cultivation, and hard fescue treatments had greater soil moisture than clover or alfalfa on June 18. Treatment differences did not occur again until September 29 when all treatments except herbicide, clover, alfalfa and tall fescue had greater soil moisture than clean cultivation. October 6, all treatments except herbicide, bromegrass, and clover had greater soil moisture than clean cultivation. All treatments had greater soil moisture than clean cultivation on October 20.

Soil moisture measurements in the alley, 155 cm from the tree, were beneath the alleyway treatments (Table 4). The herbicide treatment had greater soil moisture on May 13, at the 15 cm depth, than the Kentucky bluegrass, hard fescue, bromegrass, clover and alfalfa treatments. The herbicide treatment had greater soil moisture May 29 than clean cultivation and both had significantly greater soil moisture than all vegetative covers. On June 18, again the vegetation-free treatments had significantly greater soil moisture than all vegetative covers. The herbicide treatment had greater soil moisture than perennial ryegrass or tall fescue on August 7. No significant differences were measured during the remainder of the growing season.

Table 4: The effect of orchard floor management on mass soil moisture in the alleyway of peach trees at depths of 15, 30 and 45 cm, 155 cm from the tree--1987.[z]

TREATMENT	% MASS SOIL MOISTURE								
	15 cm Depth								
	5/13	5/29	6/18	8/7	8/25	9/8	9/29	10/6	10/20
Herbicide	14.2 a	14.8 a	17.6 a	18.6 a	17.7	17.9	18.8	18.3	17.8
Clean Cultivation	11.2 abcd	11.8 b	16.4 a	18.3 ab	17.6	17.8	19.1	18.5	18.0
Kentucky Bluegrass	10.5 bcd	8.0 c	9.9 b	16.8 abc	17.4	17.6	18.6	18.1	18.0
Perennial Ryegrass	12.1 abcd	8.5 c	10.6 b	15.5 c	17.7	18.1	18.1	17.5	17.4
Hard Fescue	10.0 d	8.0 c	11.4 b	17.3 abc	17.2	17.7	18.6	18.2	18.0
Chewings Fescue	12.5 abcd	9.3 c	11.4 b	17.9 ab	18.6	17.6	18.9	18.5	18.3
PR+KB	11.9 abcd	8.5 c	11.9 b	17.0 abc	18.5	18.7	18.7	18.3	18.1
PR+CF	13.5 abc	8.7 c	11.0 b	17.6 ab	17.5	17.8	18.7	18.2	18.1
Bromegrass	9.4 d	7.7 c	11.1 b	17.8 ab	16.5	16.7	18.8	18.4	18.2
Clover	9.6 d	7.7 c	9.8 b	17.0 abc	16.5	17.8	18.6	18.2	17.9
Alfalfa	10.2 cd	8.0 c	10.4 b	16.9 abc	17.6	17.5	18.8	18.3	18.1
Tall Fescue	13.7 ab	9.2 c	11.9 b	16.7 bc	17.5	17.7	18.5	18.1	17.9
	30 cm Depth								
TREATMENT	5/13	5/29	6/18	8/7	8/25	9/8	9/29	10/6	10/20
Herbicide	14.5 abc	14.8 a	16.5 a	15.8	16.5	16.4	16.4	16.2	15.9
Clean Cultivation	13.1 cde	13.4 b	16.1 ab	15.2	15.9	16.0	16.0	15.8	16.3
Kentucky Bluegrass	13.6 bcde	11.5 c	13.1 c	15.3	15.6	15.6	16.2	16.1	16.0
Perennial Ryegrass	15.1 ab	12.0 c	12.8 c	14.9	16.3	16.3	16.3	16.2	16.0
Hard Fescue	13.8 abcd	11.6 c	13.5 bc	15.5	16.4	16.5	16.3	16.3	16.1
Chewings Fescue	14.5 abc	12.2 c	13.3 c	15.3	16.5	15.6	16.4	16.3	15.5
PR+KB	13.7 bcd	11.7 c	13.5 bc	15.4	16.3	16.2	15.7	16.1	15.9
PR+CF	15.6 a	12.1 c	13.3 c	15.6	16.2	16.3	16.2	16.1	16.0
Bromegrass	12.6 de	10.6 d	13.8 bc	15.4	15.8	15.9	16.4	16.2	16.0
Clover	11.9 e	10.4 d	11.4 c	15.2	16.2	16.3	16.3	16.1	15.9
Alfalfa	13.6 bcde	11.5 c	12.1 c	15.1	15.7	15.8	16.4	16.2	16.1
Tall Fescue	14.9 ab	12.0 c	13.6 bc	15.6	15.7	15.8	16.3	16.2	16.0
	45 cm Depth								
TREATMENT	5/13	5/29	6/18	8/7	8/25	9/8	9/29	10/6	10/20
Herbicide	16.3 ab	16.5 a	17.0 a	15.8	16.6	16.6	16.5	16.3	16.0
Clean Cultivation	15.9 abc	15.5 ab	16.1 a	16.5	16.0	16.0	16.6	16.5	16.3
Kentucky Bluegrass	15.7 abc	12.1 ef	12.8 bc	14.4	15.7	15.7	16.4	16.3	16.2
Perennial Ryegrass	16.8 a	14.9 bc	13.9 abc	14.5	15.7	15.8	16.4	16.3	16.2
Hard Fescue	16.2 abc	12.8 de	14.5 ab	14.5	15.8	15.9	16.5	16.3	16.3
Chewings Fescue	16.6 ab	14.4 bc	14.1 abc	15.6	15.7	15.8	16.5	16.4	16.3
PR+KB	16.5 ab	12.3 def	14.0 abc	14.4	15.7	15.7	16.5	16.4	16.2
PR+CF	16.8 a	14.2 bc	14.0 abc	15.0	16.3	16.4	16.4	16.2	15.6
Bromegrass	16.0 abc	11.8 ef	13.9 abc	15.0	15.9	16.0	16.5	16.5	16.4
Clover	15.0 c	10.9 f	11.1 c	14.2	16.3	16.4	16.4	16.3	16.2
Alfalfa	15.3 bc	12.0 ef	12.1 bc	14.8	16.4	16.3	15.8	16.3	16.2
Tall Fescue	16.3 ab	13.7 cd	14.5 ab	15.0	16.3	16.4	16.3	16.2	16.0

[z] Treatment means separated by Duncan's multiple range test (P=0.05), when treatment differences are indicated by a significant F test at 5% level.

Measurements at the 30 cm depth, indicated the perennial ryegrass, PR+CF and tall fescue treatments had significantly greater soil moisture May 13 than the treatments of clean cultivation, bromegrass and clover. On May 29, the herbicide treatment had the greatest soil moisture. Clean cultivation had significantly greater soil moisture than all vegetative covers. The bromegrass or clover treatments had less soil moisture than all other vegetative covers. The herbicide treatment again had greater soil moisture June 18 than all vegetative covers. The clean cultivation treatment had greater soil moisture than all vegetative covers except hard fescue, PR+KB, bromegrass and tall fescue. There were no significant treatment differences after June 18.

Soil moisture at the 45 cm depth was significantly greater in the perennial ryegrass or PR+CF treatments than clover or alfalfa on May 13 (Table 4). On May 29, the herbicide treatment had greater soil moisture than all vegetative covers. Clean cultivation had greater soil moisture than all vegetative treatments except perennial ryegrass, chewings fescue and PR+CF. Clover had the lowest soil moisture not significantly different from the Kentucky bluegrass, PR+KB, bromegrass and alfalfa treatments. On June 18, the vegetation-free treatments had greater soil moisture than the treatments of Kentucky bluegrass, clover and alfalfa. No differences were measured during the remainder of the growing season.

Significant differences in leaf nitrogen occurred only on September 24 in 1987 and July 27 in 1988 (Table 5). Kentucky bluegrass or bromegrass treatments had lower leaf nitrogen in September, 1987 than the clean cultivation or clover treatments. In July, 1988 the perennial ryegrass, hard fescue, PR+KB and bromegrass treatments had lower leaf nitrogen than clean cultivation or alfalfa. The lowest nitrogen level

Table 5: The effect of orchard floor management on percent peach foliar nitrogen (N).[z]

TREATMENT	7/17/87	9/24/87	5/18/88	6/29/88	7/27/88	9/18/88
	% N					
Herbicide	3.67 a	3.55 ab	4.73 a	3.66 a	3.52 ab	2.86 a
Clean Cultivation	3.62 a	3.62 a	4.76 a	3.61 a	3.56 a	2.82 a
Kentucky Bluegrass	3.79 a	3.43 bc	4.87 a	3.51 a	3.43 abc	2.78 a
Perennial Ryegrass	3.70 a	3.53 ab	4.80 a	3.51 a	3.22 cd	2.73 a
Hard Fescue	3.61 a	3.48 abc	4.73 a	3.45 a	3.07 d	2.70 a
Chewings Fescue	3.74 a	3.57 ab	4.64 a	3.54 a	3.51 ab	2.69 a
PR+KB	3.59 a	3.51 abc	4.63 a	3.54 a	3.26 bcd	2.64 a
PR+CF	3.59 a	3.54 ab	4.69 a	3.49 a	3.47 abc	2.75 a
Bromegrass	3.64 a	3.36 c	4.70 a	3.61 a	3.28 bcd	2.88 a
Clover	3.73 a	3.61 a	4.87 a	3.50 a	3.39 abc	2.92 a
Alfalfa	3.51 a	3.52 abc	4.72 a	3.60 a	3.56 a	3.04 a
Tall Fescue	3.59 a	3.58 ab	4.56 a	3.37 a	3.30 abcd	2.47 a

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

was in the hard fescue treatment, significantly less than 7 of the treatments. None of the other nutrient elements analyzed in 1987 had significant treatment differences.

Cold hardiness was evaluated three times between the end of the 1987 growing season and initiation of shoot growth in 1988 (Table 6). No significant treatment differences in T50 values occurred.

Treatments did not differ in the number of fruit per mm of shoot length in 1988 (Table 7). However, fruit weight in the herbicide treatment was greater than all treatments except the PR+KB or PR+CF, and the PR+KB was greater than the tall fescue. Fruit yield did not differ between treatments at either harvest in 1988. Neither total yield, nor fruit size separation indicated significant treatment differences (Appendix II-J).

Peach leaf net photosynthetic rate was measured on three days in 1987 and once in 1988 (Table 8). Significant differences occurred only July 30 in 1987 when Kentucky bluegrass had a significantly greater photosynthetic rate than the alfalfa treatment. No other treatment differences occurred. After irrigation July 30, no treatment differences were detected the next day on July 31.

The herbicide, clean cultivation and clover treatments resulted in greater peach leaf fresh weight than bromegrass or tall fescue (Table 9). Clean cultivation resulted in greater leaf dry weight than all vegetative covers except hard fescue, PR+KB and clover. The leaves from trees in the vegetation-free treatments had greater leaf area than trees in the perennial ryegrass, bromegrass and tall fescue treatments. The clover or PR+KB treatments had greater peach leaf area than the vegetative treatments of bromegrass or tall fescue.

Table 6: The effect of orchard floor management on phloem and cambial T50 values of peach shoots after the 1987 growing season.[z]

TREATMENT	10-22-87	1-19-88	4-5-88
	T50 Values (C)		
Herbicide	19.3	23.5	18.5
Clean Cultivation	19.3	22.8	18.3
Kentucky Bluegrass	19.3	22.5	18.8
Perennial Ryegrass	17.8	21.3	19.8
Hard Fescue	19.3	23.0	18.5
Chewings Fescue	19.0	23.8	18.0
PR+KB	16.5	22.0	18.3
PR+CF	20.3	22.8	18.5
Bromegrass	19.3	23.8	19.0
Clover	17.8	24.8	18.8
Alfalfa	20.8	23.5	17.0
Tall Fescue	18.8	23.5	19.3

[z] No treatment differences detected by an F test at 5% level.

Table 7: The effect of orchard floor management on relative cropping of peach trees on July 5, 1988.[z]

TREATMENT	FRUIT/SHOOT(mm)	AVG. FRUIT WT(g)
Herbicide	0.80 a	23.9 a
Clean Cultivation	1.12 a	18.9 bc
Kentucky Bluegrass	0.96 a	19.6 bc
Perennial Ryegrass	1.23 a	19.5 bc
Hard Fescue	1.49 a	18.5 bc
Chewings Fescue	1.15 a	19.4 bc
PR+KB	1.02 a	21.5 ab
PR+CF	0.97 a	20.7 abc
Bromegrass	1.09 a	17.8 bc
Clover	0.94 a	18.1 bc
Alfalfa	1.07 a	18.5 bc
Tall Fescue	1.42 a	17.3 c

[z] Treatmeant means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Table 8: The effect of orchard floor management on peach leaf net photosynthetic rate(mg CO_2 $dm^{-2}hr^{-1}$).[z]

TREATMENT	6/23/87	7/30/87	7/31/87	7/13/88
Herbicide	25.07 a	19.31 ab	17.75 a	20.02 a
Clean Cultivation	21.12 a	19.67 ab	15.11 a	19.13 a
Kentucky Bluegrass	24.59 a	22.65 a	19.81 a	19.32 a
Perennial Ryegrass	22.33 a	19.38 ab	16.58 a	16.00 a
Hard Fescue	21.22 a	19.23 ab	15.62 a	14.97 a
Chewings Fescue	23.51 a	21.04 ab	18.24 a	17.41 a
PR+KB	22.63 a	18.85 ab	16.55 a	16.86 a
PR+CF	25.02 a	20.55 ab	17.17 a	17.99 a
Bromegrass	24.31 a	19.65 ab	16.87 a	14.50 a
Clover	24.89 a	20.08 ab	16.28 a	19.69 a
Alfalfa	23.34 a	17.92 b	15.98 a	16.21 a
Tall Fescue	22.82 a	19.79 ab	17.42 a	17.51 a

[z] Treatment means separated by Duncan's multiple range test ($P=0.05$) with significant F test at 5% level.

Table 9: The effect of orchard floor management on peach leaf area and fresh and dry weight on 10/7/88. Leaf samples taken from the 8-10th leaf from the shoot apex.[z]

TREATMENT	FRESH WT(g)	DRY WT(g)	LEAF AREA(mm^2)
Herbicide	1.08 ab	0.37 ab	468.0 a
Clean Cultivation	1.10 a	0.39 a	467.8 a
Kentucky Bluegrass	0.99 abc	0.33 bc	438.1 abc
Perennial Ryegrass	0.96 bc	0.32 bc	417.0 bc
Hard Fescue	1.04 abc	0.35 abc	437.7 abc
Chewings Fescue	1.00 abc	0.33 bc	427.2 abc
PR+KB	1.02 abc	0.34 abc	431.9 ab
PR+CF	0.97 bc	0.33 bc	430.8 abc
Bromegrass	0.94 c	0.31 bc	400.6 c
Clover	1.08 ab	0.37 ab	459.2 ab
Alfalfa	0.95 bc	0.32 bc	427.7 abc
Tall Fescue	0.92 c	0.31 c	407.3 c

[z] Treatment means separated by Duncan's multiple range test ($P=0.05$) with significant F test at 5% level.

Alfalfa was the tallest vegetative treatment followed by bromegrass or tall fescue (Table 10). Fresh weight tended to vary between sampling dates, however, clover or alfalfa generally had the greatest fresh weight. Bromegrass, tall fescue and Kentucky bluegrass tended to have greater fresh weight than the remaining vegetative covers. Alfalfa tended to have the greatest dry weight, followed by clover. Bromegrass, tall fescue and Kentucky bluegrass generally had similar dry weights, less than clover or alfalfa but greater than the other vegetative covers.

DISCUSSION

A 1.22 m wide vegetation-free herbicide strip was maintained in the tree row and supplemental irrigation was applied which appeared sufficient for maximum tree growth throughout this three-year study. The peach trees were irrigated frequently, twice in 1987 and three times in 1988 as a result of unseasonably warm and dry weather in Michigan. The large volume of water applied at each irrigation date saturated the soil to at least a depth of 45 cm. The utilization of the 1.22 m wide herbicide strip, annual fertilization and supplemental irrigation minimized the competitive effect of the vegetative covers on tree growth.

Vegetative orchard floor covers result in reduced tree growth (Lord and Vlach, 1973; Welker and Glenn, 1985; 1988; Layne and Tan, 1988). In this study, orchard floor treatments affected shoot length only in 1987. No differences occurred in TCA in any of the first three growing seasons. However, treatment differences did occur in leaf weight and area in 1988. Bromegrass or tall fescue treatments had reduced leaf weight and area compared to the vegetation-free treatments. Peach

Table 10: Height, fresh weight, and dry weight of the ten vegetative orchard floor covers. Fresh weight and dry weight are for a 12.9 cm^2 area.[z]

TREATMENT	HEIGHT(cm)						
	7/28/86	6/15/87	8/6/87	9/27/87	5/25/88	7/29/88	8/15/88
Kentucky Bluegrass	21.4 d	21.0 c	27.3 c	23.1 d	22.6 d	24.3 c	18.3 c
Perennial Ryegrass	12.9 e	16.3 de	12.6 d	24.1 d	19.8 de	15.2 d	13.7 efg
Hard Fescue	14.4 e	20.0 cd	17.3 d	14.3 f	17.3 e	14.5 d	10.6 g
Chewings Fescue	16.0 e	20.0 cd	17.1 d	17.6 ef	19.4 de	16.1 d	11.9 fg
PR+KB	14.7 e	18.7 cde	16.7 d	23.2 d	19.3 de	18.6 d	17.3 cd
PR+CF	14.8 e	16.0 e	12.8 d	22.4 d	20.3 de	15.6 d	14.3 def
Bromegrass	31.4 b	29.2 b	37.5 b	28.7 c	36.5 b	32.1 b	15.9 cde
Clover	26.5 c	19.5 cde	17.8 d	21.0 de	22.4 d	19.9 cd	13.9 defg
Alfalfa	46.2 a	52.4 a	45.8 a	59.4 a	59.4 a	46.4 a	30.4 a
Tall Fescue	24.5 cd	28.6 b	34.2 b	38.2 b	27.5 c	29.5 b	22.2 b

TREATMENT	FRESH WEIGHT(g)						
	7/28/86	6/15/87	8/6/87	9/27/87	5/25/88	7/29/88	8/15/88
Kentucky Bluegrass	83.9 de	82.7 bc	143.2 c	175.7 bc	121.8 c	101.2 c	43.6 bc
Perennial Ryegrass	33.8 f	53.0 c	64.1 d	191.8 bc	128.0 c	88.5 c	31.2 cdef
Hard Fescue	69.9 def	59.7 c	101.3 cd	114.0 c	109.7 c	90.7 c	17.6 f
Chewings Fescue	77.6 def	52.0 c	78.4 d	132.6 bc	105.0 c	84.9 c	27.5 cdef
PR+KB	43.0 ef	64.2 c	79.9 d	203.8 b	99.5 c	96.7 c	48.5 b
PR+CF	55.9 def	44.1 c	67.9 d	207.4 b	134.9 c	109.2 c	36.9 bcde
Bromegrass	148.4 c	105.1 bc	118.4 cd	142.7 bc	243.3 b	121.8 c	21.1 ef
Clover	386.7 a	177.3 b	215.9 b	310.1 a	273.7 b	198.8 b	26.2 def
Alfalfa	314.0 b	299.1 a	295.9 a	337.4 a	440.8 a	297.9 a	67.0 a
Tall Fescue	93.2 d	102.6 bc	156.9 c	209.4 b	128.9 c	173.3 b	42.5 bcd

TREATMENT	DRY WEIGHT(g)						
	7/28/86	6/15/87	8/6/87	9/27/87	5/25/88	7/29/88	8/15/88
Kentucky Bluegrass	23.7 c	27.2 bcd	48.7 b	44.4 b	36.2 c	29.7 cd	13.8 ab
Perennial Ryegrass	10.3 e	15.6 cd	19.8 e	39.1 bc	30.7 c	21.7 d	9.9 bcd
Hard Fescue	21.1 cd	19.8 bcd	32.5 cd	30.7 c	36.0 c	30.9 bcd	7.8 cd
Chewings Fescue	22.6 c	18.6 bcd	29.4 cde	33.8 bc	33.1 c	27.5 cd	10.9 bcd
PR+KB	12.3 de	19.2 bcd	25.0 de	45.1 b	27.3 c	27.1 cd	15.8 a
PR+CF	17.2 cde	11.9 d	21.8 de	41.1 bc	33.2 c	26.8 cd	11.7 abc
Bromegrass	36.7 b	29.7 bc	41.7 bc	29.1 c	57.6 b	28.7 cd	6.8 d
Clover	54.8 a	32.6 b	41.9 bc	38.7 bc	40.5 c	33.8 bc	6.8 d
Alfalfa	58.1 a	62.8 a	75.2 a	64.4 a	73.3 a	66.5 a	13.5 ab
Tall Fescue	24.5 c	28.4 bc	41.9 bc	41.9 bc	32.9 c	39.3 b	11.0 bcd

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

rooting was also severly reduced in tall fescue sod (Section III). The largest treatment effect on tree performance would have been expected in 1988, when the trees' root system would have been the most extensive and possibly interactive with orchard floor treatments outside of the herbicide strip. This study indicates vegetative competition may have affected leaf size but not severe enough to affect TCA or shoot length.

