This is to certify that the

thesis entitled

THE EFFECT OF TRAINING SYSTEMS AND IRRIGATION ON PEACH
(Prunus persica L.Batch) FRUIT QUALITY

presented by

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has been accepted towards fulfillment
of the requirements for

M.S. degree in Horticulture

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Date March 1, 1989

# THE EFFECT OF TRAINING SYSTEMS AND IRRIGATION ON PEACH (*Prunus persica* (L) Batsch) FRUIT QUALITY

By

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A THESIS

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

MASTER OF SCIENCE

Department of Horticulture

1989

# ABSTRACT

## THE EFFECT OF TRAINING SYSTEMS AND IRRIGATION ON PEACH (*Prunus persica* (L) Batsch) FRUIT QUALITY

By

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The effects of palmette and central leader training systems and irrigation on peach fruit quality on successive harvest dates were determined. Training systems alone did not appear to influence fruit yield in different size categories, fruit color or flesh firmness. Fruit harvested from central leader trained trees had higher soluble solids content than those from the palmette trees. Irrigation based on 75% EPAN facilitated the production of fruit in the larger size categories compared to no irrigation, though this aspect was not significant. The effects of irrigation on fruit color and flesh firmness were inconsistent with successive harvest dates. Fruits from irrigated trees were of lower soluble solids content. Fruit size may confound treatment effects on maturity indices.

Fruits from one harvest date were stored and maturity indices measured. The amount of red color and soluble solids content of fruit were not influenced by time in storage or temperature.

## DEDICATION

To My Grandparents

ACKNOWLEDGEMENTS

I would like to thank Dr. R.C. Herner for his guidance, and members of my committee, Dr. D.R. Dilley, Dr. J.A. Flore, and Dr. M.A. Uebersax. For statistical advice, I thank Dr. C. Cress. For help with MSTAT, I thank Ms. B. Bricker of the MSTAT Office at Michigan State University. For allowing use of their plant material, I thank again Dr. J.A. Flore.

I am also grateful to the graduate students who worked in the postharvest laboratory for helping me in various ways.

I would also like to thank my parents, Mr. and Mrs. C.T.C. Masarirambi, my brothers, Cuthbert and Tendai, and my Zimbabwean and American friends for their encouragement.

Financial assistance from the University of Zimbabwe and USAID.

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# INTRODUCTION

The quality and postharvest behavior of produce including peach (*Prunus persica* (L) Batsch) generally depends on chemical and physical changes that occur during development or growth. Growth is affected by other factors like chemicals, training systems, and weather. Practical experience has shown fruit growers and shippers that weather during the growing season has a powerful influence on the postharvest behavior of fruit (Ryall and Pentzer, 1974). It is now known that the potential quality of given produce cannot be improved even by the best postharvest handling practices. Therefore, great attention also needs to be paid to cultural practices. Among others, irrigation, training system type and/or chemicals used encompass the cultural practices used during the growth of the tree.

The peach, believed to have originated in China, is now widely distributed in temperate regions of North America and Europe. It has also spread to other parts of the world such as South Africa and Australia (Watkins, 1976). The leading peach producing states in the U.S. are California, South Carolina, Georgia, Pennsylvania, New Jersey, Michigan and North Carolina (Ryall and Pentzer, 1974). In Michigan, growers have increased new plantings and bearing trees have risen 50% since 1982. As a result, Michigan ranked fifth among peach producing states during 1985 (Michigan Agricultural Statistics, 1986).

## LITERATURE REVIEW

In this review training systems are described with emphasis being given to the effect of training systems on light conditions in the tree canopy and fruit quality. Irrigation and its possible effects on quality are also reviewed. Finally, maturity indices as quality parameters of peach will be discussed. The association between cultural practices and peach quality at harvest and during storage will be addressed.

### Training Systems

"Training" is defined as the cutting away of portions of a tree to obtain the desired shape and frame work (Westwood, 1978). Training young fruit trees is important (Stebbins and MacCaskey, 1983) because the future shape of a tree or shrub depends upon the training conducted in the early years of growth (Brown, 1972). Training normally takes three to five years from planting. Pruning, bending, spreading and tying branches are among various training practices. Strong branches that hold heavy fruit loads without breaking or needing support develop through training. Trees can be variously trained to be large and spreading, upright or with branches at an angle depending on the shape desired. Training affects other operations like pruning, spraying and harvesting. Productivity in peach as affected by training has been widely studied (Leuty and Pree, 1980; Layne et. al., 1981; Baroni and

Bargioni, 1988; and Chalmers et. al., 1981). Training may affect fruit quality prior to, during and after storage.

Training Types

Many types of training systems exist depending on the plant type and the desired production goal. Training systems used include central leader, palmette system, rectangular shape and open center. The open center, central leader and the palmette system are among the more widely used.

A. Open center shape - This training system is characterized by the center of the tree being open with branches spreading outwards. High quality yields between 6991.6 and 16979.6 kg/ha have been reported (Couvillon, 1986). The tree is headed back to force lateral buds to grow at the time of planting (Ridley, 1984). The main limbs are derived from three to five shoots selected after several growing seasons with all the others being removed. To hold producing trees in their allotted space while maintaining productivity, trees are normally pruned every year. Small limbs are suppressed by removing them. The open center of the tree allows sunlight penetration.

In a preliminary trial, trees trained as "open vase", "Y shape" and "central leader", DeSalvador and DeJong (1988) found sunlight interception similar in the three training systems with percent values as follows: 74% in the "Y", 71% in the open center and 69% in the "central leader" compared with the nontrained control.

B. Central leader (slender spindle) - Couvillon, (1986) reported that this system was developed and popularized by Italian researchers and growers. The central part of the tree is allowed to be dominant. The trees are free standing, and, normally, a tree density of 1250 trees/ha is used. Hedging may be used to maintain trees in their allotted space and this also limits shading of fruiting shoots by those growing vigorously.

Testing some peach cultivars trained to central leader, Couvillon (1986) reported yields of large fruit between 27240 and 49940 kg/ha by the sixth year after planting.

C. Palmette system - This training system derives its name from the scaffolds that resemble fingers extended from the palm of the hand. It is a training system widely used throughout Europe for the production of peaches and nectarines (Couvillon, 1986). A density of 850 trees/ha spaced at 4.45 x 2.97 meters is normally used. In peaches, a variation of the palmette involves developing only two limbs in a V shape (Stebbins and MacCaskey, 1983). Like the central leader, this system allows sunlight penetration, and the use of pruning platforms, and picking aides. Yields as high as 30508.8 kg/ha of fruit have been reported with palmette trained trees; this was higher than for the central leader system (Couvillon, 1986). However Chalmers and van den Ende (1988) found no yield differences for the palmette and central leader hedge with "Loring" peaches using several intensive planting systems.

Peach training systems affect the total amount of sunlight and possibly the quality of light a peach tree receives. Kappel et. al. (1983) found that spectral distribution determined in an open center peach tree did not follow the general trend of total radiation and that increases in shade resulted in unequal absorption of wavelengths. DeJong and DeSalvador (1988) acknowledged that sunlight distribution and interception are influenced by many factors, such as planting distance, size of trees and training system.

## Sunlight and Related Effects on Fruit Quality

Light affects many processes including photosynthesis, chlorophyll synthesis, anthocyanin pigment formation, seed germination, vegetative growth, photoperiodism, flowering and fruit quality (Westwood, 1978). The effects of light on fruit quality in apples have been widely investigated, while less information is available for peaches (Grappadelli, 1985). Light interception is determined by the amount and arrangement of the leaves, fruits and branches within the tree crown, the tree shape and size, spacing, row orientation and the angular distribution of light from the sun and sky (Palmer, 1980). In addition, the amount of sunlight reaching the earth varies from place to place depending on altitude and latitude. The effects of within row spacing on size and color suggest that competition for light is the causative factor, because shading is known to reduce fruit size and color (Palmer and Wertheim, 1980).

From their preliminary study, DeSalvador and DeJong (1988) reported that sunlight is one of the most important factors in attaining uniformity and good quality fruit in peach.

Jackson et. al. (1971), working with "Cox's Orange Pippin" apple, found that unlike thinner trees, dense trees had larger fruit on the outside than the inside of the tree canopy. Marini and Trout (1984) attempted to identify sources and magnitudes of variation in fruit color, flesh firmness, and fruit soluble solids occurring within and among peach trees. They found variation in fruit quality with fruit position within the canopy. The data revealed that fruit color varied within the canopy. Generally, the green sides of fruit were firmer than the red sides with the differences being greatest in the lower south and upper north sectors of the canopy. In the lower north sector, fruit sides had almost equal firmness. Higher soluble solids were found in fruit from the upper tree level and the red side of the fruit than those from the lower tree level and green side of the fruit. The highest soluble solids content was observed for fruit harvested from the upper north sector, intermediate soluble solids were observed for fruit from the upper and lower south sectors and fruit from the lower north sector had the lowest soluble solids (Marini and Trout, 1984).

Heinicke (1966) studied the effects of exposure to different amounts of sun light under orchard conditions on size, color, soluble solids, firmness, acidity, and pH of apples. He found that the degree of exposure to sunlight during the growing season affected several fruit characteristics of "Red Delicious" and "McIntosh" apples. Color development was directly related to exposure, with best color in fruit exposed to more than 70% of possible full sunlight (FS), adequate color in 40-70% FS and inadequate color when exposed to less than 40% FS (Heinicke, 1966). Small size fruit was obtained with exposure to less than 50% FS. Light exposure also affected the soluble solids content. Fruit from the 90-100% FS zone had the highest soluble solids content and those from 10-19% FS zone had the lowest, with all other samples falling in an intermediate range (Heinicke, 1966). Fruits from heavily shaded areas were firmer than those well exposed to sunlight. Jackson et. al. (1971) confirmed similar findings with apples; i.e., fruit from the upper zones of the tree matured earlier than those from the lower zones.

