EVALUATION OF IRRIGATION SCHEDULES AND ANNUAL RYEGRASS AS A GROUND COVER TO CONSERVE WATER AND CONTROL PEACH TREE GROWTH

BY

SUSAN MICHELE HUSLIG

Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1990

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the degree of
MASTER OF SCIENCE
May, 1992

EVALUATION OF IRRIGATION SCHEDULES AND

ANNUAL RYEGRASS AS A GROUND COVER TO

CONSERVE WATER AND CONTROL PEACH

TREE GROWTH

Thesis Approved:

Michael Smith
____
Thesis adviser

Janet C. (Henderson) Cole
____

Gerald H. Brusewitz
____

Thomas C. Collins
____
Dean of the Graduate College

PREFACE

The purpose of this study was to evaluate irrigation systems in combination with a ground cover of annual ryegrass to conserve water usage and control tree growth without adversely affecting fruit size or yield.

I wish to express my sincere appreciation to my thesis advisor, Dr. Mike Smith. His never ending patience, advise, encouragement and friendship played a vital role throughout my graduate and undergraduate work. I would like to thank him for the many hours spent helping me collect and analyze data. Many thanks for his encouragement in class work and papers given at national, southern region and industry shows.

My thanks to Dr. Janet Henderson and Dr. Gerald Brusewitz for serving on my graduate committee. Their advice and friendship was a great help.

I wish to thank Becky Cheary and Becky Carroll for their help in lab and field work, collecting and analyzing data. Thank you to Natasha Rice for her help in collecting data for my fruit quality study and to David Westfall and Chad Kucko for their help in collecting data for pruning weights. Extra special thanks to Ken Karner, Steve Simma, and Jimmy Carroll at the Perkins Fruit Research Station. Without their help at the station this study would not have been possible.

I would also like to thank Tom Moore for the long hours he spent tutoring me in Chemistry and Algebra and to thank both Tom and Sue Moore for their loving support and friendship.

My thanks to the Tulsa Garden Club for their scholarship and Mrs. Hopfer for the "David A. Hopfer Memorial Scholarship" which I received two years. This financial support was greatly appreciated and needed during my graduate work.

I would like to thank my husband, David, for his moral support and undivided time during my undergraduate and graduate degrees. I want to thank him for the early morning hours (4 a.m.) he spent with me every Tuesday for the last two summers helping me collect data at the Perkins Fruit Research Station. I also wish to thank my parents, Art and Linda Nine, for their encouragement, support and love throughout my college career.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Irrigation

Irrigation scheduling for peach production has been based on available soil moisture (Layne and Tan, 1984; Layne, et al., 1986), soil matrix potential (Horton, et al., 1981; Klein, 1983), evaporation from class A pan or free water surface (Reeder, et al., 1979; Chalmers, et al., 1981; Layne and Tan, 1988), or "best guess" estimates. The first three estimates provide a sound basis for irrigation requirements to produce healthy growth, with large fruit yields and fruit size. Klein (1983) suggested that maintaining a steady matric potential eliminated errors that arise from the estimation of soil water loss and canopy size from the class A pan. Periods of increased water consumption due to plant growth and development are identified by measuring soil matric potential. Scheduling with soil matric potential reduced water by 12-24% compared to the class A pan (Klein, 1983); however, irrigation scheduling based on evaporation from a free water surface or class A pan appears to have some distinct advantages over other scheduling methods. These advantages include a greater uniformity in tree response over diverse soil types, less equipment maintenance, and ease of use by growers.

Most studies have concentrated on improving marketable fruit yield, fruit size and tree longevity with supplemental irrigation (Hendrickson and Veihmeyer, 1934; Feldstein and Childers, 1957; Morris et al., 1962; Feldstein and Childers, 1965; Cummings and Ballinger, 1972; Smith and Kenworthy, 1979; Daniell, 1982). Few studies however, have addressed the problems associated with excessive tree growth which increases pruning costs, and may decrease fruit quality if shading is excessive. Some studies have used tree density and irrigation management to control excess growth while maintaining high yields of good quality fruit (Chalmers et al., 1981; Layne and Tan, 1984). Flower buds are formed on current season's growth; therefore, healthy growth is essential to maintain consistent production. Excessive growth requires additional pruning to maintain tree size and increase light penetration into the tree to improve fruit color and quality. If irrigation is restricted during the initial growth flush when most fruit producing regions have adequate soil moisture reserves, vegetative growth may be reduced.

Regulated deficit irrigation (RDI) is an irrigation method that applies more water during DW III (stage I-first rapid increase in fruit diameter; stage II-reduced fruit diameter increase; stage III-second rapid increase in fruit diameter immediately preceding full ripeness) than at the beginning of the season when rainfall and ground water are available and vegetative growth is occurring more rapidly than fruit growth. The aim of RDI is to reduce the amount of irrigation prior to DW III to reduce tree growth without reducing fruit yield or size. DW I corresponds to stage I and the first part of stage II fruit growth, DW II corresponds to last of stage II and first of stage III and DW III corresponding to the last of stage III. A study conducted by Chalmers et al. (1981) indicated that restricted water availability when peach fruit were at growth stage II or DW II combined with high tree density (4166 $trees.ha^{-1}$) increased fruit yield and size up to 30%. This treatment combination limited shoot growth, and reduced the water applied by 10%. Water availability was reduced during stage I and stage II fruit growth. Vegetative growth increases during DW II but not during DW I or DW III when fruit is rapidly growing (Chalmers and Wilson, 1978). Chalmers et al. (1981) also noted an increase in mean fruit weight when irrigation was reduced during DW II. Fruit number and yield per trunk cross-sectional area was also increased by reducing irrigation during DW I and DW II. In another study using RDI, 100, 50, 25, and 12.5% pan evaporation replacement prior to DW III were compared (Mitchell and Chalmers, 1982). Pan evaporation replacement treatments were then increased to 130% and 100% after DW III. Summer prunings and trunk cross-sectional area were significantly greater on trees that received 100% pan evaporation replacement compared to 50, 25 and 12.5% pan evaporation replacement prior to DW III. After DW III more summer prunings were removed from the trees receiving 130% than 100%. Fruit diameters were smaller on trees receiving 12.5% than trees receiving 100% pan evaporation replacement prior to DW III. However, when irrigation was increased to 130 or 100% after DW III there was no significant differences between fruit diameters. At harvest, trees that received 12.5% prior to DW III yielded more fruit per trunk cross-sectional area than the trees that received 100 and 50%. Mitchell et al. (1984) found on pear fruit that even though 46% pan evaporation replacement decreased fruit size compared to 92% pan evaporation replacement during the first stage of fruit growth, after RDI was discontinued prior to

DW III, fruit grew more rapidly from the 46% pan evaporation replacement than the 92% the following week. Fruit size at harvest however, was not affected. Flower bud density was increased with the use of RDI. Using 23% pan evaporation replacement before DW III increased flower bud density compared to 92% pan evaporation replacement.

RDI may also be effective when water is withheld completely from trees until after the root zone moisture is depleted. This was evident in studies conducted on pear trees in Australia in which the control treatment consisted of 69% pan evaporation replacement followed by 92% and then 120% during DW III. Other treatments included withholding irrigation followed by 23% or 46% and then 120% during DW III (Chalmers et al., 1986). Withholding water initially decreased leaf water potential at dawn and midday. During this period shoot growth declined to zero when dawn and midday water potentials decreased to -.57 and -2.22 MPa, respectively. When the withholding water treatment was replaced by 23 or 46% pan evaporation replacement leaf water potential increased; however, they remained below the water potentials of the control. Shoot growth began when 120% pan evaporation replacement was initiated. Fruit growth and size were not affected during the withholding period compared to the control even though leaf water potential was lower on the withholding treatment. When 23 or 46% pan evaporation replacement began fruit growth rate increased significantly compared to the control. Fruit growth rate and size again increased when the 23 or 46% pan evaporation replacement was increased to 120% at the beginning of stage III of fruit growth. Similar effects were observed in other studies, when water was withheld while soil moisture was available. (Mitchell et al., 1986; Mitchell et al., 1989).

Excessive water during early spring can cause problems other than increased vegetative shoot growth. Claypool et al. (1972) found that high available soil moisture increased split-pit in peaches. Claypool attributed the splitting of the pit to high turgidity in cells of the growing peach. Davis (1941) found that the common time for splitting of the pit was during pit hardening (Stage II) and up to 4 weeks afterward in some cultivars. Split-pit may also be increased by increasing nitrogen availability and light crop loads (Claypool et al., 1972).

A study in Georgia evaluated season long irrigation, irrigation until harvest, irrigation from harvest to dormancy, or no irrigation (Horton et al., 1981). Irrigation until harvest produced fruit yields and size similar to season long irrigation, and superior to no irrigation, or postharvest irrigation. Irrigation to harvest rather than all season reduced the water applied by 54%. This study indicates that after the peach crop is harvested, irrigation was not needed to produce an adequate crop the subsequent year, therefore, water could be conserved. Another study conducted in California reported that no irrigation after harvest increased return bloom and fruit set compared to applying 75 cm of water for the wet treatment and 23 cm of water for the medium treatment after June 13 or harvest (Larson et al., 1988). However, in the desert areas of California, postharvest irrigation of apricots increased flower bud formation, fruit set, and yield (Brown, 1953; Uriu, 1964). In this study, soil moisture was depleted to near the permanent wilting point soon after irrigation was terminated, but the water status of the trees was not characterized. Therefore, direct comparisons between these studies can not be made.

Measurements of Plant Water Status

Leaf-cutter psychrometers measure leaf cell water potential while pressure chambers measure xylem water potential. In situ hygrometers/psychrometers have been found to have more negative water potentials than the pressure chamber in some species (Turner et al., 1984). Young et al. (1981) reported that leaf osmotic potentials measure by in situ hygrometers/psychrometers were also more negative than those measured by the pressure chamber with an osmometer. The pressure chamber also had a higher degree of variability than the in situ hygrometer/psychrometer. Other studies have shown that pressure chambers record more negative water potential than in situ hygrometers/psychrometers and others have found agreement between pressure chambers and hygrometer readings (Brown and Tanner, 1981; Oosterhuis et al., 1983). Most studies have measured water potential with a Scholander pressure chamber, thus measuring xylem water potential. A study in Italy measured xylem water potential of peach trees with a drought stress imposed during pit hardening and another drought stress occurring during stage III of fruit growth reported reduced fruit diameter growth when trees were severely stressed (Natali et al., 1985). Leaf water potential was strongly correlated to an increase or decrease in fruit diameter. There was also found a strong correlation between predawn leaf water potentials and total soil moisture using the gravimetric method (w/w). Leaf water potentials of -0.5 and -0.6 MPa correspond to 30 and 40% total water availability, respectively. At these leaf water potentials and total soil water content they reported plants began to show signs of stress as revealed by observations in fruit growth. Another study used peach seedlings grown in a growth chamber to measure xylem water potential (Hand et al., 1982). Water and nutrients were withheld until a predetermined stress level was reached. The seedlings were then watered and allowed to recover. Xylem water potentials of stressed seedlings were from -1.7 to -3.6 MPa. The unstressed control had a xylem water potential of -1.3 MPa. The seedlings with a water potential of -3.6 MPa suffered no permanent damage; however, net photosynthesis was reduced until stomatal resistance was decreased. When seedlings were subjected to a severe drought with xylem water potentials of -5.6 MPa, seedlings were permanently damaged. Even though xylem water potential increased and stomatal resistance decreased during the recovery period, net photosynthesis experienced a lag in recovery. After this severe stress, seedling growth was irregular. Studies have shown that high evaporative demands on plants cause stomata to close increasing stomatal resistance and reducing transpiration rates. Punthakey et al. (1984) found that stomatal resistance increased when water potential dropped below -2.1 MPa on drought stressed drip irrigated peaches. Xiloyannis et al. (1980) found that irrigated 9-year-old peach trees had a predawn xylem water potential of -0.45 to -0.8 MPa. Irrigated trees remained constant in xylem water potential throughout the growing season; however, the non-irrigated trees ranged in predawn water potentials from -0.55 MPa at the beginning of the season in June to -1.5 MPa in October. The available soil moisture in the top 15 to 90 cm of the Yolo loam began at 32.5% in April and dropped to 16% by November (Xiloyannis et al., 1980). These results agree with Young et al., (1981) which reported that predawn xylem water potentials on non-stressed peach seedlings were between -0.4 and -0.6 MPa. Irrigated apple seedlings have also been reported to have late morning xylem water potentials of -0.5 to -1.0 MPa, as much as 0.6 MPa higher than non-irrigated apple seedlings (Davies and Lakso, 1978).

Ground Cover Influence on Plant Growth and Water Status

Temporary spring ground covers may reduce tree growth in the early spring, and if killed in early summer, can act as a mulch to reduce evapotranspiration during the summer months. Ground covers may also effectively control soil erosion during periods of high rainfall and increase infiltration during periods of low rainfall. Since most deciduous orchards are established on land with 1-5% slope for air drainage, erosion can be excessive if the soil surface is not protected. The use of permanent sod strips in the row middle with a weed-free strip under the tree has limited erosion without adversely affecting tree growth or yield (Layne and Tan, 1988; Welker and Glenn, 1988; Glenn and Welker, 1989). Raindrops have high erosive power which breaks down soil aggregates; therefore, there is a great risk in having the soil surface unprotected. Ghadiri and Payne (1986) showed that there was a large number of soil particles lost by the impact of raindrops, especially when soil was at or near saturation.

Young trees especially have benefitted from reducing vegetation around trunks (Welker and Glenn, 1989); however, the presence of ground covers that do not compete with mature trees have numerous advantages. Rogers (1948) indicated that soils under permanent sod decreased in soil moisture quickly and gained soil moisture through rainfall more rapidly. Rogers also found that grass sod reduced preharvest drop, improved fruit color and increased organic matter content of the soil and increased and stabilized soil aggregates compared to cultivated treatments. Competitive permanent grass sod, however, have decreased nitrogen availability for trees, therefore, more nitrogen must be added or a less competitive grass must be used. Many studies have shown that the lack of nitrogen and soil moisture limit growth, especially in young trees which were planted in permanent grass covers (Rogers et al., 1948; Bould and Jarrett, 1962; White and Holloway, 1967; Goode and Hyrycz, 1976). Ground covers that were frequently cut competed less with tree growth; however, trunk area and shoot growth were decreased by a permanent grass cover as compared with clean cultivation (Rogers et al., 1948). Straw mulch under the tree canopy has been superior method to increase shoot growth, trunk diameter, soil moisture, leaf area and number, and fruit yield and size compared to permanent sod or herbicide treatments (Cockroft, 1966; White and Holloway, 1967; Baxter, 1970; Haynes, 1980). Bluegrass sod and a hay mulch with a low C:N ratio increased soil organic matter, stabilized soil structure, and increased soil moisture retention without reducing yield compared to cultivated areas. Increasing soil organic matter increased soil moisture available to orchard crops. Havis (1941) concluded that organic matter was considerably greater under sod or mulch than under cultivated areas even if a cover crop had been used on cultivated areas. Haynes (1980) also noted that when ground covers were killed with cultivation, organic matter and soil moisture retention were decreased. Havis (1941) observed that a mulch of wheat straw and bluegrass sod also increased soil porosity and water absorption rate compared to cultivated areas. Welker and Glenn (1990), showed that young trees benefit from herbicide killed 'Kentucky 31' fescue under the tree canopy, therefore, acting as a mulch. The killed 'Kentucky-31' sod increased organic matter concentration, had a greater microporosity, stabilized soil aggregates and increased water infiltration when compared to cultivated and herbicide areas within the tree row. The killed sod roots did not compete with the trees but increased soil stability. Tree canopy area, total shoot growth and yield of killed sod, increased in this study and in others when mulches were used compared to cultivated trees (Welker and Glenn, 1985; Welker and Glenn, 1988; Welker and Glenn, 1989; Welker and Glenn, 1990). However, there have been no studies that determine whether competitiveness of temporary ground covers during early spring limits shoot growth and benefits management of mature trees. During the spring, when rainfall is high, a temporary ground cover that would compete with the tree to reduce shoot growth, and shading within and among trees could increase fruit color and quality, and reduce pruning time and cost would be beneficial. However, reducing tree growth would only be beneficial if fruit yield and size were not adversely affected.

On radiation frost nights, orchard floor management systems affect the microclimate around trees, thus affecting flower bud loss. Sharratt and Glenn (1986) studied the difference between coal dust applied under the tree or grass sod plots. They found that coal dust had a radiative temperature loss of 5 W m^{-2} resulting in a 1 C increase in orchard temperature during a radiation freeze compared to grass plots. They found an increase of 0.5 C in bud temperature due to the increase in orchard temperature from the coal dust. Other studies on soil management practices also showed increases of 1 C (Rogers et al., 1948; Leyden and Rohrbaugh, 1963; Bridley et al., 1965; Gerber et al., 1974); however, increased temperature does not insure increased survival rate of flower buds. Sharratt et al., (1989) found that coal dust did not increase peach flower bud survival rate or cold hardiness of the bud compared to a grass cover plot.

Postharvest

High quality fresh fruit without blemish is demanded by the consumer. Many studies have tested postharvest methods of handling fresh fruit to reduce damage and extend shelf life of rapidly deteriorating peaches. Peaches should be cooled as quickly as possible, because a delay of only two hours can dramatically reduce firmness. Hydrocooling or storing fruit at high humidities soon after harvest has reduced weight loss of fruit 50-80% (Wells, 1962; Gardner et al., 1987; Shewfelt et al., 1987; Brusewitz et al., 1992). Fruit maturity affects fruit strength and bruising, with the most mature fruit more susceptible to bruising, and therefore, requiring rapid cooling to maintain quality (Fridley and Adrian, 1966; Finney, 1967; Gardner et al., 1987; Hung and Prussia, 1989). Fruit ripening (flavor and color development) is inhibited at 5 C, the typical postharvest storage temperature. Therefore, fruit maturity at harvest is an important factor to consider. Shewfelt et al., (1987) used a standard color chip rating system (Delwewiche and Baumgardner 1985) with 1 being least mature and 6 the most mature. After 7 days of storage at 5 C they found a 37% loss of fruit firmness at maturity 1 and 73% at maturity 6.

Preharvest conditions such as irrigation, mineral nutrition and grass cover may affect postharvest fruit quality. Water potential can increase the elastic modulus of vegetative tissue and tomato epidermis, and change the fracture stress of apple flesh (Falk et al., 1958; Murase and Merva, 1977; De Baerdemaeker et al., 1978). De Baerdemaeker and Lemaitre (1979) noted that preharvest irrigation schedules affect postharvest storage and mechanical properties of pears even though water potential was not affected. In this study, fruit of irrigated pear trees were compared to non-irrigated pear fruits by measuring elastic modulus and failure stress during a 60 day storage period at 3.5 C and 90% relative humidity. After 30 days of storage, non-irrigated fruits showed a rapid decline in elastic modulus and failure stress compared to irrigated pear fruits. This study suggested that the altered mechanical properties were due to soil water status. Other studies have shown that irrigation decreases soluble solids compared to no irrigation, due to decreased dry weight of fruit. However, pH, titratable acidity, soluble amino acids and fruit browning were not affected by irrigation. Trickle irrigation increased soluble solids compared to sprinkle irrigation while maintaining fruit size (Cummings and Reeves, 1970; Proebsting et al., 1977). Reeves and Cummings (1970) reported that nitrogen and irrigation affect postharvest storage of peaches. In the presence of irrigation, increased nitrogen did not increase fruit firmness; however, with no irrigation, as nitrogen levels increased so did fruit firmness. High nitrogen concentrations decreased fruit size, possibly due to competition between vegetative growth and fruit growth (Ballinger et al., 1963; Claypool et al. 1972; Sharples, 1984). Competition from grass cover can increase uptake of phosphorus in apple fruit while decreasing nitrogen, and decreasing water uptake which improves fruit color and size. High phosphorus concentrations has also prevented low temperature breakdown of fruit during postharvest cold storage (Sharples, 1984). However, there were no significant effects of different soil management systems on fruit firmness after controlled atmosphere storage (Johnson et al., 1983).

Rehardening or firming of peaches occurs during the first days of postharvest cold storage. Shewfelt et al., (1987) thought rehardening to be a temporary process in which peaches became firmer after being subjected to low temperature storage. Rehardening has been shown to be inversely proportional to storage temperature. Werner et al., (1978) concluded that rehardening of peaches was not due to the recondition of pectic substances. The soluble pectin fraction with a combination of sugars and acids is thought to form a solidified gel matrix at low temperature and liquify at high temperatures. Therefore, changes in peach firmness at different temperatures may be due to soluble pectin fractions (Werner and Frenkel, 1978).

LITERATURE CITED

Ballinger, W.E., A.H. Hunter, F.E. Correll, and G.A. Cummings. 1963. Interrelationships of irrigation, nitrogen fertilization and pruning of Redhaven and Elberta peaches in the sandhills of North Carolina. Proc. Amer. Soc. Hort. Sci. 83:248-258.

Baxter, P. 1970. Orchard soil management trials. 1. Effect of a weed-free or straw mulched strip on the growth and yield of young fruit trees. Aust. J. Expt. Agri. and Animal Hus. 10:467-473.

Bould, C. and R.M. Jarrett. 1962. The effects of cover crops and N P K fertilizers on growth, crop yield and leaf nutrient status of young dessert apples. J. Hort. Sci. 37:58-82.

Bridley, S.F., R.J. Taylor, and R.T. Webber. 1965. The effects of irrigation and rolling on nocturnal air temperature in vineyards. Agri. Meteorology 2:373-383.

Brown, D.S. 1953. The effects of irrigation on flower bud development and fruiting in the apricot. Proc. Amer. Soc. Hort. Sci. 61:119-124.

Brown, P.W. and C.B. Tanner. 1981. Alfalfa water potential measurement: A comparison of the pressure chamber and leaf dew-point hygrometers. Crop Sci. 21:240-244.

Brusewitz, G.H., X. Zhang, M.W. Smith. 1992. Postharvest cooling effects on the bruising of peaches. Applied Eng. Agri. 8:84-90.