Peach leaf nitrogen has been reported to be reduced by grass covers such as tall fescue (Lord and Vlach, 1973; Welker and Glenn, 1985; 1988). No vegetative cover in this study had greater leaf nitrogen than the vegetation-free treatments at either date when significant treatment differences occurred. The lowest leaf nitrogen was 3.4% in 1987 and 3.1% in 1988. The recommended range for peach leaf nitrogen in Michigan is 3.3-4.5% (Hanson and Kesner, 1987). Trees were fertilized annually with nitrogen, which was not the case in studies reporting differences in foliar nitrogen for trees grown in some vegetative covers. When treatment differences in leaf nitrogen occurred, nitrogen levels in all treatments were above the recommended lower limit indicating that nitrogen applications were adequate to maintain tree growth.

Shoot hardiness did not differ between the orchard floor treatments. Layne and Tan (1988) also reported no difference in xylem hardiness of peach shoots between clean cultivation with winter cover crops or a permanent red fescue sod alley. This indicates that the trees were not weakened severly enough by stress from the vegetative covers to increase susceptibility to winter injury.

Glenn and Welker (1989) reported 'Kentucky 31' tall fescue reduced peach tree growth and fruit yield. In this study, yield in the third year did not differ suggesting the vegetative covers did not compete with tree growth to significantly affect yield. Fruit size differences in July may have been a result of fruiting competition before trees were uniformly thinned.

The difference in net photosynthetic rate in 1987 between Kentucky bluegrass and the alfalfa treatment cannot be explained by leaf nitrogen. Soil moisture measurements are not available for July 30 in 1987, the date treatment differences occurred, to evaluate the effect of soil moisture on leaf photosynthesis.

Alfalfa, clover or bromegrass produced the greatest fresh and dry weight but had the lowest percentage dry weight. The growth characteristics of a vegetative cover are a general indicator of the degree of competition a vegetative orchard floor could have on tree growth. Toenjes et al. (1956) and Goode (1955) reported the rooting depth of a vegetative covers is an indicator of the degree of competition that a vegetative cover would pose to tree growth. Shribbs and Skroch (1986b) also reported that apple tree growth was negatively correlated to the biomass of the vegetative cover.

A Bouyoucos moisture meter was used to measure soil moisture in May and June, 1987 and a wide range of moisture values were measured. The moisture blocks were connected to a datalogger in July, 1987 but the datalogger did not register moisture values as low as the Bouyoucos meter, recording over a range approximately 50% of that of the Bouyoucos moisture meter. This may have prevented measuring lower soil moisture values that may have occurred between treatments after July, 1987.

Many moisture blocks did not function during 1988. This required calculation of missing values and reduced the statistical sensitivity of the 1988 soil moisture data. The reduced detection range of the datalogger plus missing values in 1988 resulted in variable soil moisture data.

Soil moisture measurements in the tree row, 61 cm from the tree, were beneath the herbicide strip and probably affected mainly by the tree's moisture utilization. In 1987, significant soil moisture differences occurred in May at the 15 or 45 cm depths. Clover, a deep rooted cover, had one of the lowest values. In August, alfalfa, also deep rooted, had one of the lowest soil moisture values, and clover one of the highest. This suggests that the vegetative covers affected soil moisture in the vegetation-free herbicide strip. Although the moisture blocks are 61 cm from the tree and the vegetative cover, the reduced soil moisture values in several of the vegetative covers was either a result of increased tree utilization in the strip and/or lateral rooting of the vegetative covers. After September, soil moisture was lower in the vegetation-free treatments. The lack of soil moisture treatment differences after August 25 at the 30 or 45 cm depth may have been a result of reduced growth rate and moisture utilization of the vegetative covers, more frequent precipitation or both.

Soil moisture in the alley, 61 cm from the tree row, should be affected by both the tree and alley management. At the 15 or 30 cm depths in May of 1987, the vegetation-free treatments had greater soil moisture. These treatments had no vegetative cover competing for soil moisture. Late in the season however, soil moisture was lower in the vegetation-free treatments than the vegetative covers. At the 45 cm depth, the deep-rooted alfalfa or clover extracted soil moisture to the greatest degree in late May and June as also reported by Toenjes et al.

(1956). Late in the season, again the clean cultivation treatment had lower soil moisture levels at this depth.

At each of the previous moisture block locations the soil moisture in both vegetation-free treatments was lower than the vegetative covers late in the season. This may have been a result of reduced moisture infiltration as reported by Glenn and Welker (1989) to occur in vegetation-free treatments compared to living or killed vegetative covers.

Soil moisture in the alley, 155 cm from the tree row would be affected primarily by the alley treatment--not the tree. The vegetation-free treatments tended to have the greatest soil moisture content at all three depths in May and June with no vegetative cover to compete for soil moisture. Treatments did not differ after August 7 with relatively high soil moisture values resulting from frequent rainfall and unusually high air temperatures.

Soil moisture differences in 1987 and 1988 indicated the orchard floor vegetative covers affected soil moisture and may have competed with tree growth. Clover, alfalfa, bromegrass and tall fescue generally had greater fresh weight, dry weight and lower soil moisture levels and probably should be avoided as orchard floor covers as Glenn and Welker (1989) similarily recommended with tall fescue.

Vegetative covers adversely affected leaf size and soil moisture. When differences were detected in shoot length the Kentucky bluegrass and chewings fescue did not result in reduced shoot length compared to the herbicide treatment. Vegetative orchard floor covers utilize soil moisture and may potentially compete with tree growth. However, in this study, irrigation, fertilization and a 1.2 m herbicide strip in the tree row minimized the effect of the vegetative covers on peach tree growth.

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SECTION III

THE EFFECT OF ORCHARD FLOOR MANAGEMENT ON PEACH ROOTING

ABSTRACT

The rooting response of peach trees (*Prunus persica* L. Batsch cv. Redhaven/Halford) to six orchard floor management treatments was evaluated. Two treatments were maintained vegetation-free and four were vegetative covers in the alleyway with a 1.22 m wide herbicide strip in the tree row. The profile wall method was used to determine rooting frequency. Rooting frequency was recorded on vertical planes, 0.6 m from the tree, transversing the tree row (2.4 m), and on vertical planes 1.2 and 1.9 m from the tree row, parallel to the tree row. Trees maintained vegetation-free with herbicide had the greatest rooting frequency. Vegetation-free treatments, both herbicide or cultivation, resulted in greater root numbers 1.2 m from the tree than the vegetative covers. Peach rooting frequency, 1.2 m from the tree, was lowest in the tall fescue and alfalfa treatments. Peach rooting was intermediate in the Kentucky bluegrass and chewings fescue treatments between the vegetation-free and tall fescue treatments.

INTRODUCTION

Root distribution of various fruit crops differ in response to tree spacing, fertility level, irrigation and cultivar (Lyons and Krezdorn, 1962; Castle, 1980; Perry et al., 1983). Perry et al. (1983) reported large differences in root number and root dry weight at various depths and lateral distance from the the trunk of four *Vitis* cultivars. Root distribution of orange trees was also affected by tree density (Boswell et al., 1975; Castle, 1980). Lyons et al. (1962) reported higher peach rooting densities with medium applications of N, K, and Mg (113 g, 113 g or 57 g, respectively), with significant differences only in the surface 20 cm. Nonirrigated peach trees had greater root numbers than irrigated trees (Layne et al., 1986). However, irrigation treatments resulted in shallower rooting than the nonirrigated trees with a greater percentage of roots in the surface 30 cm.

Michigan peach orchard management is primarily clean cultivation cover crops or vegetative covers with herbicide strips in the tree row. Several literature reviews have documented the effects of different orchard floor management systems on the tree and the soil (Haynes, 1980; Hogue and Nielsen, 1987), but little has been reported about the effect on root growth and distribution (Atkinson 1980).

A vegetation-free area around fruit trees had a significant affect on tree rooting (Atkinson and White, 1976). Atkinson and White (1976) reported apple trees in complete grass had fewer roots and lower root weights while total vegetation-free treatments had the most roots. Ten-year-old apple trees maintained with herbicide strip management had greater root densities in the herbicide strip than in the vegetative alley. Tree roots under the vegetative alley were deeper than those in the herbicide strip (Atkinson et al., 1977).

Glenn and Welker (1989) reported tall fescue sod resulted in reduced peach tree root length compared to bare soil for roots less than 1 mm diameter, both under the sod and in a 50 cm vegetation-free zone between the sod and the tree. Rooting was deeper for both apple and peach trees which had not received supplemental water compared to frequently irrigated trees (Cripps, 1971; Beukes, 1984; Richards and Cockroft, 1975; Layne et al., 1986).

Soil cultivation eliminates surface rooting while mulch on the soil surface encourages both rooting in the mulch and in the soil surface for apple, peach and pear (Bechenbach and Gourley, 1932; Cockroft and Wallbrink, 1966). Cockroft and Wallbrink (1966) concluded that orchard floor management did not promote deeper rooting but affected surface rooting of peach trees.

This study was to determine the impact of various vegetative covers on the rooting of peach trees.

METHODS

The research was conducted at the Michigan State University Clarksville Horticultural Experiment Station in western Michigan on a Riddles sandy loam soil (moderately well drained, typic Hapludalfs, fine-loamy, mixed, mesic). The six orchard floor management treatments included two vegetation-free treatments and four vegetative covers with a 1.22 m wide herbicide strip in the tree row. The vegetative covers were seeded in September, 1985 in 6.1 m square plots. Three peach trees [*Prunus persica* (L.) Batsch cv. Redhaven/Halford] were planted in April, 1986 in a tree row through the middle of each plot with trees spaced 2 m apart in the row and 6.2 m between rows. The treatments were:

1. Herbicide---Maintained vegetation-free with herbicide
2. Clean cultivation---Maintained vegetation-free with cultivation
3. Park Kentucky bluegrass (*Poa pratensis* L.)
   Seeded at 100 kg/ha.
4. Wintergreen chewings fescue (*Festuca rubra* L.)
   Seeded at 199 kg/ha.

5. Peak alfalfa (*Medicago sativa*)
   Seeded at 22 kg/ha.

6. Kentucky 31 (K-31) tall fescue (*Festuca arundinacea* Schreb)
   Seeded at 305 kg/ha.

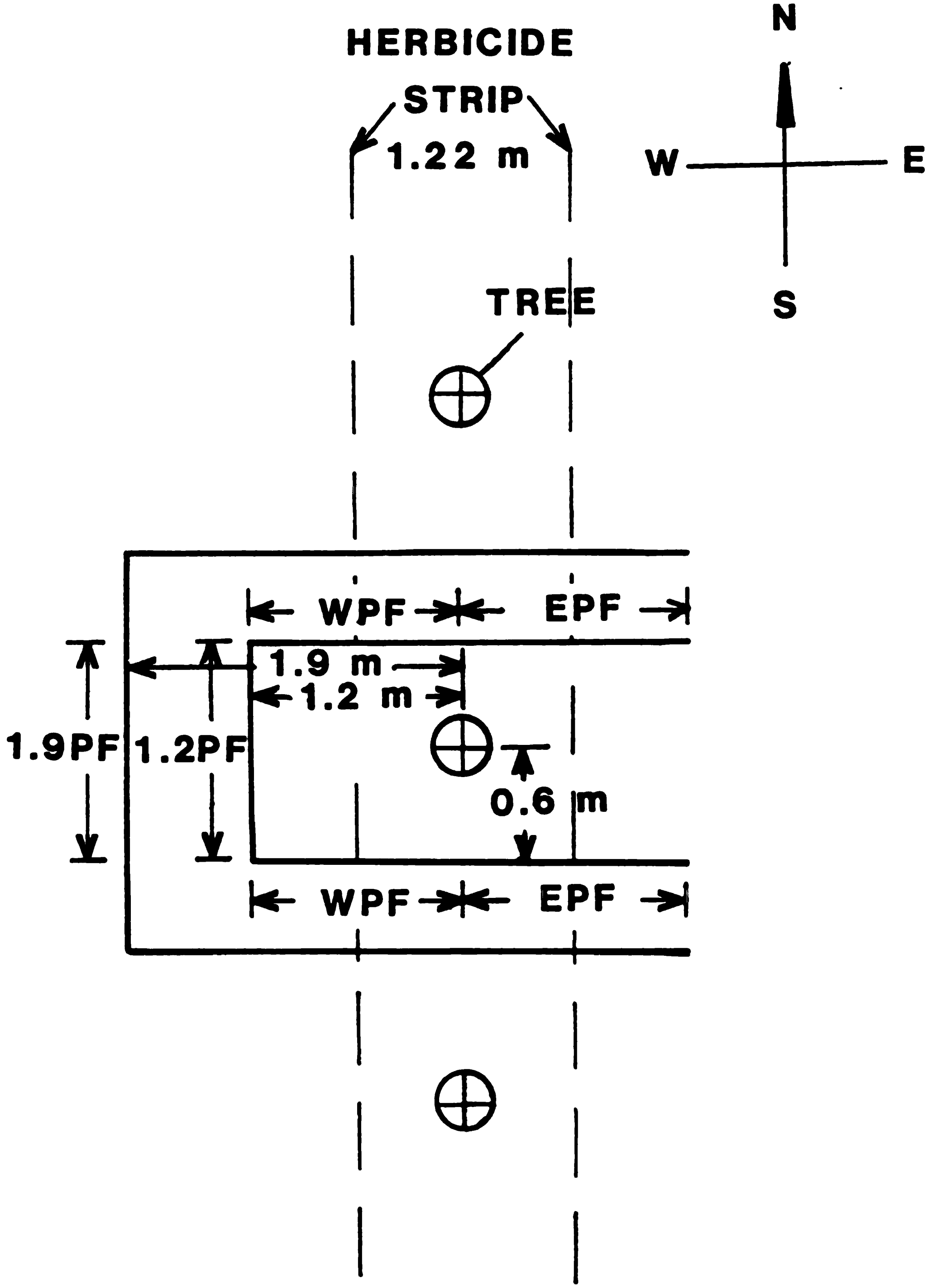
Gramoxone (1,1'-dimethyl-4-4'-bypyridinium ion), a contact herbicide was applied at 1.1 kg/ha with 0.1% X-77 surfactant at approximately 30 day intervals during each growing season to control any vegetation in the herbicide treatment and the vegetation-free strip in the tree row. The clean cultivation treatment was rototilled to a depth of 8 cm at 30-40 day intervals during the growing season to control vegetation.

Trees were pruned to an open center. The experimental design was a randomized complete block with four replications. Data were collected from the middle tree in each plot.

The profile wall method described by Bohm (1979) was utilized to quantify the trees' root systems. Trenches 51 cm wide and approximately 1.8 m deep were dug in October, 1988 and confined to three sides of each tree (Fig. 1) to prevent cave-in problems. Two trenches were dug perpendicular to the tree row, one on each side of the tree, 0.6 m from the tree trunk. The trenches extended from the center of the tree row 1.2 m into the alley on both the east and west sides of the tree. Of the 1.2 m trench on each side of the tree, 60 cm was under the alley management treatment. A trench on the west side of the tree, 1.2 m from the tree, parallel to the tree row and transversing the perpendicular trenches provided two profile-faces, one 1.2 m from the tree and the other 1.9 m from the tree. Trench faces were prepared as described by Layne et al. (1986).

A 1.2 m by 1.0 m wooden grid frame divided by string into 20 cm by 10 cm sections, was placed against the profile faces to assist in

Figure 1: Diagram of trench locations for peach tree root distribution study.


HERBICIDE
STRIP
1.22 m
N
W
E
S
TREE
WPF
EPF
1.9 m
1.2 m
1.9PF
1.2PF
0.6 m
WPF
EPF

counting and mapping root distribution. Roots on each profile-face were counted and recorded in one of two diameter categories; those 2 mm and less and those greater than 2 mm in diameter. The trenches perpendicular to the tree row 0.6 m from the tree, were divided into east and west sections at the tree row (Fig. 1). The west profile-face (WPF) and east profile-face (EPF) refer to total root numbers on the respective side of the tree originating at the tree row and extending 1.2 m into the alley. Root numbers for the WPF and EPF are the total of the north and south faces of the trenches, 2.4 m by 1.0 m total area. The 1.2 m profile-face (1.2PF) and the 1.9 m profile-face (1.9PF), 1.2 m and 1.9 m respectively from the tree row, are individual profile-faces on the west side of the tree, 1.2 m by 1.0 m total area.

Soil bulk density and organic matter content were measured in the surface 8 cm of each orchard floor cover in October, 1988. Five soil cores (Blake, 1965) were taken from each replication, 20 per orchard floor cover, randomly selected from both sides of the tree outside the herbicide strip. Soil bulk density was determined by oven dry weight/core volume (Blake, 1965) and soil organic matter determined by percentage weight change after removal from a muffle furnace.

Roots were counted in two size categories. Because no treatment differences were detected in the number of large roots, all root numbers in both size categories were combined. Data presented are for total number of exposed roots on a square meter vertical plane. Data analysis was performed for each of the four profile-face locations by analysis of variance with mean separation by Duncan's multiple range test at the 5% significance level with a significant F value at the 5% level. Data analyses were also performed for each profile-face location sectioned into 40 cm columns and 20 cm rows.

RESULTS

The soil A and B horizon interface occurred at a depth of approximately 20 cm. The data are reported in 20 cm increments when presented by depth to separate the A and B horizons. Differential rooting between the A and B horizon was not evaluated, although differences may have occurred due to depth or differences in soil characteristics.

Treatments did not significantly differ in soil bulk density which ranged from 1.41 to 1.55 g/cm^3 or soil organic matter which ranged from 2.93 to 3.58 percent in the surface 8 cm of the soil.

Total root numbers for each profile-face location are presented in Table 1. On the WPF, EPF and 1.2PF the number of roots were not significantly different in the vegetation-free plots, maintained either by cultivation or herbicide. On the WPF, significant differences occurred between the herbicide treatment and the alfalfa or tall fescue treatments and between the clean cultivation and the tall fescue treatments. Treatment differences were not significant at the EPF. The vegetation-free treatments had significantly more roots than the vegetative covers at the 1.2PF. At the 1.9PF, all treatments had significantly less roots than the herbicide treatment.

Lateral Rooting

Total root numbers at the EPF in three vertical columns, 0-40, 40-80 and 80-120 cm outward from the tree row to a depth of 1 m (Table 2) did not differ significantly between treatments. The 0-40 cm column

Table 1: The effect of orchard floor management on the number of peach tree roots at each profile-face location. Root totals expressed per m^2.[z]

	Profile-face			
Treatment	WPF	EPF	1.2PF	1.9PF
Herbicide	191.6 a	174.8 a	173.6 a	124.6 a
Clean Cultivation	160.8 ab	152.9 a	159.0 a	43.8 b
Kentucky Bluegrass	157.1 abc	152.5 a	105.3 b	37.1 b
Chewings Fescue	153.7 abc	141.2 a	75.0 bc	48.6 b
Alfalfa	114.2 bc	112.6 a	85.3 b	8.3 b
Tall Fescue	108.5 c	130.2 a	40.7 c	10.7 b

[z] Means within columns separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Table 2: The effect of orchard floor management treatments on number of peach tree roots on the east profile-face (EPF) and the west profile-face (WPF) 0.6 m from the tree perpendicular to the tree row. Root totals expressed per m^2.[z]

	EAST PROFILE-FACE		
	-----Distance From Tree Row-----		
TREATMENT	0-40 cm	40-80 cm	80-120 cm
Herbicide	216.0 a	173.1 a	135.4 a
Clean Cultivated	179.8 a	170.6 a	108.5 a
Kentucky Bluegrass	216.3 a	145.0 a	96.3 a
Chewings Fescue	215.0 a	136.0 a	72.5 a
Alfalfa	133.5 a	109.6 a	94.8 a
Tall Fescue	186.9 a	122.9 a	81.0 a
	WEST PROFILE-FACE		
	-----Distance From Tree Row-----		
TREATMENT	0-40 cm	40-80 cm	80-120 cm
Herbicide	234.1 a	215.4 a	125.4 a
Clean Cultivated	180.0 a	178.1 ab	124.4 a
Kentucky Bluegrass	232.5 a	169.1 abc	69.8 ab
Chewings Fescue	206.9 a	151.3 bcd	102.9 a
Alfalfa	148.8 a	126.0 cd	67.9 ab
Tall Fescue	178.5 a	116.0 d	31.0 b

[z] Means within columns separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

of the WPF, closest to the tree and beneath the herbicide strip, exhibited no significant treatment differences. The column 40-80 cm from the tree row included a transition zone between the herbicide strip and alley management treatment. The herbicide, clean cultivation and Kentucky bluegrass treatments had significantly greater root numbers than the tall fescue treatment. Trees in alfalfa also had significantly less roots than trees in the vegetation-free treatments. The column 80-120 cm from the tree row was completely under the alley management system. The tall fescue treatment had significantly less roots than the herbicide, clean cultivation and chewings fescue treatments.