Sansavini et. al. (1980) in Bologna, Italy, investigated tree efficiency and fruit quality in high density apple orchards. They found that fruit color was better for apples from medium density plantings (M.D.P.) regarding both the red and yellow components as well as skin brightness. Apples from lower halves of trees appeared greener than those from the upper halves. Excessive tree density was found to reduce fruit quality, ripening began earlier and was more uniform on M.D.P. Fruit from M.D.P. had brighter ground color, lower acidity and firmness in "Cooper 4" and greater sugar content in "Yellowspur" than fruit from high density planting (H.D.P.). Light intensity at noon in the lower and upper halves of the canopy of "Cooper 4" trees ranged, on the average, from 18% to 52% of full daylight in H.D.P. and from 33% to 75% in M.D.P. (Sansavini et. al., 1980). Loreti et. al. (1980) observed that peach fruit from the lower 1/3 of the canopy had soluble solids and fruit weight reduced by 14% and 17-25%, respectively, compared to fruit from the upper 2/3 of the canopy (140cm above ground level to the top of the tree). They also reported light influence on fruit color and dry weight of leaves.

Grappadelli (1985) evaluated the effects of peach fruit position, density and light intensity on quality. The author measured the light environment of fruit by photosynthetically active radiation (PAR) sensors. It was found that fruit quality depended on its position on the shoot, its distance from other fruits, and from vegetative growing points of the shoot. At equivalent levels of maturity, as assessed by ground color, the fruits closest to the tip were smaller, less colored, had lower soluble solids, and had firmer flesh (Grappadelli, 1985) A linear positive relation was found between % FS and percent blush (skin colored red).

Marini (1985) studied the effects of pruning treatments on vegetative growth, yield, and fruit quality in peach. The author found that the pruning treatment had no consistent effect on yield, fruit size, or maturity date. Red color and soluble solids of "Loring" fruit were not affected by pruning treatment, but flesh firmness was increased for summer topped trees (Marini, 1985). The pruning treatment affected quality less than crop load, canopy position, or harvest date for "Sunqueen" fruit. Fruits from the top of the tree and on moderately cropping trees were found to have more red color and a greater amount of soluble solids than those from the tree interior or trees with a heavy crop. The author noted that all aspects of fruit quality studied were influenced by harvest date although the effects were not consistent for the two years studied. Westwood (1978) reported that poor light distribution inside the tree canopy is associated with heading back pruning and that fruit blush color is poor with this pruning method.

Erez and Flore (1986) investigated the quantitative effect of solar radiation on anthocyanin pigment production in "Redhaven" peach skin. In their experiment, they used five-year-old "Redhaven" peach trees on Halford rootstock, trained to an open center. Peach fruits were exposed to various durations of radiation at the end of stage II of fruit development. They observed that anthocyanin development was markedly stimulated by exposure of only three days (total of about 6280 $J.cm^{-2}$). Color development as a function of solar radiation followed a power curve with nearly maximal level obtained after 8 days of exposure (18,003 $J.cm^{-2}$) (Erez and Flore, 1986). A similar trend with shade screen (40% and 10% FS) showed less red color development with more shade. Fruits shaded with aluminum foil were found to be smaller, with a lower level of soluble solids, compared to control fruit. They concluded that solar radiation reaching fruit may have a direct effect on fruit sink activity.

## Irrigation

Water comprises 70-90% by weight of all living organisms. When water supply reduces transpiration below potential transpiration, plant photosynthesis and, hence, biomass production decrease (Chalmers et. al., 1984). Such a relationship has resulted in the widely accepted fact that maximum crop production is obtained by minimizing the plant water deficit throughout the development of the crop. The major factors to be considered in evaluating tree performance as related to moisture supply are a) soil type, b) irrigation frequency and depth of water penetration, c) extent of root distribution, and d) the intensity and duration of external moisture stress, such as wind, temperature, and humidity (Westwood, 1978).

Trickle irrigation is one of the main irrigation methods used. It is the slow application of water on, above, or beneath the soil by surface trickle, subsurface trickle, bubbler spray, mechanical-move, and pulse systems. (Bucks and Davis, 1986). Emitters or applicators are placed along a water delivery line near the plants and water is applied as discrete or continuous drops, tiny streams, or miniature spray. This type of irrigation is based on providing a continuous supply of moisture to only part of the root system. This decreases moisture stress, as compared to conventional irrigation where water is applied periodically and varied levels of available moisture exist in the soil profile. Westwood (1978) reported that trickle irrigation applies water to about 25 percent of the root system under low pressure at the low rate of 3 to 7.5 liters per hour per plant to maintain near field capacity in the soil zone near the plant. The high water use efficiency can be attributed to improved water conveyance and water distribution to the root zone (Doorenbos and Pruitt, 1977).

Much work has been done on the effect of irrigation on yield (Chalmers et. al., 1981, 1986; Mitchell and Chalmers, 1982; Mitchell et. al., 1984). However, information on peach quality as affected by irrigation is lacking. Chalmers et. al. (1981) studied root competition (tree density), summer pruning, and regulated irrigation to determine whether they can be used to control tree vigor and productivity in ultra dense orchards of peach. The researchers found that fruit yields and fruit growth increased significantly (up to 30%) by high tree density combined with low rate of water application when water stress limited shoot growth. In their study the level of water applied and fruit development stage at application seemed important in determining fruit size. They concluded that competition from tree growth inhibited fruit growth as effectively as did the reduced supply of water (Chalmers et. al., 1981). The workers argued that increased yield with reduced irrigation was only obtainable for as long as the tree had excess vegetative vigor that could be suppressed in favor of fruit growth. It seems that tree age, density, development stage and amount of water applied are important in determining yields.

Layne et. al. (1981),working with peach (Harken/Siberian C), investigated the effect of irrigation and tree density on production. Experimental plots were either irrigated or not irrigated at a rate necessary to prevent the available soil moisture (ASM) from falling below 25 or 50%. Tree growth was stimulated in earlier but not in the later years of their experiment. Irrigation (50% ASM) increased cumulative, marketable yields in the first five years of production by up to 9.7%. Increasing tree density up to 536 trees/ha increased yields by up to 74.6% without irrigation and up to 99.5% with irrigation (50% ASM + 536 trees/ha) (Layne et. al., 1981). The proportion of large and medium sized fruit was consistently increased by irrigation while the proportion of small fruit was reduced. Neither irrigation nor tree density adversities affected split pits, raw product fruit quality, cold hardiness or canker (Leucostoma spp) susceptibility (Layne et. al., 1981). Mortality was less for control trees, implying that they were less hardy. No significant interactions of irrigation and tree planting density were found in any year. This study indicated that irrigation increased fruit size (yield) although its effects on fruit quality seemed to have received less attention.

Chalmers and van den Ende (1988) found that as the seeds developed, they influenced growth of the fruit, which was slow at first and then increased strongly towards maturity. Chalmers et. al. (1981), working with peach, confirmed Proebsting et al's (1977) findings that trickle irrigation reduced water potential and increased fruit size and yield, and improved fruit quality. Chalmers and van den Ende (1988) reported that fruit grown at the lower water potential had higher soluble solids, skin color and firmness (after cold storage) and lower water content and titratable acidity. In a separate study with pear, Chalmers and van den Ende (1988) observed that fruit grown on irrigated trees appeared to have higher water content and lower soluble solids than controls.

Ballinger, et. al. (1963) investigated the influence of different levels of pruning, nitrogen fertilizer application and irrigation, singly and in combination, on growth and fruit production of the peach under conditions that existed in the Sandhills area of North Carolina. Redhaven and Alberta varieties were used. No significant effects due to irrigation were found, though a trend toward larger fruit size on the irrigated trees was evident. The Redhaven cultivar responded to irrigation more than Alberta as shown by interactions with cultivar nitrogen amount and pruning. Responses of peach trees to irrigation appeared to be influenced by season pruning practices, nitrogen application and cultivars involved (Ballinger, et. al., 1963).

Morris, et. al. (1961) examined the interactive effects of irrigation, pruning and thinning on yield, growth, quality and foliar mineral content of Elberta peaches in Arkansas. Irrigation was found to decrease the percentage of fruit soluble solids. There was also a disproportional reduction in soluble solids with final swell irrigation and severe pruning as indicated by the pruning x irrigation interaction (Morris, et. al., 1961). Production of fruits with a minimum diameter of 5.6 cm was increased only by a combination of all-season irrigation, severe pruning and thinning to 15-17.5 cm between fruits. Fruits from irrigated trees were also found to be least firm.

## Developmental Terminology

Watada et. al. (1984) noted that terms describing or identifying developmental stages of horticultural crops are not used consistently. Some of the authors' suggested definitions are presented.

A. Development. The series of processes from the initiation of growth to the death of a plant or plant part.

B. Growth. The irreversible increase in physical attributes (characteristics) of a developing plant or plant part.

C. Maturation. The stage of development leading to the attainment of physiological or horticultural maturity.

D. Physiological maturity. The stage of development when a plant or plant part will continue ontogeny even if detached.

E. Horticultural maturity. The stage of development when a plant or plant part possesses the prerequisites for utilization by consumers for a particular purpose.

F. Ripening. The composite of the processes that occur from the later stages of growth and development through the early stages of senescence that result in characteristic aesthetic and/or food quality, as evidenced by changes in composition, color, texture, or other sensory attributes.