Chalmers, D.J., P.D. Mitchell, and L. van Heek. 1981. Control of peach tree growth and productivity by regulated water supply, tree density, and summer pruning. J. Amer. Soc. Hort. Sci. 106:307-312.

Chalmers, D.J. and I.B. Wilson. 1978. Productivity of peach trees: tree growth and water stress in relation to fruit growth and assimilate demand. Ann. Bot. 42:285-294.

Chalmers, D.J., G. Burge, P.H. Jerie, and P.D. Mitchell. 1986. The mechanism of regulation of 'Bartlett' pear fruit and vegetative growth by irrigation withholding and regulated deficit irrigation. J. Amer. Soc. Hort. Sci. 111:904-907.

Claypool, L.L., K. Uriu, and P.F. Lasker. 1972. Split pit of 'Dixon' cling peaches in relation to cultural factors. J. Amer. Soc. Hort. Sci. 97:181-185.

Cockroft, B. 1966. Soil management of peach trees in the Goulburn Valley, Victoria. Aust. J. Expt. Agri. and Animal Hus. 6:62-65.

Cummings, G.A. and W.E. Ballinger. 1972. Influence of longtime nitrogen, pruning and irrigation treatments upon yield, growth, and longevity of 'Elberta' and 'Redhaven' peach trees. HortScience 7:133-134.

Cummings, G.A. and J. Reeves. 1971. Factors influencing chemical characteristics of peaches. J. Amer. Soc. Hort. Sci. 96:320-322.

Daniell, J.W. 1982. Effect of trickle irrigation on the growth and yield of 'Loring' peach trees. J. Hort. Sci. 57:393-399.

Davies, F.S. and A.N. Lakso. 1978. Water relations in apple seedlings: changes in water potential components, abscisic acid levels and stomatal conductances under irrigated and non-irrigated conditions. J. Amer. Soc. Hort. Sci. 103:310-313.

Davis, L.D. 1941. Split-pit of peaches. Estimation of time when splitting occurs. Proc. Amer. Soc. Hort. Sci. 39:183-189.

De Baerdemaeker, J. and L. Lemaitre. 1979. Water supply and mechanical properties of agricultural crops. pp. 280-284. In P. Linko (ed). Food Process Engineering. vol.1. Food processing systems Applied Sci. Pub. LTD.

De Baerdemaeker, J., L.J. Segerlind, H. Murase and G.E. Merva. 1978. Water potential effect on tensile and compressive failure stresses of apple and potato tissue. Amer. Soc. Agri. Eng. paper 78-3057. St. Joseph, MI.

Delwiche, M.J. and R.A. Baumgardner. 1985. Ground color as a peach maturity index. J. Amer. Soc. Hort. Sci. 110:53-57.

Falk, S., C.H. Hertz, and H.I. Virgin. 1958. On the relation between turgor pressure and tissue rigidity I. Experiments on resonance frequency and tissue rigidity. Phys. Plantarum 11:802-817.

Feldstein, J. and N.F. Childers. 1957. Effect of irrigation on fruit size and yield of peaches in Pennsylvania. Proc. Amer. Soc. Hort. Sci. 69:126-130.

Feldstein, J. and N.F. Childers. 1965. Effects of irrigation on peaches in Pennsylvania. Proc. Amer. Soc. Hort. Sci. 87:145-153.

Finney, E.E. 1967. Dynamic elastic properties of some fruit during growth and development. J. Agri. Eng. Res. 12:249-256.

Fridley, R.B. and P.A. Adrian. 1966. Mechanical properties of peaches, pears, apricots and apples. Trans. Amer. Soc. Agri. Eng. 9:135-138.

Garner, J.C., S.E. Prussia, J.L. Jordan and R.L. Shewfelt. 1987. Postharvest quality of peaches after delays in cooling. Amer. Soc. Agri. Eng. paper no. 87-6521.

Gerber, J.F., J.D. Martsolf, and J.F. Bartholic. 1974. The climate of trees and vines. HortScience 9:569-572.

Ghadiri, H. and D. Payne. 1986. The risk of leaving the soil surface unprotected against falling rain. Soil and Tillage Res. 8:119-130.

Glenn, D.M. and W.V. Welker. 1989. Orchard soil management systems influence rainfall infiltration. J. Amer. Soc. Hort. Sci. 114:10-14.

Goode, J.E. and K.J. Hyrycz. 1976. The effect of nitrogen on young, newly-planted, apple rootstocks in the presence and absence of grass competition. J. Hort. Sci. 51:321-327.

Hand, J.M., E.Young and A.C. Vasconcelous. 1982. Leaf water potential, stomatal resistance, and photosynthetic response to water stress in peach seedlings. Plant Physiol. 69:1051-1054.

Havis, L. and J.H. Gourley. 1937. Soil organic matter and porosity of an orchard soil under different cultural systems. Soil Sci. 43:413-420.

Havis, L. 1941. Relation between soil organic matter and available moisture under different orchard cultural systems. Proc. Amer. Soc. Hort. Sci. 38:32-35.

Haynes, R.J. 1980. Influence of soil management practice on the orchard agro-ecosystem. Agro-Ecosystems 6:3-32.

Hendrickson, A.H. and F.J. Veihmeyer. 1934. Size of peaches as affected by soil moisture. Proc. Amer. Soc. Hort. Sci. 32:284-286.

Horton, B.D., E. J. Wehunt, J.H. Edwards, R.R. Bruce, and J.L. Chesnee. 1981. The effects of drip irrigation and soil fumigation on 'Redglobe' peach yields and growth. J. Amer. Soc. Hort. Sci. 106:438-443.

Hung, Y.C. and S.E. Prussia. 1989. Effect of maturity and storage time on the bruise susceptibility of peaches (cv. Redglobe). Trans. Amer. Soc. Agri. Eng. 32:1377-1382.

Johnson, D.S., G.R. Stinchcombe and K.G. Stott. 1983. Effect of soil management on mineral composition and storage quality of Cox's Orange Pippin apples. J. Hort. Sci. 58:317-326.

Klein, I. 1983. Drip irrigation based on soil matrix potential conserves water in peach and grape. HortScience 18:942-944.

Larson, K.D., T.M. DeJong, and R.S. Johnson. 1988. Physiological and growth responses of mature peach trees to postharvest water stress. J. Amer. Soc. Hort. Sci. 113:296-300.

Layne, R.E.C., C.S. Tan, and R.L. Perry. 1986. Characterization of peach roots in fox sand as influenced by sprinkler irrigation and tree density. J. Amer. Soc. Hort Sci. 111:670-677.

Layne, R.E.C. and C.S. Tan. 1984. Long-term influence of irrigation and tree density on growth, survival and production of peach. J. Amer. Soc. Hort. Sci. 109:795-799.

Layne, R.E.C. and C.S. Tan. 1988. Influence of cultivars, ground covers and trickle irrigation on early growth, yield, and cold hardiness of peaches in fox sand. J. Amer. Soc. Hort. Sci. 113:518-525.

Leyden, R.F. and P.W. Rohrbaugh. 1963. Protection of citrus trees from cold damage. J. Amer. Soc. Hort. Sci. 83:344-351.

Mitchell, P.D. and D.J. Chalmers. 1982. The effect of reduced water supply on peach tree growth and yields. J. Amer. Soc. Hort. Sci. 107:853-856.

Mitchell, P.D., P.H. Jerie and D.J. Chalmers. 1984. The effects of regulated water deficits on pear tree growth, flowering, fruit growth and yield. J. Amer. Soc. Hort. Sci. 109:604-606.

Mitchell, P.D., B. van den Ende, P.H. Jerie and D.J. Chalmers. 1989. Responses of 'Bartlett' pear to withholding irrigation, regulated deficit irrigation and tree spacing. J. Amer. Soc. Hort. Sci. 114:15-19.

Mitchell, P.D., D.J. Chalmers, P.H. Jerie and G. Burge. 1986. The use of initial withholding of irrigation and tree spacing to enhance the effect of regulated deficit irrigation on pear trees. J. Amer. Soc. Hort. Sci. 111:858-861.

Morris, J.R., A.A. Kattan, and E.H. Arrington. 1962. Response of 'Elberta' peaches to the interactive effects of irrigation, pruning and thinning. Proc. Amer. Soc. Hort. Sci. 80:177-189.

Murase, H. and G.E. Merva. 1977. Static elastic modulus of tomato epidermis as affected by water potential. Trans. Amer. Soc. Agri. Eng. 20:594-597.

Natali, S., C. Xiloyannis and B. Pezzarossa. 1985. Relationship between soil water content, leaf water potential and fruit growth during different fruit growing phases of peach trees. Acta Horticulturae 171:167-180.

Oosterhuis, D.M., M.J. Savage and S. Walker. 1983. Field use of in situ leaf psychrometers for monitoring water potential of soybean crop. Field Crops Res. 7:237-248.

Proebsting, E.L., J.E. Middleton, and S. Roberts. 1977. Altered fruiting and growth characteristics of 'Delicious' apple associated with irrigation method. HortScience 12:349-350.

Punthakey, J.F., M.J. McFarland and J.W. Worthington. 1984. Stomatal responses to leaf water potential of drip irrigated peach (Prunus persica). Trans. Amer. Soc. Agri. Eng. 27:1442-1450.

Reeder, B.D., J.S. Newman, and J.W. Worthington. 1979. Effect of trickle irrigation on peach trees. HortScience 14:36-37.

Reeves, J. and G. Cummings. 1970. The influence of some nutrient factor upon certain physical attributes of peach quality. J. Amer. Soc. Hort. Sci. 95:338-341.

Rogers, W.S., T.H. Raptopoulos, and D.W.P. Greenham. 1948. Cover crops for fruit plantations. IV. Long-term leys and permanent swards. J. Hort. Sci. 24:228-270.

Sharples, R.O. 1984. The influence of preharvest conditions on the quality of stored fruits. Acta Horticulturae 157:93-104.

Sharratt, B.S., G.A. Davis, E.N. Ashworth, and D.M. Glenn. 1989. Similarity of peach bud development and cold hardiness in orchards with different floor management practices. HortScience 24:699.

Sharratt, B.S. and D.M. Glenn. 1986. Orchard microclimatic observations in using soil-applied coal dust for frost protection. Agri. and For. Meteorology 38:181-192.

Shewfelt, R.L., S.C. Myers and A.V.A. Resurreccion. 1987. Effect of physiological maturity at harvest on peach quality during low temperature storage. J. Food Qual. 10:9-20.

Smith, M.W. and A.L. Kenworthy. 1979. The response of fruit trees in Michigan to trickle irrigation. Soil Sci. and Plant Anal. 10:1371-1380.

Turner, N.C., R.A. Spurway, and E.D. Schulze. 1984. Comparison of water potential measured by in situ psychrometry and pressure chamber in morphologically different species. Plant Phys. 73:316-319.

Uriu, K. 1964. Effect of post-harvest soil moisture depletion on subsequent yield of apricots. Proc. Amer. Soc. Hort. Sci. 84:93-97.

Welker, W.V. and D.M. Glenn. 1990. Peach tree growth as influenced by grass species used in a killed-sod planting system. HortScience 25:514-515.

Welker, W.V. and D.M. Glenn. 1989. Sod proximity influences growth and yield of young peach trees. J. Amer. Soc. Hort. Sci. 114:856-859.

Welker, W.V. and D.M. Glenn. 1988. Growth responses of young peach trees and changes in soil characteristics with sod and conventional planting systems. J. Amer. Soc. Hort. Sci. 113:652-656.

Welker, W.V. and D.M. Glenn. 1985. The relationship of sod proximity to the growth and nutrient composition of newly planted peach tree. HortScience 20:417-418.

Wells, A.W. 1962. Effects of storage temperature and humidity on loss of weight by fruit. U.S. Dept. Agri. Marketing Research Report 539.

Werner, R.A. and C. Frenkel. 1978. Rapid changes in firmness of peaches as influenced by temperature. HortScience 13:470-471.

Werner, R.A., L.F. Hough and C. Frenkel. 1978. Rehardening of peach fruit in cold storage. J. Amer. Soc. Hort. Sci. 103:90-91.

White, G.C. and R.I.C. Holloway. 1967. The influence of simazine or straw mulch on the establishment of apple trees in grassed down or cultivated soil. J. Hort. Sci. 42:377-389.

Xiloyannis, C., K. Uriu, and G.C. Martin. 1980. Seasonal and diurnal variations in abscisic acid, water potential, and diffusive resistance in leaves from irrigated and non-irrigated peach trees. J. Amer. Soc. Hort. Sci. 105:412-415.

Young, E., J.M. Hand, and S.C. Wiest. 1981. Diurnal variation in water potential components and stomatal resistance of irrigated peach seedlings. J. Amer. Soc. Hort. Sci. 106:337-340.2

CHAPTER II

EVALUATION OF IRRIGATION SCHEDULES AND ANNUAL RYEGRASS AS A GROUND COVER TO CONSERVE WATER AND CONTROL PEACH TREE GROWTH

Susan M. Huslig, Michael W. Smith, and Gerald H. Brusewitz
Department of Horticulture and Landscape Architecture
Oklahoma State University
Stillwater, Ok 74078

Additional index words: Prunus persica, peach, ground covers, water potential, postharvest storage.

Abstract: Irrigation schedules were evaluated on 'Cresthaven' to determine if water could be conserved without reducing fruit size or yield. Tensiometers were used to schedule trickle irrigation in 1984-88. Treatments were no irrigation or irrigation when soil matric potential reached 40 or 60 kPa 30 cm deep. When production began in 1986, trees were either irrigated until Oct. or until harvest (1-7 Aug.). In 1989, class A pan evaporation was used to schedule irrigation by replacing 60% evaporation. Trees were irrigated from budbreak to harvest or Oct., beginning at stage III fruit growth to harvest or Oct., or not irrigated. The irrigation treatments were in factorial combination with an annual ryegrass ground cover or herbicide-strip. The ryegrass was seeded in Oct., then killed at the onset of stage III fruit growth. Trunk diameter, canopy area, flower bud density, fruit set, total fruit yield and fruit size were determined yearly. Trees were mechanically hedged, then hand pruned and prunings weighed from each replication.Water application was reduced 24-36% when irrigation was discontinued after harvest compared to irrigation until Oct. Irrigation before bud break did not increase fruit yield or size, however, it did not increase shoot growth. Non-irrigated trees had smaller trunks than irrigated trees; however, there were no differences in trunk size among irrigation treatments. Non-irrigated trees yielded less total fruit and fruit over 70-mm diameter than trees irrigated until Oct. The annual ryegrass decreased amount of shoot growth in 1990 and flower bud density in 1991, however, annual ryegrass did not decrease fruit set. Flower bud density was not affected by irrigation treatments.

Introduction

Water is a scarce resource in many areas of the world, and management technologies to improve water conservation are necessary. Irrigation scheduling for peach production has been based on available soil moisture (Layne, et al.1986; Layne and Tan, 1984), soil matric potential (Klein, 1983; Horton et al., 1981), evaporation from a class A pan (Reeder, et al.,1979; Layne and Tan, 1988; Chalmers, et al. 1981), or "best guess" estimates. The first three methods provide a sound basis for irrigation requirements to produce healthy growth, with large fruit yields and fruit size. However, water conservation may be improved if irrigation schedules are developed that provide supplemental water only at critical times of fruit or tree growth, and adjust water application based on environmental conditions. Additionally, certain orchard floor management strategies may improve water conservation.

Peach trees produce abundant growth during the spring which shades the interior of the tree and increases the need for pruning. Irrigation during early spring may cause excess growth without benefiting fruit yield or size. Therefore, restricting irrigation during initial growth stage may conserve water and reduce shoot growth without detrimental affects on fruit production. Cool season ground covers may also be utilized to reduce early season growth, then killed to avoid competition with the tree as water becomes limiting. Additionally, the killed vegetation may act as a mulch, reducing evaporation from the soil.

Most studies have concentrated on improving marketable fruit yield, fruit size, and tree longevity with supplemental irrigation (Hendrickson and Veihmeyer, 1934;

Feldstein and Childers, 1965; Feldstein and Childers, 1957; Smith and Kenworthy, 1979). However, recent work has addressed water conservation in addition to tree performance. Mitchell et al. (1984) reported that pear fruit were smaller at the end of the first fruit growth stage when 46% of the evaporative losses from a class A pan were replaced by irrigation compared to 96% pan evaporation replacement. When trees in both treatments were increased to replace 100 and 120% of pan evaporation during the third stage of fruit growth, fruit growth was more rapid on trees receiving 46% pan evaporation replacement than those receiving 96%. At harvest there were no significant differences in fruit size among the irrigation treatments. Flower bud density was increased when 23% of pan evaporation was replaced before dry weight three (DW III) compared to 96% pan evaporation replacement.

Some studies have addressed problems associated with excessive growth which increases pruning costs, and may decrease fruit quality if shading is excessive. Regulated deficit irrigation (RDI) has been utilized to decrease shoot growth in the early spring without reducing yield (Layne and Tan, 1984; Chalmers et al., 1981). A RDI study in Australia, compared 100, 50, 25, or 12.5% pan evaporation replacement prior to fruit DW III and 130 or 100% pan evaporation replacement after DW III (Mitchell and Chalmers, 1982). Summer pruning weights were reduced by replacing 50, 25 or 12.5% pan evaporation replacement prior to DW III compared to 100% replacement. However, winter prunings were not affected.

Withholding irrigation while adequate moisture was available from the root zone did not reduce fruit growth or fruit size (Chalmers et al., 1986). In fact, when the withholding treatment was replaced by of 23 or 46% pan evaporation fruit growth was increased compared to the fully irrigated control in which 92% pan evaporation was replaced. In other studies similar effects were observed, withholding irrigation did not affect fruit growth or yield, and decreased shoot growth and water consumption compared to fully irrigated trees (Mitchell et al., 1986; Mitchell et al., 1989).

Horton et al. (1981) working in Georgia found that discontinuing irrigation after harvest (about 4 August) resulted in fruit yields and size similar to season long irrigation. Both irrigation through harvest and irrigation throughout the growing season were superior to no irrigation, or postharvest irrigation. Discontinuing irrigation after harvest reduced water application by 54% compared to irrigation throughout the growing season. Another study conducted in California reported that discontinuing irrigation after harvest increased return bloom and fruit set compared to applying 75 cm or 23 cm of water after harvest (13 June) (Larson, 1988). In contrast, other studies in the desert areas of California indicated that postharvest irrigation of apricots increased flower bud formation, fruit set, and yield (Brown, 1953; Uriu, 1964).

Rogers et al. (1948) reported soils under permanent grass sod lost moisture quicker and gained moisture more rapidly than cultivated soils. Soil organic matter content was greater than in cultivated treatments, but nitrogen availability for trees was reduced by grass sod. Mulching underneath the tree canopy with straw increased shoot growth, trunk diameter, soil moisture, leaf area and number, and fruit yield and size compared to permanent sod or herbicide treatments (Cockroft, 1966; White and Holloway, 1967; Baxter, 1970; Haynes, 1980). Bluegrass sod and a hay mulch with a low C:N ratio increased soil organic matter, stabilized soil structure, and increased soil moisture retention when compared to cultivated soils without reducing yield. Increasing organic matter content in soil increases soil moisture available to orchard crops (Havis and Gourley, 1937). Welker and Glenn (1990), showed that young trees benefit from herbicide killed 'Kentucky 31' fescue under the tree canopy. The killed 'Kentucky-31' sod increased soil organic matter concentration, had a greater soil microporosity, stabilized soil aggregates and increased water infiltration compared to cultivated or herbicide treated areas under the trees. Canopy area, total shoot growth and yield were increased compared to trees with cultivation. On radiation frost nights, orchard floor management systems have been found to affect the microclimate around trees thus, affecting flower bud loss. Sharratt and Glenn (1986) studied the difference between coal dust applied under the tree or grass plots. They found an increase of 0.5 C in bud temperature due to the increase in orchard temperature from the coal dust. Other studies on soil management practices also showed increases of 1 C in temperature (Rogers et al., 1948; Leyden and Rohrbaugh, 1963; Bridley et al., 19??; Gerber et al., 1974). However, this does not indicate survival rate of flower buds due to the increase in temperature. Sharratt et al., (1989) found that coal dust did not increase peach flower bud survival rate or cold hardiness of the bud compared to a grass cover plot.

The purpose of this study was to evaluate irrigation schedules and ground covers that conserve water and control tree growth without adversely affecting fruit size and fruit yield. Water application was initially regulated utilizing tensiometers, and later was scheduled using pan evaporation. Annual ryegrass or herbicide strips in the tree row were evaluated to determine their effect on tree performance.

Materials and Methods

This study was conducted at the Fruit Research Station near Perkins, Ok. The soil is a Teller sandy loam (fine-loamy, mixed, thermic, Udic Agiustolls; Mollisols). 'Cresthaven' trees were planted in 1984, and trickle irrigation was installed. Two 3.5 liter hr^{-1} emitters were installed, per tree, one on each side of the tree, 45 cm from the trunk. In 1986, two additional emitters were installed, 90 cm from the trunk. Total water applied was measured with totalizing flow meters.

Trees were trained to a three-scaffold open-center. Pest management followed Oklahoma State University recommendations for a commercial orchard (Taylor, 1990). Annual fertilization was based on leaf analysis. Fruit were thinned by hand each year when fruit diameter was about 10 mm to a density of about four fruit per meter of shoot growth. Strips 1.5 M wide on each side of the tree were maintained weed-free with herbicides until 1989 when ground cover treatments were incorporated into the study.

Irrigation 1984-88. Tensiometers were used to schedule irrigation from 1984-1988. Tensiometers were set in a triangle pattern 45 cm from the tree and emitters at 30 cm and 60 cm deep. Irrigation began when the soil matric potential reached either 40 or 60 kPa and was discontinued when the soil matric potential reached 10 kPa at the 30 cm level. The treatments were A) no irrigation, B) irrigation when matric potential reached 40 kPa, and C) irrigation when matric potential reached 60 kPa. There were four 8-tree replications per treatment in a randomized complete block design. All treatments were bordered with like treatments.

When fruit production began in 1986, trees were irrigated at the same soil matric potentials described earlier, and trees were either irrigated throughout the growing season (late March to October) or irrigation was discontinued after harvest (for 'Cresthaven' harvest is the first week in August). There were four 4-tree replications per treatment.