Table 3 presents root numbers in 40 cm columns on the 1.2PF. The vegetation-free treatments had significantly greater root numbers than the chewings or tall fescue treatments. No significant differences occurred between the chewings fescue, Kentucky bluegrass and alfalfa treatments or between the tall fescue, alfalfa and chewings fescue treatments.

The 1.9PF was also divided into three 40 cm columns (Table 4). Significant treatment differences occurred in two of the three columns. In the center column, directly adjacent to the tree, the herbicide treatment had significantly greater root numbers than all vegetative treatments. In the southern most column (right), the herbicide treatment had significantly more roots than all other treatments.

Depth of Rooting

Root numbers at different depths were significant between treatments on the WPF (Table 5), but not on the EPF (data not shown). Differences were significant only in the top 20 cm on the WPF. The herbicide, clean cultivation and Kentucky bluegrass treatments had

Table 3: The effect of orchard floor management on total peach root number in columns 40 cm wide by 100 cm deep on the profile-face 1.2 m (1.2PF) from the tree parallel to the tree row. Root totals expressed per m^2.[z]

TREATMENT	60 cm – 20 cm	20 cm – 0 (TREE) – 20 cm	20 cm – 60 cm
Herbicide	171.3 a	209.5 a	140.0 ab
Clean Cultivated	158.8 a	157.0 ab	161.3 a
Kentucky Bluegrass	104.5 b	115.0 bc	96.3 bc
Chewings Fescue	81.3 bc	71.3 c	72.5 cd
Alfalfa	73.3 bc	93.8 bc	88.8 bcd
Tall Fescue	38.3 c	2.0 c	32.0 d

[z] Means in columns separated by Duncan's multiple range test ($P=0.05$) with significant F test at 5% level.

Table 4: The effect of orchard floor management on total peach root number in columns 40 cm wide by 100 cm deep on the profile-face 1.9 m (1.9PF) from the tree parallel to the tree row. Root totals expressed per m^2.[z]

TREATMENT	60 cm – 20 cm	20 cm – 0 (TREE) – 20 cm	20 cm – 60 cm
Herbicide	124.5 a	133.3 a	116.3 a
Clean Cultivation	37.0 a	62.0 ab	32.5 b
Kentucky Bluegrass	50.8 a	30.8 b	30.0 b
Chewings Fescue	59.5 a	44.5 b	42.0 b
Alfalfa	8.8 a	5.0 b	11.3 b
Tall Fescue	8.3 a	12.0 b	12.0 b

[z] Means separated in columns by Duncan's multiple range test (P=0.05) with signficant F test at 5% level.

Table 5: The effect of orchard floor management on total peach root number and percentage (%) of total roots in each orchard floor treatment at 20 cm depth increments on the west profile-face (WPF) 0.6 m from the tree perpendicular to the tree row. Root totals expressed per m^2.[z]

Depth (cm)	Herbicide	Clean Cultivation	Kentucky Bluegrass	Chewings Fescue	Alfalfa	Tall Fescue	TREE
0-20	436.0 a[x] (45.5)[y]	436.5 a (54.2)	421.9 a (53.6)	364.2 ab (47.5)	251.7 b (44.1)	280.2 b (51.7)	
20-40	227.7 a (23.8)	148.5 a (18.5)	190.6 a (24.3)	178.1 a (23.2)	154.8 a (27.1)	120.4 a (22.2)	
40-60	109.0 a (11.4)	99.0 a (12.3)	91.3 a (11.6)	112.5 a (14.6)	87.5 a (15.3)	68.3 a (12.6)	
60-80	108.3 a (11.3)	65.2 a (8.1)	57.9 a (7.4)	62.5 a (8.1)	41.7 a (7.3)	37.5 a (6.9)	
80-100	77.1 a (8.0)	55.2 a (6.9)	24.0 a (3.1)	51.0 a (6.6)	35.4 a (6.2)	36.0 a (6.6)	

[z] Means separated within rows by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

[y] Root percentage of total root numbers in each orchard floor treatment.

[x] Total root numbers per m^2.

significantly more roots than the alfalfa or tall fescue treatments. These treatment differences were present in the area from the tree row outward 1.2 m into the alley under both the herbicide strip and alley management system.

The surface 20 cm of this 1.2 m zone was divided into three 40 cm columns to determine if differences were present under the different floor management practices (Table 6). In the column 0-40 cm from the tree, beneath the herbicide strip, there were no significant treatment differences. In the 40-80 cm column, a transition zone between the herbicide strip and the alley management treatment, the herbicide, clean cultivation and Kentucky bluegrass treatments had significantly more tree roots than the alfalfa or tall fescue treatments. The 80-120 cm column was beneath the alley management treatment and both vegetation-free treatments had significantly more roots than the alfalfa or tall fescue treatments.

Treatment differences occurred at all depths on the 1.2PF (Table 7). In the surface 20 cm, the herbicide treatment had significantly more roots than all other treatments. Clean cultivation had significantly more roots than all vegetative covers. At the 20-40 cm depth, the herbicide treatment had significantly more roots than the chewings fescue, alfalfa and tall fescue treatments. Clean cultivation or Kentucky bluegrass had significantly greater root numbers than the tall fescue treatment. Root numbers at the 40-60 cm depth were significantly greater in the herbicide, clean cultivation, Kentucky bluegrass and alfalfa treatments than the tall fescue treatment. At the 60-80 cm depth, the vegetation-free treatments had significantly more roots than the chewings fescue or tall fescue treatments. The clean

Table 6: The effect of orchard floor management on total peach root number and percentage (%) of total roots in each orchard floor treatment in 40 cm columns on the west profile-face (WPF) 0.6 m from the tree perpendicular to the tree row in the surface 20 cm. Root totals expressed per m^2.[z]

Distance from tree row (cm)	Herbicide	Clean Cultivation	Kentucky Bluegrass	Fine Fescue	Alfalfa	Tall Fescue	TREE
0-40	596.9 a[x] (45.6)[y]	505.0 a (38.6)	687.5 a (54.3)	589.4 a (54.0)	389.4 a (51.6)	478.1 a (56.8)	
40-80	440.6 ab (33.7)	495.6 a (37.8)	428.1 ab (33.8)	331.3 bc (30.3)	268.8 c (35.6)	292.5 c (34.8)	
80-120	270.6 a (20.7)	309.4 a (23.6)	150.0 ab (11.9)	171.9 ab (15.7)	96.9 b (12.8)	70.6 b (8.4)	

[z] Means separated within rows by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

[y] Root percentage of total root numbers in each vegetative cover.

[x] Total root numbers per m^2.

Table 7. The effect of orchard floor management on total peach root number and percentage (%) of total roots in each orchard floor treatment at 20 cm depth increments on the west profile-face 1.2 m (1.2PF) from the tree parallel to the tree row. Root totals expressed per m^2.[z]

Depth (cm)	Herbicide	Clean Cultivation	Kentucky Bluegrass	Chewings Fescue	Alfalfa	Tall Fescue
0-20	417.9 a[x] (48.2)[y]	292.9 b (36.9)	185.4 c (35.2)	150.0 c (39.9)	129.2 c (30.3)	91.7 c (45.0)
20-40	211.7 a (24.4)	161.7 ab (20.3)	154.2 ab (29.3)	113.8 bc (30.3)	118.8 bc (27.9)	61.7 c (30.3)
40-60	84.6 ab (9.7)	137.5 a (17.3)	111.7 ab (21.2)	63.8 bc (17.0)	91.7 ab (21.5)	22.1 c (10.8)
60-80	85.4 ab (9.8)	117.9 a (14.8)	55.4 bc (10.5)	29.2 c (7.8)	52.1 b (12.2)	12.5 c (6.1)
80-100	68.8 ab (7.9)	85.4 a (10.7)	20.0 b (3.8)	18.8 b (5.0)	34.6 b (8.1)	15.8 b (7.8)

[z] Means separated within rows by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

[y] Root percentage of total root numbers in each orchard floor treatment.

[x] Total root numbers per m^2.

cultivation treatment had significantly greater root numbers than all vegetative treatments. At the 80-100 cm depth, the clean cultivation treatment had significantly more roots than all vegetative covers. Only in the top 20 cm did root numbers significantly differ between the herbicide and clean cultivation treatments.

Rooting Percentages

Another way to consider root distribution is on a percentage basis, referred to as rooting percentage. Rooting percentages, expressed as the percentage of total roots in each treatment at a particular depth or distance from the tree, are presented in Tables 5, 6 and 7.

Rooting percentages for the WPF are presented in Table 5 by depth and there were minor treatment variations. Rooting percentages decreased with increased depth for each treatment. In Table 6, rooting percentages are presented in 40 cm columns from the tree row on the WPF. In the first 40 cm column, under the herbicide strip, the vegetation-free treatments had less rooting percentages than the four vegetative covers, but greater root numbers. In the 40-80 cm column, intermediate between the herbicide strip and the orchard floor treatment, there appeared to be little difference between all treatments. Rooting percentages under the orchard floor treatments, 80-120 cm from the tree trunk, were greater in the vegetation-free treatments than all vegetative covers. The vegetation-free treatments had a relatively gradual decrease in rooting between all three columns but there were relatively large differences for the vegetative treatments between the columns.

Rooting percentages at the 1.2PF are presented in Table 7. Rooting percentages in the surface 20 cm were greatest in the herbicide or tall fescue treatments and lowest in the alfalfa. The clean cultivation treatment had less rooting percentage than the herbicide treatment in the surface 40 cm. In the 20-60 cm depth, the vegetation-free treatments had lower rooting percentages than the vegetative covers, except between the clean cultivation and tall fescue treatments at the 40-60 cm depth. Below 40 cm no single treatment had the lowest or highest rooting percentages at both depths, although clean cultivation did have greater percentages at the 60-100 cm depths.

DISCUSSION

Orchard floor management treatments affected root number and distribution, both horizontally and vertically. The herbicide treatment had the greatest number of roots. The clean cultivation treatment had more roots than any of the vegetative covers on the profile-face 1.2 m from the tree. Roots at the 1.2PF were directly beneath the orchard floor management system. Reduced root numbers at the 1.2PF occurred as a result of differential competition of the vegetative covers on tree root growth, not affected by the herbicide strip in the tree row.

All treatments had fewer roots with increased depth or distance from the tree as reported by Cowart (1938) and Lyons and Krezdorn (1962). There were also large differences in root numbers under the orchard floor treatments at each profile-face location. On the WPF, 0.6 m from the tree, treatment differences in root number were not present in the first 40 cm from the tree under the herbicide strip where root numbers were the greatest. Atkinson and White (1976) also reported greater root numbers under the herbicide strip than the vegetative alleys for apple. Treatment differences would not be expected in this vegetation-free strip as there would be no vegetative cover competiting with the trees' root growth. In the following 40-80 cm area, a transition zone between the herbicide strip and alley management, root numbers were greatly reduced under the vegetative treatments. Tall fescue had 47% fewer roots and the chewings fescue treatment 21% fewer roots than the herbicide treatment. Root numbers were further reduced in the 80-120 cm zone, totally under the alley management system, where tall fescue had 25% as many roots as found in the herbicide treatment compared to 82% for the chewings fescue treatment. Peach rooting was reduced under the vegetative treatments as well as under the transition zone from the herbicide strip to the vegetative cover as also reported by Glenn and Welker (1989).

There appeared to be differential interference of the vegetative covers on tree rooting. Tall fescue had the fewest roots, both in depth and lateral spread. Tall fescue had no roots in the 60 to 100 cm depth at the 1.9PF. The alfalfa treatment also had reduced root numbers, but greater than the tall fescue. The Kentucky bluegrass had significantly greater root numbers than the tall fescue. Statistical analysis did not always indicate significant treatment differences between the vegetative covers because of null data and treatment variations. However, the large differences in root numbers between the wintergreen chewings fescue or Kentucky bluegrass treatments and the alfalfa or tall fescue treatments suggest differential rooting between vegetative covers that should be examined further.

Cockroft and Wallbrink (1966) reported orchard soil management did not result in deeper peach tree rooting. The same response was found in this study. The vegetative covers had reduced root numbers compared to the vegetation-free treatments at all depths and locations.

Reduced root numbers in the surface 20 cm of the clean cultivated treatment on the 1.2PF, compared to the herbicide treatment, resulted from the elimination of surface roots by the mechanical cultivation. Cockroft and Wallbrink (1966) reported that cultivation eliminated roots in the surface 8 cm of the soil. Clean cultivation, even though root numbers were reduced by cultivation, had greater root numbers than the vegetative covers on the 1.2PF.

The reduction in root numbers under the vegetative covers compared to the vegetation-free plots suggests interference. Interference is the effect on plant growth of one plant induced by another (Radosevich and Holt, 1984), and can either promote or inhibit plant growth. The mechanisms by which interference may affect plant growth are numerous. In this study, two probable effects of inhibitory interference were competition and allelopathy. Competition for nutrients and water would be a direct effect of interference. Allelopathy, the inhibition of growth of one plant due to toxic substances released from another (Putnam and Tang, 1986) would be an indirect effect. Further study is needed to determine if any of these factors are involved in affecting peach tree rooting under vegetative covers.

The distance from the tree to the center column on the 1.2PF is approximately 6 cm less than the distance from the tree to the center of the columns on either side of the center column. This increased distance resulted from using straight faced trenches centered on the tree. The increased distance was unavoidable due to the trenching methods utilized. However, only small differences were present in rooting between the three columns indicating no real differences between the three columns resulted from the increased distance.

Trees in this study did not exhibit symmetrical rooting around the tree. There were no treatment differences on the EPF, but treatment differences did occur on the WPF. This differential in rooting was not observed in orange trees by Castle (1980). Prevailing winds may have contributed to this situation. The site was moderately windy, and trees leaned slightly to the east, away from the prevailing west winds. Rooting differences may have resulted on the windward side to anchor the trees in response to the wind or a result of shading which may have affected soil surface drying.

The limited sampling depth and possible insufficient sample number did not reveal significant treatment differences in response to orchard management in soil bulk density and organic matter as has been reported by others (Welker and Glenn, 1988; Atkinson and White, 1976). Another explantion could have been the relatively short duration of this study compared to the average life span of a commercial orchard.

The orchard floor management systems affected peach rooting. The very vigorous and deeper rooting covers of K-31 tall fescue and Peak alfalfa resulted in fewer tree roots both vertically and horizontally than the vegetation-free treatments. Greater rooting occurred in the relatively low vigor cover of Park Kentucky bluegrass than in K-31 tall fescue. Treatments controlling all orchard floor vegetation resulted in the greatest number of tree roots, both horizontally and vertically. Clean cultivation to a depth of 8 cm did reduce root numbers in the surface 20 cm compared to the Paraquat herbicide treatment.

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APPENDICES

Appendix I-A: The effect of six different vegetation-free areas around apple trees on shoot length of trees grown in Reliant hard fescue. Measurements for the 1986-1988 growing seasons.[z]

DATE	COMPLETE SOD	61 cm SQUARE	122 cm SQUARE	122 cm STRIP	183 cm STRIP	244 cm STRIP
	TREATMENTS					
	AVERAGE SHOOT LENGTH (cm)					
11/5/86	48.3 a	56.9 a	55.6 a	58.1 a	55.7 a	60.4 a
6/3/87	28.6 c	32.3 b	34.4 ab	35.7 ab	34.3 ab	37.3 a
6/30/87	49.4 c	54.1 c	65.1 ab	67.1 ab	61.8 b	70.6 a
9/24/87	64.5 d	76.0 c	80.4 bc	88.4 ab	82.7 abc	89.7 a
6/3/88	27.6 a	27.3 a	28.5 a	28.2 a	27.7 a	28.0 a
6/13/88	38.7 a	38.8 a	38.5 a	39.9 a	38.4 a	39.2 a
6/20/88	46.6 a	48.3 a	48.6 a	49.7 a	47.9 a	48.1 a
6/27/88	48.3 b	50.8 ab	51.1 ab	52.7 a	52.0 ab	52.8 a
7/6/88	49.2 b	52.0 ab	52.1 ab	54.7 a	54.8 a	55.4 a
7/14/88	52.7 b	55.6 ab	54.8 ab	57.5 ab	57.8 ab	58.8 a
7/21/88	58.1 b	61.9 ab	59.8 ab	62.4 ab	63.4 ab	64.6 a
7/27/88	65.6 a	67.9 a	65.6 a	67.8 a	68.5 a	69.7 a
8/3/88	72.1 a	74.1 a	71.9 a	72.1 a	74.7 a	75.6 a
8/10/88	78.2 a	79.7 a	79.5 a	79.3 a	78.9 a	80.9 a
8/17/88	82.1 a	83.3 a	83.1 a	82.7 a	83.0 a	85.0 a
8/24/88	81.5 a	84.4 a	83.1 a	84.0 a	84.1 a	84.9 a
8/31/88	82.6 a	84.6 a	84.4 a	84.2 a	83.9 a	86.1 a
9/7/88	83.2 a	84.0 a	84.6 a	85.4 a	84.0 a	86.6 a
9/15/88	83.8 a	84.7 a	85.1 a	85.0 a	84.5 a	86.6 a

[z] Treatment means separated by Duncan's multiple range test ($P=0.05$) with significant F test at 5% level.

Appendix I-B: The effect of six different vegetation-free areas around apple trees on shoot length for trees grown in Kentucky 31 tall fescue. Measurements for the 1986-1988 growing seasons.[z]

	TREATMENTS					
DATE	COMPLETE SOD	61 cm SQUARE	122 cm SQUARE	122 cm STRIP	183 cm STRIP	244 cm STRIP
	AVERAGE SHOOT LENGTH(cm)					
11/5/86	33.8 c	38.8 c	41.0 bc	51.1 a	49.2 ab	51.4 a
6/3/87	20.8 c	25.4 b	32.1 a	35.0 a	34.6 a	33.9 a
6/30/87	29.2 c	34.5 c	51.7 b	60.6 a	64.9 a	66.7 a
9/24/87	38.5 c	45.4 c	70.4 b	78.3 ab	85.3 a	82.1 ab
6/3/88	23.7 b	24.4 ab	26.3 ab	26.8 a	26.5 a	26.7 a
6/13/88	33.1 b	33.9 b	37.6 a	38.0 a	37.9 a	37.9 a
6/20/88	38.0 b	39.2 b	45.9 a	47.2 a	47.7 a	47.3 a
6/27/88	39.2 b	39.8 b	48.3 a	49.1 a	51.4 a	51.5 a
7/6/88	40.2 b	41.0 b	49.9 a	51.1 a	53.6 a	54.3 a
7/14/88	43.4 b	45.2 b	52.8 a	53.5 a	55.7 a	57.6 a
7/21/88	48.7 b	48.9 b	58.4 a	58.3 a	60.7 a	63.0 a
7/27/88	53.1 b	52.4 b	63.0 a	62.0 a	65.6 a	67.9 a
8/3/88	56.7 b	55.3 b	66.4 a	66.6 a	69.5 a	71.8 a
8/10/88	60.8 b	60.7 b	73.9 a	73.8 a	79.8 a	79.8 a
8/17/88	63.7 b	63.1 b	77.5 a	76.5 a	80.1 a	83.2 a
8/24/88	64.3 b	63.2 b	78.2 a	77.4 a	81.1 a	82.7 a
8/31/88	65.3 b	63.5 b	79.2 a	78.2 a	80.8 a	84.3 a
9/7/88	66.7 b	62.8 b	78.3 a	77.4 a	80.9 a	84.0 a
9/15/88	68.0 b	63.8 b	79.3 a	77.8 a	81.2 a	84.6 a

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix I-C: The effect of six different vegetation-free areas around apple trees on trunk cross-sectional area for trees grown in Reliant hard fescue. Measurements taken for the 1986-1988 growing seasons.[z]