## Quality

Quality in fruits is that combination of characteristics or properties that make them desirable to the buyer or user (Ryall and Pentzer, 1974; Kader, 1983). The casual purchaser chooses fruit by appearance because other methods for determination of quality are rarely available. Components of quality include appearance, texture, flavor, and nutritive value (Kader, 1983). The search is for more than surface quality and for standards which measure other quality factors in fruits such as flavor, texture and freedom from external defects (Francis, 1980; Ryall and Pentzer, 1974; Delwiche, 1987). All of this begins with the producer, long before harvest (Horton and Hopfinger, 1987) and decisions made years before continue to be influential. Quality parameters are affected by the environment during growth, maturity at harvest, and holding conditions after harvest. Useful indices are needed for evaluation of quality in the field, proper time of harvest, and for maintenance or deterioration of quality after harvest (Ryall and Pentzer, 1974).

Optimum dessert quality is obtained when the fruits are fully ripened on the tree. However, tree-ripened fruits will not survive the handling and transport necessary for delivery to markets which are often far distant from the point of production. (Ryall and Pentzer, 1974). So compromise between optimum maturity and optimum quality is necessary. Maturity indices are important for deciding when a given commodity should be harvested to provide some marketing flexibility and to ensure the attainment of acceptable eating quality to the consumer (Kader, 1983). Ryall and Pentzer (1974) suggested that for making such decisions certain subjective and objective tests must be used, each adapted to certain types or cultivars of fruit. Some of the maturity indices (also quality factors) important to peach will be briefly discussed.

Maturity indices used for peach include size, ground color, percent blush, flesh color, flesh firmness (on blush and non-blush side) and amount of soluble solids. During the maturation of peaches the flesh softens, the composition changes, a characteristic flavor develops, the green color of the skin decreases, and the yellow or orange color of yellow-fleshed varieties increases and becomes more evident (Rood, 1957). Rood carried out a three year study to determine the optimum maturity to harvest peaches and to obtain information necessary for inspection and regulatory agencies. Measurements included the use of color charts to assess the skin ground color and flesh color and use of the Magness-Taylor flesh firmness tester with an 8 mm diameter plunger to measure flesh firmness. Titratable acidity and chlorophyll content were also determined. Measurements at harvest (Rood, 1957) ranked in the following order of usefulness in estimating the edible quality of peaches when ripe: flesh firmness readings made on both pared cheeks, skin ground color, flesh color, chlorophyll of the flesh, titratable acidity of the juice, and the percentage of soluble solids in the juice.

A. Size. Yield is a function of size that can be measured as weight. Size increases as the fruit matures. Upshall and van Haarlem (1947) measured peach volume increases during four seasons and found increases of up to 35 percent in the seven days preceding optimum maturity. After being picked, peaches do not increase in size, and there may actually be a slight shrinkage due to loss of moisture (Haller, 1951).

B. Skin ground color. Generally the importance of color to the consumer has been well documented by Bourne (1980). The peach ground color changes from leaf-green to a lighter shade of green with maturity and then to yellow when the fruit is fully ripe. Color charts can be used to measure peach developmental changes (Delwiche, 1987).

C. Blush. The development of red color or blush, is very desirable from the standpoint of attractiveness of the fruit (Haller, 1952). As peach fruit matures and ripens on the tree a fairly rapid development of red color occurs, which varies greatly with cultivar and exposure to light (Rood, 1957; Erez and Flore, 1986).

D. Flesh firmness. Flesh firmness measurements are used in the fruit industry as one of the indicators of maturity (Watada et. al., 1976). A flesh firmness tester is normally used. Flesh firmness determinations and observations showed a softening of the fruit during maturation and ripening - from a hard, tough, woody condition when mature to a very soft, juicy condition when fully ripe (Haller, 1952). Haller also reported that flesh firmness readings at different stages of maturity and ripeness varied with the size of the plunger point used and the method of testing. Flesh firmness values reported were as follows: 5 kg to 6.4 kg for shipping, 2.5 kg to 4.5 kg for canning, and less than 2.5 kg being considered as soft/tree ripe (Haller, 1952).

E. Soluble solids. Chemical composition of fruit is important and is used to determine readiness for harvest or eating quality. Quality standards for several tree fruits, including peach are based partly on sugar content, usually expressed as soluble solids (Ryall and Pentzer, 1974). Haller (1952) reviewed peach literature and concluded that soluble solids increased slightly during maturation, but that under some conditions the increase was insignificant or lacking. The author cited percentage of soluble solids in different cultivars of peaches grown under different conditions as varying from 10.5 to 14.3%.

## Storage

Peaches and nectarines are seldom stored except for short periods to carry them over an excess supply in the market or to extend the processing season (Hardenburg et. al., 1986). The postharvest life of peaches stored at -0.5$^{o}$C to 0$^{o}$C and 90 to 95% relative humidity varies from about two to four weeks depending upon the cultivar and growing conditions (Haller, 1952; Haller and Harding, 1939; Salunkhe and Desai, 1984). Early cultivar peaches have a relatively short storage life compared to main season cultivars.

Peaches ripen satisfactorily at temperatures between 18 and 29$^{o}$C (Hardenburg et. al., 1986). Haller (1952) reported no softening of peach fruit properly stored at 0$^{o}$C The author acknowledged that the influence of temperature on the rate of ripening and on the rate of development of decay and breakdown is of great importance. Peaches can be ripened to good quality after about 10 to 20 days at 31$^{o}$ to 32$^{o}$, depending on the cultivar and other factors (Haller, 1952). Peaches held longer than three to four weeks in cold storage often fail to ripen satisfactorily on removal to higher temperatures (Hardenburg et. al., 1986). Such fruit develop a disorder called internal breakdown or wooliness characterized by flesh which may become dry and mealy, or wet and mushy and may be brown around the stone.

Generally less decay and better quality peaches are obtained when fruit is ripened after storage than when ripened before storage. Rapid cooling of peaches after harvest to temperatures below 4$^{o}$C is important to retard respiratory activity, ripening and decay (Hardenburg et. al., 1986). Peaches especially at higher temperatures e.g., 20$^{o}$C compared to 0$^{o}$C, loose water and shrivel. Working with nectarine, Gentry et. al. (1963) found that shrivel was visible after four to five percent loss in weight.

The objectives in this study were to determine:

a) how peach fruit quality at harvest is affected by the following cultural practices:

    1. Training systems - the palmette and central leader system.

    2. Summer hedging of palmette trained trees.

    3. Trickle or drip irrigation based on 75% EPAN.

b) how fruit blush, flesh firmness and soluble solids content for fruits from a single harvest date change with time and temperature of storage.

c) the reliability of single harvest date data.

# MATERIALS AND METHODS

Peach fruits were harvested on the 7th, 10th, 13th and 17th of August, 1987 at the Clarksville Horticultural Experiment Station, Michigan. Rows and trees used for the different treatments were randomly chosen. Harvested fruits were separated into seven different categories on the basis of fruit diameter. The size categories used were as follows: those with a diameter greater than 7.5 cm, 6.9 cm, 6.6 cm, 6.25 cm, 5.94 cm, 5 cm, and fruits with a diameter less than 5 cm. Fruit weight was measured and expressed as a percentage of the total weight of harvest per treatment.

Some of the fruit samples were assessed for quality attributes/maturity indices in the postharvest laboratory at Michigan State University. The maturity indices were measured as follows:

Blush - The amount of blush or reddish brown color on a peach fruit was assessed subjectively. The scale ranged from one to five, where

1 = 20% of fruit covered with red pigment,

2 = 40% of fruit covered with red pigment,

3 = 60% of fruit covered with red pigment,

4 = 80% of fruit covered with red pigment, and

5 = 100% of fruit covered with red pigment.

Flesh firmness - Flesh firmness measured as force on the blush and non-blush sides of individual fruit without skin was determined using an

Effe-gi, flesh firmness tester, model #335-25926 with an 8 mm diameter plunger. Fruit skin had been removed using hand peelers.

Soluble Solids - The soluble solids content were measured for juice from a wedge of mesocarp tissue using a hand refractometer.

Newhaven Training System, Hedging and Irrigation Experiment

Two training systems, central leader and palmette, were investigated for Newhaven trees established in 1985 on Halford rootstock. Hedging was done on palmette trained trees two weeks before the first harvest, with a third of current season's foliage removed on sides and tops of the trees. Trickle/drip irrigation according to Evaporation Pan (EPAN) was used as soon as there was foliage. Evaporated water was replaced.

The treatments in this experiment were arranged as follows:

a) No irrigation, central leader

b) Irrigation, central leader

c) No irrigation, palmette

d) No irrigation, palmette, hedged

e) Irrigation, palmette

f) Irrigation, palmette, hedged.

Ten randomly chosen fruits per treatment per tree were used in evaluating maturity and quality indices. Three or six trees representative if each treatment were used.

Variation of maturity indices with time and temperature of storage.

Maturity indices of the fruit from different treatments was measured with differing times and temperature of storage. The fruit used in this experiment were samples taken from the 7th of August, 1987 harvest. The amount of fruit blush, flesh firmness and percent soluble solids content were measured according to the following time scheme:

1. at harvest
2. after one week a 20$^{o}$C
3. after one week at 0$^{o}$C
4. after one week at 0$^{o}$C and one week at 20$^{o}$C
5. after two weeks at 0$^{o}$C
6. after two weeks at 0$^{o}$C and one week at 20$^{o}$C
7. after three weeks at 0$^{o}$C
8. after three weeks at 0$^{o}$C and one week at 20$^{o}$C
9. after four weeks at 0$^{o}$C
10. after four weeks at 0$^{o}$C and one week at 20$^{o}$C.

The results reported were analyzed as completely randomized designs. The treatment, time and temperature factors were considered in the analysis of variance. A correlation analysis was performed to clarify the effect of size on maturity indices. Mean separation was by LSD at P = 5%.