Irrigation 1989-91. In 1989 the treatments were altered. Irrigation was scheduled based on evaporation from a class A pan. Sixty percent of the pan evaporation was replaced on alternate days, except during 1990 growing season, when a freeze eliminated fruit production. In 1990, forty percent of the pan evaporation was replaced, and irrigation scheduling using fruit growth was based on 1989 data. The formula used to calculate water application was (mm of pan evaporation/1000 mm) * (canopy area in m^2) * (1000 liter/m^3) * (.60) = liters per tree (Reeder et al., 1979). Rainfall was considered 50% efficient, ie. one mm of rainfall = 0.5 mm of pan evaporation. The irrigation treatments were A) no irrigation, B) irrigation beginning at bud break and continuing through September, C) same irrigation schedule as B, except irrigation was discontinued after harvest, D) irrigation beginning at stage III fruit growth and continued through September, E) same treatment as D, except irrigation was discontinued after harvest.

Irrigation treatments were in factorial combination with two orchard floor management systems. One system utilized a permanent native sod between rows and 1.5 m herbicide strips on each side of the tree. The second was native sod between rows with annual ryegrass hand seeded during October in a 1.5 m strip on each side of the tree. The annual ryegrass was allowed to grow until the beginning of stage III fruit growth, then was killed with paraquat. Regrowth was treated with paraquat as required. Diameters of twenty fruit were measured weekly from each treatment beginning at fruit set to determine the stages of fruit growth.

Soil moisture was measured weekly utilizing a time domain reflectometer (Soil Moisture Equipment Corp., Santa Barbara, CA). Probes were set 30 cm deep and 45 cm from the trunk and emitter in a triangular pattern. Water potential was measured weekly with leaf-cutter psychrometers (J.R.D. Merrill, Logan, Utah) (Smith and Ager, 1988) between dawn and 10:00 a.m. during 1989 and before dawn in 1990 and 1991.

Fruit samples were harvested, divided into four size groups and weighed. Twenty fruit were collected randomly from each tree and analyzed for fruit firmness using the penetrometer (Effe-gi, 48011, Afolnsine, Italy) equipped with a 11 mm diameter probe. Total solids and soluble solids were measured using a hand refractometer (Bausch and Lomb, Abbe). Fruit exocarp color was measured on opposite sides using the colorimeter (Minolta Cr200, Ramsey, N.J.) using the A(red-green) axis band. Negative values of A indicate a green color and positive values indicate a red color.

Trunk diameter was measured 30 cm above the ground during the winter of each year and trunk cross-sectional area was calculated. Canopy area was determined by measuring the canopy in a north/south and east/west direction, then calculating area using the appropriate geometric form. Flower buds were counted and shoot length measured during November each year on 20 shoots per tree, and flower buds/meter of shoot growth were calculated. Fruit set was determined in a similar manner, prior to fruit thinning. Trees were mechanically hedged in March to 3 M tall and 3 M wide

(1987 first year hedged), then hand pruned to improve light penetration. Prunings were collected and weighed from each replication.

There were four 4-tree replications per treatment. The treatments were arranged into a split-plot design with irrigation treatments as the main plot and ground cover as the sub plot. Data were analyzed with analysis of variance with a mean separation by Duncan's multiple range test. The relationship between soil moisture and leaf water potential was determined by regression analysis.

Postharvest Storage. Two mature fruit with an exocarp color of the greenest area corresponding to the South Carolina color chip 4 (less ripe) and two fruit with an exocarp color of chip 6 (more ripe) were harvested from each tree in three treatments. The treatments selected for the postharvest study were no irrigation, irrigation beginning at budbreak until October, and irrigation beginning at stage III fruit growth until October. All irrigation treatments were those managed with herbicide strips. The fruit were immediately taken to the lab. Six cores were cut from each fruit using a cork borer. The cores (mesocarp) were then trimmed to the same length using a razor blade, individually weighed and placed in mannitol solutions from 0M to 0.9M for 2 hours to determine the water potential (Salisbury and Ross, 1985). After the cores came to equilibrium they were blotted dry and individually weighed, and water potential determined using regression analysis.

Sixteen fruit from each of the treatments mentioned above were collected corresponding to color chip 4 and 6. The fruit were placed into storage at 2 C and 90% RH. After 3, 6, 9, 12, 16, or 20 days of storage the fruit removed, and allowed to warm to 23 C before uniaxial compression and drop impact parameters were measured. The uniaxial compression test measured bioyield force (N) by a modified Effe-gi that controlled the rate of force application. The 8 mm probe was mounted in an Instron universal testing machine. Drop impact parameters were measured by an impact force transducer. An apparatus held each fruit by a vacuum, until the vacuum was interrupted and the peach then fell 150 mm onto piezoelectric force transducer. The data were collected by a digital oscilloscope and transmitted to a microcomputer for data analysis (Brusewitz and Bartsch, 1989). The impact parameters computed include energy absorbed (% of applied energy), impact contact time (ms), peak force/time-to-peak force (N/ms) and skewness. Energy absorbed refers to the amount of energy absorbed by the fruit during the impact. Contact time is the amount of time the fruit is in direct contact with the transducer. Peak force is the maximum force incurred during the fruit's impact. Skewness of the impact force vs time in contact with the transducer is the degree of asymmetry from a normal distribution (a positive value indicates skewness to the right of the normal distribution). A softer fruit has a longer contact, a higher % absorbed energy, lower peak force/time-to-peak force and higher skewness number.

Results

Irrigation 1984-88. Irrigation beginning when the soil reached 60 kPa decreased water applied by 27-37% compared to irrigation beginning at 40 kPa from 1985-1988 (Table 1). During 1987-1988, discontinuing irrigation after harvest decreased water applied by 40-60% compared to irrigating until October.

Trunk cross-sectional area was not affected during the first growing season by irrigation treatments (Fig. 1). In 1986, non-irrigated trees had smaller trunk areas than irrigated trees. As tree age increased differences in trunk cross-sectional area between the irrigated and non-irrigated treatments increased; however, there were no significant differences in trunk area among irrigated trees. There were no significant differences in total fruit yield the first 2 years of production regardless of irrigation treatment (Table 2). However, non-irrigated trees produced fewer fruit larger than 70 mm in diameter than irrigated trees.

Peaches from non-irrigated trees weighed less than peaches from trees irrigated beginning at budbreak until October at 40 kPa, or 60 kPa, or irrigation beginning at budbreak to harvest at 60 kPa (Table 3). There were no significant differences in fruit firmness in 1988; however, there were significant differences in fruit color (Table 3). Peaches from trees irrigated at 60 kPa had more red coloring (positive or smaller negative numbers) than peaches from trees irrigated at 40 kPa (larger negative numbers).

Irrigation 1989-91. Supplemental irrigation rates increased with tree age, until 1989 when rainfall from May through October was above normal (Table 1). In 1989, above normal rainfall with uniform distribution throughout the growing season reduced irrigation application to three times during the growing season (Fig. 2a). There was no crop in 1990, and 40% rather than 60% of the evaporation from the class A pan was replaced by irrigation. Irrigation based on fruit development for 1990 utilized data obtained from 1989. Trees were not irrigated until after stage III of fruit growth based on pan evaporative losses (Fig. 3a). During 1991, irrigation replaced 60% of pan evaporation because there was a full crop. Although rainfall was higher during the spring of 1991 (Fig. 4a) than 1990 (Fig. 3a) trees were irrigated three times before the beginning of stage III fruit growth. Higher evaporation rates during 1991 than 1990 dictated the water applications. Also, rainfall frequently occurred soon after irrigation, negating its value. Trees were only irrigated prior to stage III fruit growth one year (1991) during the study based on soil moisture (1984-1988) or pan evaporation (1989-1991). Trees irrigated until October required 24% more water in 1988, 34% more water in 1989 and 32-36% more water in 1991 than those trees where irrigation was discontinued after harvest (Table 1).

In 1989, trees irrigated until October yielded significantly more fruit than the non-irrigated trees (Table 2). Trees in which irrigation was discontinued after harvest were intermediate in total yield. Trees irrigated until October yielded more fruit 64-70 mm in diameter than non-irrigated trees during 1989. In 1991, trees irrigated from budbreak until October produced more fruit 64-70 mm in diameter than non-irrigated trees, but total yield and fruit weight in the other size categories was not affected.

There were no significant differences in fruit weight, fruit firmness, fruit color, soluble solids or total solids among irrigation treatments during 1991 (Table 4).

Flower bud density and fruit set were not affected by irrigation treatments during 1989-1992 (Table 5). Differences between 1989 and 1991 fruit set reflect the freeze damage suffered during 1989. However, fruit set in 1989 exceeded the optimum crop load (4 fruit/m), thus thinning was required during 1989 and 1991. In 1991, there was a slight increase in fruit derived from multiple carpels on non-irrigated trees (1.3

fruit/m) compared to irrigated trees (0.9 flowers/m); however, the differences were not significant (Table 5).

During 1989, because of the high rainfall received throughout the year, there were few significant differences in soil matric potential or leaf water potential among irrigation treatments (Fig. 2b and 2d). During 1990, available soil moisture was lower on non-irrigated trees than irrigated trees during stage III fruit growth (Fig. 3b); however, there were no significant differences in leaf water potential (Fig. 3d). Available soil moisture dropped to levels near the non-irrigated treatment when irrigation was discontinued after the normal harvest time in 1990. However, on the treatments in which irrigation was continued, available soil moisture remained above non-irrigated values. No differences in leaf water potential were observed during the 1990 growing season (Fig. 3d).

In 1991, there were few differences in soil moisture prior to stage III fruit growth (Fig. 4b). During stage III of fruit growth soil moisture was usually greater in irrigated than non-irrigated treatments. After harvest, the treatments continuing to receive irrigation had higher soil moisture content than non-irrigated treatments until rainfall in September increased soil moisture of all treatments. There were few significant differences in leaf water potential among irrigation treatment during 1991 (Fig. 4d).

Leaf water potential was highly correlated to available soil moisture (R^2 0.84) (Fig. 5). This relationship between leaf water potential and available soil moisture explains the lack of differences in leaf water potential among irrigation treatments (Figs. 2d, 3d, and 4d). Leaf water potential was insensitive to changes in available soil moisture between 14 and 23%. Above 24% available soil moisture, leaf water potential increased rapidly, and below 14% available soil moisture, leaf water potential declined rapidly. In this study, soil moisture in irrigated and non-irrigated treatments was usually between 14% and 24% available soil moisture.

Irrigation treatments did not affect pruning weights during 1989 or 1990 (Table 6). Leaf elemental concentrations of N, P, K, Ca, Mg, Zn, Fe and Mn were not affected by irrigation treatments (Appendix A).

Annual ryegrass as a ground cover did not affect total fruit yield during 1989 or 1991 (Table 7). In fact, during these years trees with annual ryegrass as a ground cover produced fewer small peaches (57-63 mm diameter) than the herbicide treatments. In 1991, trees with annual ryegrass as a ground cover produced more peaches larger than 70 mm in diameter and fewer peaches with diameters less than or equal to 63 mm in diameter than herbicide treatments.

Annual ryegrass did not affect pruning weights in 1989; however, in 1990 annual ryegrass decreased pruning weights (Table 6). Soil moisture was generally not affected by soil management during 1989 due to the high rainfall (Figs. 2a and 2c).

During 1990, soil moisture was lower with an annual ryegrass ground cover than herbicide strips until the annual ryegrass was killed at the beginning of stage III fruit growth (Fig. 3c). After the beginning of stage III, soil moisture was greater in the killed annual ryegrass plots than the herbicide plots (julian date 160 to 194). This suggests water infiltration was greater in the killed annual ryegrass plots than the herbicide treated plots, and/or the killed annual ryegrass acted as a mulch decreasing water loss from the soil. Because of the large rainfall amounts and unusual cool weather beginning at julian day 202 germination of the annual ryegrass occurred depleting, soil moisture during this period.

In 1991, annual ryegrass affected soil moisture until the annual ryegrass was killed at the beginning of stage III fruit growth at julian day 172 (Fig. 4c). Soil moisture in the killed annual ryegrass plots remained higher than the herbicide plots until high rainfall occurred during September and increased the soil moisture of both plots.

Annual ryegrass increased fruit weight compared to the herbicide treatment during 1991 (Table 4). Fruit firmness, fruit color, soluble and total solids were not affected by ground cover treatments.

Flower bud density was not affected by ground cover treatments, except in 1991 (Table 5). Annual ryegrass reduced flower bud density compared to herbicide treatments. However, fruit set was not decreased during 1991 or any other year.

Leaf elemental concentrations were not effected by soil management systems (Appendix B). Soil management systems also did not affect leaf water potentials during 1989-91 (Appendix C, D, and E).

Postharvest Storage. Irrigation treatments did not affect postharvest measurements of uniaxial compression (Fig. 6) or drop impact parameters (Appendix F). There were however, significant differences for maturity of fruit in uniaxial compression (Fig. 6) and drop impact parameters (Appendix G). The less ripe fruit, (4) as determined by the South Carolina color chip, had a higher bioyield force indicating a firmer fruit than the more ripe fruit (6) (Fig. 6). However, irrigation beginning at budbreak, stage III fruit growth, or no irrigation did not affect bioyield force. From the drop impact tests the less ripe fruit had a lower impact contact time and absorbed energy; indicating a firmer fruit (Appendix G). Water potential was not affected by preharvest irrigation scheduling (Fig. 7). There were also no significant differences among fruit water potentials of the two levels of fruit ripenesses.

Discussion

Irrigation based on evaporation from a class A pan had several advantages compared to using tensiometers. First, tensiometers required extensive maintenance for accurate readings. The vacuum on the water column inside the tensiometer plus high summer temperatures caused water loss from the tensiometers requiring frequent maintenance. Tensiometers, also required calibration at least once a year, with the replacement of many vacuum gages. These problems limit tensiometer's effectiveness, especially for growers, since they have a high labor requirement and are subject to error unless accurately calibrated. Pan evaporation rates can be measured at the site or some areas of the U.S. weather stations report evaporation rates, and are easily accessible by the growers. One problem experienced with the class A pan is the incorporation of rainfall into the equation to schedule irrigation. If the rainfall intensity did not exceed the soil intake rate then rainfall could be subtracted from evaporation to determine water application rates. However, in Oklahoma rainfall normally occurs with high intensities in thunderstorms; therefore, rainfall rate exceeds the soil intake which causes runoff. We considered rainfall 50% efficient to partially adjust for runoff.

Irrigation increased fruit size during most years and occasionally increased yield compared to no irrigation. Trunk cross-sectional area of irrigated trees were larger than non-irrigated trees; however, there were no significant differences in trunk cross-sectional area among irrigation treatments.

Irrigation before stage III of fruit growth was unnecessary in this study because of adequate rainfall which allowed water to be conserved during the early spring. Flower bud density, fruit set, fruit yield and fruit size were not affected by irrigation prior to stage III of fruit growth compared to irrigation beginning at stage III fruit growth. Similar studies in Australia observed that fruit growth and size were not affected by withholding irrigation prior to stage III of fruit growth while moisture reserves were available (Chalmers et al., 1986; Mitchell et al., 1986; Mitchell et al., 1989). However, Chalmers et al. (1981) concluded that reduced irrigation during stage II fruit growth combined with high tree density increased fruit yield and size up to 30%, which did not occur during this study. Mitchell et al. (1984) reported that flower bud density and fruit set of pear were increased by restricted irrigation prior to stage III fruit growth compared to full irrigation prior to stage III. Irrigation prior to stage III of fruit growth increased summer tree pruning weights. Other regulated deficit irrigation studies in Australia also reported irrigation before stage III increased tree summer pruning weights (Chalmers et al., 1986; Mitchell et al., 1986; Mitchell et al., 1989). However, winter pruning weights were not affected. Results of this study and those of others suggest that irrigation before stage III of fruit growth is of no benefit in increasing fruit yield or size. Withholding irrigation prior to stage III of fruit growth was effective in Australia in reducing summer pruning weights, but was ineffective in reducing winter pruning weights. In this study pruning weights were not affected by irrigation treatments.

Irrigation did not affect fruit firmness, soluble solids, uniaxial compression, drop impact parameters, or water potentials of peach fruit stored at 2 C for selected periods. This indicates that reduced irrigation schedules did not adversely affect fruit quality. However, De Baerdemaeker and Lemaitre (1979) found that fruit from non-irrigated pear trees had a rapid decline in elastic modulus and failure stress after 30 days of storage at 3.5 C. They also observed that preharvest irrigation schedules did not affect pear fruit water potential.

Flower bud density, fruit set, and tree pruning weights were not affected by discontinuing irrigation after harvest on 'Cresthaven', a mid-season cultivar. Therefore, discontinuing irrigation after harvest appears to be an effective method to conserve water without affecting yield potential on mid-season and late-season cultivars. These results agree with those in Georgia in which peach trees that received irrigation until harvest were superior in yield compared to no irrigation or postharvest irrigation (Horton et al., 1981). However, other studies have reported that no postharvest irrigation increased flower bud density and fruit set (Larson et al., 1988) and others that no postharvest irrigation decreased flower bud density (Brown, 1953; Uriu, 1964). The severity of drought stress could explain the differences among these studies.

Fruit yield was only affected during 1989 when trees that received irrigation until harvest were intermediate in yield compared to non-irrigated trees and trees irrigated until October. Fruit size was not significantly different among irrigated trees in 1989 and 1991. Horton et al. (1981) in California, reported similar results, irrigation discontinued after harvest did not affect peach fruit yield or size compared to irrigation all season.

Irrigation schedules did not affect the number of fruit derived from multiple carpels. However, Handley et al. (1989) observed that deficit irrigation in which 25% of evaporation from a class A pan was replaced with irrigation increased the number of fruit from multiple carpels.

For Oklahoma and areas with similar climatic conditions, an irrigation schedule that would conserve water without adversely affecting tree performance would begin at stage III of fruit growth and end after harvest. This schedule reduced water application 24-44% compared to conventional irrigation scheduling from budbreak to October.

Annual ryegrass decreased pruning weights compared to herbicide treatments. Therefore, annual ryegrass could reduce the amount of time and resources needed to prune trees. Studies have shown that a grass ground cover could initially decrease shoot growth and trunk girth increment, but this effect gradually decreased as trees became older compared to clean cultivation and mulching (Bould and Jarrett, 1962). However, in the current study, the trees were fully mature and the ground cover was not competitive with the tree after the annual ryegrass was killed before stage III of fruit growth. Leaf elemental concentrations were not affected by annual ryegrass, this indicates that tree competition with annual ryegrass was minimal, and no additional nitrogen would be required with this ground cover, as suggested by other studies when using a permanent competitive cover (Rogers et al., 1948; Bould and Jarrett, 1962; Goode and Hyrycz, 1976).

Flower bud density and fruit set were not affected by annual ryegrass except in 1991. Annual ryegrass decreased flower bud density significantly during 1991; however, fruit set during 1991 was unaffected. Therefore, annual ryegrass did not decrease the orchard microclimate sufficiently enough to reduce fruit set, compared to the herbicide strips. Sharratt et al. (1989) found that a grass sod did decrease orchard temperature however, the decrease was not significant enough to reduce flower bud survival rate compared to coal dust treated strips.

Annual ryegrass improved soil moisture retention after being killed at stage III of fruit growth by acting as a mulch and/or increasing water infiltration during 1990 and 1991. Other studies have indicated that a grass cover or mulch can increase rainfall infiltration, thus, improving soil moisture (Havis, 1937; Rogers et al., 1948; Havis, 1941; Welker and Glenn, 1990).

Trees with annual ryegrass produced more fruit of larger size and fewer fruit of smaller size than trees with the herbicide treatment. Fruit weight was also increased by annual ryegrass plots compared to herbicide treated plots. This effect could be due to soil moisture retention of the annual ryegrass during stage III of fruit growth compared to the herbicide plots. Yield was not affected by annual ryegrass. However, regrowth of annual ryegrass must be avoided until after stage III of fruit growth when trees require large quantities of water.

LITERATURE CITED

Bridley, S.F., R.J. Taylor, and R.T. Webber. 1965. The effects of irrigation and rolling on nocturnal air temperature in vineyards. Agri. Meteorology 2:373-383.

Baxter, P. 1970. Orchard soil management trials. 1. Effect of a weed-free or straw mulched strip on the growth and yield of young fruit trees. Aust. J. Expt. Agri. and Animal Hus. 10:467-473.

Bould, C. and R.M. Jarrett. 1962. The effects of cover crops and N P K fertilizers on growth, crop yield and leaf nutrient status of young dessert apples. J. Hort. Sci. 37:58-82.

Brown, D.S. 1953. The effects of irrigation on flower bud development and fruiting in the apricot. Proc. Amer. Soc. Hort. Sci. 61:119-124.

Brusewitz, G.H. and J.A. Bartsch. 1989. Impact parameters related to postharvest bruising of apples. Trans. Amer. Soc. Agri. Eng. 32:953-957.

Chalmers, D.J., G. Burge, P.H. Jerie, and P.D. Mitchell. 1986. The mechanism of regulation of 'Bartlett' pear fruit and vegetative growth by irrigation withholding and regulated deficit irrigation. J. Amer. Soc. Hort. Sci. 111:904-907.

Chalmers, D.J., P.D. Mitchell, and L. van Heek. 1981. Control of peach tree growth and productivity by regulated water supply, tree density, and summer pruning. J. Amer. Soc. Hort. Sci. 106:307-312.

Cockroft, B. 1966. Soil management of peach trees in the Goulburn Valley, Victoria. Aust. J. Expt. Agri. and Animal Hus. 6:62-65.

De Baerdemaeker, J. and L. Lemaitre. 1979. Water supply and mechanical properties of agricultural crops. pp. 280-284. In P. Linko (ed). Food Process Engineering. vol.1. Food processing systems Applied Sci. Pub. LTD.

Feldstein, J. and N.F. Childers. 1957. Effect of irrigation on fruit size and yield of peaches in Pennsylvania. Proc. Amer. Soc. Hort. Sci. 69:126-130.

Feldstein, J. and N.F. Childers. 1965. Effects of irrigation on peaches in Pennsylvania. Proc. Amer. Soc. Hort. Sci. 87:145-153.