	TREATMENTS					
DATE	COMPLETE SOD	61 cm SQUARE	122 cm SQUARE	122 cm STRIP	183 cm STRIP	244 cm STRIP
	AVERAGE TRUNK CROSS-SECTIONAL AREA (cm^2)					
5/15/86	0.7 a	0.8 a	0.8 a	0.8 a	0.7 a	0.8 a
7/24/86	1.4 a	1.3 a	1.4 a	1.3 a	1.3 a	1.3 a
10/30/86	1.9 b	2.2 a	2.5 a	2.4 a	2.5 a	2.6 a
5/29/87	2.2 c	2.6 bc	3.1 ab	3.0 ab	3.1 ab	3.2 a
6/4/87	2.2 c	2.8 b	3.2 ab	3.2 ab	2.9 ab	3.4 a
7/14/87	3.0 d	3.8 cd	4.5 abc	4.6 ab	4.2 bc	5.0 a
8/12/87	3.8 c	4.8 b	5.8 a	6.1 a	5.7 a	6.5 a
9/24/87	4.4 d	5.6 c	6.9 b	7.4 ab	7.0 b	8.1 a
6/3/88	5.3 d	6.5 c	8.0 b	8.7 ab	8.1 b	9.7 a
6/13/88	5.6 d	7.0 c	8.7 b	9.3 ab	8.8 b	10.4 a
6/20/88	5.9 d	7.2 c	9.1 b	9.9 b	9.3 b	11.3 a
6/27/88	6.0 d	7.5 c	9.7 b	10.4 b	9.9 b	11.9 a
7/6/88	6.4 d	8.1 c	10.3 b	11.1 b	10.7 b	12.7 a
7/14/88	7.0 d	8.8 c	11.3 b	12.0 b	11.5 b	13.8 a
7/21/88	7.4 d	9.3 c	11.8 b	12.7 b	12.2 b	14.6 a
7/27/88	7.6 d	9.7 c	12.3 b	13.4 b	12.8 b	15.3 a
8/3/88	7.9 d	10.3 c	12.8 b	14.0 b	13.6 b	16.1 a
8/10/88	8.5 d	10.6 c	13.6 b	14.7 b	14.3 b	16.8 a
8/17/88	8.9 d	11.0 c	14.2 b	15.3 b	14.9 b	17.6 a
8/24/88	9.2 d	11.5 c	14.7 b	16.1 b	15.5 b	18.3 a
8/31/88	9.4 d	12.0 c	15.4 b	16.5 b	16.1 b	18.8 a
9/7/88	9.7 d	12.4 c	15.9 b	17.0 b	16.7 b	19.8 a
9/15/88	10.0 d	12.7 c	16.3 b	17.6 b	17.2 b	20.1 a

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix I-D: The effect of six different vegetation-free areas around apple trees on trunk cross-sectional area for trees grown in Kentucky 31 tall fescue. Measurements taken for the 1986-1988 growing seasons.[z]

DATE	COMPLETE SOD	61 cm SQUARE	122 cm SQUARE	122 cm STRIP	183 cm STRIP	244 cm STRIP
	TREATMENTS					
	AVERAGE TRUNK CROSS-SECTIONAL AREA (cm^2)					
5/15/86	0.7 a	0.7 a	0.8 a	0.8 a	0.8 a	0.8 a
7/24/86	1.1 a	1.0 a	1.2 a	1.3 a	1.2 a	1.1 a
10/30/86	1.4 c	1.6 bc	2.0 ab	2.4 a	2.0 ab	2.1 a
5/29/87	1.7 b	1.9 b	2.6 a	2.8 a	2.5 a	2.6 a
6/4/87	1.8 b	2.0 b	2.8 a	3.1 a	2.7 a	2.8 a
7/14/87	2.3 b	2.5 b	3.9 a	4.4 a	4.4 a	4.4 a
8/12/87	2.5 c	2.9 c	4.8 b	5.7 ab	5.8 ab	6.0 a
9/24/87	2.9 b	3.2 b	6.8 a	6.9 a	7.2 a	7.6 a
6/3/88	3.6 c	3.8 c	7.0 b	7.5 ab	8.5 ab	9.0 a
6/13/88	3.7 c	4.1 c	7.5 b	8.7 ab	9.0 a	9.8 a
6/20/88	3.9 c	4.1 c	7.9 b	9.2 ab	9.6 a	10.4 a
6/27/88	4.0 c	4.3 c	8.2 b	9.7 ab	10.4 a	11.1 a
7/6/88	4.3 c	4.6 c	8.7 b	10.3 ab	11.0 a	11.8 a
7/14/88	4.6 c	4.9 c	9.4 b	11.1 ab	11.9 a	12.8 a
7/21/88	4.7 d	5.2 d	9.9 c	11.6 bc	12.6 ab	13.5 a
7/27/88	5.0 c	5.4 c	10.4 b	12.2 ab	13.1 a	14.0 a
8/3/88	5.2 c	5.9 c	10.9 b	12.9 ab	14.1 a	15.1 a
8/10/88	5.5 d	6.0 d	11.5 c	13.6 b	14.8 ab	15.8 a
8/17/88	5.8 d	6.3 d	12.0 c	14.2 b	15.1 ab	16.6 a
8/24/88	5.8 c	6.5 c	12.5 b	15.0 a	16.1 a	17.0 a
8/31/88	6.2 d	6.7 d	12.7 c	15.3 b	16.6 ab	17.8 a
9/7/88	6.3 d	7.0 d	13.4 c	15.6 bc	17.3 ab	18.6 a
9/15/88	6.4 d	7.0 d	13.6 c	15.9 bc	17.7 ab	19.0 a

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix I-E: The effect of six different vegetation-free areas around cherry trees on shoot length for trees grown in Reliant hard fescue. Measurements for the 1986-1988 growing seasons.[z]

DATE	COMPLETE SOD	61 cm SQUARE	122 cm SQUARE	122 cm STRIP	183 cm STRIP	244 cm STRIP
	AVERAGE SHOOT LENGTH (cm)					
11/5/86	35.7 a	33.5 a	38.4 a	34.2 a	29.2 a	30.5 a
6/3/87	15.0 c	18.3 bc	24.8 a	26.5 a	21.9 ab	25.6 a
6/30/87	26.2 c	37.4 bc	45.7 ab	52.7 a	42.8 ab	49.5 ab
9/24/87	39.3 b	52.5 a	61.2 a	65.7 a	57.8 a	62.0 a
6/3/88	18.6 b	21.0 ab	22.8 a	22.1 a	22.6 a	21.6 a
6/13/88	25.7 b	30.0 a	32.1 a	31.1 a	31.5 a	30.8 a
6/20/88	29.9 b	36.5 a	38.6 a	40.1 a	40.5 a	39.8 a
6/27/88	30.7 c	38.1 b	41.0 ab	43.0 a	44.0 a	42.8 a
7/6/88	29.9 c	38.9 b	41.8 ab	44.7 a	45.2 a	44.7 a
7/14/88	31.7 c	39.0 b	41.9 ab	46.0 a	46.3 a	46.1 a
7/21/88	34.0 c	39.8 b	43.4 ab	47.0 a	47.6 a	48.2 a
7/27/88	36.3 b	43.9 a	45.7 ab	50.4 a	49.9 a	51.5 a
8/3/88	40.6 b	47.2 a	48.6 a	56.7 a	52.7 a	55.5 a
8/10/88	45.0 c	47.9 bc	53.3 abc	60.5 ab	54.6 abc	64.6 a
8/17/88	49.2 b	52.3 ab	57.3 ab	61.8 ab	58.2 ab	66.5 a
8/25/88	51.5 b	54.3 b	61.1 ab	69.0 ab	62.0 ab	72.8 a
8/31/88	55.5 b	59.5 ab	61.3 ab	69.4 ab	65.3 ab	74.1 a
9/7/88	54.9 b	57.7 b	63.4 ab	72.7 ab	64.7 ab	76.8 a
9/15/88	54.7 b	55.4 b	61.5 ab	71.7 ab	63.7 ab	77.2 a

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix I-F: The effect of six different vegetation-free areas around cherry trees on shoot length for trees grown in Kentucky 31 tall fescue. Measurements taken for the 1986-1988 growing seasons.[z]

DATE	COMPLETE SOD	61 cm SQUARE	122 cm SQUARE	122 cm STRIP	183 cm STRIP	244 cm STRIP
	TREATMENTS					
	AVERAGE SHOOT LENGTH(cm)					
11/5/86	26.7 a	31.2 a	31.3 a	30.0 a	28.1 a	30.1 a
6/3/87	9.8 c	16.3 bc	23.4 a	20.9 ab	23.8 a	25.6 a
6/30/87	16.0 b	18.2 b	42.8 a	38.6 a	49.2 a	48.3 a
9/24/87	20.2 c	18.7 c	52.4 ab	41.5 b	63.7 a	58.3 ab
6/3/88	15.2 c	19.1 b	24.1 a	22.5 ab	21.8 ab	22.1 ab
6/13/88	20.8 c	27.2 b	32.6 a	31.0 ab	30.1 ab	30.8 ab
6/20/88	24.7 c	31.8 b	40.7 a	39.5 a	38.4 a	38.9 a
6/27/88	26.6 b	32.6 b	43.0 a	42.7 a	41.0 a	42.3 a
7/6/88	26.8 b	33.5 b	44.1 a	44.1 a	42.8 a	44.2 a
7/14/88	27.2 b	33.7 b	45.0 a	45.6 a	43.5 a	45.5 a
7/21/88	28.3 b	34.6 b	46.5 a	47.6 a	45.9 a	47.5 a
7/27/88	29.9 b	35.8 b	50.2 a	51.4 a	51.5 a	52.2 a
8/3/88	31.0 b	40.2 b	54.0 a	56.1 a	54.6 a	53.4 a
8/10/88	31.3 c	43.4 bc	57.9 ab	61.1 a	63.7 a	58.4 ab
8/17/88	32.1 c	48.1 bc	60.6 ab	65.7 ab	66.3 a	59.4 ab
8/25/88	32.7 c	48.0 bc	61.3 ab	70.1 a	71.7 a	64.0 ab
8/31/88	33.9 b	52.0 a	62.6 a	69.2 a	69.4 a	63.9 a
9/7/88	33.4 c	46.9 bc	61.4 ab	69.9 a	70.5 a	66.0 a
9/15/88	33.9 c	50.8 bc	65.0 ab	70.4 a	71.3 a	64.6 ab

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix I-G: The efffect of six different vegetation-free areas around cherry trees on trunk cross-sectional area for trees grown in Reliant hard fescue. Measurements for the 1986-1988 growing seasons.[z]

DATE	COMPLETE SOD	61 cm SQUARE	122 cm SQUARE	122 cm STRIP	183 cm STRIP	244 cm STRIP
	TREATMENTS					
	AVERAGE TRUNK CROSS-SECTIONAL AREA (cm^2)					
5/15/86	0.8 ab	0.9 a	0.9 a	1.0 a	0.8 ab	0.6 b
7/24/86	1.4 a	1.6 a	1.7 a	1.7 a	1.4 a	1.4 a
10/30/86	1.6 a	2.1 a	2.3 a	2.4 a	1.7 a	1.9 a
5/29/87	1.9 a	2.4 a	2.8 a	2.9 a	2.2 a	2.4 a
6/4/87	2.0 b	2.5 ab	3.0 a	3.0 a	2.3 ab	2.6 ab
7/14/87	2.7 c	3.7 abc	4.3 ab	4.6 a	3.4 bc	4.0 ab
8/12/87	3.3 c	4.7 b	5.7 ab	6.1 a	4.6 b	5.4 ab
9/24/87	3.7 c	5.4 b	6.5 ab	7.1 a	5.3 b	6.2 ab
6/3/88	4.2 b	6.2 a	7.3 a	7.8 a	6.1 a	7.0 a
6/13/88	4.3 c	6.6 ab	7.6 ab	8.3 a	6.4 b	7.5 ab
6/20/88	4.4 c	6.7 b	7.8 ab	8.8 a	6.8 b	7.9 ab
6/27/88	4.6 c	7.0 b	8.1 ab	9.1 a	7.1 b	8.2 ab
7/6/88	4.9 c	7.4 b	8.6 ab	9.8 a	7.7 b	8.8 ab
7/14/88	5.2 c	7.9 b	9.3 ab	10.5 a	8.4 ab	9.7 ab
7/21/88	5.5 c	8.5 b	9.8 ab	11.4 a	9.0 b	10.4 ab
7/27/88	5.8 c	9.2 b	10.4 ab	12.1 a	9.6 b	11.2 ab
8/3/88	6.1 c	10.0 b	11.1 ab	13.1 a	10.5 b	12.2 ab
8/10/88	6.5 c	10.5 b	11.6 ab	14.0 a	11.4 ab	13.0 ab
8/17/88	6.6 c	11.4 b	12.3 ab	14.9 a	12.0 ab	13.7 ab
8/25/88	7.1 d	11.4 c	12.9 bc	16.0 a	12.8 bc	14.6 ab
8/31/88	7.1 d	12.1 c	13.2 bc	16.6 a	13.2 bc	15.5 ab
9/7/88	7.3 d	12.5 c	14.0 bc	17.4 a	13.9 abc	16.4 ab
9/15/88	7.5 c	13.7 b	14.4 b	18.2 a	14.4 b	16.8 ab

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix I-H: The effect of six different vegetation-free areas around cherry trees on trunk cross-sectional area for trees grown in Kentucky 31 tall fescue. Measurements taken for the 1986-1988 growing seasons.[z]

DATE	COMPLETE SOD	61 cm SQUARE	122 cm SQUARE	122 cm STRIP	183 cm STRIP	244 cm STRIP
	AVERAGE TRUNK CROSS-SECTIONAL AREA (cm^2)					
5/15/86	0.9 a	0.8 a	0.9 a	0.7 a	0.9 a	0.8 a
7/24/86	1.3 a	1.4 a	1.4 a	1.3 a	1.4 a	1.3 a
10/30/86	1.4 a	1.5 a	1.6 a	1.4 a	1.6 a	1.5 a
5/29/87	1.5 a	1.7 a	1.9 a	1.8 a	1.9 a	1.8 a
6/4/87	1.5 a	1.7 a	2.1 a	2.0 a	2.1 a	2.0 a
7/14/87	1.7 c	2.0 bc	2.8 ab	2.9 a	3.3 a	3.0 a
8/12/87	1.9 b	2.1 b	3.6 a	3.8 a	4.4 a	3.9 a
9/25/87	2.0 b	2.2 b	4.0 a	4.4 a	5.2 a	4.6 a
6/3/88	2.4 b	2.6 b	4.6 a	5.0 a	5.8 a	5.2 a
6/13/88	2.4 b	2.6 b	4.8 a	5.3 a	6.2 a	5.6 a
6/20/88	2.5 b	2.7 b	5.1 a	5.5 a	6.6 a	5.9 a
6/27/88	2.5 b	2.8 b	5.3 a	5.7 a	6.8 a	6.2 a
7/6/88	2.7 b	2.9 b	5.8 a	6.2 a	7.5 a	6.7 a
7/14/88	2.8 b	3.1 b	6.2 a	6.8 a	8.3 a	7.5 a
7/21/88	3.0 b	3.3 b	6.7 a	7.4 a	8.9 a	8.0 a
7/27/88	3.1 b	3.5 b	7.2 a	7.9 a	9.6 a	8.7 a
8/3/88	3.2 b	3.6 b	8.0 a	8.7 a	10.5 a	9.6 a
8/10/88	3.3 b	3.8 b	8.7 a	9.5 a	11.1 a	10.3 a
8/17/88	3.6 b	4.1 b	8.9 a	9.8 a	12.4 a	10.9 a
8/25/88	3.6 b	4.1 b	9.4 a	10.5 a	12.7 a	11.6 a
8/31/88	3.9 b	4.5 b	9.9 a	11.0 a	10.9 a	12.4 a
9/7/88	3.9 b	4.5 b	10.4 a	11.5 a	13.8 a	13.1 a
9/15/88	4.0 b	4.6 b	10.8 a	12.0 a	14.5 a	13.7 a

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix I-1: The effect of six different vegetation-free areas around the tree on the 1988 mass soil moisture values in the tree row for apple trees in Reliant hard fescue[z].

% Mass soil moisture

-15 cm Depth-

TREATMENT	5/6/88	5/13/88	5/27/88	6/6/88	6/13/88	6/20/88	6/27/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
Complete sod	15.4	11.4 c	18.5 b	7.7 c	7.7 c	7.7 b	7.7 b	19.1	16.4 b	8.6 d	17.1 c	12.5 c	19.5	19.2	18.7	19.2	17.8	18.4	13.9 b
61 cm square	16.2	12.5 bc	19.2 a	8.6 c	7.9 c	7.7 b	7.7 b	19.4	17.2 ab	10.8 c	18.0 abc	15.2 b	19.5	19.0	18.3	19.2	17.1	18.0	13.0 b
122 cm square	16.7	13.6 abc	19.5 a	13.0 b	9.6 b	8.3 b	8.4 b	19.5	16.6 ab	12.3 b	17.9 bc	16.0 b	19.5	19.4	19.0	19.5	17.9	18.6	15.7 a
122 cm strip	15.4	13.3 abc	19.5 a	18.4 a	14.9 a	12.4 a	11.4 a	19.4	18.0 a	15.3 a	19.2 a	18.6 a	19.5	19.5	19.1	19.4	18.5	18.2	17.3 a
183 cm strip	16.1	14.9 a	19.4 a	17.3 a	14.2 a	12.0 a	11.4 a	19.5	17.9 a	14.4 a	19.2 a	18.2 a	19.5	19.5	19.4	19.1	18.4	18.8	16.6 a
244 cm strip	15.0	14.0 ab	19.5 a	17.9 a	14.3 a	12.4 a	11.6 a	19.5	17.4 ab	14.0 a	18.8 ab	17.8 a	19.5	19.5	19.5	19.3	17.9	18.5	16.1 a

-30 cm Depth-

TREATMENT	5/6/88	5/13/88	5/27/88	6/6/88	6/13/88	6/20/88	6/27/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
Complete sod	16.2	13.8 b	16.6	11.0 e	10.4 d	10.4 c	10.4 b	16.8	15.9 c	12.3 d	15.3 cd	13.4 c	16.8	16.8	15.8 b	16.8	16.4	16.4	14.9 c
61 cm square	16.5	15.5 a	16.8	12.4 d	10.4 d	10.3 c	10.4 b	16.8	16.5 ab	13.4 c	16.3 bc	15.8 b	16.8	16.5	16.2 b	16.2	16.0	16.1	14.4 c
122 cm square	16.5	15.7 a	16.9	15.0 c	12.1 c	11.3 b	11.1 b	16.7	16.1 bc	14.1 b	14.8 d	15.3 b	16.8	16.8	16.4 b	16.9	16.8	16.8	15.7 b
122 cm strip	16.6	15.7 a	16.9	16.5 b	16.3 b	15.2 a	14.9 a	16.9	16.8 a	16.2 a	16.8 ab	17.3 a	16.8	16.9	17.6 a	17.1	17.2	17.4	16.9 a
183 cm strip	16.3	16.2 a	16.9	17.8 a	17.4 a	15.1 a	14.3 a	16.8	16.7 a	15.9 a	18.0 a	17.1 a	16.8	16.7	16.6 b	16.6	16.6	16.5	15.6 b
244 cm strip	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

-45 cm Depth-

TREATMENT	5/6/88	5/13/88	5/27/88	6/6/88	6/13/88	6/20/88	6/27/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
Complete sod	16.8 a	16.2 bc	17.0 a	13.4 b	10.5 c	10.6 d	10.5 b	17.0	16.6	13.9 b	14.7	14.0	15.5	16.9	16.2	16.8	16.7	16.5	15.9
61 cm square	16.4 a	16.2 bc	16.6 a	15.0 a	11.3 bc	10.4 d	10.4 b	16.2	16.5	14.2 b	15.6	14.8	17.1	16.6	16.4	16.3	16.0	16.0	15.0
122 cm square	16.4 a	16.0 c	16.7 a	15.0 a	12.4 b	12.1 c	11.0 b	16.4	16.3	14.6 b	15.8	14.8	16.7	17.1	15.8	16.7	16.5	16.4	14.7
122 cm strip	16.6 a	16.7 ab	16.4 a	16.2 a	16.5 a	15.7 b	14.9 a	16.6	16.7	15.9 a	16.0	15.7	16.7	16.9	16.4	16.6	16.4	16.3	16.1
183 cm strip	15.1 b	15.9 c	14.2 b	16.0 a	16.4 a	15.3 b	14.4 a	16.2	16.4	15.8 a	15.8	15.6	17.0	16.7	16.2	16.6	16.3	16.2	16.0
244 cm strip	16.8 a	16.7 a	16.7 a	16.4 a	16.5 a	16.8 a	15.4 a	17.2	17.0	15.9 a	16.3	15.9	16.4	16.8	16.7	16.5	16.5	16.4	16.3

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix I-J: The effect of six different vegetation-free areas around the tree on the 1988 mass soil moisture values in the tree row for apple trees in Kentucky 31 tall fescue[z].