## RESULTS

### Size and Maturity Indices

A positive correlation (r = 0.9) was found between individual fruit weight and the amount of blush on the fruit. As fruit weight increased, the greater the amount of blush found on the fruit. Fruit size (r = 0.7) was found to be negatively correlated to flesh firmness of the fruit. As individual fruit weight increased, the respective flesh firmness was found to decrease. The soluble solids content of the fruit was not related to fruit size.

### Size Categories

Training system type, irrigation and/or hedging of palmette trained trees did not significantly affect fruits in the different (P = 5%) size categories over the four harvest dates (Table 1). However strong trends were apparent. Irrigated trees produced more fruit in the larger size categories and less fruit in the smaller size categories compared to non-irrigated trees over the four harvest dates. There was a lot of variation in fruit weight in the different size categories for fruit from the same treatment.

### Harvest dates and maturity indices.

The amount of fruit blush, flesh firmness and soluble solids content were affected differently by the date of harvest.

Table 1. **Effect of training system, irrigation and summer hedging on % weight of fruit in different size categories.**

| | Size Category Fruit Diameter (cm) | | | | | | |
|---|---|---|---|---|---|---|---|
| **Treatment** | >7.5 | 6.9 | 6.6 | 6.25 | 5.94 | 5.0 | 5.0< |
| **No irrigation,** | | | | | | | |
| **Central Leader** | 2.32 | 5.11 | 1.60 | 45.70 | 42.07 | 3.10 | 0.08 |
| **SE** | ±2.74 | ±3.64 | ±1.50 | ±6.92 | ±12.68 | ±1.84 | ±0.14 |
| **Irrigation,** | | | | | | | |
| **Central Leader** | 3.67 | 8.69 | 4.66 | 55.87 | 25.62 | 1.39 | 0.34 |
| **SE** | ±0.90 | ±16.7 | ±0.40 | ±2.23 | ±3.31 | ±2.50 | ±0.50 |
| **No Irrigation,** | | | | | | | |
| **Palmette** | 0.38 | 1.36 | 0.73 | 31.24 | 53.18 | 12.20 | 0.91 |
| **SE** | ±0.54 | ±1.15 | ±0.82 | ±18.96 | ±7.80 | ±13.0 | ±1.14 |
| **No Irrigation,** | | | | | | | |
| **Palmette, Hedged** | 0.37 | 2.51 | 0.99 | 42.94 | 49.25 | 2.80 | 0.70 |
| **SE** | ±0.22 | ±1.02 | +0.98 | ±5.05 | ±3.54 | ±1.94 | ±0.87 |
| **Irrigation,** | | | | | | | |
| **Palmette** | 2.21 | 7.92 | 3.15 | 56.73 | 28.67 | 1.70 | 0.12 |
| **SE** | ±0.61 | ±1.93 | ±1.04 | ±4.62 | ±7.15 | ±1.41 | ±0.11 |
| **Irrigation,** | | | | | | | |
| **Palmette, Hedged** | 8.75 | 10.81 | 4.67 | 50.84 | 23.50 | 1.30 | 0.34 |
| **SE** | +6.60 | +5.90 | +2.32 | +7.16 | +11.19 | +1.28 | +0.27 |

Fruit Color

The amount of blush on the fruit generally remained constant or increased with the date of harvest (Fig. 1 and 2). The differences of the effect of training system, irrigation or hedging of palmette trained trees on the amount of blush was found to be inconsistent for the three different harvest dates. However, fruit harvested from the irrigated trees showed trends of more colored fruit than fruit harvested from non-irrigated trees. The effects of training system type and hedging were not clear and inconsistent. No treatment x harvest date interaction was evident.

Flesh Firmness

At the first harvest date, the irrigated trees produced fruit of lower flesh firmness when compared to fruit that was harvested from non-irrigated trees. This trend changed by the second harvest date (Fig. 3 and 4). Fruit harvested from the non-irrigated trees were initially firmer (August 7 harvest date) than those from irrigated trees, and their flesh firmness decreased with each harvest date.

Fruit firmness differences due to the training system type and hedging were minor and inconsistent. A tendency of fruit becoming softer with harvest date was observed regardless of the treatment given to the trees.

Soluble Solids

The soluble solids content of fruits generally decreased with harvest dates (Fig. 4 and 5). Fruits harvested from irrigated trees

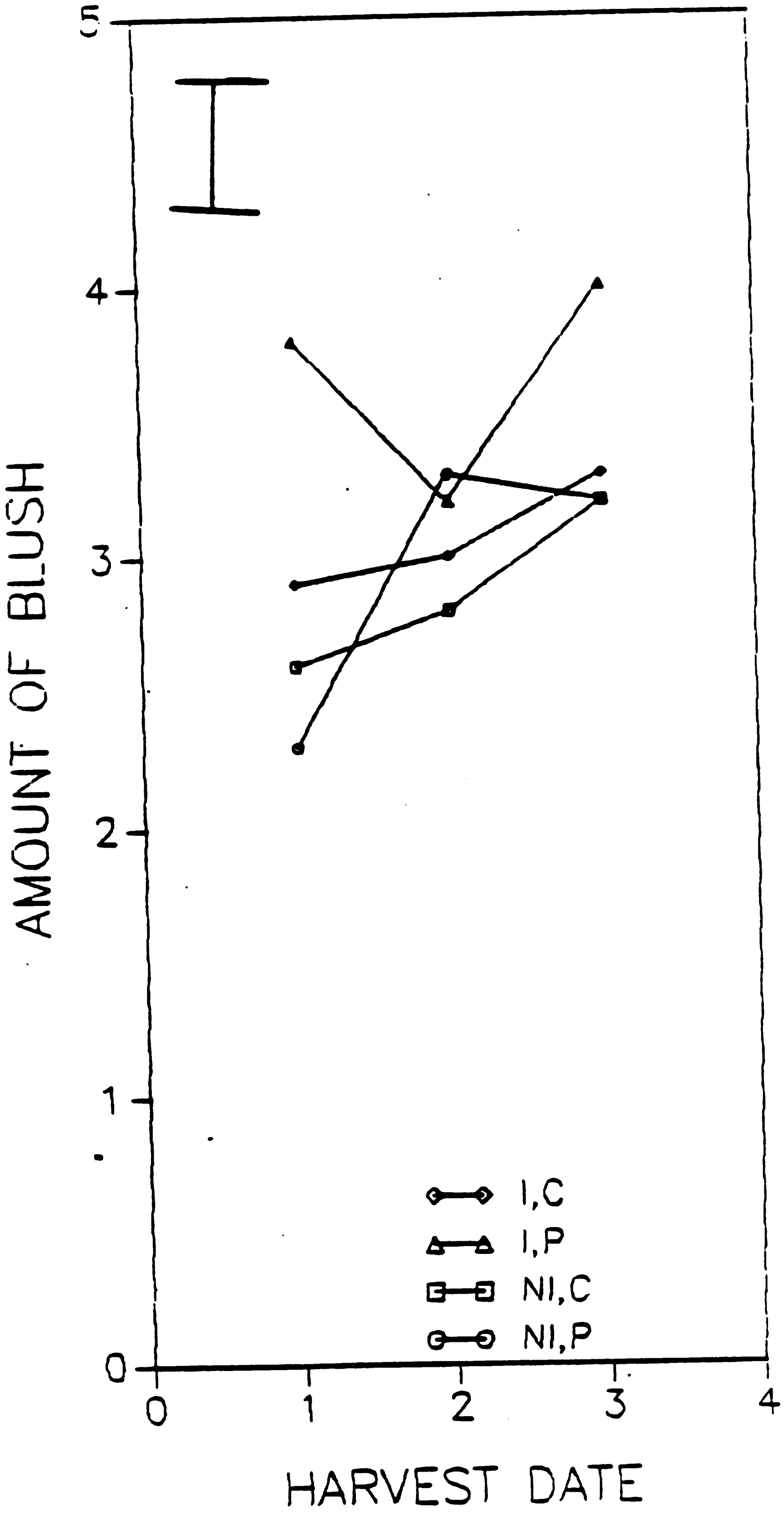



Fig. 1. Effect of training system and irrigation on the amount of blush over three harvest dates. (I = irrigated, NI = non-irrigated, P = palmette, CL = central leader). Bars ± SE.