Gerber, J.F., J.D. Martsolf, and J.F. Bartholic. 1974. The climate of trees and vines. HortScience 9:569-572.

Goode, J.E. and K.J. Hyrycz. 1976. The effect of nitrogen on young, newly-planted apple rootstocks in the presence and absence of grass competition. J. Hort. Sci. 51:321-327.

Handley, D., R.S. Johnson, and D.A. Goldhamer. 1989. Doubling of peaches as a response to water deficit. HortScience 141:502. (Abstr.)

Havis, L. and J.H. Gourley. 1937. Soil organic matter and porosity of a orchard soil under different cultural systems. Soil Sci. 43:413-420.

Havis, L. 1941. Relation between soil organic matter and available moisture under different orchard cultural systems. Proc. Amer. Soc. Hort. Sci. 38:32-35.

Haynes, R.J. 1980. Influence of soil management practice on the orchard agro-ecosystem. Agro-Ecosystems 6:3-32.

Hendrickson, A.H. and F.J. Veihmeyer. 1934. Size of peaches as affected by soil moisture. Proc. Amer. Soc. Hort. Sci. 32:284-286.

Horton, B.D., E. J. Wehunt, J.H. Edwards, R.R. Bruce, and J.L. Chesnee. 1981. The effects of drip irrigation and soil fumigation on 'Redglobe' peach yields and growth. J. Amer. Soc. Hort. Sci. 106:438-443.

Klein, I. 1983. Drip irrigation based on soil matrix potential conserves water in peach and grape. HortScience 18:942-944.

Larson, K.D., T.M. DeJong, and R.S. Johnson. 1988. Physiological and growth responses of mature peach trees to postharvest water stress. J. Amer. Soc. Hort. Sci. 113:296-300.

Layne, R.E.C., C.S. Tan, and R.L. Perry. 1986.Characterization of peach roots in fox sand as influenced by sprinkler irrigation and tree density. J. Amer. Soc. Hort Sci. 111:670-677.

Layne, R.E.C. and C.S. Tan. 1984. Long-term influence of irrigation and tree density on growth, survival and production of peach. J. Amer. Soc. Hort. Sci. 109:795-799.

Layne, R.E.C. and C.S. Tan. 1988. Influence of cultivars, ground covers and trickle irrigation on early growth, yield, and cold hardiness of peaches in fox sand. J. Amer. Soc. Hort. Sci. 113:518-525.

Leyden, R.F. and P.W. Rohrbaugh. 1963. Protection of citrus trees from cold damage. J. Amer. Soc. Hort. Sci. 83:344-351.

Mitchell, P.D., D.J. Chalmers, P.H. Jerie and G. Burge. 1986. The use of initial withholding of irrigation and tree spacing to enhance the effect of regulated deficit irrigation on pear trees. J. Amer. Soc. Hort. Sci. 111:858-861.

Mitchell, P.D. and D.J. Chalmers. 1982. The effect of reduced water supply on peach tree growth and yields. J. Amer. Soc. Hort. Sci. 107:853-856.

Mitchell, P.D., B. van den Ende, P.H. Jerie and D.J. Chalmers. 1989. Responses of 'Bartlett' pear to withholding irrigation, regulated deficit irrigation and tree spacing. J. Amer. Soc. Hort. Sci. 114:15-19.

Mitchell, P.D., P.H. Jerie and D.J. Chalmers. 1984. The effects of regulated water deficits on pear tree growth, flowering, fruit growth and yield. J. Amer. Soc. Hort. Sci. 109:604-606.

Reeder, B.D., J.S. Newman, J.W. Worthington. 1979. Effect of trickle irrigation on peach trees. HortScience. 14:36-37.

Rogers, W.S., T.H. Raptopoulos, and D.W.P. Greenham. 1948. Covercrops for fruit plantations. IV. Long-term leys and permanent swards. J. Hort. Sci. 24:228-270.

Salisbury, F.B. and C.W. Ross. 1985. Plant Physiology. p. 39-43. 3rd ed. In: F.B. Salisbury and C.W. Ross (eds.). Osmosis. Wadsworth Publishing Co., Belmont California.

Sharratt, B.S. and D.M. Glenn. 1986. Orchard microclimatic observations in using soil applied coal dust for frost protection. Agri. and For. Meteorology. 38:181-192.

Sharratt, B.S., G.A. Davis, E.N. Ashworth, and D.M. Glenn. 1989. Similarity of peach bud development and cold hardiness in orchards with different floor management practices. HortScience 24:699.

Smith, M.W. and P.L. Ager. 1988. Effects of soil flooding on leaf gas exchange of seedling pecan trees. HortScience. 23:370-372.

Smith, M.W. and A.L. Kenworthy. 1979. The response of fruit trees in Michigan to trickle irrigation. Soil Sci. and Plant Anayl. 10:1371-1380.

Taylor, G. 1990. Annual pruning of fruit trees. OSU Ext. Facts. No. 6228.

Uriu, K. 1964. Effect of postharvest soil moisture depletion on subsequent yield of apricots. Proc. Amer. Soc. Hort. Sci. 84:93-97.

Welker, W.V. and D.M. Glenn. 1990. Peach tree growth as influenced by grass species used in a killed-sod planting system. HortScience 25:514-515.

White, G.C. and R.I.C. Holloway. 1967. The influence of simazine or straw mulch on the establishment of apple trees in grassed down or cultivated soil. J. Hort. Sci. 42:377-389.

Table 1. Influence of Irrigation Treatments on Fruit Size and Yield.

Treatment	Fruit diameter (mm) >70	64-70	57-63	<57	Total yield (T/ha)
		1987			
None	0.32a[z]	0.55a	0.23a	0.05a	1.16a
Budbreak to Oct. 40 kPa	0.69a	0.79a	0.23a	0.06a	1.78a
Budbreak to Oct. 60 kPa	0.34a	0.64a	0.19a	0.05a	1.22a
Budbreak to harv. 40 kPa	0.64a	0.90a	0.19a	0.07a	1.81a
Budbreak to harv. 60 kPa	0.33a	0.45a	0.05a	0.02a	0.84a
		1988			
None	2.86b	5.41a	3.37a	1.66a	13.30a
Budbreak to Oct. 40 kPa	6.13a	5.57a	4.09a	1.63a	17.42a
Budbreak to Oct. 60 kPa	6.89a	5.18a	3.39a	1.34a	16.80a
Budbreak to harv. 40 kPa	6.55a	5.61a	4.45a	1.66a	18.26a
Budbreak to harv. 60 kPa	6.76a	4.69a	2.67a	1.50a	15.62a
		1989			
None	8.40a	9.78b	7.06a	3.54a	28.78b
Budbreak to Oct.	12.00a	12.24a	8.20a	3.21a	35.64a
Budbreak to harv.	12.55a	11.32ab	6.69a	2.90a	33.46ab
Stage III to Oct.	13.23a	12.20a	7.90a	3.14a	36.39a
Stage III to harv.	11.41a	10.95ab	7.43a	2.74a	32.53ab
		1991			
None	1.11a	5.82b	17.95a	2.63a	27.51a
Budbreak to Oct.	3.17a	7.04ab	17.48a	1.80a	29.49a
Budbreak to harv.	3.12a	9.56a	17.77a	1.75a	32.20a
Stage III to Oct.	2.92a	7.05ab	16.26a	2.22a	28.46a
Stage III to harv.	3.58a	7.37ab	14.53a	1.43a	26.90a

[z] Mean separation within column and year by Duncan's multiple range test, 5% level.

Table 2. Summary of Irrigation and Rainfall Amounts by Year.

	Water applied (liter/tree)								
	Irrigation treatment								Rainfall
	Budbreak to Oct.		Budbreak to harv.						May
					Budbreak	Budbreak	Stage III	Stage III	to Oct.
Year	40 kPa	60 kPa	40 kPa	60 kPa	to Oct.	to harv.	to Oct.	to harv.	(mm)
1985	1549	1036	---	---	---	---	---	---	740
1986	1986	1405	---	---	---	---	---	---	644
1987	3689	2687	1682	1055	---	---	---	---	648
1988	8447	5253	5041	2823	---	---	---	---	515
1989	---	---	---	---	454	345	454	345	760
1990	---	---	---	---	4239	2809	4239	2809	425
1991	---	---	---	---	5345	3644	4677	2977	479

Table 3. Influence of Irrigation Treatments on Fruit Weight, Fruit Firmness and Fruit Color in 1988.

Treatment	Fruit weight (g)	Fruit firmness (kg)	Fruit exocarp color (A value)
None	118c[z]	13.2a	-2.71b
Budbreak to Oct. 40 kPa	136ab	11.5a	-2.06b
Budbreak to Oct. 60 kPa	146a	12.9a	0.14a
Budbreak to harv. 40 kPa	126bc	10.4a	-2.26b
Budbreak to harv. 60 kPa	139ab	12.1a	-0.16a

[z] Mean separation within columns by Duncan's multiple range test, 5% level.

Table 4. Influence of Irrigation and Ground Cover Treatments on Fruit Weight, Fruit Firmness, Fruit Color, Fruit Soluble Solids and Total Solids in 1991.

Treatment	Fruit weight (g)	Fruit firmness (kg)	Fruit exocarp color (A value)	Soluble solids (%)	Total solids (%)
		Irrigation treatments			
None	125a	7.9a	5.5a	12.4a	14.2a
Budbreak to Oct.	128a	8.2a	7.1a	11.5a	14.0a
Budbreak to harv.	135a	8.4a	5.9a	12.5a	13.3a
Stage III to Oct.	154a	10.3a	7.5a	11.5a	13.0a
Stage III to harv.	138a	7.7a	7.7a	11.7a	12.9a
		Ground cover treatment			
None	129a[y]	8.1a	6.1a	11.8a	13.6a
Ryegrass	146b	8.9a	7.6a	12.0a	13.3a

[z] Mean separation within columns by Duncan's multiple range test, 5% level.

[y] Mean separation within columns by Fisher's F-test, 5% level.

Table 5. Influence of Irrigation and Ground Cover Treatments on Flower Buds and Fruit Set During 1989-92, and Fruit With Multiple Carpels in 1991.

	Flower buds/m				Fruit/m		Fruit from Multiple carpels, 1991
Treatment	1989	1990	1991	1992	1989	1991	(Fruit/m)
			Irrigation treatment				
None	58a[z]	47a	60a	41a	6a	35a	1.3a
Budbreak to Oct.	57a	50a	61a	41a	6a	37a	0.8a
Budbreak to harv.	63a	55a	58a	41a	6a	36a	0.9a
Stage III to Oct.	55a	54a	57a	41a	6a	34a	0.9a
Stage III to harv.	60a	66a	61a	41a	6a	36a	0.9a
			Ground cover treatment				
None	58a[y]	52a	61a	41a	6a	36a	1.0a
Ryegrass	59a	59a	58b	40a	6a	35a	0.9a

[z] Mean separation within columns by Duncan's multiple range test, 5% level.

[y] Mean separation within columns by Fisher's F-test, 5% level.

Table 6. Influence of Irrigation and Ground Cover Treatments on Tree Pruning Weights.

	Pruning wt. (kg/tree)	
Treatment	1989	1990
Irrigation treatments		
None	10.1a[z]	14.7a
Budbreak to Oct.	11.1a	17.1a
Budbreak to harv.	12.2a	17.7a
Stage III to Oct.	11.6a	17.7a
Stage III to harv.	11.2a	15.7a
Ground cover treatment		
None	11.0a	17.7a
Ryegrass	11.5a	15.4b

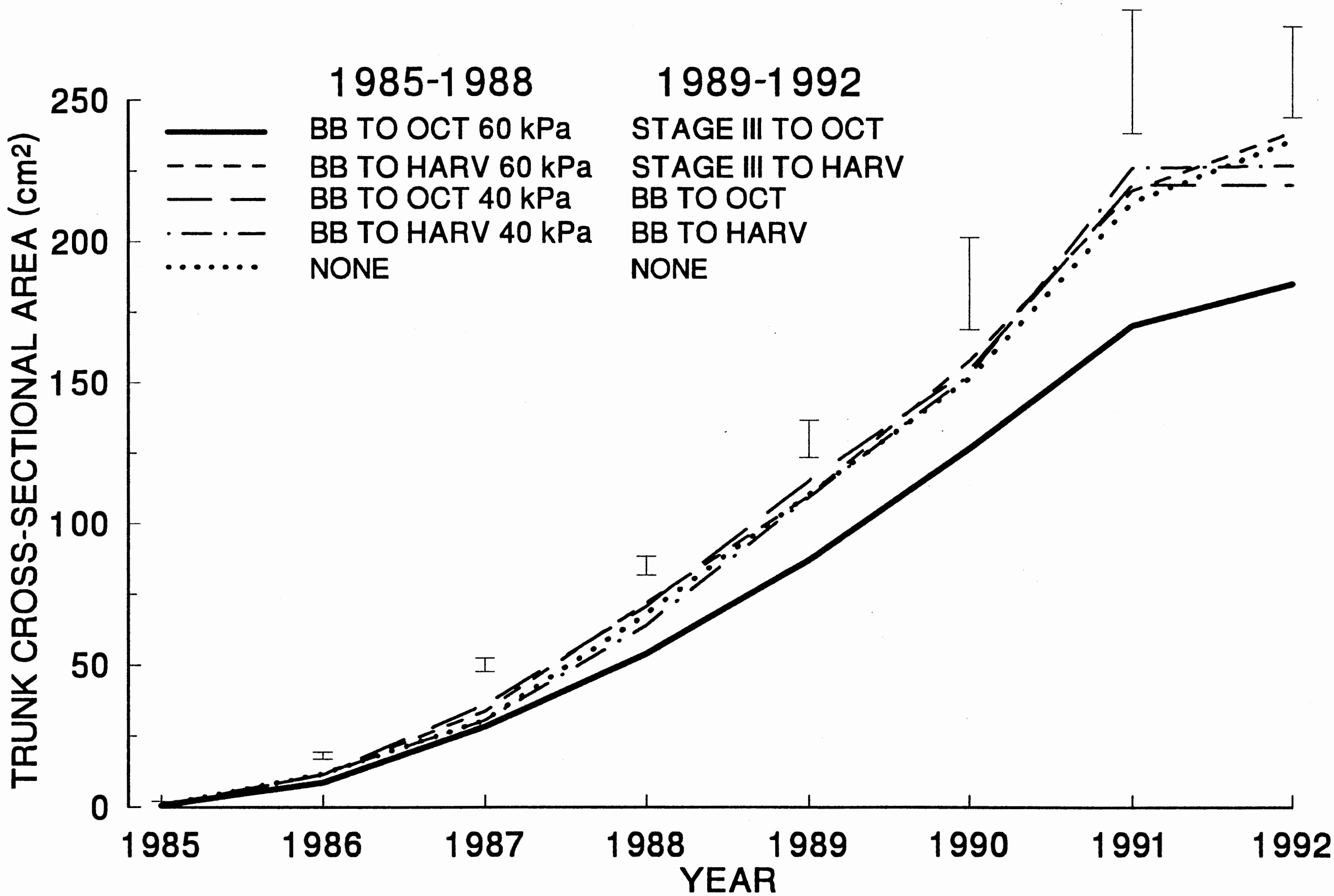
[z] Mean separation within year and main-effect treatment by Duncan's multiple range test, 5% level.

Table 7. Influence of Ground Cover Treatments on Fruit Size and Yield.

	Fruit weight (T/ha)				
	Fruit diameter (mm)				Total yield
Ground cover	>70	64-70	57-63	<57	(T/ha)
		1989			
None	10.97a[z]	11.95a	8.34a	3.41a	34.69a
Ryegrass	12.07a	10.64a	6.56b	2.79a	32.06a
		1991			
None	1.76b	6.69a	19.58a	2.47a	30.50a
Ryegrass	3.91a	8.15a	13.89b	1.39b	27.34a

[z] Mean separation within column and year by Fisher's F-test, 5% level.

Figure 1. Influence of Irrigation Treatments on Trunk Cross-Sectional Area from 1985-1992 Measured 30 cm Above the Ground. Vertical Bars Indicate LSD 0.05.



1985-1988
1989-1992
BB TO OCT 60 kPa
STAGE III TO OCT
BB TO HARV 60 kPa
STAGE III TO HARV
BB TO OCT 40 kPa
BB TO OCT
BB TO HARV 40 kPa
BB TO HARV
NONE
NONE
TRUNK CROSS-SECTIONAL AREA (cm2)
0
50
100
150
200
250
1985
1986
1987
1988
1989
1990
1991
1992
YEAR

Figure 2. Irrigation Application and Rainfall Amounts (A), Soil Matric Potential of Irrigation Treatments (B), Soil Matric Potential of Ground Cover Treatments (C), and Early Morning Leaf Water Potential of Irrigation Treatments (D) Measured During 1989 from May 1 (julian date 120) to October 1 (julian date 270) on 'Cresthaven' Peaches.

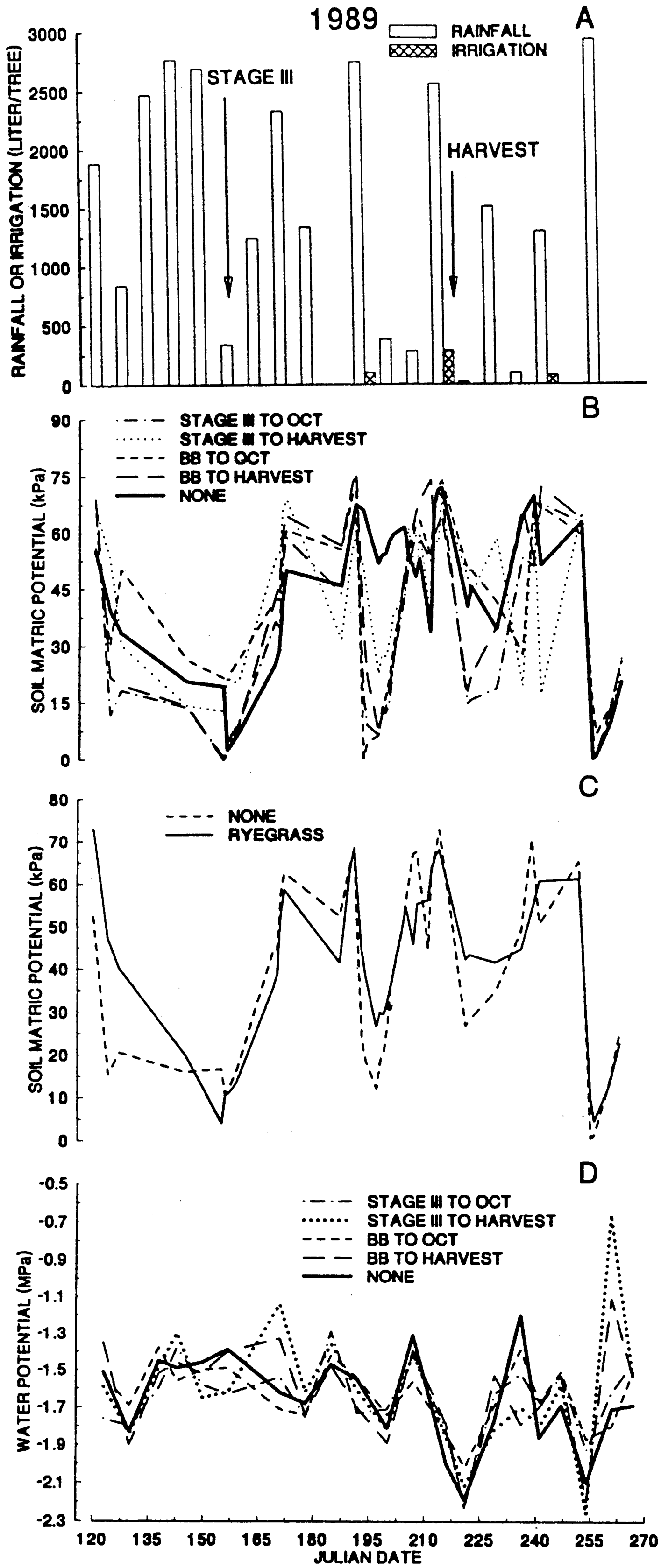

1989
RAINFALL
IRRIGATION
A
STAGE III
HARVEST
RAINFALL OR IRRIGATION (LITER/TREE)
3000
2500
2000
1500
1000
500
0
B
STAGE III TO OCT
STAGE III TO HARVEST
BB TO OCT
BB TO HARVEST
NONE
SOIL MATRIC POTENTIAL (kPa)
90
75
60
45
30
15
0
C
NONE
RYEGRASS
SOIL MATRIC POTENTIAL (kPa)
80
70
60
50
40
30
20
10
0
D
STAGE III TO OCT
STAGE III TO HARVEST
BB TO OCT
BB TO HARVEST
NONE
WATER POTENTIAL (MPa)
-0.5
-0.7
-0.9
-1.1
-1.3
-1.5
-1.7
-1.9
-2.1
-2.3
120 135 150 165 180 195 210 225 240 255 270
JULIAN DATE

Figure 3. Irrigation Application and Rainfall Amounts (A), Available Soil Moisture of Irrigation Treatments (B), Available Soil Moisture of Ground Cover Treatments (C), and Predawn Leaf Water Potential of Irrigation Treatments (D) Measured During 1990 from May 1 (julian date 120) to October 1 (julian date 270) on 'Cresthaven' Peaches.