	% Mass soil moisture																
	15 cm Depth																
TREATMENT	5/6/88	5/27/88	6/6/88	6/13/88	6/20/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
Complete sod	18.1 a	19.1	7.8 c	7.7 b	7.7 b	19.1	14.8 c	8.0 b	15.9 c	10.1 c	19.5	18.2 bc	18.3	18.7 b	13.0 c	16.4 b	9.1 b
61 cm square	18.7 a	18.9	7.7 c	7.8 b	7.7 b	19.2	16.4 b	7.8 b	15.1 c	10.7 c	19.4	17.7 c	17.4	18.6 b	14.9 b	15.9 b	9.6 b
122 cm square	18.4 a	19.2	10.6 b	7.7 b	7.7 b	19.0	17.3 ab	10.1 b	17.5 b	13.5 b	19.5	19.1 ab	18.8	19.4 a	17.8 a	17.9 a	14.6 a
122 cm strip	18.6 a	19.5	18.2 a	13.8 a	11.1 a	19.4	18.1 a	14.3 a	19.0 ab	17.8 a	19.5	19.2 ab	18.9	19.4 a	18.0 a	18.3 a	16.0 a
183 cm strip	18.7 a	19.5	18.4 a	14.7 a	13.0 a	19.5	18.3 a	14.5 a	19.7 a	18.8 a	19.5	19.5 a	19.6	19.5 a	18.6 a	19.2 a	16.6 a
244 cm strip	16.8 b	19.5	18.4 a	15.1 a	12.1 a	19.4	17.9 ab	14.8 a	18.9 ab	18.2 a	19.5	19.4 a	17.4	19.5 a	18.3 a	18.7 a	16.7 a
	30 cm Depth																
TREATMENT	5/6/88	5/27/88	6/6/88	6/13/88	6/20/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
Complete sod	------	16.8	12.0 bc	10.5 cd	10.5 c	16.8	15.6 c	10.3 d	15.2 c	13.6 c	16.8	16.6	14.4 c	16.3	14.7	15.1 cd	12.8 c
61 cm square	16.2	16.9	9.9 c	10.4 d	10.3 c	16.8	16.5 b	10.5 d	13.7 d	11.3 d	16.8	15.0	14.2 c	14.7	16.2	14.9 d	11.9 c
122 cm square	16.8	16.7	12.9 abc	11.1 c	10.1 c	16.8	17.2 a	13.4 c	16.0 bc	14.0 c	16.9	16.7	15.7 b	16.7	17.7	16.4 ab	15.3 ab
122 cm strip	16.4	16.8	16.5 a	16.9 a	14.5 ab	17.1	15.6 c	15.6 b	15.4 c	15.0 b	16.8	16.5	15.9 b	16.8	15.1	15.9 bc	15.0 b
183 cm strip	16.9	16.9	15.9 a	16.8 a	15.5 a	16.8	17.3 a	16.7 a	17.1 a	17.0 a	16.9	16.7	16.8 a	16.9	17.5	16.9 ab	16.6 a
244 cm strip	15.8	16.8	15.1 ab	15.5 b	13.5 b	16.8	17.2 a	16.3 a	16.8 ab	16.7 a	16.8	16.1	16.8 a	16.5	17.8	17.0 a	16.3 ab
	45 cm Depth																
TREATMENT	5/6/88	5/27/88	6/6/88	6/13/88	6/20/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
Complete sod	16.4	16.7	11.9 bc	10.0 b	9.3 c	16.6	16.5	10.8 c	12.4 d	11.4 c	16.9	16.7	14.5 c	14.9 b	14.5 c	13.7 b	12.2 d
61 cm square	16.5	16.8	10.4 c	10.8 b	11.1 c	16.8	16.7	13.7 b	13.7 c	13.1 b	16.8	17.6	15.9 ab	15.4 b	15.4 bc	15.4 a	13.7 c
122 cm square	16.3	16.9	13.5 b	10.8 b	10.4 c	16.8	16.6	13.4 b	15.6 b	13.8 b	16.8	16.7	15.7 b	16.5 a	16.3 ab	16.0 a	15.0 bc
122 cm strip	16.8	16.8	16.8 a	16.0 a	14.1 b	16.8	16.8	16.1 a	16.6 ab	16.2 a	16.8	16.7	16.4 ab	16.9 a	16.7 a	16.5 a	16.0 ab
183 cm strip	16.8	16.9	16.5 a	16.5 a	14.8 ab	16.9	17.0	16.6 a	17.3 a	17.1 a	16.9	16.6	16.5 ab	16.8 a	16.7 a	16.6 a	16.2 ab
244 cm strip	16.5	16.9	16.5 a	16.5 a	16.3 a	16.9	17.0	17.0 a	17.3 a	17.2 a	16.9	16.6	16.6 a	16.8 a	16.7 a	16.7 a	16.8 a

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix I-K: The effect of six different vegetation-free areas around the tree on the 1988 mass soil moisture values in the tree row for cherry trees in Reliant hard fescue[z].

% Mass soil moisture

TREATMENT	5/6/88	5/13/88	5/27/88	6/6/88	6/13/88	6/20/88	6/27/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
15 cm Depth																			
Complete sod	16.8	12.6	18.5	7.4 c	7.6 c	7.5 c	7.5	19.4	17.1	8.8	17.1	12.4	19.5	19.5	19.3	19.4	17.8	18.3	13.2
61 cm square	16.9	13.7	19.3	9.8 c	8.4 bc	8.4 bc	8.4	19.4	17.0	10.3	17.8	14.6	19.5	19.3	18.0	19.3	17.2	18.3	13.1
122 cm square	15.6	13.4	19.6	13.0 b	10.1 b	9.5 abc	9.3	19.5	16.4	12.0	16.9	14.1	19.5	19.2	18.4	19.4	17.0	17.8	14.1
122 cm strip	16.9	14.5	19.3	16.0 a	12.8 a	10.0 ab	8.7	19.7	15.3	11.1	16.8	14.5	19.5	18.6	17.2	19.3	15.6	16.5	13.3
183 cm strip	17.4	14.6	17.5	15.4 ab	13.0 a	10.4 ab	9.9	19.5	15.5	12.1	17.3	15.4	19.5	19.2	19.2	19.3	16.7	17.6	14.3
244 cm strip	16.5	14.4	19.5	17.3 a	13.2 a	10.7 a	9.7	19.5	16.0	11.7	17.7	15.6	19.5	19.3	18.6	19.3	16.4	17.4	13.9
30 cm Depth																			
Complete sod	15.4	14.5	16.6	11.4 d	10.1 d	10.2 d	10.2 d	16.9	16.3	12.1	15.7	13.3	16.8	16.9	16.4	16.9	16.2	16.4	14.5
61 cm square	16.0	15.8	16.9	13.3 c	11.0 d	10.7 d	10.8 cd	16.9	16.5	13.1	15.9	14.7	16.8	16.9	16.4	16.7	16.1	16.0	14.4
122 cm square	16.8	15.7	16.8	14.6 bc	12.6 c	11.8 c	11.4 bc	16.8	16.3	14.1	15.8	14.7	16.8	16.8	15.3	16.8	16.2	16.2	14.8
122 cm strip	16.2	16.7	16.9	16.6 a	15.0 a	13.4 a	12.9 a	16.9	16.1	14.2	16.3	15.8	16.8	16.8	16.0	16.8	16.1	16.3	14.1
183 cm strip	15.1	14.6	16.8	15.4 ab	13.5 bc	12.2 bc	11.7 b	16.8	16.2	13.5	15.8	15.0	16.8	16.8	16.4	16.8	16.0	16.7	15.2
244 cm strip	15.9	16.0	16.9	16.4 a	14.5 ab	12.7 ab	12.0 b	16.7	15.9	13.7	15.3	14.7	16.8	16.8	14.2	16.7	15.9	15.9	14.8
45 cm Depth																			
Complete sod	16.7	16.5	16.9	13.6 c	10.6 c	10.7 c	10.6 cd	16.8	16.7	13.8	14.9	13.4 c	16.8	16.9	16.2	16.9	16.8	16.6	15.2
61 cm square	15.9	15.6	15.9	15.0 bc	13.4 b	11.8 bc	10.9 cd	16.8	16.7	15.5	15.9	15.8 ab	16.8	16.8	16.1	16.6	16.3	16.1	15.0
122 cm square	16.8	16.6	16.8	16.2 ab	13.2 b	12.2 b	11.4 bc	16.8	16.8	14.8	15.4	14.6 abc	16.8	16.8	15.7	16.3	16.1	15.9	15.1
122 cm strip	16.6	16.4	16.6	16.3 ab	15.4 a	13.4 a	10.3 d	16.8	16.3	14.8	14.5	14.3 bc	16.8	16.8	15.5	16.0	15.7	15.4	14.4
183 cm strip	16.1	15.7	16.7	15.9 ab	15.6 a	13.9 a	12.8 a	16.8	16.7	13.7	16.9	16.2 a	16.8	16.8	16.5	16.8	16.6	16.6	16.2
244 cm strip	17.0	16.7	16.9	17.0 a	16.5 a	13.9 a	12.1 ab	16.8	16.5	14.6	15.5	14.9 abc	16.8	16.8	15.6	17.0	16.5	16.2	15.0

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

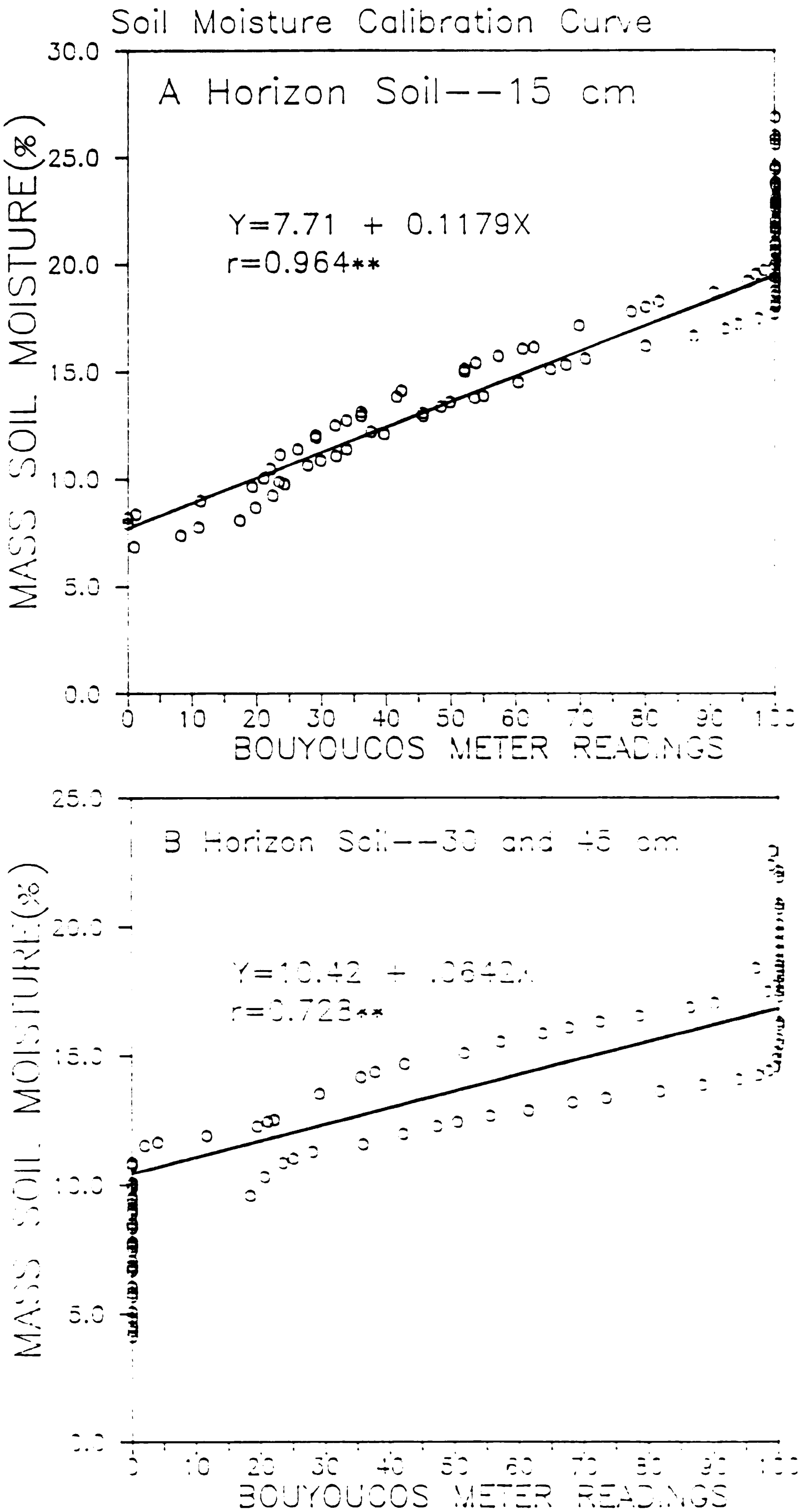
Appendix I-L: The effect of six different vegetation-free areas around the tree on the 1988 mass soil moisture values in the tree row for cherry trees in Kentucky 31 tall fescue[z].

% Mass soil moisture

TREATMENT	5/6/88	5/27/88	6/6/88	6/13/88	6/20/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
	15 cm Depth																
Complete sod	18.7	19.3	11.5 b	9.8 b	7.9 c	19.4	16.5	8.9	18.0	13.8 bc	19.5	19.0	18.9	19.3	16.0	17.0 ab	10.5 b
61 cm square	17.7	18.8	9.4 b	9.0 b	8.8 bc	19.2	17.3	9.6	16.2	12.5 c	19.5	18.8	18.9	19.1	14.9	16.1 b	9.8 b
122 cm square	18.6	19.4	9.6 b	7.7 b	7.7 c	19.4	17.7	11.4	17.5	14.2 abc	19.5	19.2	19.2	19.4	17.5	18.0 a	14.2 a
122 cm strip	18.4	19.4	17.9 a	13.9 a	10.7 bc	19.3	16.1	11.1	17.1	14.5 abc	19.5	19.4	18.9	19.2	15.4	16.8 ab	11.4 b
183 cm strip	18.5	19.5	18.1 a	16.2 a	13.7 a	19.5	18.2	13.2	18.4	17.3 a	19.5	19.5	19.5	19.4	16.7	18.3 a	14.1 a
244 cm strip	17.3	19.4	18.3 a	14.7 a	11.1 ab	19.3	16.8	12.6	18.1	16.5 ab	19.5	19.4	19.4	19.4	17.2	17.8 a	14.8 a
	30 cm Depth																
TREATMENT	5/6/88	5/27/88	6/6/88	6/13/88	6/20/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
Complete sod	16.2	16.9	10.7 c	10.4 b	10.1 b	16.8	16.0	11.3 d	15.9 a	12.9 cd	16.8	16.3	14.2	16.9	15.5 abc	13.8	11.7 c
61 cm square	16.6	16.3	10.2 c	10.1 b	10.2 b	16.6	14.9	11.5 cd	14.2 b	11.8 d	16.8	16.0	15.2	17.1	13.9 bc	14.7	12.9 c
122 cm square	15.3	17.0	14.8 b	10.6 b	10.9 b	16.9	17.1	16.3 a	16.8 a	16.7 a	16.8	16.8	16.9	16.9	17.6 a	16.7	17.0 a
122 cm strip	15.8	17.0	16.1 a	15.4 a	13.5 a	16.8	16.1	13.3 bc	16.0 a	14.1 bc	16.8	16.5	15.1	16.5	13.4 c	15.4	12.8 c
183 cm strip	15.9	16.9	16.9 a	16.5 a	15.0 a	16.9	17.0	16.1 a	17.0 a	16.7 a	16.8	16.8	16.4	17.1	17.2 a	16.2	15.7 ab
244 cm strip	15.3	16.8	16.5 a	14.4 a	14.5 a	16.9	16.5	14.9 ab	16.5 a	15.7 ab	16.8	16.5	15.8	16.6	16.3 ab	14.4	14.9 b
	45 cm Depth																
TREATMENT	5/6/88	5/27/88	6/6/88	6/13/88	6/20/88	7/1/88	7/8/88	7/15/88	7/22/88	7/28/88	8/4/88	8/11/88	8/19/88	8/25/88	9/1/88	9/8/88	9/16/88
Complete sod	16.6	16.8	11.5 c	10.3 b	10.5 b	16.9	16.5	11.7 c	16.1 ab	12.9 b	16.8	16.8	15.7 ab	16.6 ab	15.1 a	13.6	12.3
61 cm square	16.2	16.5	10.3 d	10.3 b	10.5 b	16.6	16.0	13.0 bc	14.9 b	12.8 b	16.8	16.6	13.7 c	15.3 c	13.7 b	13.0	11.1
122 cm square	16.5	16.8	15.8 b	10.7 b	10.1 b	16.8	16.4	14.9 ab	15.4 b	14.9 ab	16.8	16.5	15.1 abc	16.0 bc	15.5 a	15.3	15.1
122 cm strip	16.8	16.8	16.6 ab	16.7 a	16.0 a	16.9	16.8	15.8 a	17.6 a	16.1 a	16.8	16.9	16.2 a	17.6 a	16.4 a	15.8	14.9
183 cm strip	16.9	16.8	16.8 ab	16.8 a	13.9 a	16.8	16.6	13.5 abc	14.4 b	13.9 ab	16.8	16.7	14.2 bc	16.2 bc	16.2 a	14.6	13.4
244 cm strip	16.6	16.8	16.9 a	16.1 a	14.7 a	16.8	16.4	15.2 ab	16.0 ab	15.7 a	16.8	16.5	15.4 ab	16.3 bc	15.9 a	15.8	15.5

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with signficant F test at 5% level.

Appendix 1-M: Soil calibration curves for Bouyoucos moisture meter and percent mass soil moisture for a Riddles sandy loam. Solid line is the best fit regression line.



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Appendix II-A: The effect of orchard floor management on peach trunk cross-sectional area and shoot length-1986.[z]

	Trunk cross-sectional area (cm^2)			Average shoot length (cm)
TREATMENT	5/15	7/24	10/30	11/5
Herbicide	1.41 a	2.09 ab	6.08 a	73.0 a
Clean Cultivation	1.32 a	1.70 c	4.88 a	67.8 a
Kentucky Bluegrass	1.43 a	1.96 abc	5.58 a	70.6 a
Perennial Ryegrass	1.36 a	1.76 bc	4.79 a	58.9 a
Hard Fescue	1.40 a	1.97 abc	4.95 a	67.7 a
Chewings Fescue	1.35 a	1.71 c	4.52 a	61.0 a
PR+KB	1.54 a	1.97 abc	4.75 a	73.5 a
PR+CF	1.37 a	1.90 bc	4.71 a	66.7 a
Bromegrass	1.39 a	2.00 abc	5.48 a	70.7 a
Clover	1.38 a	1.77 bc	4.21 a	61.8 a
Alfalfa	1.64 a	2.30 a	5.17 a	74.3 a
Tall Fescue	1.46 a	2.05 abc	5.17 a	75.1 a

[z] Treatment means separated by Duncan's multiple range test (P=0.050) with significant F test at 5% level.

Appendix II-B: The effect of orchard floor management on peach trunk cross-sectional area and shoot length-1987.[z]

TREATMENT	TRUNK CROSS-SECTIONAL AREA(cm^2) 5/29	6/4	7/14	8/12	9/25	5/29-9/25 RGRX1000
Herbicide	7.35 a	7.77 a	12.62 a	17.87 a	25.30 a	5.25 a
Clean Cultivation	5.95 a	6.27 a	10.07 a	14.10 a	21.53 a	5.39 a
Kentucky Bluegrass	6.71 a	6.92 a	10.45 a	14.29 a	20.69 a	4.74 a
Perennial Ryegrass	5.70 a	5.86 a	9.35 a	12.44 a	18.60 a	5.05 a
Hard Fescue	5.79 a	6.03 a	9.72 a	13.23 a	19.71 a	5.16 a
Chewings Fescue	5.52 a	5.66 a	8.94 a	12.55 a	18.93 a	5.12 a
PR+KB	5.77 a	5.90 a	9.82 a	13.26 a	19.37 a	5.05 a
PR+CF	5.74 a	5.96 a	9.27 a	12.66 a	18.83 a	5.04 a
Bromegrass	6.42 a	6.76 a	10.81 a	14.02 a	20.47 a	4.84 a
Clover	5.03 a	5.17 a	8.43 a	11.47 a	18.31 a	5.39 a
Alfalfa	6.40 a	6.49 a	9.94 a	12.96 a	19.06 a	4.80 a
Tall Fescue	5.81 a	6.07 a	9.27 a	12.11 a	17.60 a	4.64 a

TREATMENT	AVERAGE SHOOT LENGTH(cm) 6/3	6/30	9/24	6/3-9/25 RGRX100
Herbicide	37.3 a	83.5 a	145.3 a	1.19 a
Clean Cultivation	36.9 a	80.1 a	134.9 ab	1.13 a
Kentucky Bluegrass	36.2 a	79.5 a	140.7 a	1.18 a
Perennial Ryegrass	33.5 a	71.9 a	117.4 bc	1.10 a
Hard Fescue	33.2 a	72.2 a	115.9 bc	1.09 a
Chewings Fescue	37.3 a	81.5 a	145.2 a	1.18 a
PR+KB	33.6 a	75.8 a	116.3 bc	1.08 a
PR+CF	34.2 a	74.4 a	123.9 abc	1.13 a
Bromegrass	33.3 a	74.8 a	116.2 bc	1.09 a
Clover	27.3 a	61.3 a	110.2 c	1.22 a
Alfalfa	33.0 a	71.2 a	112.1 c	1.07 a
Tall Fescue	31.3 a	71.4 a	113.6 bc	1.11 a

[z] Treatment means separated by Duncan's multiple range test (P=0.05) with significant F test at 5% level.