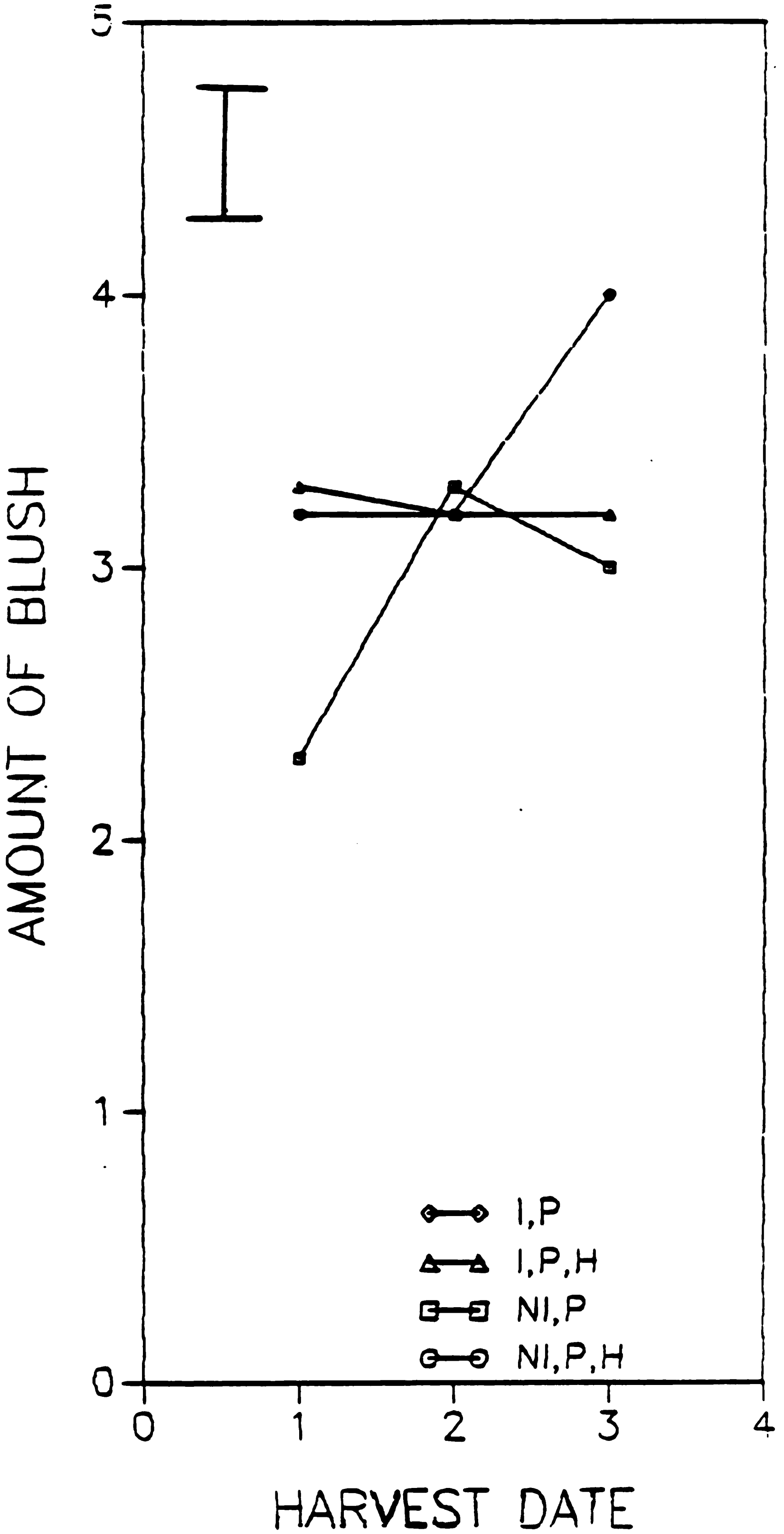



Fig. 2. Effect of hedging on palmette trained trees on blush over three harvest dates. (I - irrigated, NI - non-irrigated, P - palmette, CL - central leader). Bars ± SE.

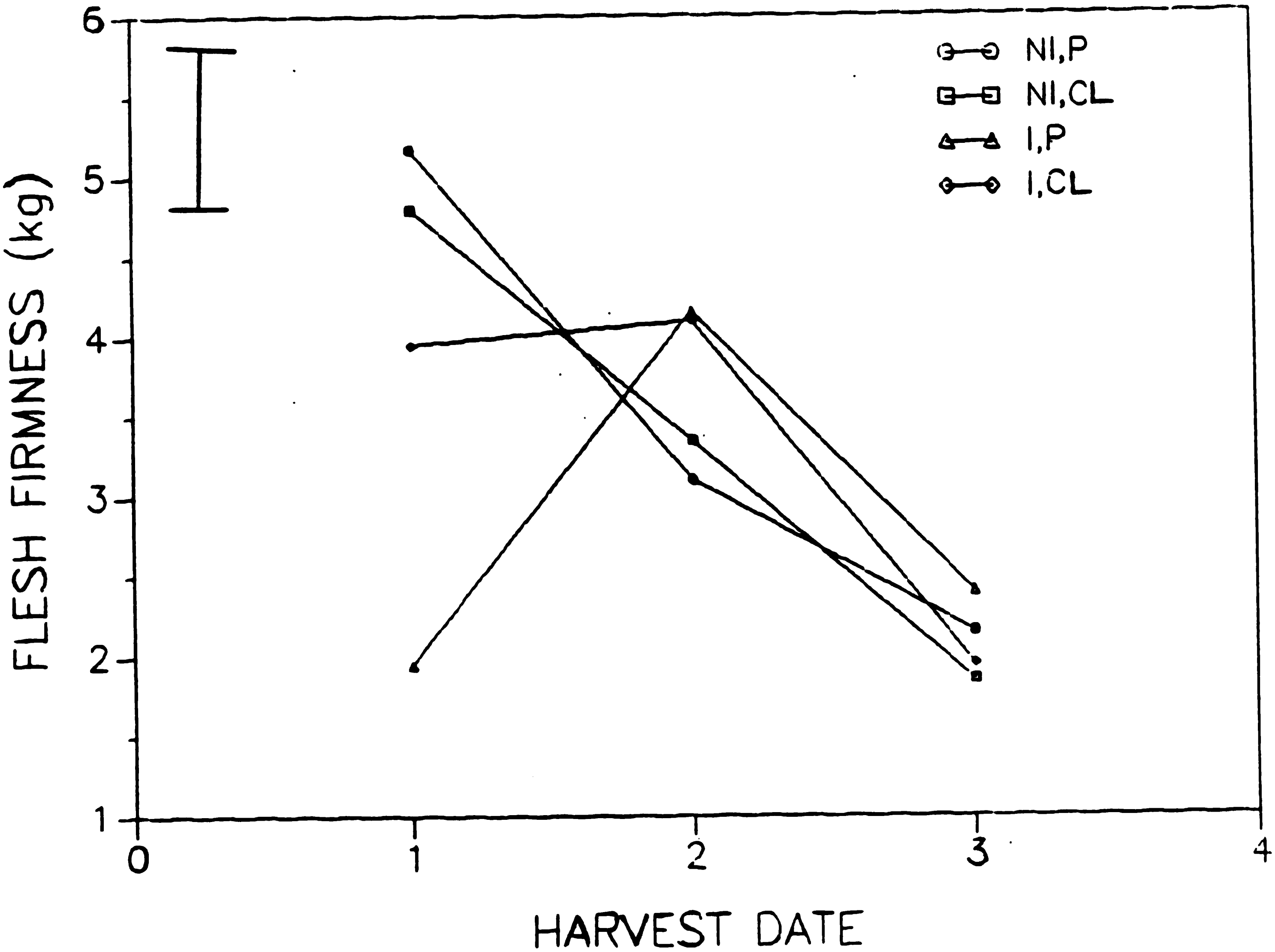



Fig. 3. Effect of training system and irrigation on fruit flesh firmness over three harvest dates. (I = irrigated, NI = non-irrigated, P = palmette, CL = central leader). Bars ± SE.

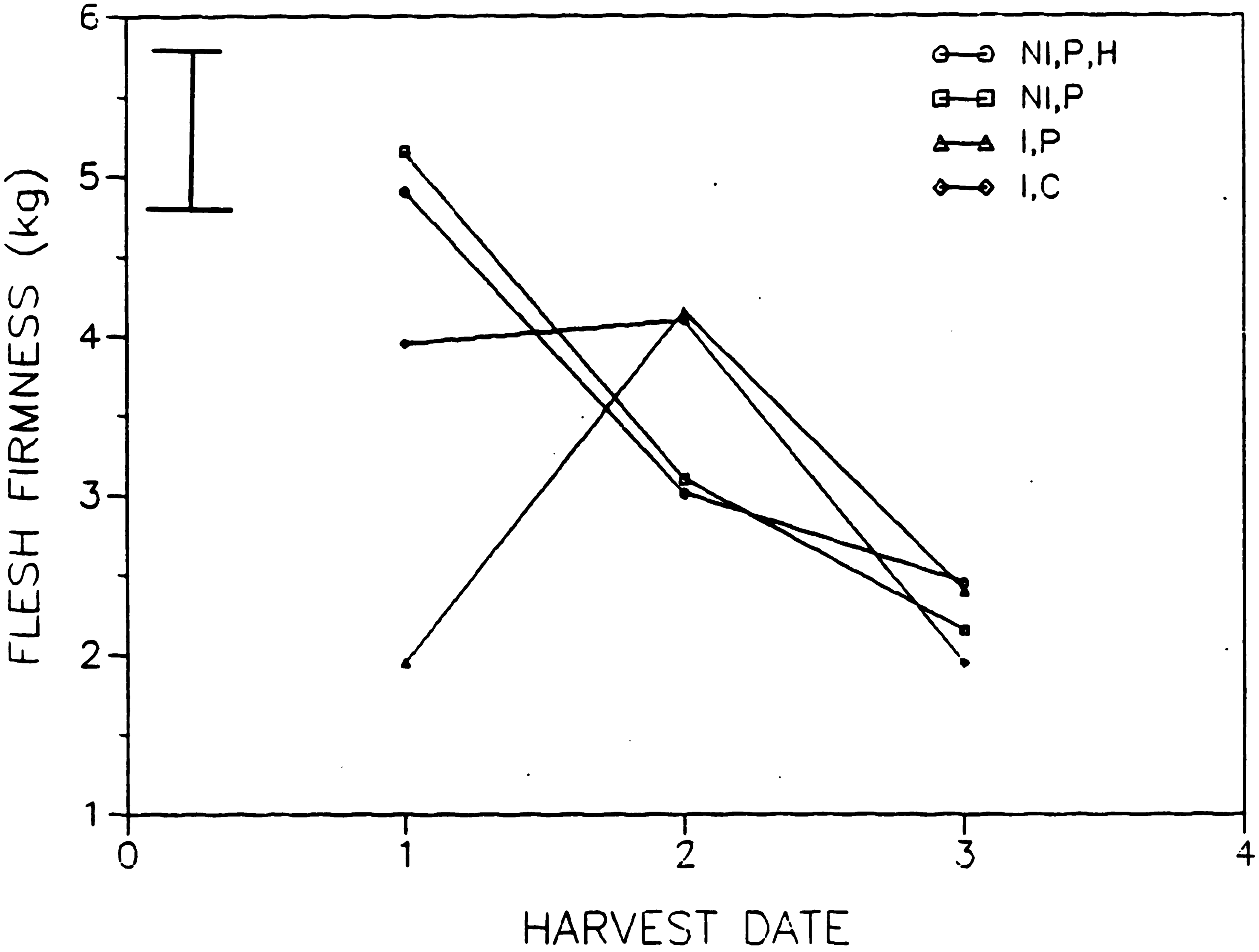



Fig. 4. Effect of hedging on palmette trained trees on flesh firmness over three harvest dates. (I = irrigated, NI = non-irrigated, P = palmette, CL = central leader). Bars ± SE.