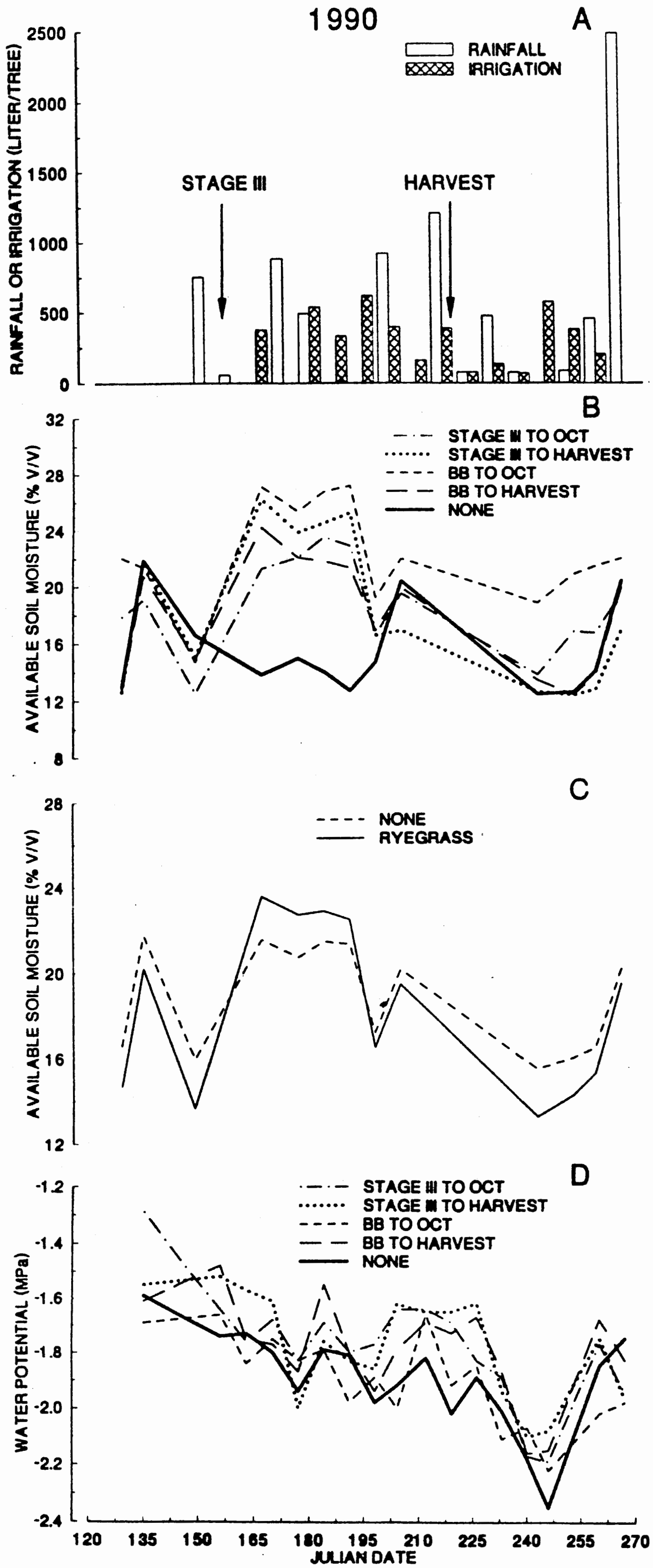

1990
A
RAINFALL
IRRIGATION
RAINFALL OR IRRIGATION (LITER/TREE)
STAGE III
HARVEST
B
STAGE III TO OCT
STAGE III TO HARVEST
BB TO OCT
BB TO HARVEST
NONE
AVAILABLE SOIL MOISTURE (% V/V)
C
NONE
RYEGRASS
AVAILABLE SOIL MOISTURE (% V/V)
D
STAGE III TO OCT
STAGE III TO HARVEST
BB TO OCT
BB TO HARVEST
NONE
WATER POTENTIAL (MPa)
JULIAN DATE

Figure 4. Irrigation Application and Rainfall Amounts (A), Available Soil Moisture of Irrigation Treatments (B), Available Soil Moisture of Ground Cover Treatments (C), and Predawn Leaf Water Potential of Irrigation Treatments (D) Measured During 1991 from May 1 (julian date 120) to October 1 (julian date 270) on 'Cresthaven' Peaches.

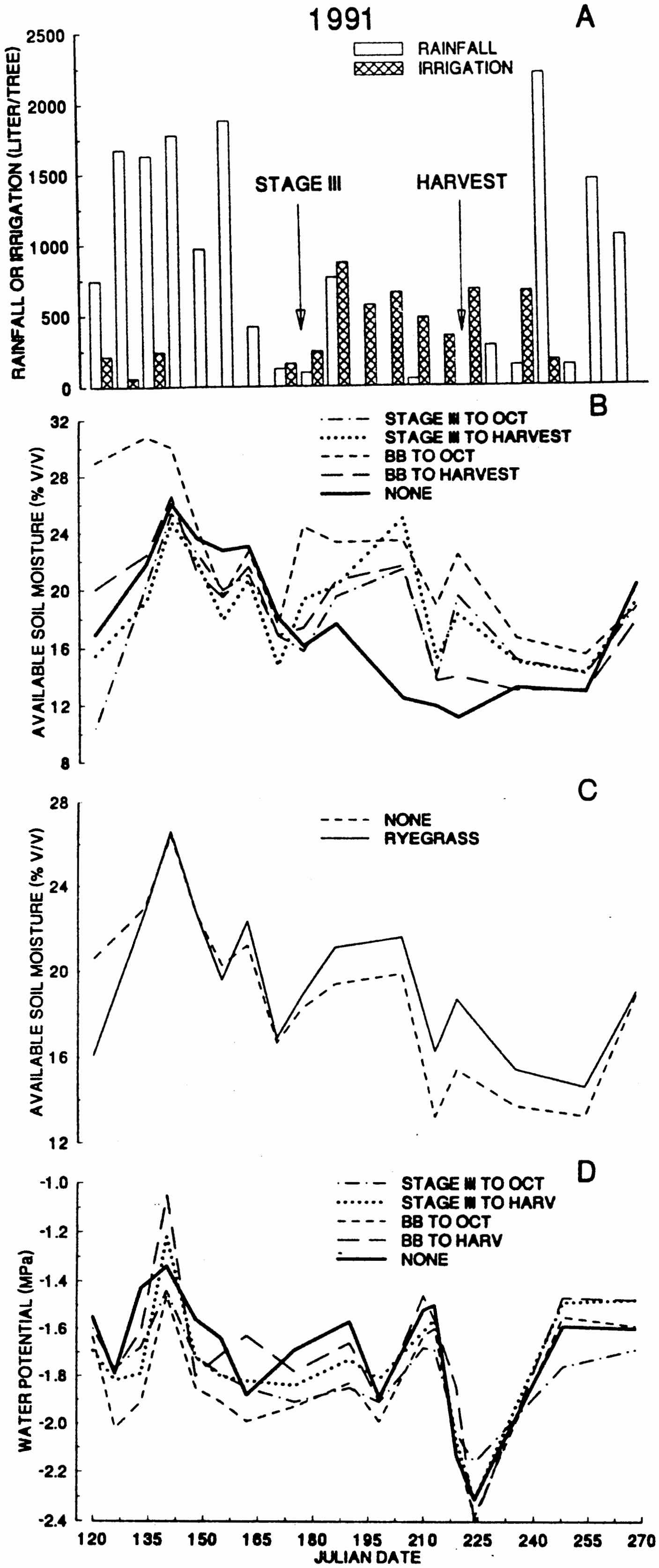
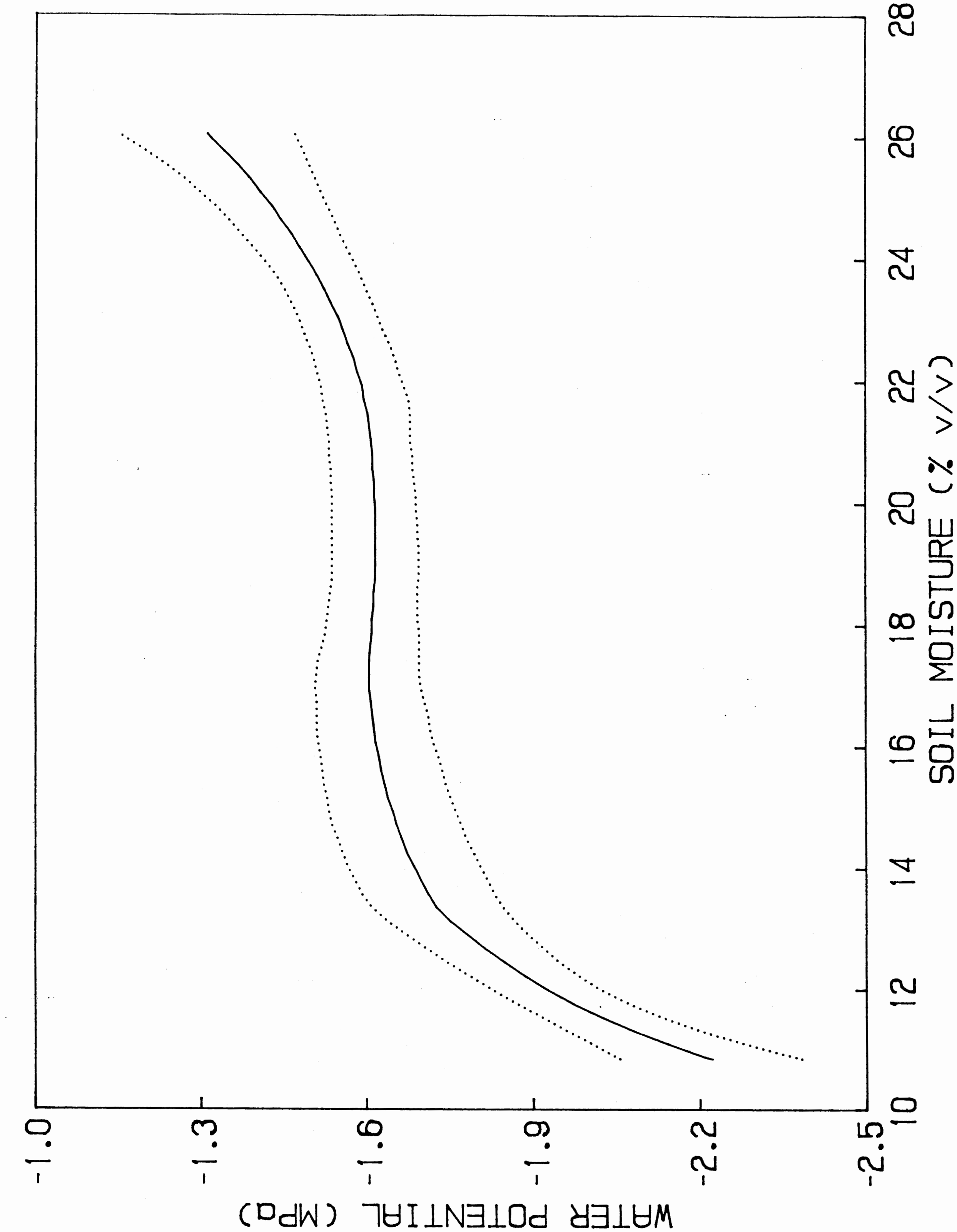

1991
A
RAINFALL
IRRIGATION
RAINFALL OR IRRIGATION (LITER/TREE)
STAGE III
HARVEST
B
STAGE III TO OCT
STAGE III TO HARVEST
BB TO OCT
BB TO HARVEST
NONE
AVAILABLE SOIL MOISTURE (% V/V)
C
NONE
RYEGRASS
AVAILABLE SOIL MOISTURE (% V/V)
D
STAGE III TO OCT
STAGE III TO HARV
BB TO OCT
BB TO HARV
NONE
WATER POTENTIAL (MPa)
JULIAN DATE

Figure 5. The relationship between Available Soil Moisture and Leaf Water Potential of Non-Irrigated Trees. ($Y=16.8+(-1.01)x+(-110.4)/x+0.02x*2$, $R^2=0.84$, $P \geq 0.001$). Dotted Lines Indicate 95% Confidence Limits.



WATER POTENTIAL (MPa)
-1.0
-1.3
-1.6
-1.9
-2.2
-2.5
10
12
14
16
18
20
22
24
26
28
SOIL MOISTURE (% v/v)

Figure 6. Influence of Irrigation Treatments and Fruit Ripeness on Bioyield Force of Peach Fruit After Storage Periods at 2 C. Ripeness Corresponded to the South Carolina Color Chip 4 (less ripe) 6 (more ripe).

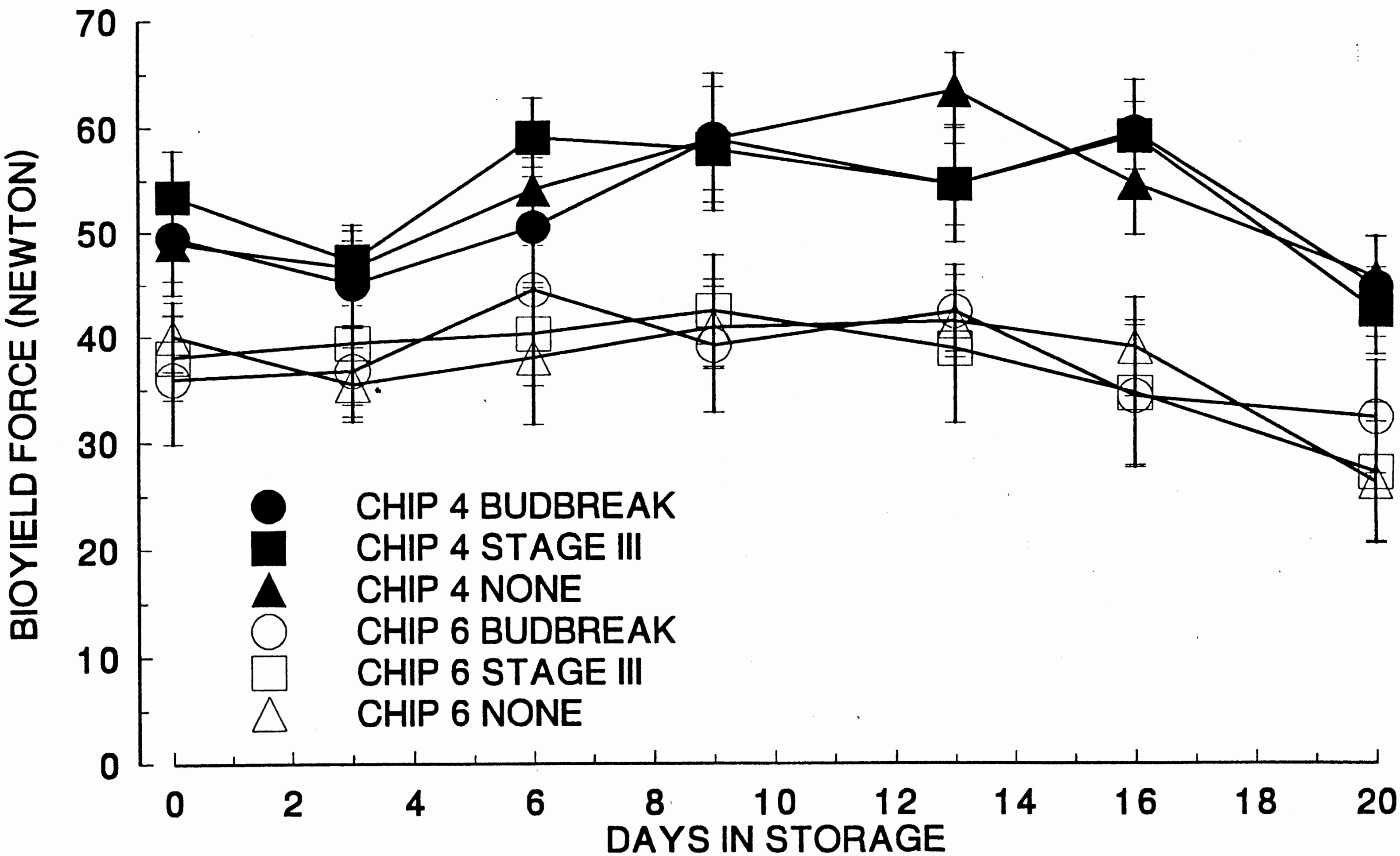
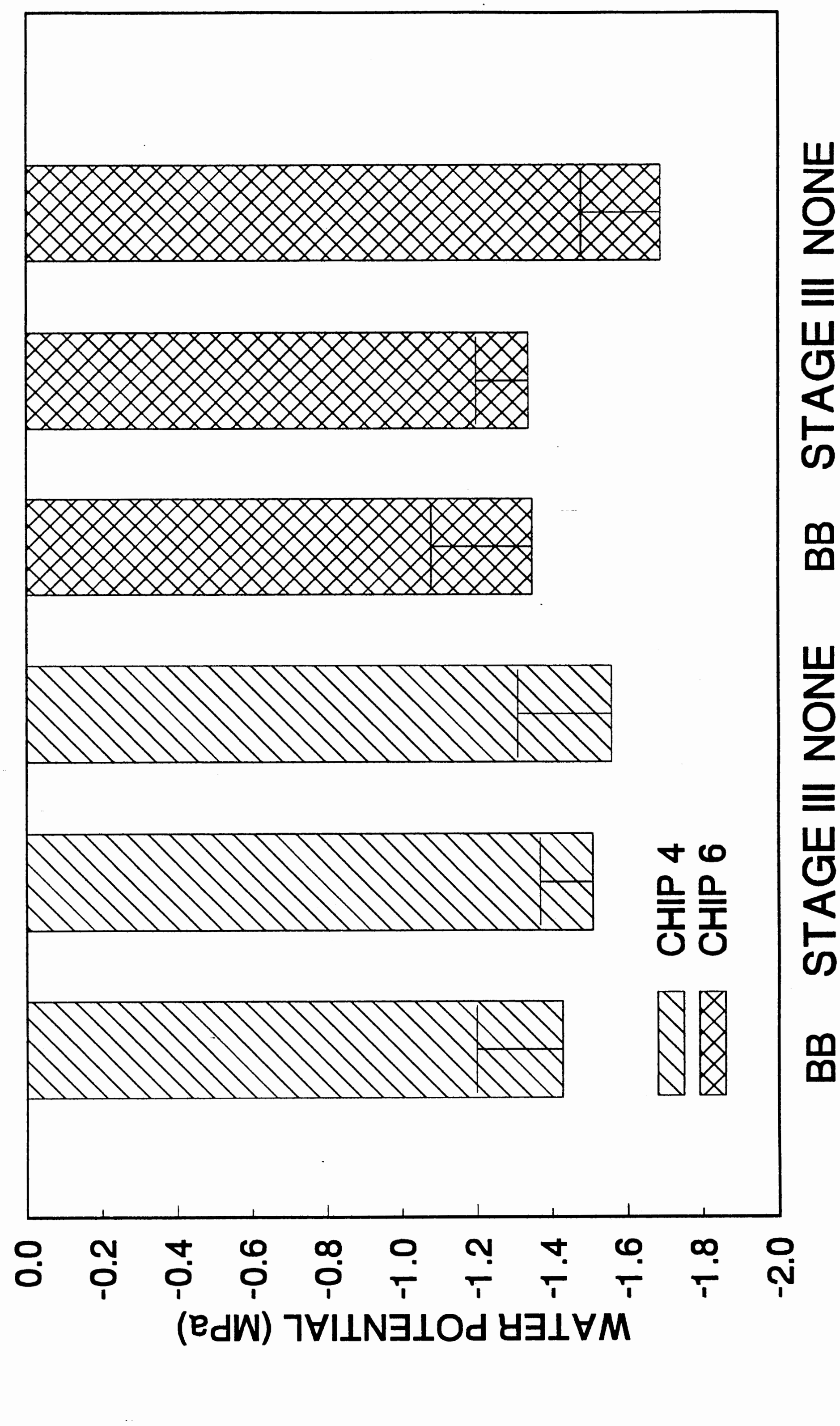

70
60
50
40
30
20
10
0
BIOYIELD FORCE (NEWTON)
0
2
4
6
8
10
12
14
16
18
20
DAYS IN STORAGE
CHIP 4 BUDBREAK
CHIP 4 STAGE III
CHIP 4 NONE
CHIP 6 BUDBREAK
CHIP 6 STAGE III
CHIP 6 NONE

Figure 7. Influence of Irrigation Treatments and Fruit Ripeness on Peach Fruit Water Potential. Ripeness Corresponded to the South Carolina Color Chip 4 (less ripe) and 6 (more ripe).



0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
-2.0
WATER POTENTIAL (MPa)
CHIP 4
CHIP 6
BB
STAGE III
NONE
BB
STAGE III
NONE

CHAPTER III

SUMMARY

Oklahoma is a temperate climate receiving between 381 mm and 1422 mm of rainfall yearly, with 610 mm to 1422 mm of rainfall yearly in the peach producing regions of the state. However, because Oklahoma has an uneven rainfall distribution during the growing season most growers in the state would benefit from supplemental irrigation. Water has become a scarce and valuable resource in many areas of the world, including Oklahoma. Therefore, the problem arises, how irrigation should be applied, when should irrigation begin and when should irrigation end to conserve water but obtain the maximum production from peach trees.

Reliable irrigation scheduling for peach production has been based on available soil moisture, evaporation from a class A pan, and soil matric potential. Growers use of visual estimates to schedule irrigation may waste large quantities of water or irrigation may be insufficient for maximum yield and fruit size. Therefore, an irrigation schedule is needed that conserves water while controlling tree growth without adversely affecting fruit yield or size is needed.

Peach trees produce abundant growth during the spring, all of which is not necessary to produce an adequate crop the subsequent year. Excess growth shades the interior of the tree and increases the need for pruning. Therefore, restricting irrigation during the early spring may conserve water and control tree growth. Temporary ground covers may also reduce early season growth, and act as a mulch when killed later in the season.

Evaluation of irrigation schedules were conducted to determine a satisfactory irrigation schedule for Oklahoma. Tensiometers were used to schedule irrigation from 1985-88. The schedules were: no irrigation, irrigation when matric potential reached either 40 or 60 kPa until fruit were harvested, and irrigation when the matric potential reached 40 or 60 kPa until October. Irrigation beginning at 60 kPa decreased water applied by 27-37% compared to irrigation beginning at 40 kPa. Discontinuing irrigation after harvest decreased water applied by 40-60% compared to irrigation to October. Trunk cross-sectional area was not affected until 1986 when the irrigated trees had significantly greater trunk cross-sectional area than the non-irrigated trees. Fruit size and weight were increased by irrigation.