Appendix II-C: The effect of 12 orchard floor treatments on 1988 trunk cross-sectional area, average shoot length and relative growth rates.[z]

TREATMENT	AVERAGE SHOOT EXTENSION(cm) 6/3	6/10	6/17	6/23	6/30	7/7	7/14	7/22	7/28	8/3	8/10	8/17	8/25	9/1	9/7	9/15	6/3-9/15 RGRX1000
Herbicide	22.83	32.58	44.04	51.54	54.88	60.46	69.08	78.44	84.97	91.20	100.07	109.35	113.46	117.58	117.83	118.46	1.58
Clean Cultivated	24.67	33.50	43.25	48.42	50.42	57.29	62.96	70.25	75.95	82.63	90.07	99.63	104.52	106.44	106.92	106.19	1.39
Kentucky Bluegrass	27.71	37.79	48.29	53.04	54.42	59.92	66.25	75.17	82.97	95.30	106.13	119.32	124.25	127.50	126.75	127.17	1.45
Perennial Ryegrass	23.52	33.21	42.29	46.90	47.98	51.75	60.13	67.81	74.22	82.70	90.06	102.57	105.02	106.75	106.60	107.58	1.45
Hard Fescue	20.55	30.63	39.63	42.00	43.17	48.08	54.71	62.29	69.00	76.55	86.08	95.88	101.00	102.17	102.00	101.96	1.46
Chewings Fescue	24.13	33.38	43.00	47.75	48.83	53.00	60.25	70.08	77.65	87.30	95.65	107.40	112.83	114.50	115.58	115.25	1.49
PR+KB	23.46	32.92	42.83	47.21	48.58	54.25	61.13	68.21	74.32	81.03	89.22	100.55	104.83	106.42	106.65	106.23	1.44
PR+CF	23.38	32.08	40.54	44.37	45.50	49.96	56.13	62.25	67.97	74.57	82.97	92.25	95.00	98.21	102.85	100.88	1.39
Bromegrass	21.21	30.29	39.67	43.33	44.46	49.58	55.60	64.38	69.43	77.42	85.08	97.07	104.85	105.25	104.77	105.25	1.53
Clover	21.83	30.21	40.08	43.63	44.71	49.29	55.92	64.92	71.95	80.55	90.07	100.15	103.21	109.73	109.81	109.81	1.54
Alfalfa	25.75	35.75	45.58	50.42	51.58	57.17	65.25	74.21	81.15	89.27	96.88	107.10	115.83	114.00	119.13	121.71	1.48
Tall Fescue	23.04	32.33	40.50	43.54	44.29	49.25	55.35	63.46	70.22	76.95	84.93	95.47	100.71	101.75	102.04	101.79	1.42

TREATMENT	TRUNK CROSS-SECTIONAL AREA(cm^2) 6/3	6/10	6/17	6/23	6/30	7/7	7/14	7/22	7/28	8/3	8/10	8/17	8/25	9/1	9/7	9/15	10/20	6/3-10/20 RGRX1000
Herbicide	29.60	30.22	31.08	31.42	31.56	32.40	33.28	34.94	36.06	36.95	38.49	38.78	39.56	40.85	41.90	42.30	43.74	1.38
Clean Cultivated	25.84	26.43	26.95	27.27	27.88	27.81	28.54	29.82	30.20	31.24	32.05	32.92	34.39	35.48	36.65	36.93	38.36	1.39
Kentucky Bluegrass	24.72	25.18	26.06	25.89	26.64	27.00	27.78	28.89	29.67	30.89	31.99	33.32	34.45	34.92	36.19	37.13	38.72	1.60
Perennial Ryegrass	22.21	22.47	23.08	23.04	23.43	23.33	23.71	24.67	25.15	26.05	26.96	27.45	29.36	29.65	30.65	31.16	32.34	1.35
Hard Fescue	23.51	25.67	26.16	25.62	26.60	26.82	27.12	28.29	29.12	30.22	31.36	32.35	33.65	34.26	35.47	36.18	37.69	1.41
Chewings Fescue	22.81	23.22	23.94	23.87	24.60	24.94	25.48	26.98	28.02	29.16	30.00	31.15	32.54	32.92	34.19	34.76	35.91	1.60
PR+KB	23.11	23.52	23.98	23.63	24.23	24.50	24.62	25.58	26.27	27.09	27.56	28.46	29.52	30.29	31.82	32.63	33.67	1.34
PR+CF	22.30	22.61	23.03	22.64	23.34	23.50	23.99	24.81	25.23	26.24	27.31	28.05	29.61	30.18	31.10	31.88	33.36	1.45
Bromegrass	23.57	24.31	24.83	24.59	24.90	25.62	25.36	26.62	27.12	27.95	28.72	29.45	30.87	31.53	32.53	33.17	34.13	1.31
Clover	21.89	22.34	22.79	22.57	23.16	23.23	23.87	24.83	25.17	26.11	26.90	27.78	29.55	29.87	30.98	31.96	33.11	1.47
Alfalfa	23.04	23.48	23.95	23.98	24.56	24.88	25.21	26.41	26.96	27.86	29.16	30.03	31.76	32.63	33.74	34.34	36.28	1.62
Tall Fescue	20.81	21.23	21.51	21.36	21.76	22.10	22.15	23.25	23.57	24.17	25.29	26.17	26.79	27.67	28.19	28.69	29.66	1.25

[z] Treatment means not significantly different as determined by Duncan's multiple range test(P=0.05) with significant F test at 5 % level.

Appendix II-D: The effect of orchard floor management on mass soil moisture of peach trees at depths of 15, 30 and 45 cm, 61 cm from the tree in the tree row--1987.[z]

% MASS SOIL MOISTURE

TREATMENT	5/13	5/29	6/18	6/24	8/7	8/18	8/25	9/1	9/8	9/15	9/22	9/29	10/6	10/13	10/20
	15 cm Depth														
Herbicide	14.3 ab	13.6	14.0	14.4	17.0 a	18.7	17.0	17.1	17.0 a	15.7 bc	16.9	15.1 c	15.4 b	14.8 cd	14.7
Clean Cultivation	12.0 abc	12.2	13.3	17.4	15.5 abc	18.6	17.0	17.7	14.8 b	14.6 c	17.5	15.7 bc	15.7 b	14.6 d	14.6
Kentucky Bluegrass	13.6 ab	12.2	14.3	16.5	15.5 abc	18.7	16.2	16.3	16.1 ab	16.8 ab	17.1	17.6 a	17.3 a	16.4 ab	16.2
Perennial Ryegrass	10.9 bc	11.3	12.9	16.5	16.0 abc	18.5	17.0	17.1	17.0 a	16.2 ab	15.3	16.7 abc	15.7 b	15.9 abc	15.0
Hard Fescue	11.1 bc	11.0	14.0	15.9	16.1 abc	18.6	18.0	18.1	17.9 a	16.6 ab	18.0	16.8 ab	16.9 a	15.9 abc	15.2
Chewings Fescue	13.2 abc	13.6	14.9	16.3	16.9 a	18.7	18.0	18.1	18.0 a	17.5 a	18.1	17.7 a	17.2 a	16.2 ab	15.9
PR+KB	12.5 abc	11.9	12.7	13.4	14.9 bc	17.7	16.2	16.3	16.2 ab	15.7 bc	16.2	16.3 abc	16.9 a	15.9 abc	15.0
PR+CF	13.2 abc	12.2	13.8	14.8	16.6 ab	18.5	17.4	18.4	18.2 a	16.9 ab	16.2	17.6 a	17.3 a	16.6 a	16.3
Bromegrass	15.3 a	12.4	14.2	13.7	16.7 a	18.7	17.8	18.0	17.7 a	16.5 ab	17.8	17.4 ab	17.1 a	16.1 ab	15.1
Clover	9.9 c	10.8	13.0	14.2	16.8 a	18.6	17.2	18.2	17.1 a	16.9 ab	18.0	17.9 a	17.2 a	16.1 ab	15.9
Alfalfa	12.9 abc	11.0	10.0	12.0	14.7 c	17.4	17.0	17.2	17.2 a	17.5 a	16.3	18.0 a	17.2 a	16.2 ab	16.0
Tall Fescue	13.5 ab	12.3	13.0	13.5	15.5 abc	17.3	17.9	18.1	18.0 a	16.3 ab	16.8	16.3 abc	16.3 ab	15.2 bcd	15.4

TREATMENT	5/13	5/29	6/18	6/24	8/7	8/18	8/25	9/1	9/8	9/15	9/22	9/29	10/6	10/13	10/20
	30 cm Depth														
Herbicide	14.7	14.3	14.7	14.4	15.7	16.4	15.8	15.7	15.7	14.9	15.9	14.9	14.7	14.4	14.3
Clean Cultivation	14.5	14.2	14.9	15.2	15.4	16.4	15.4	16.2	15.1	14.3	15.4	14.8	14.7	14.3	13.9
Kentucky Bluegrass	14.3	13.5	14.8	14.6	15.3	16.3	16.1	15.6	15.7	15.4	16.1	15.5	15.7	15.3	14.8
Perennial Ryegrass	15.4	14.4	14.8	14.1	15.5	16.5	16.4	16.4	15.9	15.4	16.0	15.5	15.5	15.3	14.8
Hard Fescue	14.7	13.6	15.4	14.9	15.4	16.4	16.3	16.3	15.9	15.3	16.2	15.6	15.5	15.0	14.6
Chewings Fescue	14.7	14.6	15.4	15.2	15.9	16.2	16.2	16.3	16.1	15.8	16.2	15.7	15.7	15.4	14.9
PR+KB	14.3	13.5	14.4	14.0	14.5	16.2	15.6	15.7	15.2	15.2	16.0	15.2	15.5	15.0	14.4
PR+CF	15.7	14.4	14.8	14.0	14.7	16.4	16.2	16.2	15.8	15.2	15.7	15.1	15.1	14.9	14.4
Bromegrass	15.2	13.6	14.5	13.3	14.5	16.1	16.1	16.1	15.9	15.2	15.9	15.2	15.1	14.8	14.2
Clover	12.3	12.8	13.9	13.2	15.5	16.4	15.8	15.8	15.5	15.6	16.2	15.7	15.7	15.3	15.0
Alfalfa	14.0	13.1	12.7	12.1	14.6	16.2	15.6	15.6	15.2	15.1	16.1	15.6	15.6	15.2	14.6
Tall Fescue	14.8	13.6	14.9	13.8	14.6	16.0	16.1	16.1	15.9	15.0	15.9	15.0	15.1	14.7	14.3

TREATMENT	5/13	5/29	6/18	6/24	8/7	8/18	8/25	9/1	9/8	9/15	9/22	9/29	10/6	10/13	10/20
	45 cm Depth														
Herbicide	16.4 a	15.8 a	16.2	15.2	15.2	15.8	15.0	15.0	14.7	14.6	14.8	14.5	14.4	15.0	14.9
Clean Cultivation	16.2 a	16.0 a	16.4	15.9	14.7	15.8	16.3	16.4	15.8	15.0	15.1	14.8	15.3	15.1	14.3
Kentucky Bluegrass	16.4 a	15.6 a	16.0	15.1	15.4	16.2	16.2	16.3	15.9	15.4	15.9	15.4	15.2	15.0	14.6
Perennial Ryegrass	16.7 a	16.6 a	16.6	15.7	15.0	16.3	16.4	16.4	15.9	15.2	15.1	15.4	16.0	15.7	15.5
Hard Fescue	16.7 a	16.5 a	16.4	16.1	15.1	15.7	15.7	15.7	15.6	15.4	15.6	15.8	15.6	15.4	15.0
Chewings Fescue	16.7 a	16.3 a	15.9	15.6	15.4	16.5	15.8	15.8	15.5	15.4	15.5	15.5	15.0	14.6	14.4
PR+KB	16.5 a	16.2 a	16.3	15.7	13.9	16.1	16.3	16.3	15.7	15.1	15.4	15.0	15.1	14.9	14.6
PR+CF	16.8 a	16.5 a	16.2	15.9	15.1	16.3	15.5	15.6	15.2	15.1	15.1	15.0	15.1	14.8	14.8
Bromegrass	16.4 a	14.9 ab	15.8	14.3	14.6	16.3	16.2	16.3	16.1	15.5	15.9	15.4	14.9	15.2	14.7
Clover	14.5 b	13.9 b	14.1	13.6	14.8	16.6	15.1	15.8	15.3	15.4	15.8	16.0	16.0	15.8	15.3
Alfalfa	16.5 a	15.6 a	14.6	13.6	14.9	15.1	16.4	16.5	16.0	15.6	16.2	15.8	15.5	15.3	15.0
Tall Fescue	16.4 a	15.3 ab	15.8	15.1	14.7	15.7	15.7	15.8	15.3	15.5	16.0	15.3	15.0	14.7	14.6

[z] Treatment means separated by Duncan's multiple range test (P=0.05), when treatment differences are indicated by a significant F test at 5% level.

Appendix II-E: The effect of orchard floor management on mass soil moisture in the alleyway of peach trees at depths of 15, 30 and 45 cm, 61 cm from the tree--1987.[z]

% MASS SOIL MOISTURE

TREATMENT	5/13	5/29	6/18	6/24	8/7	8/18	8/25	9/1	9/8	9/15	9/22	9/29	10/6	10/13	10/20
15 cm Depth															
Herbicide	13.6 a	12.2 ab	12.4	17.8	16.4	18.6	18.1	18.3	17.7 a	16.1 cd	16.3	17.0 bc	16.6 bc	15.7 cd	15.6 bcd
Clean Cultivation	12.5 ab	13.7 a	12.7	18.1	15.4	18.3	16.2	16.4	14.6 b	15.4 d	16.1	14.8 d	14.9 d	14.8 d	14.8 d
Kentucky Bluegrass	12.5 ab	9.4 c	12.6	16.8	16.8	18.8	18.3	18.3	18.4 a	18.2 a	18.4	18.3 a	17.9 a	17.4 a	17.4 a
Perennial Ryegrass	12.4 ab	9.1 c	11.2	16.5	15.9	18.4	17.2	17.2	18.1 a	17.8 ab	18.1	18.0 ab	17.6 abc	17.0 ab	17.0 ab
Hard Fescue	10.0 bc	8.6 c	11.9	17.0	16.2	15.3	17.4	17.5	17.4 a	17.4 ab	17.5	18.0 ab	17.7 ab	17.1 ab	17.0 ab
Chewings Fescue	13.7 a	10.7 bc	12.6	17.4	17.5	17.5	17.7	18.1	17.9 a	18.2 a	16.4	18.0 ab	17.7 ab	16.9 ab	16.4 abc
PR+KB	12.3 ab	8.7 c	12.0	16.6	15.7	18.4	18.1	18.2	18.1 a	17.8 ab	18.2	18.0 ab	17.5 abc	16.7 ab	16.9 ab
PR+CF	12.8 ab	9.5 bc	10.8	14.9	16.7	18.6	17.6	17.4	16.5 ab	17.9 ab	18.2	18.0 ab	17.6 abc	17.1 ab	17.1 ab
Bromegrass	10.4 abc	8.6 c	11.1	16.7	16.7	18.7	17.3	17.3	17.3 a	17.5 ab	16.3	17.6 abc	17.2 abc	16.4 abc	16.0 abcd
Clover	9.0 c	8.9 c	11.0	14.1	16.1	17.7	17.4	17.4	17.4 a	18.0 ab	17.4	17.9 ab	17.6 abc	16.9 ab	16.9 ab
Alfalfa	11.1 abc	9.1 c	9.0	15.2	15.0	18.6	17.4	17.5	17.3 a	16.8 bc	16.4	16.5 c	16.5 c	16.0 bc	15.4 cd
Tall Fescue	12.5 ab	9.2 c	10.9	14.9	16.0	18.5	16.4	16.4	16.4 ab	17.2 abc	17.2	17.1 abc	17.1 abc	16.3 abc	15.7 bcd
30 cm Depth															
Herbicide	14.5	13.9 a	14.6	14.0	15.2	15.7	16.1	16.1	15.5	15.0 bc	15.9	15.2	14.8	14.2	14.3
Clean Cultivation	14.5	13.5 a	14.6	15.2	15.1	16.3	15.9	16.1	15.3	14.9 c	16.0	15.0	14.9	14.5	14.1
Kentucky Bluegrass	14.6	12.0 b	14.1	14.4	15.5	16.2	16.2	16.2	16.2	16.1 a	16.2	16.1	15.9	15.7	15.7
Perennial Ryegrass	14.9	12.1 b	12.8	13.0	15.2	16.3	15.0	15.0	16.2	15.5 abc	16.2	16.1	16.0	15.8	15.7
Hard Fescue	14.5	11.6 b	14.6	14.7	15.5	16.4	15.7	15.7	15.6	15.5 abc	16.1	16.0	15.8	15.6	15.3
Chewings Fescue	14.5	12.9 ab	14.0	14.5	15.8	16.3	15.8	15.8	15.6	16.2 a	16.3	16.2	16.0	15.8	15.6
PR+KB	14.1	12.0 b	13.7	14.0	15.0	16.2	16.1	16.1	16.0	15.9 ab	16.1	15.9	15.8	15.6	15.4
PR+CF	15.1	12.0 b	13.1	13.1	15.7	16.3	16.2	16.3	16.2	16.0 a	16.2	16.1	15.9	15.8	15.6
Bromegrass	13.7	11.6 b	13.8	13.8	15.7	16.1	16.3	16.3	16.1	15.8 abc	16.1	15.9	15.7	15.4	15.1
Clover	12.5	11.5 b	12.5	12.5	16.1	16.6	15.8	15.8	15.7	16.1 a	16.3	16.1	16.0	15.7	15.4
Alfalfa	14.2	12.0 b	11.8	12.9	14.9	15.6	16.2	16.2	16.0	15.4 abc	16.1	15.7	15.7	15.5	15.2
Tall Fescue	14.9	12.0 b	13.1	12.9	15.1	16.2	16.2	15.7	15.5	15.9 ab	16.2	15.9	15.8	15.5	15.3
45 cm Depth															
Herbicide	16.5 a	15.9 a	16.1 a	15.2 a	15.8	15.1	15.7	15.1	15.2	15.3	15.6	15.1 ab	14.8 bc	15.7 a	15.6 a
Clean Cultivation	16.4 a	15.6 ab	15.5 a	15.5 a	14.8	16.4	16.1	16.3	15.5	14.5	15.0	14.4 b	14.7 c	14.2 b	13.8 b
Kentucky Bluegrass	16.4 a	13.9 cde	14.3 ab	13.9 ab	14.5	15.1	15.8	15.8	15.7	15.7	15.9	16.2 a	16.2 a	16.1 a	16.0 a
Perennial Ryegrass	16.6 a	14.1 cd	13.5 ab	13.2 ab	15.5	16.4	15.8	15.8	15.1	15.7	15.8	16.3 a	16.1 a	15.8 a	15.5 a
Hard Fescue	16.5 a	14.6 abc	15.5 a	15.2 a	15.3	15.8	16.4	16.4	16.3	16.2	16.3	16.1 a	15.8 ab	15.4 a	15.4 a
Chewings Fescue	16.1 a	14.2 bcd	14.8 ab	14.6 ab	15.3	16.5	14.5	14.5	14.5	15.7	15.8	16.2 a	16.0 a	15.2 a	15.0 a
PR+KB	16.4 a	13.1 cdef	14.5 ab	14.2 ab	15.5	16.3	16.4	16.4	16.3	16.2	16.4	16.3 a	16.1 a	16.0 a	15.8 a
PR+CF	16.7 a	13.7 cde	13.6 ab	13.1 ab	16.0	16.4	16.4	16.5	16.4	16.3	16.4	16.3 a	16.1 a	16.0 a	15.9 a
Bromegrass	16.1 a	13.0 def	14.6 ab	14.1 ab	15.3	16.3	15.2	15.9	15.8	15.4	15.5	15.9 a	15.5 abc	15.3 a	15.1 a
Clover	14.5 b	11.8 f	12.2 b	12.2 b	14.8	16.5	16.6	16.6	16.3	16.1	16.3	15.4 ab	15.7 abc	15.6 a	15.4 a
Alfalfa	16.1 a	12.5 ef	12.4 b	12.1 b	14.9	16.2	16.4	16.4	16.0	15.6	16.2	15.6 ab	16.1 a	16.0 a	16.0 a
Tall Fescue	16.4 a	12.8 def	13.8 ab	13.0 ab	14.9	15.7	15.8	15.8	15.8	15.6	15.7	15.3 ab	16.0 a	16.0 a	15.9 a

[z] Treatment means separated by Duncan's multiple range test (P=0.05), when treatment differences are indicated by a significant F test at 5% level.