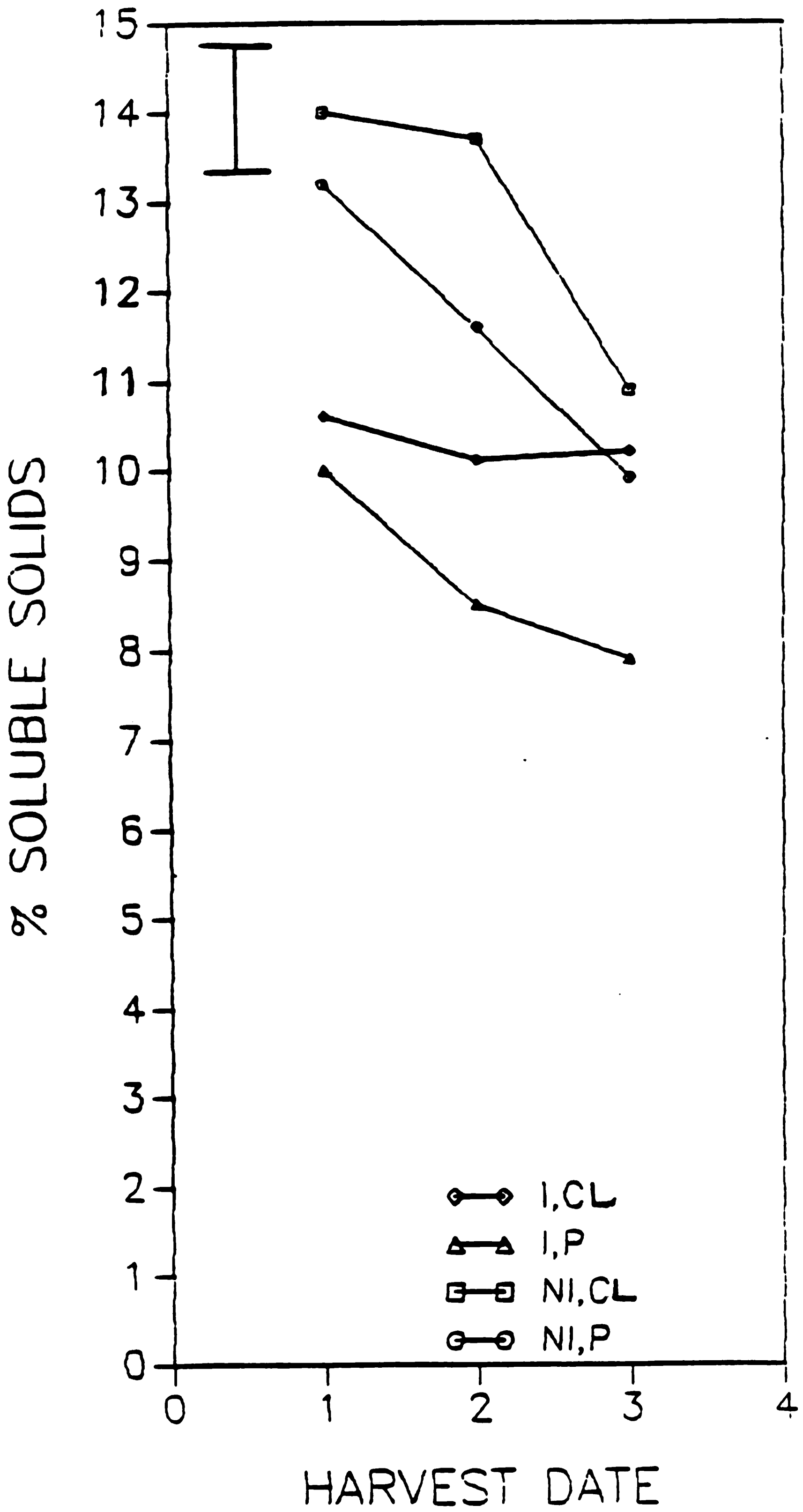



Fig. 5. **Effect of training system and irrigation on % soluble solids of peach fruit. (I = irrigated, NI = non-irrigated, P = palmette, CL = central leader). Bars ± SE.**

had lower soluble solids content than fruits harvest from non-irrigated trees (P = 5%). Fruits from central leader trained trees appeared to have higher soluble solids content than fruit from palmette trained trees though this trend was not apparent on the last harvest date for the irrigated central leader trees (Fig. 5). Irrigated palmette trained trees produced fruit with the lowest percent soluble solids compared to fruit from non-irrigated palmette trees and irrigated or non-irrigated central leader trained trees.

Hedged palmette trained trees produced fruit of lower soluble solids content on the first harvest date, increased by the second harvest date and then decreased by the last harvest date (Fig. 6). The non-irrigated palmette trees yielded fruit with higher soluble solids content than non-irrigated palmette trees, irrespective of whether they had been hedged or not. A treatment x harvest date interaction was observed.

Changes n maturity indices after harvest.

First Harvest

On the 7th of August, 1987, fruit maturity indices were found to vary with irrigation and hedging (Table 2) though these differences were not consistent when measured at other harvest dates. This demonstrates the importance of evaluation of fruit harvested at successive times.

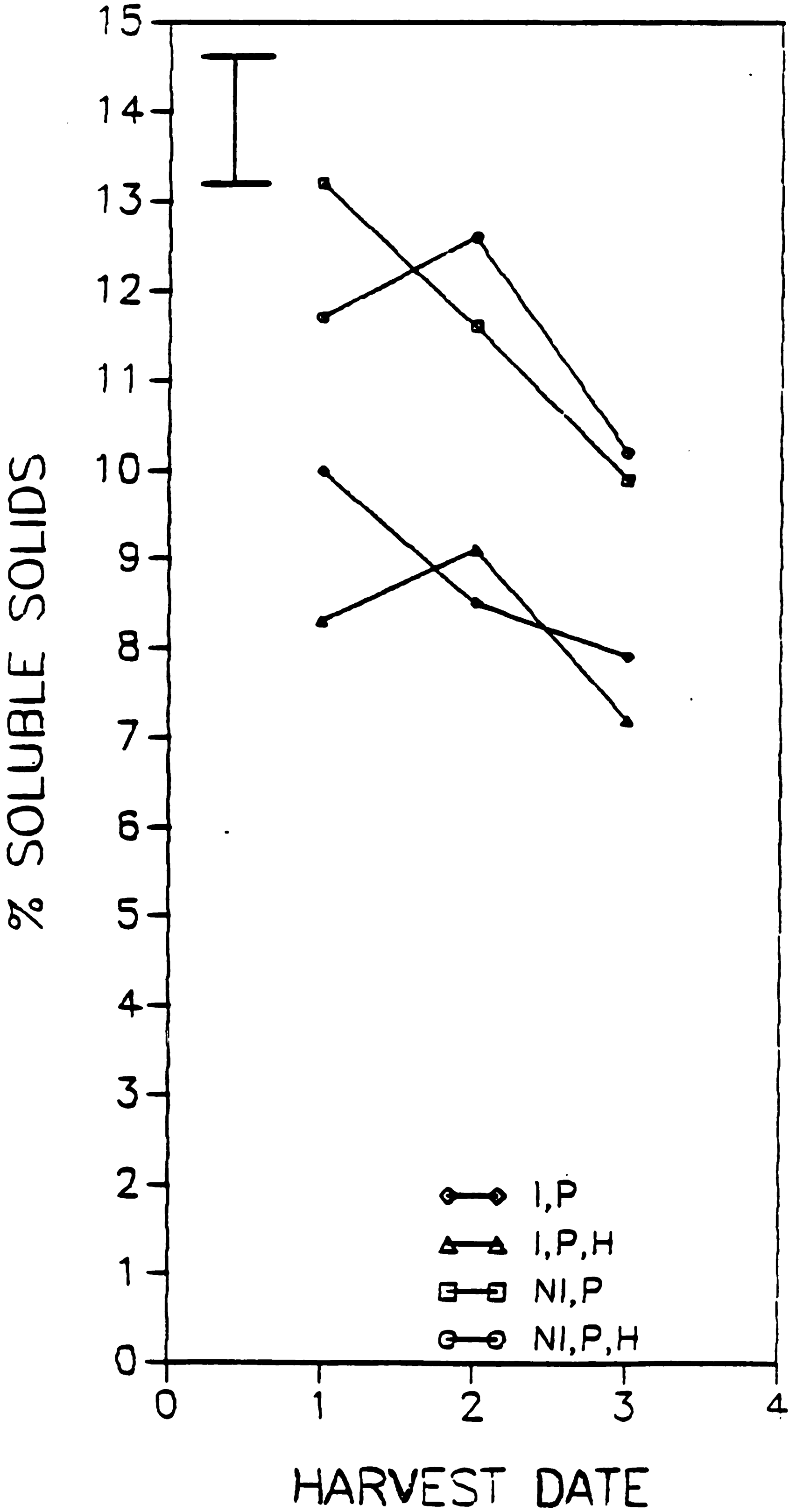



Fig. 6. Effect of hedging on palmette trained trees on % soluble solids of peach fruits. (I = irrigated, NI = non-irrigated, P = palmette, CL = central leader). Bars ± SE.