In 1989, irrigation schedules were altered and based on evaporation from a class A pan in which 60% of the evaporation from the pan was replaced with irrigation. The irrigation schedules were: no irrigation, irrigation beginning at budbreak and discontinued after harvest, irrigation beginning at budbreak and continuing to October, and irrigation beginning at stage III fruit growth and discontinued after harvest, and irrigation beginning at stage III fruit growth and continuing to October. Irrigation before stage III of fruit growth was not necessary except during 1991. Trees irrigated to October required 24%-44% more water from 1989-1991. Irrigation beginning at stage III of fruit growth did not affect fruit yield, fruit size, flower bud density, fruit set, tree pruning weights or leaf elemental concentration compared to irrigation beginning at budbreak. Discontinuing irrigation after harvest reduced fruit yield and size during 1989 and fruit size during 1991. However, discontinuing irrigation after harvest did not affect flower bud density, fruit set or tree pruning weights compared to continuing irrigation to October.

Leaf water potentials, measured by leaf-cutter psychrometers, were not different among irrigation treatments. However, leaf water potential was highly correlated to available soil moisture. During this study, available soil moisture in irrigated and non-irrigated treatments was between 14-23%. Leaf water potential was insensitive to changes in available soil moisture between 14% and 23%. This explains the lack of difference among irrigation treatments.

Irrigation treatments did not affect fruit firmness, soluble solids, total solids, fruit water potential, uniaxial compression or drop impact parameters. This indicates that reduced irrigation schedules did not adversely affect fruit quality.

This study determined the optimum irrigation schedule to conserve water without adversely affecting fruit yield or size to be irrigation beginning at stage III fruit growth and then discontinued after harvest.

Annual ryegrass as a ground cover did not affect total fruit yield during 1989 or 1991 compared to herbicide plots. In fact, annual ryegrass increased fruit size and weight during 1989 and 1991. Annual ryegrass increased soil moisture retention after it was killed beginning at stage III of fruit growth during 1990 and 1991, and thereby increasing fruit size and weight. Annual ryegrass as a ground cover did not affect pruning weights during 1989; however, in 1990 tree pruning weights were decreased. Annual ryegrass decreased available soil moisture while it was actively growing in the early spring during 1990 therefore, reducing tree pruning weights.

Flower bud density was not affected by ground cover treatments, except in 1991. Annual ryegrass decreased flower bud density compared to herbicide plots; however, fruit set was not affected. Because annual ryegrass decreased shoot growth it could be reducing the number of nodes on shoots thus, reducing flower bud density. Therefore, more research is needed to confirm the effect of annual ryegrass on flower bud density and shoot growth.

SELECTED BIBLIOGRAPHY

Ballinger, W.E., A.H. Hunter, F.E. Correll, and G.A. Cummings. 1963. Interrelationships of irrigation, nitrogen fertilization and pruning of Redhaven and Elberta peaches in the sandhills of North Carolina. Proc. Amer. Soc. Hort. Sci. 83:248-258.

Baxter, P. 1970. Orchard soil management trials. 1. Effect of a weed-free or straw mulched strip on the growth and yield of young fruit trees. Aust. J. Expt. Agri. and Animal Hus. 10:467-473.

Bould, C. and R.M. Jarrett. 1962. The effects of cover crops and N P K fertilizers on growth, crop yield and leaf nutrient status of young dessert apples. J. Hort. Sci. 37:58-82.

Bridley, S.F., R.J. Taylor, and R.T. Webber. 1965. The effects of irrigation and rolling on nocturnal air temperature in vineyards. Agri. Meteorology 2:373-383.

Brown, D.S. 1953. The effects of irrigation on flower bud development and fruiting in the apricot. Proc. Amer. Soc. Hort. Sci. 61:119-124.

Brown, P.W. and C.B. Tanner. 1981. Alfalfa water potential measurement: A comparison of the pressure chamber and leaf dew-point hygrometers. Crop Sci. 21:240-244.

Brusewitz, G.H. and J.A. Bartsch. 1989. Impact parameters related to postharvest bruising of apples. Trans. Amer. Soc. Agri. Eng. 32:953-957.

Brusewitz, G.H., X. Zhang, M.W. Smith. 1992. Postharvest cooling effects on the bruising of peaches. Amer. Soc. Agri. Eng. paper no. 916036.

Chalmers, D.J., P.D. Mitchell, and L. van Heek. 1981. Control of peach tree growth and productivity by regulated water supply, tree density, and summer pruning. J. Amer. Soc. Hort. Sci. 106:307-312.

Chalmers, D.J. and I.B. Wilson. 1978. Productivity of peach trees: tree growth and water stress in relation to fruit growth and assimilate demand. Ann. Bot. 42:285-294.

Chalmers, D.J., G. Burge, P.H. Jerie, and P.D. Mitchell. 1986. The mechanism of regulation of 'Bartlett' pear fruit and vegetative growth by irrigation withholding and regulated deficit irrigation. J. Amer. Soc. Hort. Sci. 111:904-907.

Claypool, L.L., K. Uriu, and P.F. Lasker. 1972. Split pit of 'Dixon' cling peaches in relation to cultural factors. J. Amer. Soc. Hort. Sci. 97:181-185.

Cockroft, B. 1966. Soil management of peach trees in the Goulburn Valley, Victoria. Aust. J. Expt. Agri. and Animal Hus. 6:62-65.

Cummings, G.A. and W.E. Ballinger. 1972. Influence of longtime nitrogen, pruning and irrigation treatments upon yield, growth, and longevity of 'Elberta' and 'Redhaven' peach trees. HortScience 7:133-134.

Cummings, G.A. and J. Reeves. 1971. Factors influencing chemical characteristics of peaches. J. Amer. Soc. Hort. Sci. 96:320-322.

Daniell, J.W. 1982. Effect of trickle irrigation on the growth and yield of 'Loring' peach trees. J. Hort. Sci. 57:393-399.

Davies, F.S. and A.N. Lakso. 1978. Water relations in apple seedlings: changes in water potential components, abscisic acid levels and stomatal conductances under irrigated and non-irrigated conditions. J. Amer. Soc. Hort. Sci. 103:310-313.

Davis, L.D. 1941. Split-pit of peaches. Estimation of time when splitting occurs. Proc. Amer. Soc. Hort. Sci. 39:183-189.

De Baerdemaeker, J. and L. Lemaitre. 1979. Water supply and mechanical properties of agricultural crops. pp. 280-284. In P. Linko (ed). Food Process Engineering. vol.1. Food processing systems applied Sci. Pub. LTD.

De Baerdemaeker, J., L.J. Segerlind, H. Murase and G.E. Merva. 1978. Water potential effect on tensile and compressive failure stresses of apple and potato tissue. Amer. Soc. Agri. Eng. paper 78-3057. St. Joseph, MI.

Delwiche, M.J. and R.A. Baumgardner. 1985. Ground color as a peach maturity index. J. Amer. Soc. Hort. Sci. 110:53-57.

Falk, S., C.H. Hertz, and H.I. Virgin. 1958. On the relation between turgor pressure and tissue rigidity I. Experiments on resonance frequency and tissue rigidity. Phys. Plantarum 11:802-817.

Feldstein, J. and N.F. Childers. 1957. Effect of irrigation on fruit size and yield of peaches in Pennsylvania. Proc. Amer. Soc. Hort. Sci. 69:126-130.

Feldstein, J. and N.F. Childers. 1965. Effects of irrigation on peaches in Pennsylvania. Proc. Amer. Soc. Hort. Sci. 87:145-153.

Finney, E.E. 1967. Dynamic elastic properties of some fruit during growth and development. J. Agri. Eng. Res. 12:249-256.

Fridley, R.B. and P.A. Adrian. 1966. Mechanical properties of peaches, pears, apricots and apples. Trans. Amer. Soc. Agri. Eng. 9:135-138.

Garner, J.C., S.E. Prussia, J.L. Jordan and R.L. Shewfelt. 1987. Postharvest quality of peaches after delays in cooling. Amer. Soc. Agri. Eng. paper no. 87-6521.

Gerber, J.F., J.D. Martsolf, and J.F. Bartholic. 1974. The climate of trees and vines. HortScience 9:569-572.

Ghadiri, H. and D. Payne. 1986. The risk of leaving the soil surface unprotected against falling rain. Soil and Tillage Res. 8:119-130.

Glenn, D.M. and W.V. Welker. 1989. Orchard soil management systems influence rainfall infiltration. J. Amer. Soc. Hort. Sci. 114:10-14.

Goode, J.E. and K.J. Hyrycz. 1976. The effect of nitrogen on young, newly-planted, apple rootstocks in the presence and absence of grass competition. J. Hort. Sci. 51:321-327.

Hand, J.M., E.Young and A.C. Vasconcelous. 1982. Leaf water potential, stomatal resistance, and photosynthetic response to water stress in peach seedlings. Plant Physiol. 69:1051-1054.

Havis, L. and J.H. Gourley. 1937. Soil organic matter and porosity of a orchard soil under different cultural systems. Soil Sci. 43:413-420.

Havis, L. 1941. Relation between soil organic matter and available moisture under different orchard cultural systems. Proc. Amer. Soc. Hort. Sci. 38:32-35.

Haynes, R.J. 1980. Influence of soil management practice on the orchard agro-ecosystem. Agro-Ecosystems 6:3-32.

Hendrickson, A.H. and F.J. Veihmeyer. 1934. Size of peaches as affected by soil moisture. Proc. Amer. Soc. Hort. Sci. 32:284-286.

Horton, B.D., E. J. Wehunt, J.H. Edwards, R.R. Bruce, and J.L. Chesnee. 1981. The effects of drip irrigation and soil fumigation on 'Redglobe' peach yields and growth. J. Amer. Soc. Hort. Sci. 106:438-443.

Hung, Y.C. and S.E. Prussia. 1989. Effect of maturity and storage time on the bruise susceptibility of peaches (cv. Redglobe). Trans. Amer. Soc. Agri. Eng. 32:1377-1382.

Johnson, D.S., G.R. Stinchcombe and K.G. Stott. 1983. Effect of soil management on mineral composition and storage quality of Cox's Orange Pippin apples. J. Hort. Sci. 58:317-326.

Klein, I. 1983. Drip irrigation based on soil matrix potential conserves water in peach and grape. HortScience 18:942-944.

Larson, K.D., T.M. DeJong, and R.S. Johnson. 1988. Physiological and growth responses of mature peach trees to postharvest water stress. J. Amer. Soc. Hort. Sci. 113:296-300.

Layne, R.E.C., C.S. Tan, and R.L. Perry. 1986.Characterization of peach roots in fox sand as influenced by sprinkler irrigation and tree density. J. Amer. Soc. Hort Sci. 111:670-677.

Layne, R.E.C. and C.S. Tan. 1984. Long-term influence of irrigation and tree density on growth, survival and production of peach. J. Amer. Soc. Hort. Sci. 109:795-799.

Layne, R.E.C. and C.S. Tan. 1988. Influence of cultivars, ground covers and trickle irrigation on early growth, yield, and cold hardiness of peaches in fox sand. J. Amer. Soc. Hort. Sci. 113:518-525.

Leyden, R.F. and P.W. Rohrbaugh. 1963. Protection of citrus trees from cold damage. J. Amer. Soc. Hort. Sci. 83:344-351.

Mitchell, P.D. and D.J. Chalmers. 1982. The effect of reduced water supply on peach tree growth and yields. J. Amer. Soc. Hort. Sci. 107:853-856.

Mitchell, P.D., P.H. Jerie and D.J. Chalmers. 1984. The effects of regulated water deficits on pear tree growth, flowering , fruit growth and yield. J. Amer. Soc. Hort. Sci. 109:604-606.

Mitchell, P.D., B. van den Ende, P.H. Jerie and D.J. Chalmers. 1989. Responses of 'Bartlett' pear to withholding irrigation, regulated deficit irrigation and tree spacing. J. Amer. Soc. Hort. Sci. 114:15-19.

Mitchell, P.D., D.J. Chalmers, P.H. Jerie and G. Burge. 1986. The use of initial withholding of irrigation and tree spacing to enhance the effect of regulated deficit irrigation on pear trees. J. Amer. Soc. Hort. Sci. 111:858-861.

Morris, J.R., A.A. Kattan, and E.H. Arrington. 1962. Response of 'Elberta' peaches to the interactive effects of irrigation, pruning and thinning. Proc. Amer. Soc. Hort. Sci. 80:177-189.

Murase, H. and G.E. Merva. 1977. Static elastic modulus of tomato epidermis as affected by water potential. Trans. Amer. Soc. Agri. Eng. 20:594-597.

Natali, S., C. Xiloyannis and B. Pezzarossa. 1985. Relationship between soil water content, leaf water potential and fruit growth during different fruit growing phases of peach trees. Acta Horticulturae 171:167-180.

Oosterhuis, D.M., M.J. Savage and S. Walker. 1983. Field use of in situ leaf psychrometers for monitoring water potential of soybean crop. Field Crops Res. 7:237-248.

Proebsting, E.L., J.E. Middleton, and S. Roberts. 1977. Altered fruiting and growth characteristics of 'Delicious' apple associated with irrigation method. HortScience 12:349-350.

Punthakey, J.F., M.J. McFarland and J.W. Worthington. Stomatal responses to leaf water potential of drip irrigated peach (Prunus persica). Trans. Amer. Soc. Agri. Eng. 27:1442-1450.

Reeder, B.D., J.S. Newman, and J.W. Worthington. 1979. Effect of trickle irrigation on peach trees. HortScience 14:36-37.

Reeves, J. and G. Cummings. 1970. The influence of some nutrient factor upon certain physical attributes of peach quality. J. Amer. Soc. Hort. Sci. 95:338-341.

Rogers, W.S., T.H. Raptopoulos, and D.W.P. Greenham. 1948. Covercrops for fruit plantations. IV. Long-term leys and permanent swards. J. Hort. Sci. 24:228-270.

Salisbury, F.B. and C.W. Ross. 1985. Plant Physiology. p. 39-43. 3rd ed. In: F.B. Salisbury and C.W. Ross (eds.). Osmosis. Wadsworth Publishing Co., Belmont California.

Sharples, R.O. 1984. The influence of preharvest conditions on the quality of stored fruits. Acta Horticulturae 157:93-104.

Sharratt, B.S., G.A. Davis, E.N. Ashworth, and D.M. Glenn. 1989. Similarity of peach bud development and cold hardiness in orchards with different floor management practices. HortScience 24:699.

Sharratt, B.S. and D.M. Glenn. 1986. Orchard microclimatic observations in using soil applied coal dust for frost protection. Agri. and For. Meteorology. 38:181-192.

Shewfelt, R.L., S.C. Myers and A.V.A. Resurreccion. 1987. Effect of physiological maturity at harvest on peach quality during low temperature storage. J. Food Qual. 10:9-20.

Smith, M.W. and P.L. Ager. 1988. Effects of soil flooding on leaf gas exchange of seedling pecan trees. HortScience. 23:370-372.

Smith, M.W. and A.L. Kenworthy. 1979. The response of fruit trees in Michigan to trickle irrigation. Soil Sci. and Plant Anayl. 10:1371-1380.

Taylor, G. 1990. Annual pruning of fruit trees. OSU Ext. Facts. No. 6228.

Turner, N.C., R.A. Spurway, and E.D. Schulze. 1984. Comparison of water potential measured by in situ psychrometry and pressure chamber in morphologically different species. Plant Phys. 73:316-319.

Uriu, K. 1964. Effect of post-harvest soil moisture depletion on subsequent yield of apricots. Proc. Amer. Soc. Hort. Sci. 84:93-97.

Welker, W.V. and D.M. Glenn. 1990. Peach tree growth as influenced by grass species used in a killed-sod planting system. HortScience 25:514-515.

Welker, W.V. and D.M. Glenn. 1989. Sod proximity influences growth and yield of young peach trees. J. Amer. Soc. Hort. Sci. 114:856-859.

Welker, W.V. and D.M. Glenn. 1988. Growth responses of young peach trees and changes in soil characteristics with sod and conventional planting systems. J. Amer. Soc. Hort. Sci. 113:652-656.

Welker, W.V. and D.M. Glenn. 1985. The relationship of sod proximity to the growth and nutrient composition of newly planted peach tree. HortScience 20:417-418.

Wells, A.W. 1962. Effects of storage temperature and humidity on loss of weight by fruit. U.S. Dept. Agri. Marketing Research Report 539.

White, G.C. and R.I.C. Holloway. 1967. The influence of simazine or straw mulch on the establishment of apple trees in grassed down or cultivated soil. J. Hort. Sci. 42:377-389.

Werner, R.A. and C. Frenkel. 1978. Rapid changes in firmness of peaches as influenced by temperature. HortScience 13:470-471.

Werner, R.A., L.F. Hough and C. Frenkel. 1978. Rehardening of peach fruit in cold storage. J. Amer. Soc. Hort. Sci. 103:90-91.

Xiloyannis, C., K. Uriu, and G.C. Martin. 1980. Seasonal and diurnal variations in abscisic acid, water potential, and diffusive resistance in leaves from irrigated and non-irrigated peach trees. J. Amer. Soc. Hort. Sci. 105:412-415.

Young, E., J.M. Hand, and S.C. Wiest. 1981. Diurnal variation in water potential components and stomatal resistance of irrigated peach seedlings. J. Amer. Soc. Hort. Sci. 106:337-340.

APPENDIXES

APPENDIX A

INFLUENCE OF IRRIGATION TREATMENTS

ON LEAF ELEMENTAL CONCENTRATION

DURING 1989-91

Influence of Irrigation Treatments on Leaf Elemental Concentration During 1989-91.

	Percent dry weight							
	N	P	K	Ca	Mg	Zn	Fe	Mn
Treatment	%	%	%	%	%	$\mu g.g^{-1}$	$\mu g.g^{-1}$	$\mu g.g^{-1}$
				1989				
None	3.62a[z]	0.19a	2.45a	3.49a	0.63a	23a	89a	98a
Budbreak to Oct.	3.56a	0.19a	2.34a	3.81a	0.66a	22a	84a	69b
Budbreak to harv.	3.51a	0.19a	2.37a	4.14a	0.66a	21a	77a	64b
Stage III to Oct.	3.51a	0.20a	2.43a	3.78a	0.58a	23a	90a	67b
Stage III to harv.	3.58a	0.19a	2.33a	3.87a	0.66a	25a	99a	65b
				1990				
None	2.83b	0.16a	2.28a	1.98a	0.43a	13a	64a	44a
Budbreak to Oct.	2.86b	0.18a	2.60a	2.02a	0.43a	17a	72a	38a
Budbreak to harv.	3.07a	0.17a	2.33a	2.03a	0.44a	16a	64a	37a
Stage III to Oct.	3.06a	0.17a	2.42a	1.81a	0.41a	15a	68a	37a
Stage III to harv.	2.94ab	0.17a	2.37a	2.05a	0.40a	19a	63a	37a
				1991				
None	3.00a	0.17a	2.34a	1.95a	0.42a	15a	134b	47a
Budbreak to Oct.	3.14a	0.16a	2.30a	1.80a	0.40a	14a	138ab	48a
Budbreak to harv.	3.09a	0.17a	2.37a	1.90a	0.40a	14a	140ab	47a
Stage III to Oct.	3.08a	0.17a	2.26a	1.78a	0.40a	14a	141ab	44a
Stage III to harv.	3.07a	0.17a	2.40a	1.83a	0.40a	15a	142a	53a

[z] Mean separation within columns and year by Duncan's multiple range test, 5% level.

APPENDIX B

INFLUENCE OF SOIL MANAGEMENT SYSTEMS ON LEAF ELEMENTAL CONCENTRATION DURING 1989-91

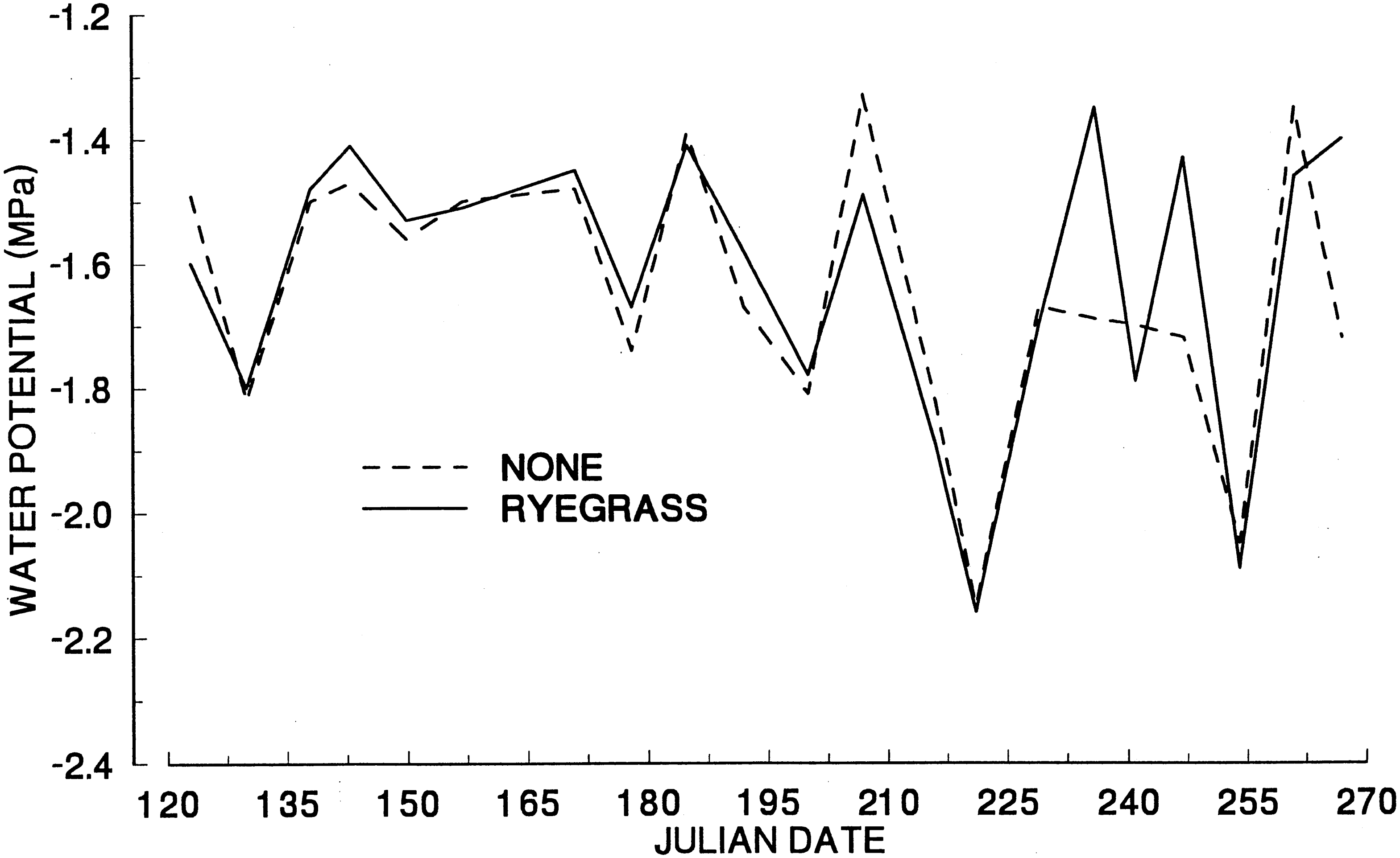
Influence of Soil Management Systems on Leaf Elemental Concentration During 1989-91.