Appendix II-F: The effect of orchard floor management on mass soil moisture in the alleyway of peach trees at depths of 15, 30 and 45 cm, 155 cm from the tree--1987.[z]

% MASS SOIL MOISTURE

15 cm Depth

TREATMENT	5/13	5/29	6/18	6/24	8/7	8/18	8/25	9/1	9/8	9/15	9/22	9/29	10/6	10/13	10/20
Herbicide	14.2 a	14.8 a	17.6 a	18.9 a	18.6 a	19.1	17.7	17.8	17.9	18.8	18.7	18.8	18.3	17.6	17.8
Clean Cultivation	11.2 abcd	11.8 b	16.4 a	19.5 a	18.3 ab	18.0	17.6	17.7	17.8	17.7	17.8	19.1	18.5	17.7	18.0
Kentucky Bluegrass	10.5 bcd	8.0 c	9.9 b	12.9 b	16.8 abc	17.8	17.4	17.5	17.6	18.7	16.6	18.6	18.1	17.8	18.0
Perennial Ryegrass	12.1 abcd	8.5 c	10.6 b	12.6 b	15.5 c	18.2	17.7	17.9	18.1	17.0	17.9	18.1	17.5	17.1	17.4
Hard Fescue	10.0 d	8.0 c	11.4 b	15.4 ab	17.3 abc	18.9	17.2	17.6	17.7	18.8	17.6	18.6	18.2	17.9	18.0
Chewings Fescue	12.5 abcd	9.3 c	11.4 b	13.5 b	17.9 ab	18.0	18.6	18.6	17.6	18.6	17.8	18.9	18.5	18.1	18.3
PR+KB	11.9 abcd	8.5 c	11.9 b	14.8 ab	17.0 abc	18.9	18.5	18.6	18.7	18.7	17.7	18.7	18.3	17.9	18.1
PR+CF	13.5 abc	8.7 c	11.0 b	13.5 b	17.6 ab	18.9	17.5	17.6	17.8	18.6	17.6	18.7	18.2	17.7	18.1
Bromegrass	9.4 d	7.7 c	11.1 b	15.1 ab	17.8 ab	17.9	16.5	16.7	16.7	18.7	17.7	18.8	18.4	18.0	18.2
Clover	9.6 d	7.7 c	9.8 b	10.5 b	17.0 abc	18.7	16.5	17.9	17.8	18.5	16.5	18.6	18.2	17.7	17.9
Alfalfa	10.2 cd	8.0 c	10.4 b	12.9 b	16.9 abc	18.9	17.6	17.6	17.5	18.6	18.6	18.8	18.3	17.8	18.1
Tall Fescue	13.7 ab	9.2 c	11.9 b	14.9 ab	16.7 bc	18.7	17.5	17.6	17.7	18.6	16.6	18.5	18.1	17.8	17.9

30 cm Depth

TREATMENT	5/13	5/29	6/18	6/24	8/7	8/18	8/25	9/1	9/8	9/15	9/22	9/29	10/6	10/13	10/20
Herbicide	14.5 abc	14.8 a	16.5 a	16.6 a	15.8	16.6	16.5	16.5	16.4	16.4	16.5	16.4	16.2	15.9	15.9
Clean Cultivation	13.1 cde	13.4 b	16.1 ab	16.7 a	15.2	16.3	15.9	16.0	16.0	16.0	16.1	16.0	15.8	15.7	16.3
Kentucky Bluegrass	13.6 bcde	11.5 c	13.1 c	12.5 b	15.3	16.2	15.6	15.6	15.6	16.3	16.3	16.2	16.1	15.9	16.0
Perennial Ryegrass	15.1 ab	12.0 c	12.8 c	12.4 b	14.9	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.2	16.0	16.0
Hard Fescue	13.8 abcd	11.6 c	13.5 bc	13.5 b	15.5	16.5	16.4	16.5	16.5	16.4	16.4	16.3	16.3	16.1	16.1
Chewings Fescue	14.5 abc	12.2 c	13.3 c	13.4 b	15.3	16.5	16.5	15.8	15.6	15.8	16.5	16.4	16.3	16.1	15.5
PR+KB	13.7 bcd	11.7 c	13.5 bc	13.5 b	15.4	16.4	16.3	16.3	16.2	16.4	16.3	15.7	16.1	16.0	15.9
PR+CF	15.6 a	12.1 c	13.3 c	13.0 b	15.6	16.3	16.2	16.2	16.3	16.3	16.3	16.2	16.1	16.0	16.0
Bromegrass	12.6 de	10.6 d	13.8 bc	13.8 b	15.4	16.5	15.8	15.9	15.9	16.4	16.4	16.4	16.2	16.0	16.0
Clover	11.9 e	10.4 d	11.4 c	11.2 b	15.2	16.3	16.2	16.3	16.3	16.3	16.3	16.3	16.1	15.9	15.9
Alfalfa	13.6 bcde	11.5 c	12.1 c	12.7 b	15.1	16.4	15.7	15.8	15.8	16.4	16.4	16.4	16.2	16.1	16.1
Tall Fescue	14.9 ab	12.0 c	13.6 bc	13.5 b	15.6	16.3	15.7	15.8	15.8	16.4	16.4	16.3	16.2	16.0	16.0

45 cm Depth

TREATMENT	5/13	5/29	6/18	6/24	8/7	8/18	8/25	9/1	9/8	9/15	9/22	9/29	10/6	10/13	10/20
Herbicide	16.3 ab	16.5 a	17.0 a	17.0 a	15.8	15.9	16.6	16.5	16.6	16.5	16.5	16.5	16.3	16.0	16.0
Clean Cultivation	15.9 abc	15.5 ab	16.1 a	16.2 ab	16.5	16.7	16.0	16.0	16.0	16.6	16.6	16.6	16.5	16.4	16.3
Kentucky Bluegrass	15.7 abc	12.1 ef	12.8 bc	12.5 c	14.4	16.4	15.7	15.8	15.7	15.9	15.9	16.4	16.3	16.3	16.2
Perennial Ryegrass	16.8 a	14.9 bc	13.9 abc	13.4 bc	14.5	15.6	15.7	16.4	15.8	16.4	16.4	16.4	16.3	16.2	16.2
Hard Fescue	16.2 abc	12.8 de	14.5 ab	14.2 abc	14.5	15.9	15.8	15.8	15.9	15.9	15.9	16.5	16.3	16.3	16.3
Chewings Fescue	16.6 ab	14.4 bc	14.1 abc	14.0 bc	15.6	16.5	15.7	15.8	15.8	16.5	16.5	16.5	16.4	16.3	16.3
PR+KB	16.5 ab	12.3 def	14.0 abc	13.9 bc	14.4	16.3	15.7	15.8	15.7	15.8	15.8	16.5	16.4	16.2	16.2
PR+CF	16.8 a	14.2 bc	14.0 abc	13.8 bc	15.0	16.3	16.3	16.4	16.4	16.4	16.4	16.4	16.2	15.6	15.6
Bromegrass	16.0 abc	11.8 ef	13.9 abc	13.7 bc	15.0	16.6	15.9	16.0	16.0	15.9	16.0	16.5	16.5	16.4	16.4
Clover	15.0 c	10.9 f	11.1 c	11.1 c	14.2	16.3	16.3	16.4	16.4	16.4	16.4	16.4	16.3	16.2	16.2
Alfalfa	15.3 bc	12.0 ef	12.1 bc	12.2 c	14.8	15.8	16.4	16.4	16.3	16.4	16.4	15.8	16.3	16.1	16.2
Tall Fescue	16.3 ab	13.7 cd	14.5 ab	14.2 abc	15.0	16.4	16.3	16.4	16.4	16.4	16.4	16.3	16.2	16.1	16.0

[z] Treatment means separated by Duncan's multiple range test (P=0.05), when treatment differences are indicated by a significant F test at 5% level.

Appendix II-G: The effect of orchard floor management on mass soil moisture of peach trees at depths of 15, 30 and 45 cm, 61 cm from the tree in the tree row--1988 growing season.[z]

% MASS SOIL MOISTURE

15 cm Depth

TREATMENT	5/10	5/13	5/20	5/27	6/1	6/6	6/13	6/20	6/29	7/1	7/8	7/15	7/22	7/28	7/31	8/4	8/11	8/16	10/7	10/14
Herbicide	14.9	15.4	18.0	18.1	15.4	14.6	14.6	14.6	18.0	17.8	14.6	14.6	14.6	14.6	17.0	15.8 ab	14.6	14.6	15.4	15.1
Clean Cultivation	14.8	14.6	17.7	18.0	15.1	14.6	14.6	14.6	17.9	17.5	14.6	14.6	14.6	14.6	17.3	17.0 a	14.7	14.6	16.3	15.4
Kentucky Bluegrass	14.8	15.6	18.0	18.4	15.6	14.7	14.6	14.6	17.8	17.7	14.6	14.6	14.6	14.6	16.7	18.3 a	14.6	14.6	16.5	15.3
Perennial Ryegrass	15.0	14.5	17.3	17.7	14.5	14.5	14.6	14.6	17.5	17.4	14.6	14.6	14.6	14.6	17.0	14.2 b	14.6	14.6	16.4	16.3
Hard Fescue	14.7	15.1	17.9	17.9	15.0	14.6	14.6	14.6	17.7	17.5	14.6	14.6	14.6	14.6	17.3	16.4 ab	14.6	14.6	16.3	15.4
Chewings Fescue	16.0	15.9	18.0	18.3	16.4	15.4	14.6	14.6	17.8	17.7	14.6	14.6	14.6	14.6	17.3	17.0 a	14.7	14.6	16.7	15.4
PR+KB	16.2	15.9	17.7	18.3	14.6	14.6	14.6	14.6	17.9	17.8	14.6	14.6	14.6	14.6	17.7	18.1 a	14.6	14.6	15.6	15.9
PR+CF	15.9	15.6	17.8	18.1	16.4	15.2	14.6	14.6	17.4	17.3	14.6	14.6	14.6	14.6	16.6	18.2 a	14.6	14.6	16.5	15.3
Bromegrass	17.0	16.2	18.0	18.2	16.8	14.6	14.6	14.6	17.9	17.6	14.6	14.6	14.6	14.6	18.0	17.6 a	14.7	14.6	16.4	15.7
Clover	15.7	15.3	17.9	18.2	15.8	14.6	14.6	14.6	17.9	17.0	14.6	14.6	14.6	14.6	18.0	17.3 a	14.7	14.6	16.0	15.0
Alfalfa	16.3	14.8	18.1	18.2	16.4	14.7	14.6	14.6	18.3	18.0	14.6	14.6	14.6	14.6	17.9	17.3 a	14.6	14.6	15.8	16.1
Tall Fescue	16.1	16.6	18.1	18.0	15.6	15.4	14.6	14.6	17.8	17.7	14.6	14.6	14.6	14.6	17.8	17.9 a	14.8	14.6	15.9	14.9

30 cm Depth

TREATMENT	5/10	5/13	5/20	5/27	6/1	6/6	6/13	6/20	6/29	7/1	7/8	7/15	7/22	7/28	7/31	8/4	8/11	8/16	10/7	10/14
Herbicide	15.0	15.0 bcd	14.8	15.0 b	14.6	14.0	13.9	13.9	15.0	14.8	13.9	13.9	13.9	13.9	16.0	14.4	13.8	13.9	13.9 c	14.2
Clean Cultivation	14.6	15.6 ab	16.1	16.1 a	15.7	14.3	13.9	13.9	15.6	15.6	13.9	13.9	13.9	13.9	15.9	14.9	13.9	13.9	15.5 a	14.6
Kentucky Bluegrass	15.6	15.4 abc	16.0	16.1 a	15.4	14.3	13.9	13.9	16.0	16.0	13.9	13.9	13.9	13.9	15.5	15.0	14.4	13.9	14.9 ab	14.7
Perennial Ryegrass	14.5	15.8 a	14.9	16.1 a	15.8	14.7	13.9	13.9	15.3	15.3	13.9	13.9	13.9	13.9	15.8	14.4	13.9	13.9	14.6 abc	14.2
Hard Fescue	15.2	14.9 cd	15.7	15.6 a	15.0	13.8	13.9	13.9	15.0	15.4	13.9	13.9	13.9	13.9	14.9	15.9	14.5	13.9	14.4 bc	15.2
Chewings Fescue	15.7	15.6 ab	16.1	16.2 a	15.5	14.6	13.9	13.9	15.8	15.9	14.0	13.9	13.9	13.9	15.3	14.9	13.9	13.9	15.2 ab	14.6
PR+KB	15.3	15.6 ab	15.5	16.2 a	15.6	13.9	13.9	13.9	15.4	15.3	13.9	13.9	13.9	13.9	14.9	15.0	14.4	13.9	13.9 c	14.2
PR+CF	15.1	15.6 ab	16.2	16.2 a	15.5	14.3	13.9	13.9	15.9	15.8	13.9	13.9	13.9	13.9	15.9	15.0	14.4	13.9	14.3 bc	14.7
Bromegrass	15.3	15.5 abc	16.1	16.2 a	15.4	14.1	13.9	13.9	15.5	15.8	13.9	13.9	13.9	13.9	16.0	15.4	13.9	13.9	14.5 bc	15.0
Clover	14.9	14.5 d	15.9	16.0 a	15.0	13.8	13.9	13.9	15.4	15.9	13.9	13.9	13.9	13.9	15.5	15.3	14.5	13.9	15.0 ab	14.8
Alfalfa	15.3	15.2 abc	14.8	16.0 a	15.2	13.8	13.9	13.9	14.9	15.1	13.9	13.9	13.9	13.9	15.0	15.0	13.8	13.9	14.4 bc	14.7
Tall Fescue	15.5	15.6 ab	15.5	16.1 a	15.1	14.0	13.9	13.9	15.7	15.7	13.9	13.9	13.9	13.9	15.5	14.4	13.9	13.9	14.4 bc	14.3

45 cm Depth

TREATMENT	5/10	5/13	5/20	5/27	6/1	6/6	6/13	6/20	6/29	7/1	7/8	7/15	7/22	7/28	7/31	8/4	8/11	8/16	10/7	10/14
Herbicide	16.0	15.8	16.3	16.2	15.8	15.1	14.0	13.9	16.1	15.9	14.5	13.9	13.9	13.9 b	15.6 bcde	14.4	13.9	13.9	13.8 c	13.8
Clean Cultivation	16.1	16.0	16.3	16.3	16.0	14.9	13.9	13.9	16.1	15.9	13.9	13.9	13.9	13.9 b	15.2 abcd	15.0	13.9	13.9	15.6 a	14.3
Kentucky Bluegrass	15.9	15.9	16.2	16.3	15.9	14.8	14.0	13.9	15.9	16.0	14.2	13.9	13.9	13.9 b	15.0 abcde	15.0	14.4	14.2	14.2 bc	14.4
Perennial Ryegrass	16.0	16.0	16.3	16.2	16.0	14.8	13.9	13.9	15.4	15.4	14.0	13.9	13.9	13.9 b	14.9 abcde	14.4	13.9	13.9	14.3 bc	13.9
Hard Fescue	15.9	15.9	16.2	16.2	16.1	15.2	13.9	13.9	15.9	15.8	14.1	13.9	13.9	14.8 a	13.9 e	15.9	14.6	14.2	14.9 ab	14.4
Chewings Fescue	16.0	16.0	16.2	16.3	16.1	15.0	13.9	13.9	16.1	16.0	13.9	13.9	13.9	13.9 b	14.2 de	15.2	13.8	13.9	14.1 bc	14.3
PR+KB	16.0	15.5	15.9	15.8	15.4	14.7	13.9	13.9	15.6	15.5	14.1	13.9	13.9	13.9 b	15.3 abc	15.0	14.4	14.2	13.9 c	13.9
PR+CF	15.9	15.9	16.2	16.3	15.8	14.7	13.9	13.9	15.9	15.9	14.1	13.9	13.9	13.9 b	15.8 ab	15.0	14.4	14.2	14.3 bc	14.3
Bromegrass	15.7	15.8	16.2	16.3	16.0	14.6	13.9	13.9	15.4	15.4	13.9	13.9	13.9	13.9 b	16.0 a	15.5	13.9	13.9	14.3 bc	14.7
Clover	15.7	15.6	16.1	16.2	15.7	14.1	13.9	13.9	16.2	16.1	14.1	13.9	13.9	14.0 a	15.2 abcd	15.1	14.6	14.3	14.3 bc	14.4
Alfalfa	15.9	15.8	16.0	16.2	15.6	14.6	13.9	13.9	14.9	15.4	13.9	13.9	13.9	13.9 b	14.4 cde	15.0	13.9	13.9	14.2 bc	14.3
Tall Fescue	16.0	16.0	16.3	16.3	16.0	14.7	13.9	13.9	15.4	15.7	14.0	13.9	13.9	13.9 b	15.5 abc	14.4	13.9	13.9	14.0 bc	14.3

[z] Treatment means separated by Duncan's multiple range test (P=0.05), when treatment differences are indicated by a significant F test at 5% level.

Appendix II-H: The effect of orchard floor management on mass soil moisture at depths of 15, 30 and 45 cm in the alleyway, 61 cm from the peach tree--1988 growing season.[z]

% MASS SOIL MOISTURE

15 cm Depth

TREATMENT	5/10	5/13	5/20	5/27	6/1	6/6	6/13	6/20	6/29	7/1	7/8	7/15	7/22	7/28	7/31	8/4	8/11	8/16	10/7	10/14
Herbicide	15.7	14.9	17.5	18.2	17.0	16.1	14.6	14.6	18.3	18.5	14.6	14.6	14.7	14.6	14.7 c	18.0	14.6	14.6	15.9 b	15.3
Clean Cultivation	16.0	14.6	18.0	18.1	14.7	14.7	14.6	14.6	16.8	18.1	14.6	14.6	14.6	14.6	18.7 a	16.5	14.6	14.6	20.0 a	14.5
Kentucky Bluegrass	17.2	15.8	17.7	18.4	17.7	15.8	14.6	14.6	17.7	17.6	14.7	14.6	14.5	14.6	18.1 a	16.2	14.7	14.6	16.8 b	15.0
Perennial Ryegrass	16.4	15.3	16.8	18.1	16.9	14.8	14.6	14.6	16.8	17.9	14.6	14.6	14.6	14.6	18.5 a	18.0	14.7	14.6	17.3 b	15.8
Hard Fescue	15.4	15.0	17.5	17.9	16.3	14.5	14.6	14.6	17.7	17.8	14.6	14.6	15.3	14.6	18.7 a	18.0	14.7	14.6	16.8 b	15.1
Chewings Fescue	15.8	16.0	17.9	18.0	16.7	14.7	14.6	14.6	18.2	17.7	14.6	14.6	14.6	14.6	17.9 ab	16.4	14.6	14.6	16.3 b	14.5
PR+KB	16.7	15.1	17.7	18.1	16.4	14.7	14.6	14.6	16.8	16.8	14.5	14.6	14.7	14.6	17.2 ab	17.8	14.7	14.6	16.7 b	15.6
PR+CF	16.3	15.7	17.9	18.2	17.1	15.0	14.6	14.6	17.9	17.9	14.6	14.6	14.5	14.6	18.2 a	17.8	14.7	14.6	17.1 b	15.8
Bromegrass	16.0	15.2	17.4	17.8	16.8	15.2	14.6	14.6	18.2	17.4	14.6	14.6	14.5	14.6	17.9 ab	16.7	14.7	14.6	16.8 b	14.7
Clover	15.4	14.4	17.6	18.2	16.3	14.5	14.6	14.6	17.7	17.9	14.6	14.6	14.6	14.6	18.1 a	16.6	14.6	14.6	16.5 b	15.1
Alfalfa	15.3	15.0	17.9	18.4	14.6	14.7	14.6	14.6	18.0	18.1	14.7	14.6	14.5	14.6	18.3 a	18.2	14.7	14.6	17.1 b	15.5
Tall Fescue	15.5	16.1	17.6	18.0	16.9	15.4	14.6	14.6	18.3	18.1	14.8	14.6	14.7	14.6	16.6 b	15.7	14.6	14.6	16.6 b	15.2

30 cm Depth

TREATMENT	5/10	5/13	5/20	5/27	6/1	6/6	6/13	6/20	6/29	7/1	7/8	7/15	7/22	7/28	7/31	8/4	8/11	8/16	10/7	10/14
Herbicide	15.6	15.4	16.2	16.0	15.7	14.6	14.3	13.9	14.6 c	16.1	14.1	13.9	13.9 b	13.9	15.3	15.3	14.5	13.9	14.2 c	14.9
Clean Cultivation	15.6	15.4	14.8	16.0	15.7	14.0	13.9	13.9	16.1 a	14.9	13.9	13.9	13.9 b	13.9	16.3	14.1	14.5	13.9	15.1 ab	15.0
Kentucky Bluegrass	15.5	15.3	15.9	16.0	15.9	14.9	13.9	13.9	15.8 ab	15.8	14.2	13.9	13.9 b	13.9	15.5	14.9	13.9	13.9	15.6 a	14.6
Perennial Ryegrass	15.1	14.9	15.0	16.0	15.2	14.9	13.9	13.9	15.1 bc	15.0	14.6	13.9	14.8 a	13.9	16.0	15.5	13.9	13.9	14.7 bc	14.9
Hard Fescue	14.8	15.3	16.0	16.0	15.8	14.5	13.9	13.9	15.9 ab	15.8	14.4	13.9	14.7 a	13.9	15.5	15.3	14.5	13.9	15.5 ab	15.0
Chewings Fescue	15.3	15.0	14.9	15.8	15.7	14.8	13.9	13.9	15.9 ab	15.5	14.2	13.9	13.9 b	13.9	15.9	14.5	14.4	13.9	15.6 a	14.4
PR+KB	15.4	15.3	15.9	16.0	15.7	14.6	13.9	13.9	15.9 ab	15.8	14.2	13.9	14.1 ab	13.9	15.4	15.4	13.9	13.9	15.1 ab	14.7
PR+CF	15.2	15.2	15.4	16.0	15.9	14.8	13.9	13.9	15.9 ab	15.9	14.3	13.9	14.1 ab	13.9	14.9	15.4	13.9	13.9	15.3 ab	14.9
Bromegrass	15.5	14.7	15.6	15.6	15.2	14.2	13.9	13.9	15.5 ab	15.4	14.0	13.9	14.1 ab	13.9	15.9	13.9	13.9	13.9	15.0 ab	13.9
Clover	15.6	14.5	15.3	15.9	15.5	13.9	13.9	13.9	15.9 ab	15.9	14.4	13.9	13.9 b	13.9	15.5	15.0	14.4	13.9	15.2 ab	14.8
Alfalfa	15.2	14.5	15.5	16.0	15.4	14.6	13.9	13.9	15.9 ab	15.8	13.9	13.9	13.9 b	13.9	15.4	14.9	13.9	13.9	15.4 ab	14.6
Tall Fescue	14.9	15.5	15.4	16.0	15.8	14.4	13.9	13.9	16.2 a	15.6	14.9	13.9	14.4 ab	13.9	14.9	14.4	13.9	13.9	15.2 ab	14.2