Table 2. Effect of irrigation, training system, and summer hedging on Newhaven peach fruit maturity indices for the August 7, 1987 harvest date.

| | Maturity Indices | | | | |
|---|---|---|---|---|---|
| | | Flesh Firmness (kg) | | | |
| | Fruit Weight (g) | Blush[x] | Non-blush Side | blush Side | % Soluble Solids |
| No irrigation, Central leader | 74.7a[z] | 2.6a | 4.7a | 4.9a | 14.0a |
| Irrigation, Central leader | 108.7b | 3.8b | 3.6ab | 4.3ab | 10.66b |
| No irrigation, Palmette | 80.7a | 2.3a | 5.2a | 5.1a | 13.2a |
| No irrigation, Palmette | 76.3a | 2.3a | 4.9a | 4.9a | 11.7ab |
| Irrigation, Palmette | 128.7b | 3.8b | 1.8c | 2.1c | 10.0b |
| Irrigation, Palmette, Hedged | 110.2b | 3.3ab | 3.5ab | 3.4ab | 8.3b |

[x] Blush scoring system 1-5, 1 = least, 5 = most

[z] Values are mean of 30 fruit, separated by LSD, P = 5%. Means followed by the same letter are not significantly different.

Recognizing that a single harvest date may bias conclusions, the information presented here concerning the storage characteristics of peaches harvested from the different treatments may provide information which would be useful in designing further experiments.

On the first date of harvest, irrigated trees produced fruit of higher individual weight than fruit from non-irrigated trees while neither the training system nor the hedging had an effect (P = 5%). However results for the four different harvests showed no percentage differences in fruit weights in the different size categories. Irrigated fruits had more blush than non-irrigated ones. This trend persisted to a lesser extent at the different harvest dates for the irrigated or non-irrigated central leader and non-hedged palmette trees (Fig. 1). The effects of hedging were inconsistent. Irrigated palmette trees yielded fruit of lower flesh firmness than all other treatments. This was untrue when measured at later harvest dates.

Percent soluble solids were influenced by irrigation. This was found to be true to a great extent for the three different harvest dates analyzed.

## Maturity changes after harvest.

### Blush

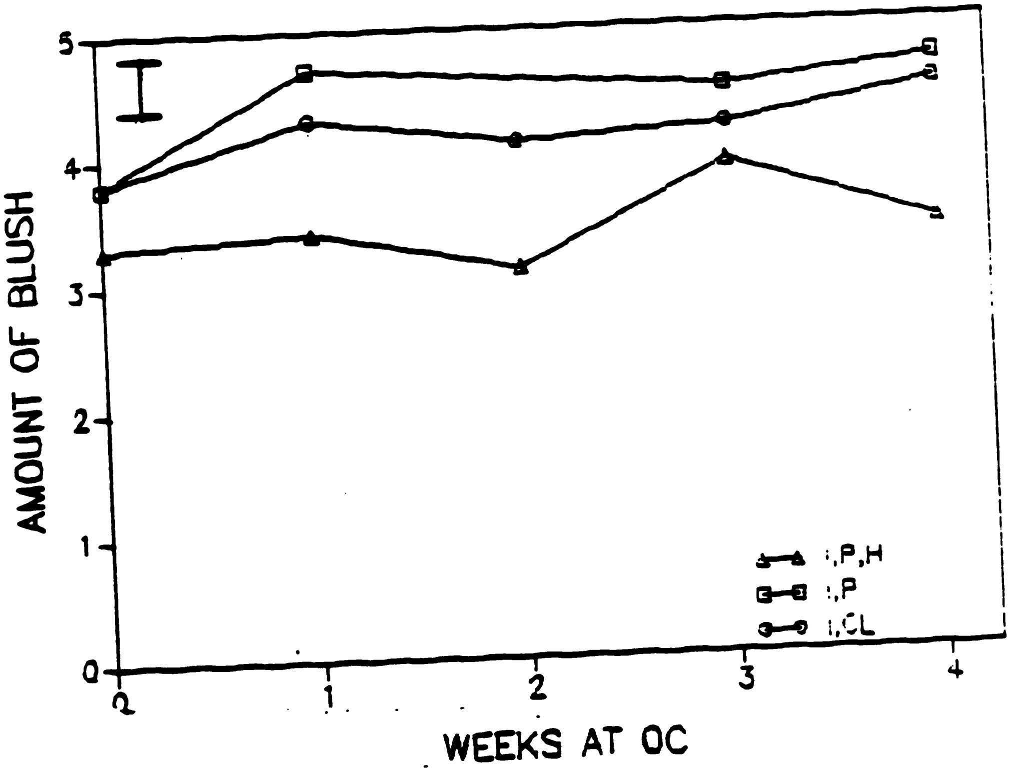
Generally, irrigated trees had fruit with more blush during the three to four weeks of storage compared to non-irrigated trees (Fig 7 and 8). Time and temperature did not influence the differences in blush between irrigated and non-irrigated treatments. Hedged, irrigated, palmette trees maintained fruit with less blush throughout storage at 0°C and for fruit later transferred to 20°C compared to fruit that came from irrigated palmette and irrigated central leader trees at the same harvest date. This hedging effect on fruit color was unclear and inconsistent with successive harvests (Fig. 1 and 2).

## Flesh Firmness

Generally, flesh firmness of fruit gradually decreased with time for fruit stored at 0°C (Fig. 9). Fruits were too soft for their firmness to be measured after one week at 20°C for all treatments irrespective of time of storage at 0°C. Irrigated treatments maintained less firm fruit compared to non-irrigated treatments. This observation for the first harvest date was not consistent with successive harvest.

## Soluble Solids

Percent soluble solids of stored fruit were generally higher for the non-irrigated trees ($P < 0.05$) (Fig. 10, 11 and 12). This trend was persistent to a great extent with successive harvests. Time and temperature of fruit storage did not influence percent soluble solids



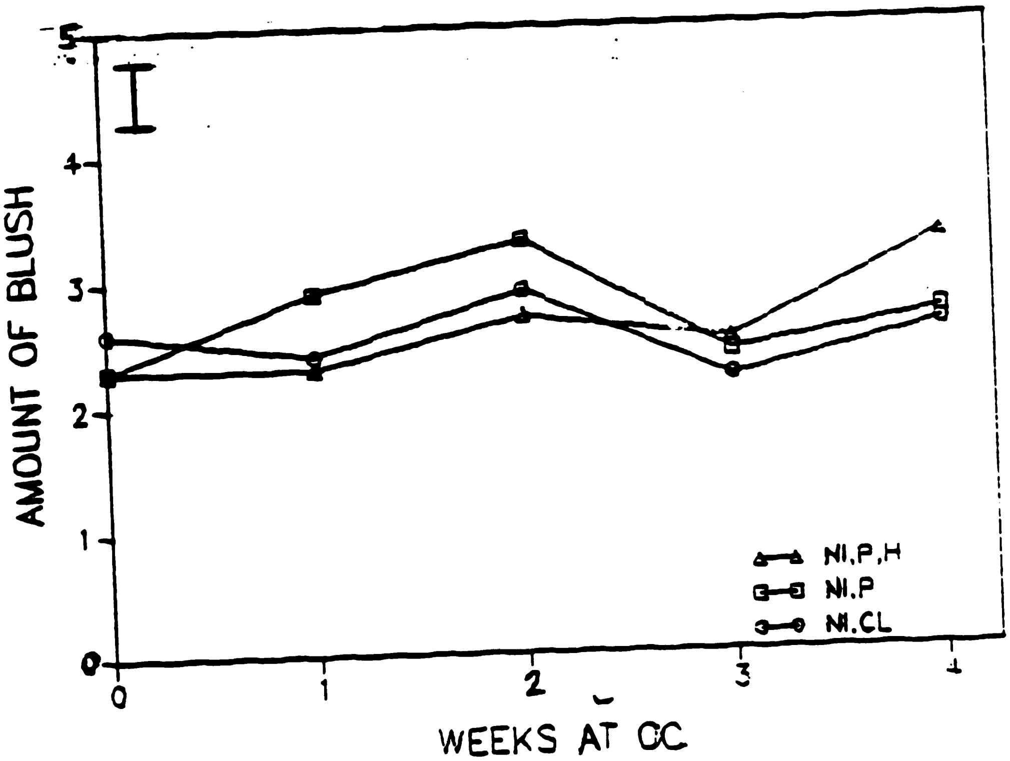




Fig. 7. Effect of training system, irrigation and hedging on blush for fruit stored at 0°C. (I - irrigated, NI - non-irrigated, P - Palmette, CL - Central Leader, H - hedged.) Bars + SE.