	Percent dry weight							
	N	P	K	Ca	Mg	Zn	Fe	Mn
Treatment	%	%	%	%	%	$\mu g.g^{-1}$	$\mu g.g^{-1}$	$\mu g.g^{-1}$
				1989				
None	3.60a[z]	0.19a	2.38a	3.80a	0.63a	23a	88a	72a
Ryegrass	3.51a	0.19a	2.39a	3.84a	0.64a	23a	88a	73a
				1990				
None	3.00a	0.17a	2.43a	1.95a	0.41a	18a	68a	40a
Ryegrass	2.92a	0.17a	2.36a	2.00a	0.43a	14a	65a	37a
				1991				
None	3.09a	0.17a	2.32a	1.79a	0.40a	14.9a	139a	47a
Ryegrass	3.06a	0.17a	2.34a	1.92a	0.41a	14.3a	139a	47a

[z] Mean separation within column and year by Fisher's F-test, 5% level.

APPENDIX C

EARLY MORNING LEAF WATER POTENTIALS COMPARING TWO SOIL MANAGEMENT SYSTEMS DURING 1989

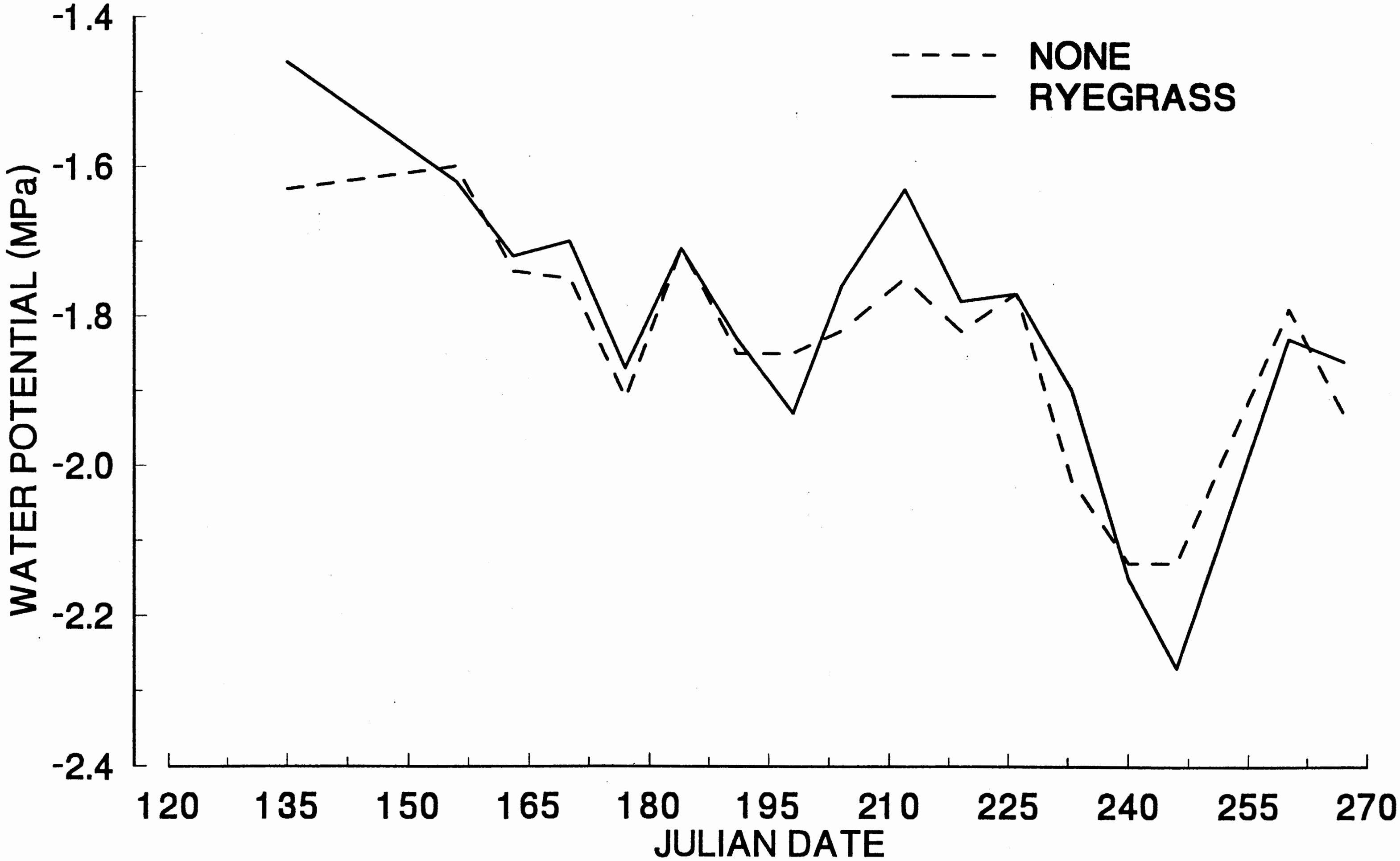

WATER POTENTIAL (MPa)
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
NONE
RYEGRASS
120
135
150
165
180
195
210
225
240
255
270
JULIAN DATE

APPENDIX D

PREDAWN LEAF WATER POTENTIALS COMPARING

TWO SOIL MANAGEMENT SYSTEMS

DURING 1990



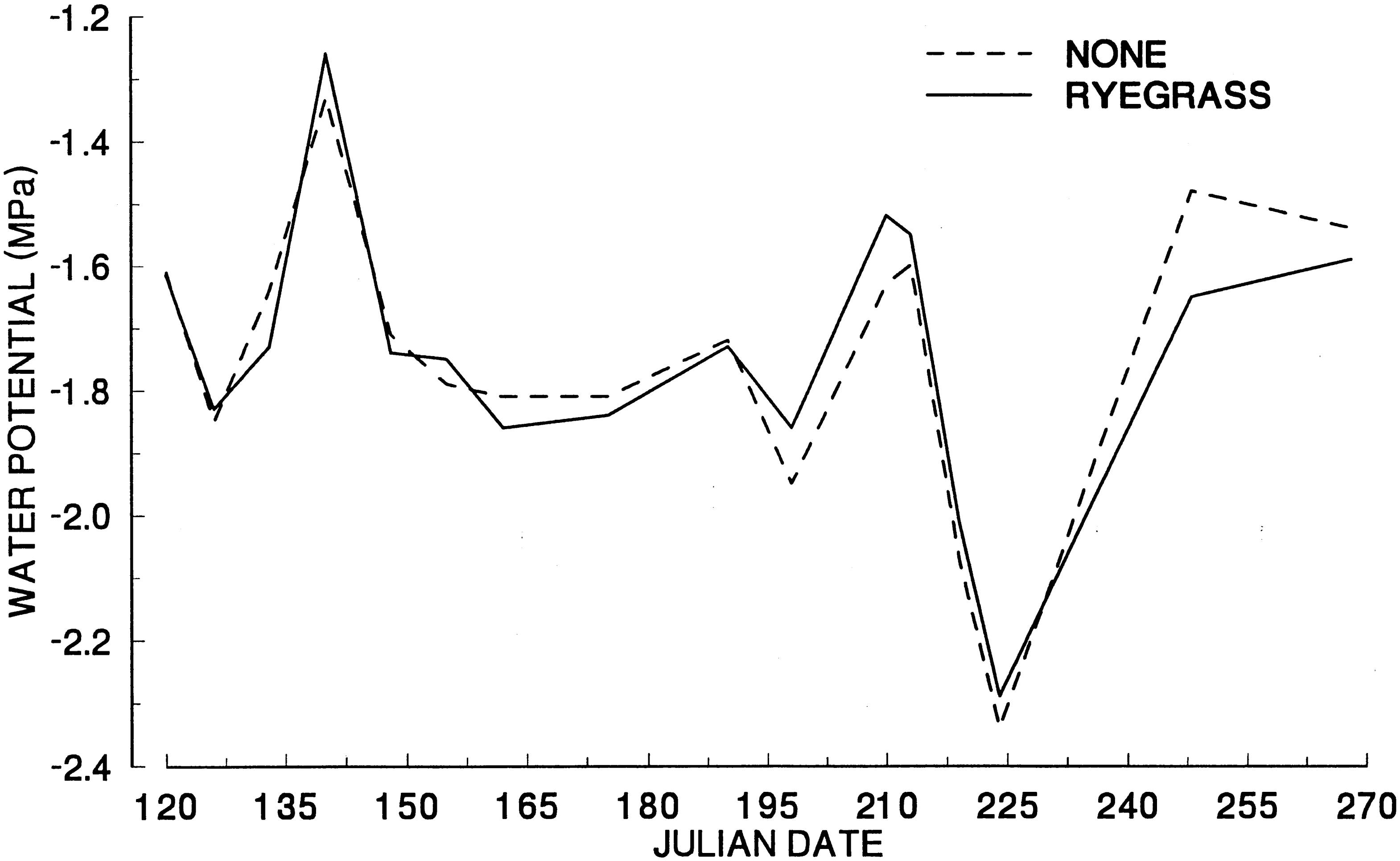
NONE
RYEGRASS
WATER POTENTIAL (MPa)
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
120
135
150
165
180
195
210
225
240
255
270
JULIAN DATE

APPENDIX E

PREDAWN LEAF WATER POTENTIALS COMPARING

TWO SOIL MANAGEMENT SYSTEMS

DURING 1991

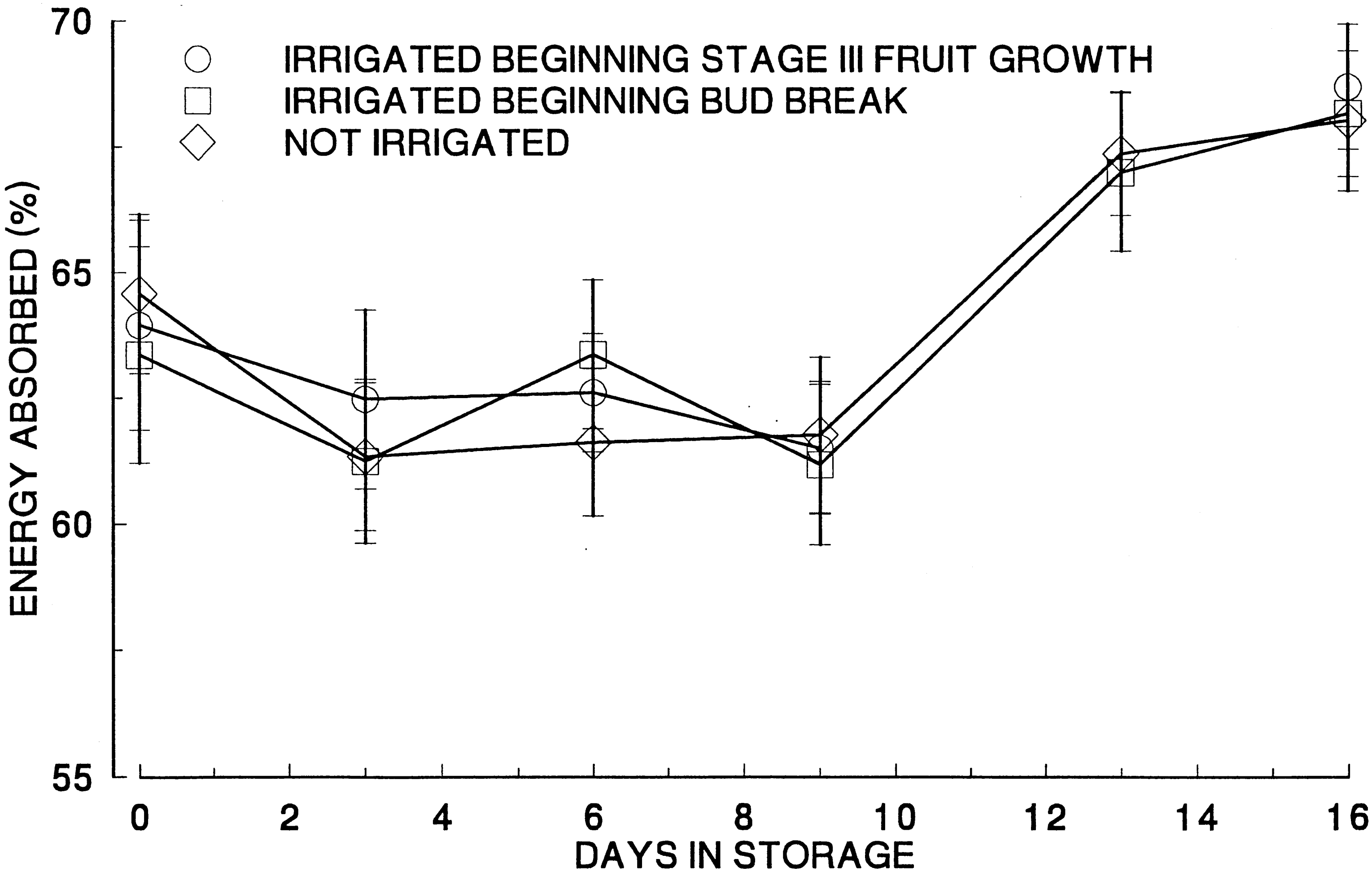

NONE
RYEGRASS
WATER POTENTIAL (MPa)
-1.2
-1.4
-1.6
-1.8
-2.0
-2.2
-2.4
120 135 150 165 180 195 210 225 240 255 270
JULIAN DATE