45 cm Depth

TREATMENT	5/10	5/13	5/20	5/27	6/1	6/6	6/13	6/20	6/29	7/1	7/8	7/15	7/22	7/28	7/31	8/4	8/11	8/16	10/7	10/14
Herbicide	15.9	15.8	15.5	16.3	15.7	14.7	13.9	13.9	16.4	16.3	14.6	13.9 b	13.9	13.9 b	15.3	15.0	14.4	14.2	13.9	14.3
Clean Cultivation	16.0	15.9	16.2	16.3	16.5	14.4	13.9	13.9	15.5	15.4	13.9	13.9 b	13.9	14.0 b	15.6	14.5	14.4	14.2	15.2	14.7
Kentucky Bluegrass	16.0	15.9	16.2	16.3	16.0	15.2	13.9	13.9	16.0	16.1	14.5	14.9 a	13.9	15.0 a	15.6	15.6	13.6	13.8	15.0	14.4
Perennial Ryegrass	16.1	15.2	16.3	16.3	16.2	15.7	14.4	13.9	16.1	16.1	15.0	14.0 b	14.4	13.9 b	15.9	15.5	13.8	13.9	15.0	14.0
Hard Fescue	16.1	15.9	16.2	16.3	16.1	15.5	14.7	13.9	15.9	15.9	14.9	13.9 b	14.7	13.9 b	15.8	15.0	14.5	14.2	15.0	14.7
Chewings Fescue	15.9	15.6	16.4	16.4	16.2	15.4	13.8	13.9	16.1	16.3	14.5	14.3 b	13.9	13.9 b	15.0	14.6	14.5	14.3	15.7	14.3
PR+KB	15.5	16.0	16.3	16.3	16.2	15.4	14.4	14.0	16.1	16.0	14.6	14.1 b	14.4	14.5 ab	15.5	15.5	13.9	13.9	14.8	14.0
PR+CF	16.1	16.0	16.3	16.3	16.3	15.9	14.1	13.9	16.0	15.5	15.0	13.9 b	14.0	13.9 b	14.4	15.5	13.9	13.9	15.1	14.3
Bromegrass	16.0	15.6	16.1	16.1	16.0	15.3	13.8	13.9	15.4	15.3	14.3	13.9 b	14.1	13.9 b	15.1	13.8	13.8	13.9	14.9	13.8
Clover	15.9	15.7	16.2	16.3	16.0	15.2	14.0	13.9	16.1	16.1	15.0	13.9 b	14.1	13.9 b	15.5	15.0	14.4	14.2	14.7	14.7
Alfalfa	15.7	15.2	15.6	16.1	15.5	15.0	13.9	13.9	16.1	16.0	14.5	13.9 b	13.9	13.9 b	14.9	15.0	13.9	13.9	14.5	14.0
Tall Fescue	15.9	15.9	16.1	16.3	16.1	15.6	13.9	13.9	16.1	16.1	15.1	13.9 b	13.9	13.9 b	14.8	14.4	13.8	13.9	15.1	13.8

[z] Treatment means separated by Duncan's multiple range test (P=0.05), when treatment differences are indicated by a significant F test at 5% level.

Appendix II-1: The effect of orchard floor management on mass soil moisture at depths of 15, 30 and 45 cm, 155 cm from the peach tree in the alleyway--1988 growing season.[z]

% MASS SOIL MOISTURE

15 cm Depth

TREATMENT	5/10	5/13	5/20	5/27	6/1	6/6	6/13	6/20	6/29	7/1	7/8	7/15	7/22	7/28	7/31	8/4	8/11	8/16	10/7	10/14
Herbicide	15.9	15.9	18.1	18.3 ab	17.9	16.1	15.5	14.6	18.0	18.1	16.1	14.6	15.4	14.6	17.3	17.8	14.6	14.6	16.7	15.8 abcd
Clean Cultivation	15.5	15.4	17.0	18.4 a	17.2	15.8	14.7	14.6	17.5	17.4	16.0	14.6	14.7	14.6	19.1	16.5	14.6	14.6	18.0	16.6 a
Kentucky Bluegrass	16.1	14.8	17.8	17.9 abc	17.7	15.1	14.8	14.6	17.8	18.0	17.5	14.6	17.2	14.6	18.3	16.3	14.6	14.6	17.7	14.6 e
Perennial Ryegrass	16.0	15.9	18.1	18.0 abc	17.7	16.4	14.7	14.6	17.7	17.9	16.3	14.6	16.7	14.6	18.2	18.6	14.7	14.6	17.8	14.7 de
Hard Fescue	15.0	14.6	17.5	17.6 c	16.5	15.4	14.7	14.6	17.7	17.7	15.3	14.6	17.0	14.6	16.8	16.6	14.6	14.6	17.7	15.7 abcde
Chewings Fescue	15.8	15.0	17.8	18.1 abc	17.3	14.6	14.5	14.6	18.1	18.1	16.3	14.6	17.1	14.6	18.2	17.6	14.6	14.6	17.3	16.1 ab
PR+KB	14.7	14.5	17.7	17.9 abc	17.1	14.8	14.7	14.6	17.8	18.0	16.1	14.6	16.8	14.6	16.9	17.3	14.7	14.6	17.7	14.7 de
PR+CF	15.4	14.6	18.1	17.9 abc	16.9	14.5	14.5	14.6	17.8	17.8	15.5	14.6	16.2	14.6	16.8	17.4	14.7	14.6	17.5	14.6 de
Bromegrass	15.2	14.5	17.5	17.8 c	17.0	14.6	14.5	14.6	17.9	17.7	16.1	14.6	16.6	14.6	18.2	16.7	14.6	14.6	16.8	15.7 abcde
Clover	16.3	14.6	17.2	17.7 c	17.2	14.4	14.5	14.6	17.8	17.8	15.2	14.6	15.6	14.6	18.1	15.7	14.6	14.6	17.3	16.1 ab
Alfalfa	14.6	14.6	16.9	18.0 abc	17.8	15.2	14.6	14.6	17.3	18.1	16.5	14.6	16.8	14.6	17.4	17.3	14.7	14.6	16.9	15.0 cde
Tall Fescue	14.8	15.0	17.7	17.8 c	16.9	15.6	14.8	14.6	17.7	17.9	16.6	14.6	15.9	14.6	18.2	17.9	14.7	14.6	17.7	15.4 bcde

30 cm Depth

TREATMENT	5/10	5/13	5/20	5/27	6/1	6/6	6/13	6/20	6/29	7/1	7/8	7/15	7/22	7/28	7/31	8/4	8/11	8/16	10/7	10/14
Herbicide	15.6	15.5	16.0	16.2	16.1	15.8	14.4 b	13.9	16.1	16.0	15.3	13.9 b	14.4	13.9	16.0	15.9	14.5	13.9	14.9	15.3
Clean Cultivation	14.6	14.7	15.6	15.7	15.6	15.1	14.1 b	13.9	15.6	15.5	15.0	14.0 b	14.2	13.9	16.2	15.4	13.9	13.9	15.1	15.2
Kentucky Bluegrass	15.5	14.9	15.5	15.7	15.7	15.1	13.9 b	13.9	15.2	15.7	15.4	13.9 b	14.9	13.9	16.1	14.5	14.4	13.9	15.2	14.4
Perennial Ryegrass	15.0	15.1	15.9	16.0	15.9	14.7	14.2 b	13.9	15.3	15.4	15.0	14.2 b	14.8	13.9	16.0	14.5	14.4	13.9	15.8	14.4
Hard Fescue	15.3	14.9	15.7	15.7	15.6	15.0	14.0 b	13.9	14.8	15.2	14.8	13.9 b	14.5	13.9	14.9	14.9	13.9	13.9	15.2	14.6
Chewings Fescue	15.2	15.1	15.0	15.9	15.4	14.9	13.9 b	13.9	15.5	16.0	15.4	13.9 b	15.1	13.9	15.5	15.4	13.9	13.9	15.0	14.9
PR+KB	14.6	14.6	15.2	15.9	15.5	14.3	13.9 b	13.9	14.9	15.4	14.7	13.9 b	14.6	13.9	14.9	14.5	14.4	13.9	15.8	14.4
PR+CF	15.5	15.1	15.2	15.9	15.8	15.1	13.9 b	13.9	15.7	15.7	15.2	13.9 b	14.8	13.9	15.9	14.5	14.6	13.9	15.7	14.4
Bromegrass	15.4	15.2	15.9	16.1	16.1	15.6	15.2 a	13.9	15.4	15.1	15.3	15.0 a	15.3	13.9	16.2	15.1	13.8	13.9	15.9	14.6
Clover	14.7	14.1	15.2	15.4	15.4	14.7	13.9 b	13.9	15.4	15.2	15.1	13.9 b	14.5	13.9	15.9	14.9	13.9	13.9	15.4	14.6
Alfalfa	15.3	14.6	15.6	16.0	16.1	15.6	14.4 b	13.9	15.4	15.9	15.3	13.9 b	15.6	13.9	15.0	15.0	14.4	13.9	15.8	14.7
Tall Fescue	15.3	15.1	15.8	16.0	15.9	15.0	13.9 b	13.9	15.9	15.9	15.3	13.9 b	14.0	13.9	15.3	14.4	13.9	13.9	15.8	14.2

45 cm Depth

TREATMENT	5/10	5/13	5/20	5/27	6/1	6/6	6/13	6/20	6/29	7/1	7/8	7/15	7/22	7/28	7/31	8/4	8/11	8/16	10/7	10/14
Herbicide	15.4	15.2	15.7	16.2 bc	16.2	15.9	15.1	14.6 b	15.9	15.8	14.9	14.5 bc	14.6	14.0	14.7 cd	16.0	14.5	14.2	14.3 c	14.7
Clean Cultivation	15.9	16.0	16.3	16.4 ab	16.5	16.4	16.2	16.0 a	16.0	16.0	16.0	15.4 ab	15.4	14.5	16.0 abc	15.5	13.9	13.9	15.9 ab	14.8
Kentucky Bluegrass	15.9	15.9	16.1	16.4 abc	16.4	16.1	15.3	13.9 b	15.3	15.7	16.0	14.4 bc	15.0	13.9	15.7 abc	14.5	14.6	14.3	16.2 a	14.3
Perennial Ryegrass	15.4	15.5	16.2	16.3 bc	15.7	15.6	15.3	14.3 b	14.9	14.9	15.0	14.7 bc	14.8	14.0	16.1 ab	14.5	14.4	14.2	15.5 ab	14.3
Hard Fescue	15.5	15.4	15.7	16.4 abc	15.8	15.7	15.5	14.7 b	15.1	15.0	15.3	14.4 bc	15.3	13.9	14.9 bcd	15.0	13.9	13.9	15.0 bc	14.3
Chewings Fescue	15.8	15.8	16.0	16.3 bc	16.3	16.1	15.6	14.8 b	15.0	15.4	15.9	14.7 bc	15.6	13.9	15.5 abc	15.5	13.9	13.9	15.4 ab	14.3
PR+KB	15.9	15.9	16.1	16.3 bc	16.3	16.1	15.5	13.9 b	14.6	14.7	14.9	14.1 c	14.5	13.9	13.7 d	14.5	14.6	14.3	16.1 a	14.3
PR+CF	16.0	15.9	16.2	16.3 bc	16.3	16.2	15.6	13.9 b	15.3	15.8	15.9	14.7 bc	15.1	13.9	15.9 abc	14.5	14.5	14.2	15.9 ab	14.3
Bromegrass	16.1	16.3	16.6	16.6 a	16.6	16.5	16.2	15.7 a	16.6	16.6	16.4	16.0 a	16.0	13.9	16.7 a	15.2	13.8	13.8	16.3 a	13.8
Clover	15.9	15.7	15.3	16.1 c	16.1	16.1	15.2	13.9 b	14.4	14.8	15.4	14.4 bc	14.9	13.9	15.5 abc	15.0	13.9	13.9	16.0 ab	14.3
Alfalfa	15.9	15.6	15.8	16.1 c	16.2	16.1	15.4	13.9 b	15.9	15.9	16.0	14.6 bc	15.4	14.0	14.9 bcd	15.0	14.4	14.2	15.7 ab	14.3
Tall Fescue	15.9	15.6	16.0	16.1 bc	16.2	15.9	14.6	13.9 b	14.9	15.7	15.4	14.0 c	14.0	13.9	15.1 bc	14.4	13.9	13.9	15.8 ab	13.9

[z] Treatment means separated by Duncan's multiple range test (P=0.05), when treatment differences are indicated by a significant F test at 5% level.

Appendix II-J: The effect of orchard floor management on peach tree fruit yield.[z]

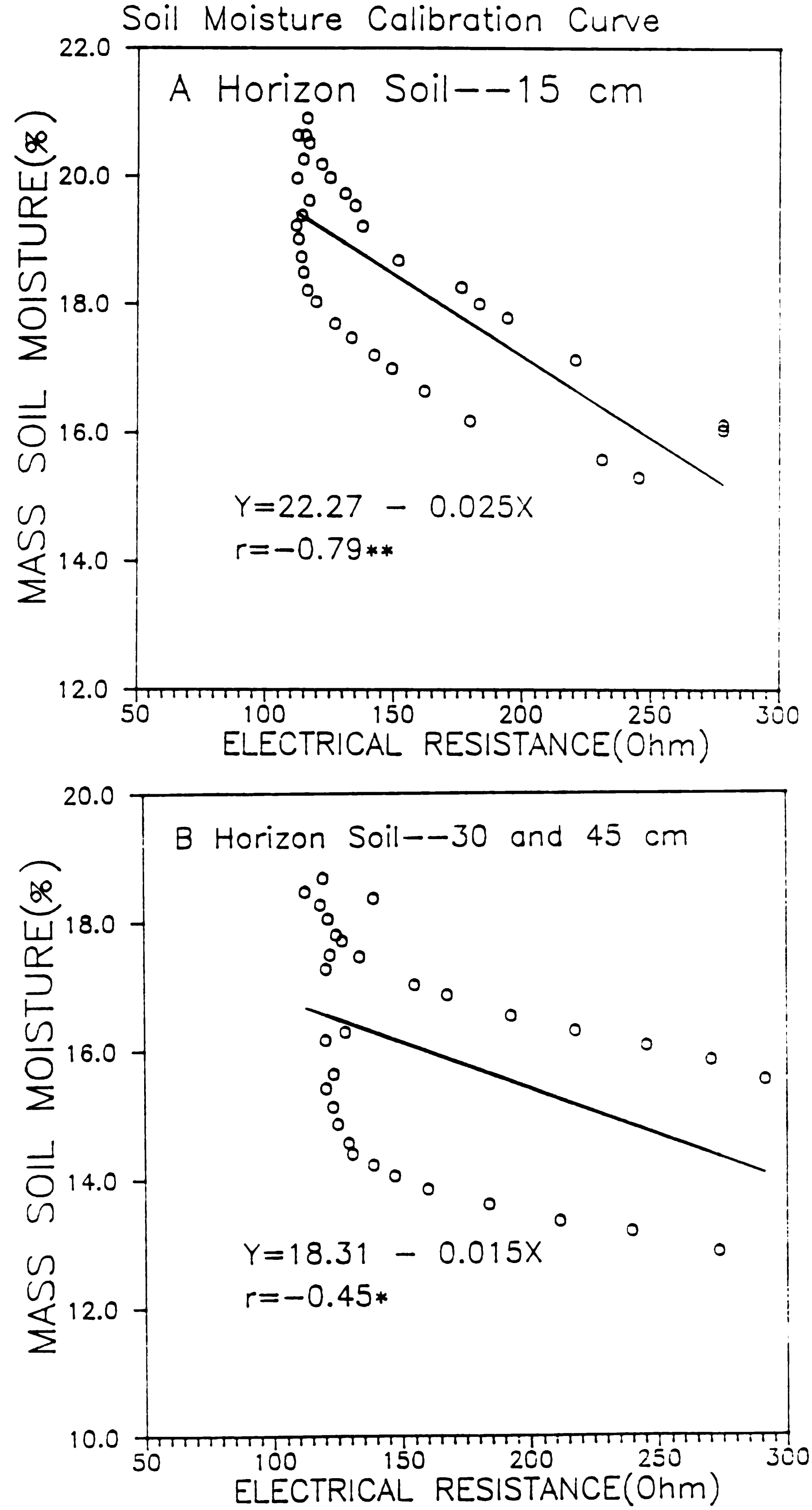
TREATMENT	SIZE6	SIZE5	SIZE4	SIZE3	SIZE2	SIZE1	8/12 TOTAL	8/15 TOTAL	1988 TOTAL
	kg						kg		
Herbicide	0.0	0.3	2.0	4.4	4.4	2.2	8.5	4.9	13.3
Clean Cultivation	0.0	0.7	2.8	5.4	3.8	2.0	10.4	4.2	14.7
Kentucky Bluegrass	0.0	0.5	2.0	5.6	2.9	1.3	9.1	3.4	12.5
Perennial Ryegrass	0.0	0.5	3.4	5.7	3.2	0.8	9.6	3.9	13.5
Hard Fescue	0.0	0.3	2.3	4.7	3.4	2.1	10.7	2.2	12.8
Chewings Fescue	0.0	0.4	1.6	4.1	3.4	2.0	8.9	2.5	11.4
PR+KB	0.0	0.4	2.5	5.5	5.5	1.6	12.0	3.6	15.6
PR+CF	0.0	0.4	3.8	7.1	3.4	0.4	12.5	2.6	15.1
Bromegrass	0.0	0.7	3.5	5.3	3.8	1.1	11.1	3.3	14.4
Clover	0.0	0.5	2.1	4.0	4.1	2.0	9.2	3.6	12.7
Alfalfa	0.0	0.5	2.9	5.8	3.4	0.9	7.8	5.6	13.4
Tall Fescue	0.2	0.6	3.3	4.7	2.9	0.9	9.3	3.1	12.4

DIAMETER

SIZE1-- >75 mm
SIZE2-- 74.0-65.7 mm
SIZE3-- 65.6-62.6 mm
SIZE4-- 62.5-59.5 mm
SIZE5-- 59.4-50.0 mm
SIZE6-- < 49 mm

[z] No treatment differences detected by F test at 5% level.

Appendix II-K: Soil calibration curve for electrical resistance values from a datalogger and percent mass soil moisture for a Riddles sandy loam. Solid line is the best fit regression line.



Soil Moisture Calibration Curve
A Horizon Soil--15 cm
Y=22.27 - 0.025X
r=-0.79**
MASS SOIL MOISTURE(%)
ELECTRICAL RESISTANCE(Ohm)
22.0
20.0
18.0
16.0
14.0
12.0
50
100
150
200
250
300
B Horizon Soil--30 and 45 cm
Y=18.31 - 0.015X
r=-0.45*
MASS SOIL MOISTURE(%)
ELECTRICAL RESISTANCE(Ohm)
20.0
18.0
16.0
14.0
12.0
10.0
50
100
150
200
250
300

Appendix III-A: The effect of orchard floor management on total peach root number at 20 cm depth increments on the west profile-face 1.9 m (1.9PF) from the tree parallel to the tree row. Root totals expressed per m^2.[z]

Depth (cm)	Herbicide	Clean Cultivation	Kentucky Bluegrass	Chewings Fescue	Alfalfa	Tall Fescue
0-20	311.7 a[x]	95.8 a	102.1 a	117.9 a	15.8 a	35.4 a
20-40	151.3 a	67.9 b	42.9 b	70.8 b	5.4 b	14.6 b
40-60	61.7 a	26.3 a	28.3 a	43.8 a	5.4 a	3.3 a
60-80	67.9 a	15.8 b	10.4 bc	9.6 b	7.5 b	0.0 b
80-100	31.3 a	13.8 a	2.1 a	1.3 a	8.3 a	0.0 a

[z] Means separated within rows by Duncan's multiple range test (P=0.05) with significant F test at 5% level.