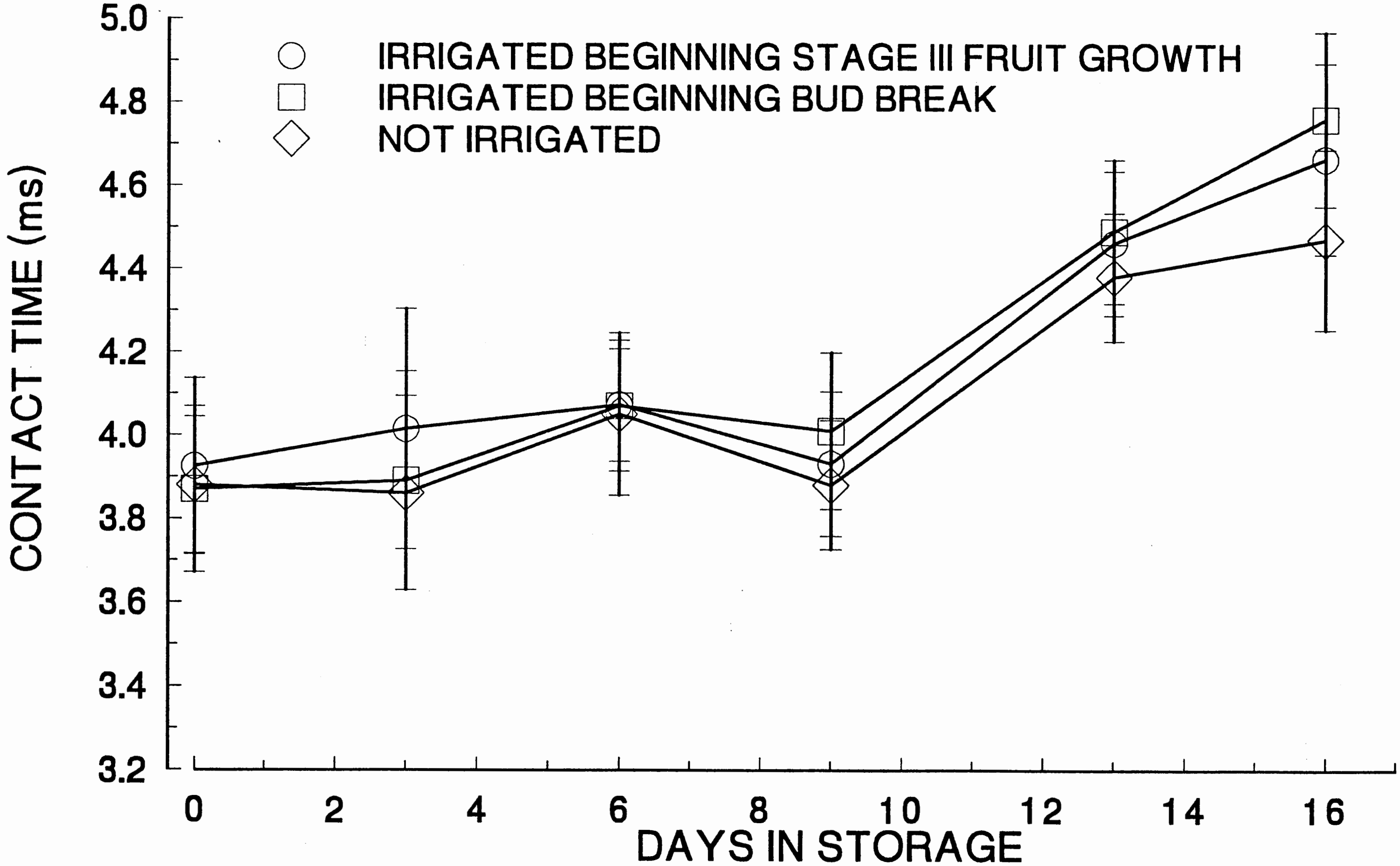
APPENDIX F

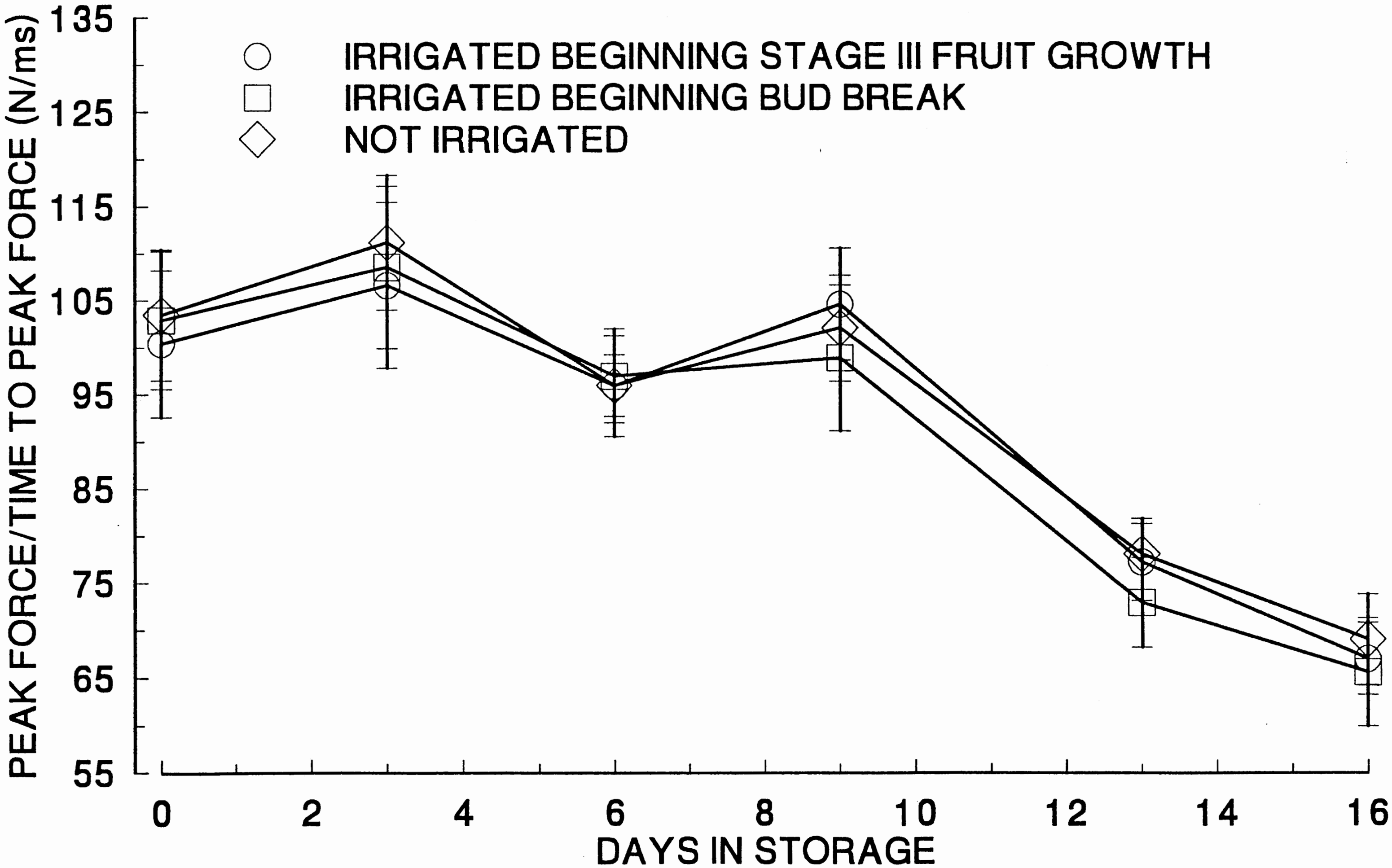
DROP IMPACT PARAMETERS OF PEACH

FRUIT WITH THREE IRRIGATION

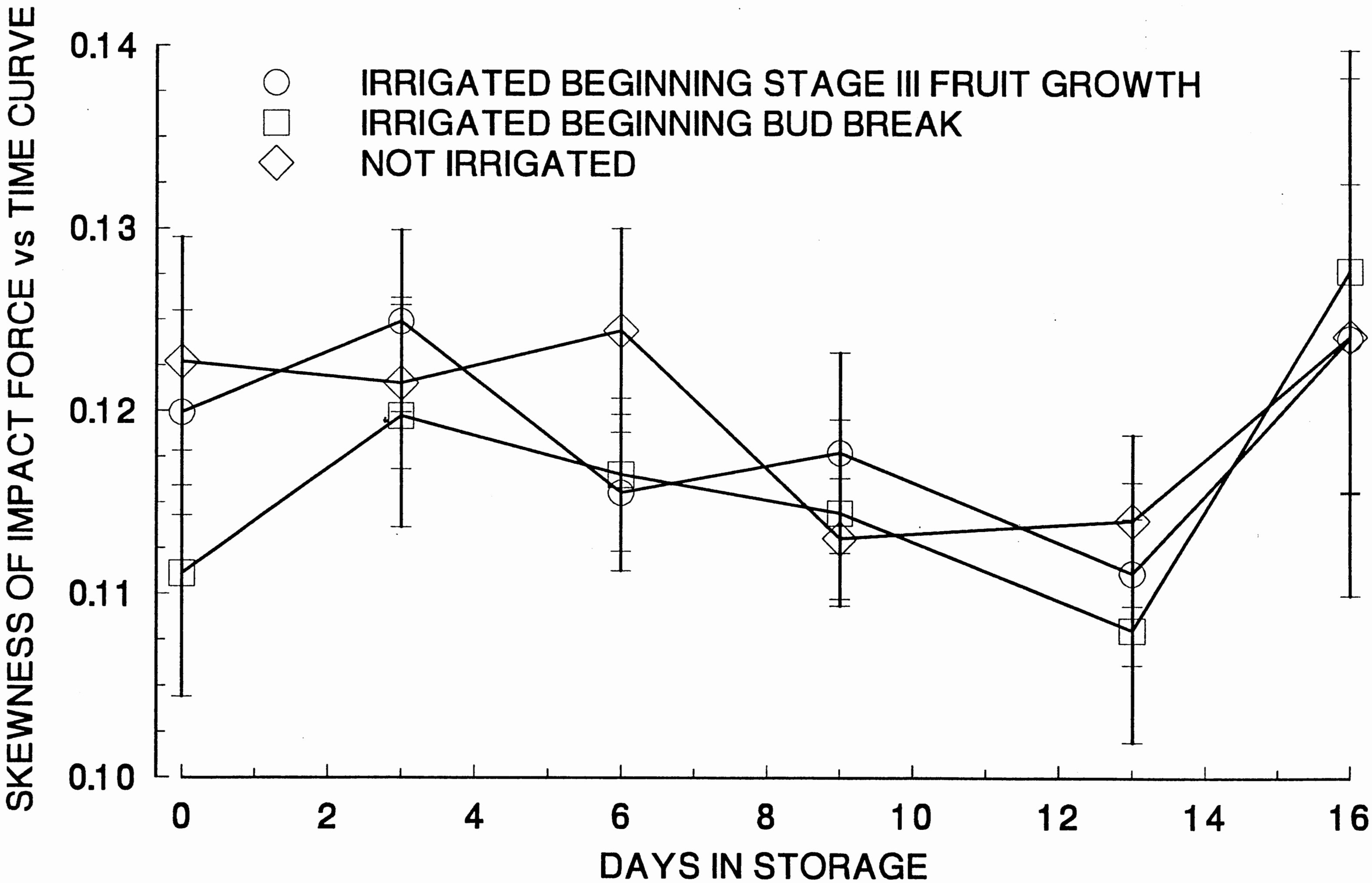
TREATMENTS


IRRIGATED BEGINNING STAGE III FRUIT GROWTH
IRRIGATED BEGINNING BUD BREAK
NOT IRRIGATED
ENERGY ABSORBED (%)
70
65
60
55
0
2
4
6
8
10
12
14
16
DAYS IN STORAGE


IRRIGATED BEGINNING STAGE III FRUIT GROWTH
IRRIGATED BEGINNING BUD BREAK
NOT IRRIGATED
CONTACT TIME (ms)
5.0
4.8
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
0
2
4
6
8
10
12
14
16
DAYS IN STORAGE

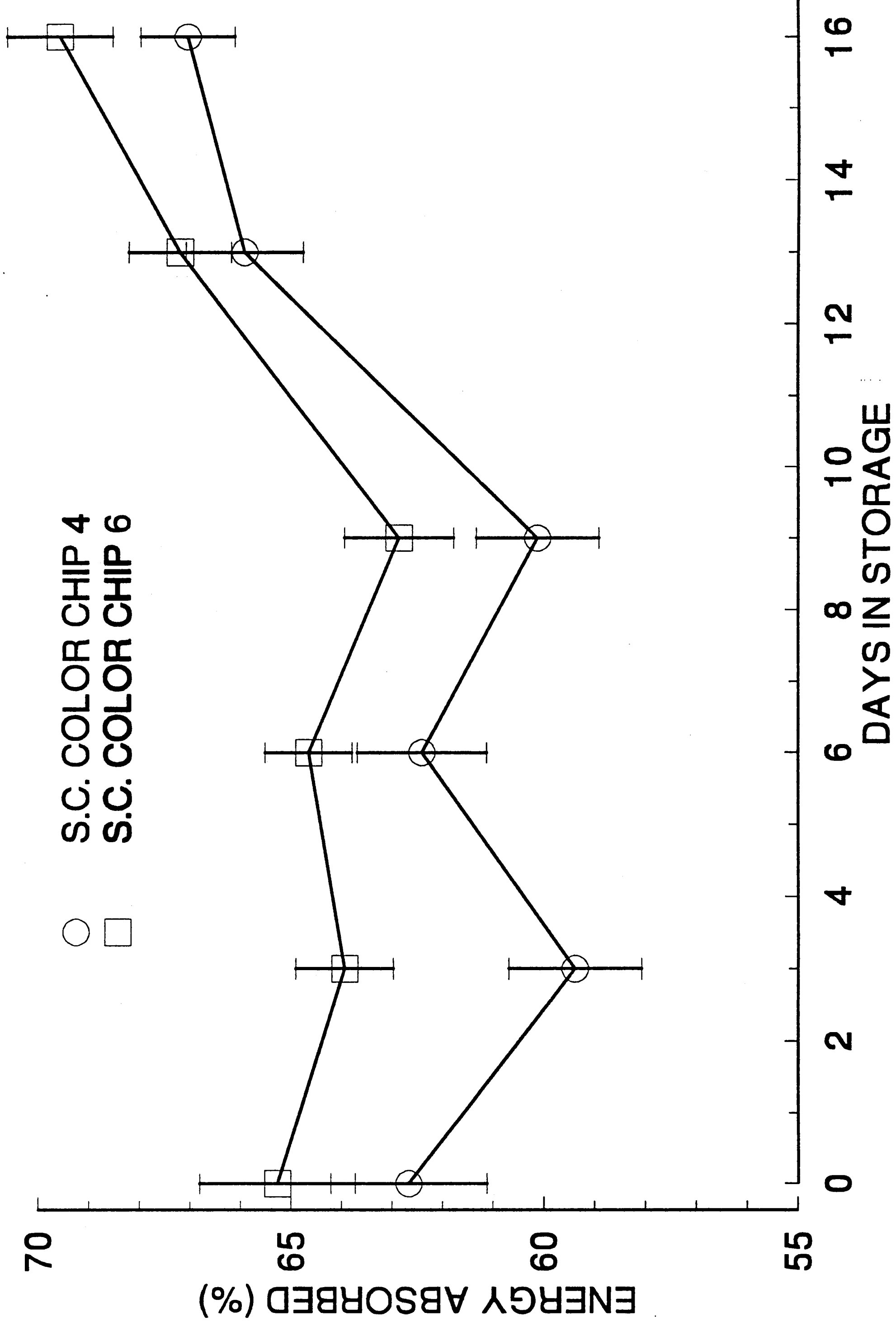


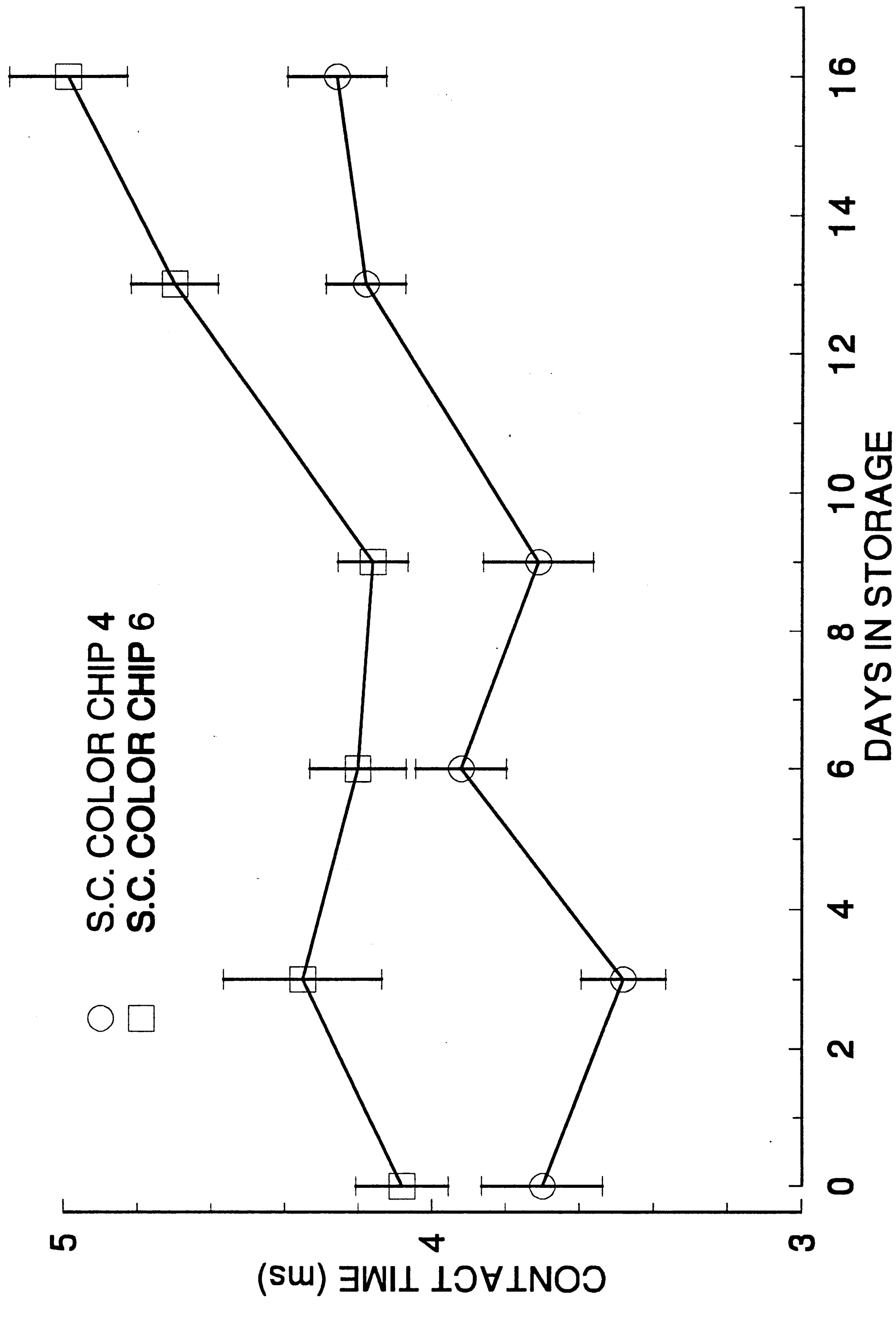
IRRIGATED BEGINNING STAGE III FRUIT GROWTH
IRRIGATED BEGINNING BUD BREAK
NOT IRRIGATED
PEAK FORCE/TIME TO PEAK FORCE (N/ms)
135
125
115
105
95
85
75
65
55
0
2
4
6
8
10
12
14
16
DAYS IN STORAGE

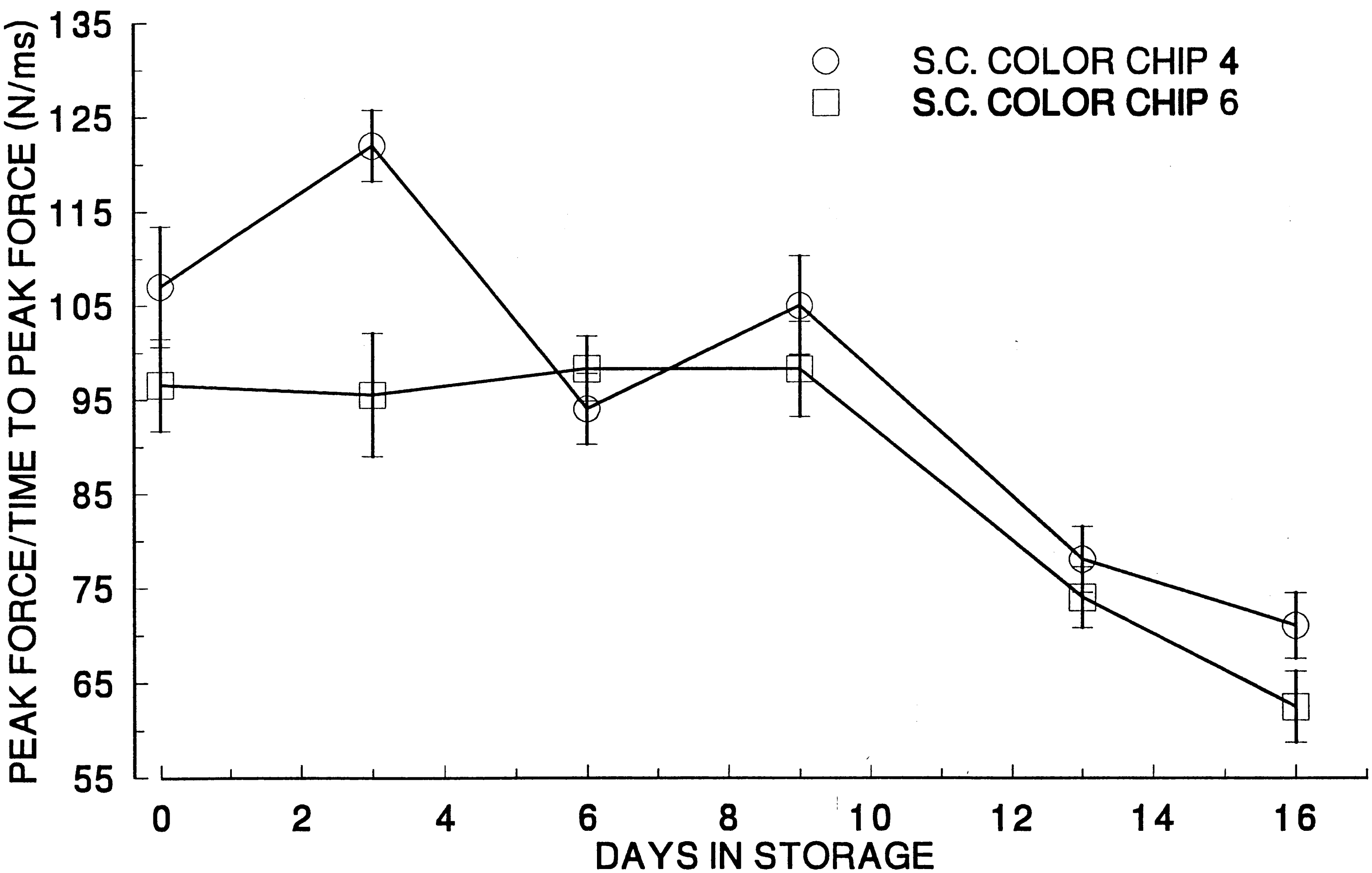

IRRIGATED BEGINNING STAGE III FRUIT GROWTH
IRRIGATED BEGINNING BUD BREAK
NOT IRRIGATED
SKEWNESS OF IMPACT FORCE vs TIME CURVE
0.10
0.11
0.12
0.13
0.14
0
2
4
6
8
10
12
14
16
DAYS IN STORAGE

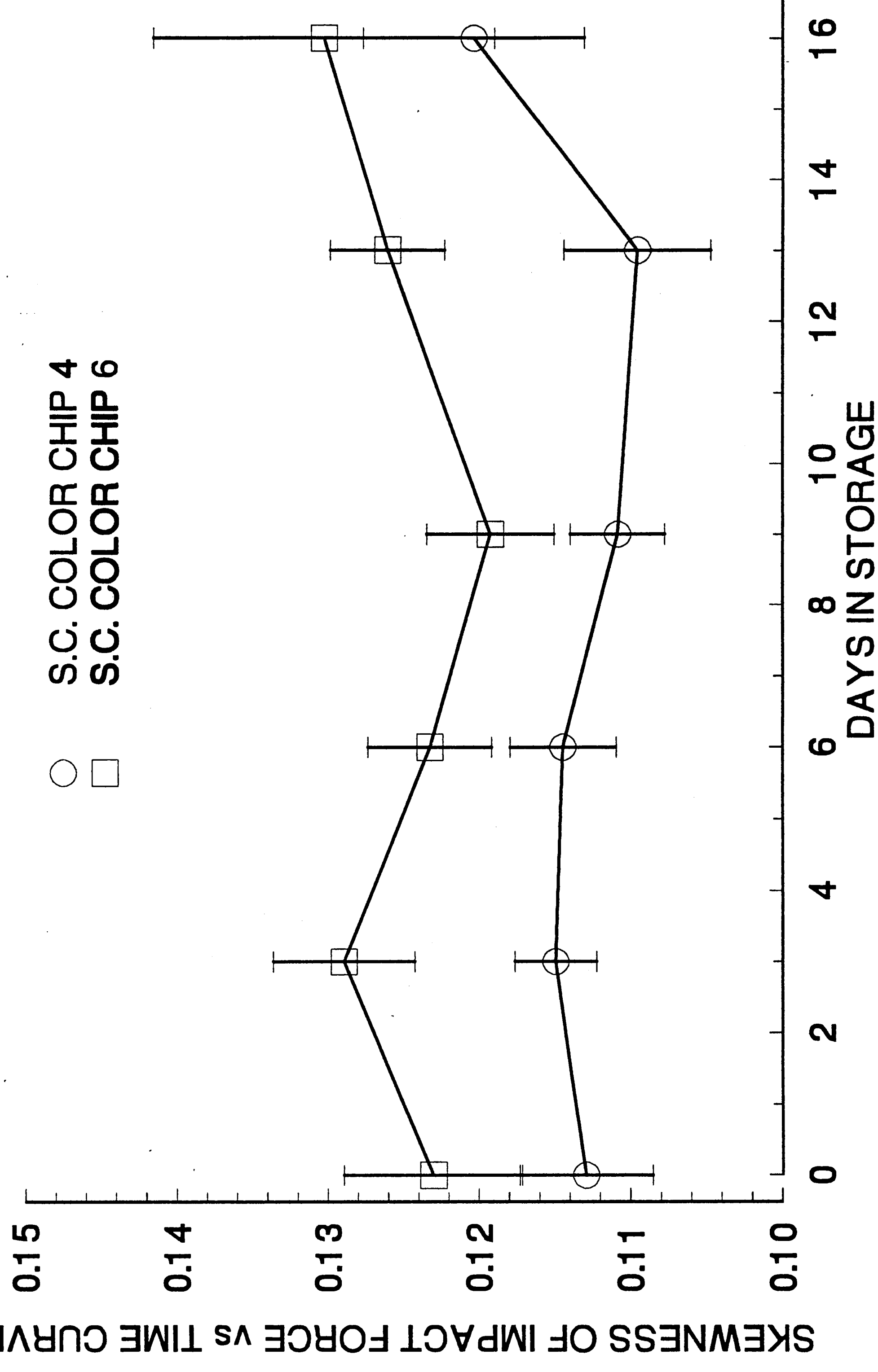
APPENDIX G

DROP IMPACT PARAMETERS OF PEACH FRUIT COMPARING TWO FRUIT RIPENESS


S.C. COLOR CHIP 4
S.C. COLOR CHIP 6
DAYS IN STORAGE
0
2
4
6
8
10
12
14
16
ENERGY ABSORBED (%)
55
60
65
70


S.C. COLOR CHIP 4
S.C. COLOR CHIP 6
CONTACT TIME (ms)
5
4
3
0
2
4
6
8
10
12
14
16
DAYS IN STORAGE


PEAK FORCE/TIME TO PEAK FORCE (N/ms)
135
125
115
105
95
85
75
65
55
S.C. COLOR CHIP 4
S.C. COLOR CHIP 6
0
2
4
6
8
10
12
14
16
DAYS IN STORAGE



S.C. COLOR CHIP 4
S.C. COLOR CHIP 6
SKEWNESS OF IMPACT FORCE vs TIME CURVE
0.10
0.11
0.12
0.13
0.14
0.15
0
2
4
6
8
10
12
14
16
DAYS IN STORAGE

VITA

Susan M. Huslig

Candidate for the Degree of

Master of Science

Thesis: EVALUATION OF IRRIGATION SCHEDULES AND ANNUAL RYEGRASS AS A GROUND COVER TO CONSERVE WATER AND CONTROL PEACH TREE GROWTH

Major field: Horticulture

Specialty: Pomology

Biographical:

Personal Data: Born in West Memphis, Arkansas, March 21, 1968, the daughter of Art and Linda Nine.

Education: Graduated from Gage High School, Gage, Ok, in May, 1986. Received Bachelor of Science degree in Horticulture from Oklahoma State University in May, 1989. Completed requirements for the Master of Science degree at Oklahoma State University in May, 1992.

Professional Experience: Greenhouse assistant, Oklahoma State University Research Greenhouses, August, 1986 to May, 1987. Research assistant, USDA Research Station, Woodward, Ok, May, 1987 to August, 1987. Greenhouse assistant, Quality Plants Inc., Stillwater, Ok, August, 1987 to May 1989. Research assistant, Department of Horticulture, Oklahoma State University, May, 1989 to May, 1990. Graduate research assistant and teaching assistant, Department of Horticulture, Oklahoma State University, May, 1990 to May, 1992.