FLESH FIRMNESS (kg)

FLESH FIRMNESS (kg)

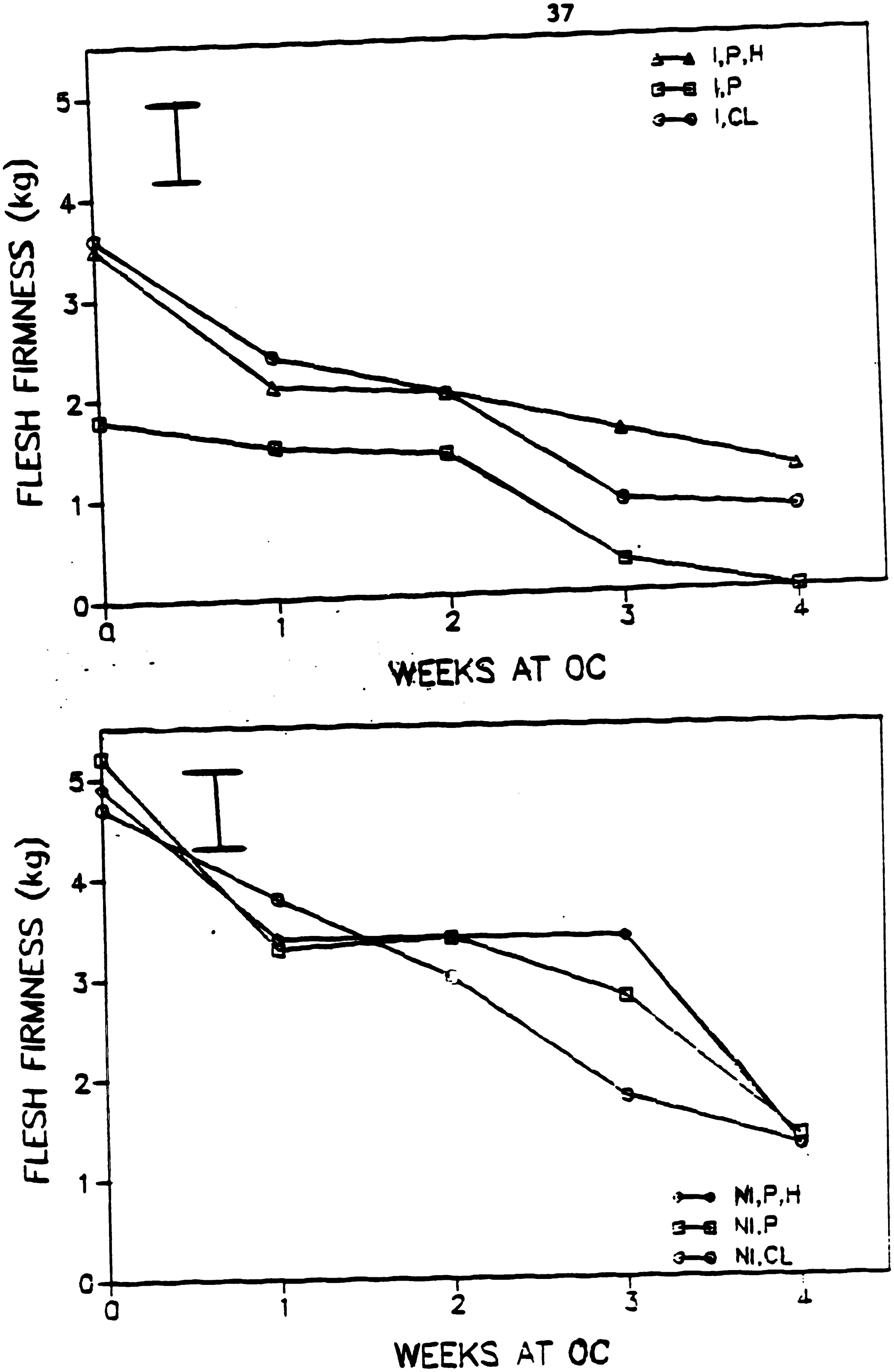



Fig. 8. Effect of fruit training system, irrigation and hedging on blush for fruit stored 0, 1, 2, 3 weeks at 0°C then transferred to 20°C for one week. (I = irrigated, NI = non-irrigated, P = Pal ette, CL = Central Leader, H = hedged.) Bars + SE.

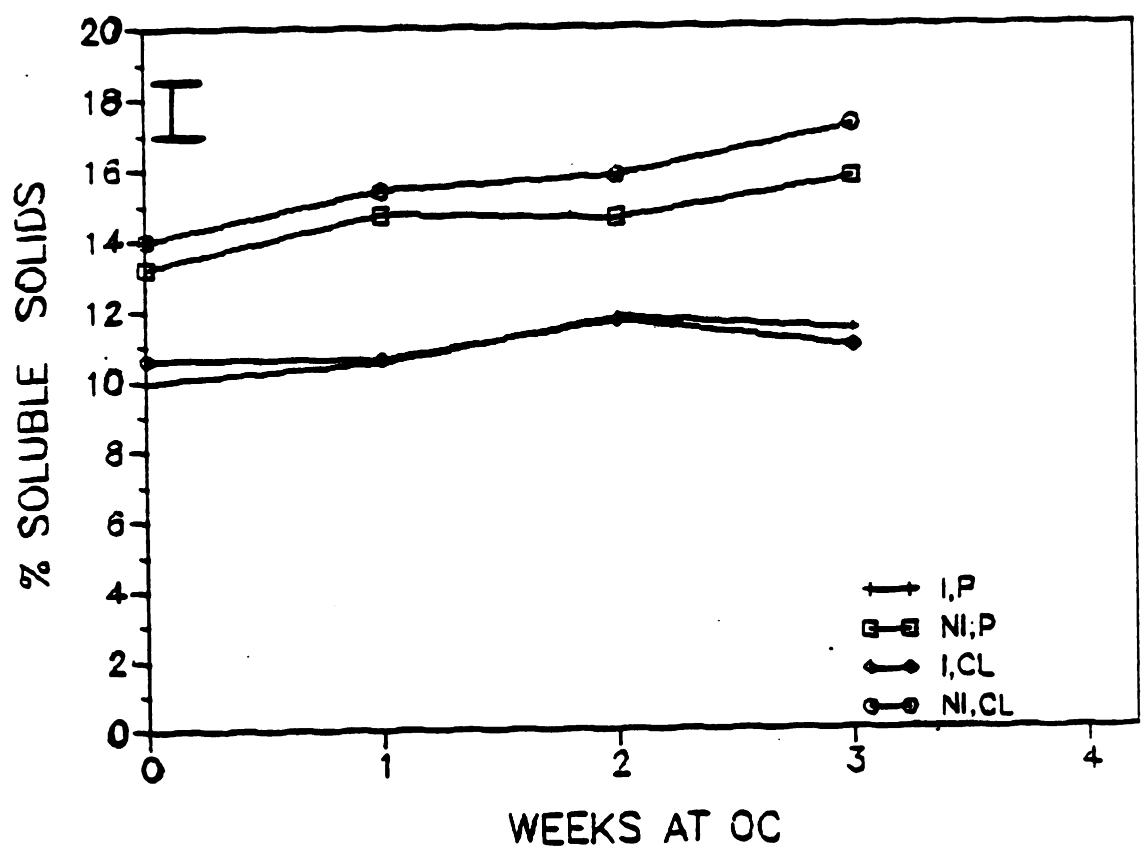



Figure 9. Effect of training system and irrigation on % soluble solids for fruit stored at $0^{o}C$. (I= irrigated, NI= non-irrigated, P= palmette, CL= central leader)

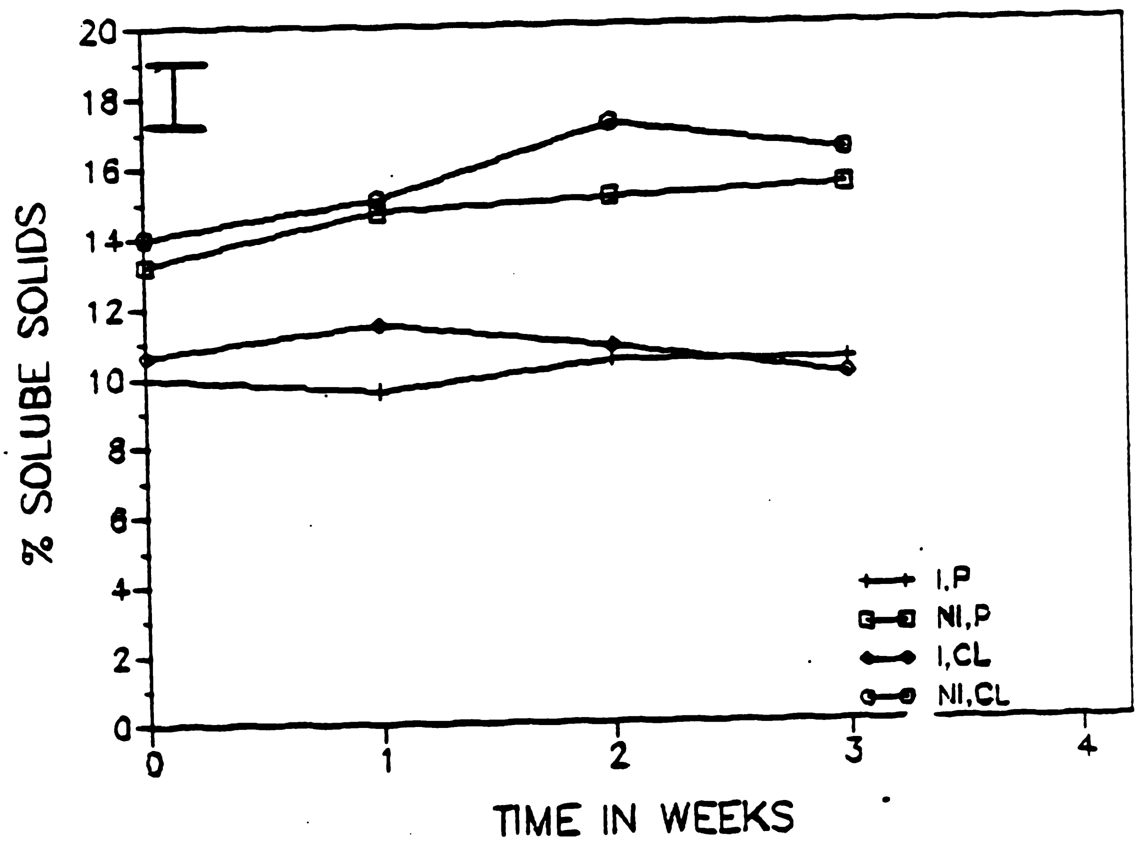



Figure 10. Effect of training system and irrigation on % soluble solids for fruit stored at 0°C for 0, 1, 2, 3 weeks then transferred to 20°C for one week. (I= irrigated, NI= non-irrigated, P= palmette, CL= central leader)

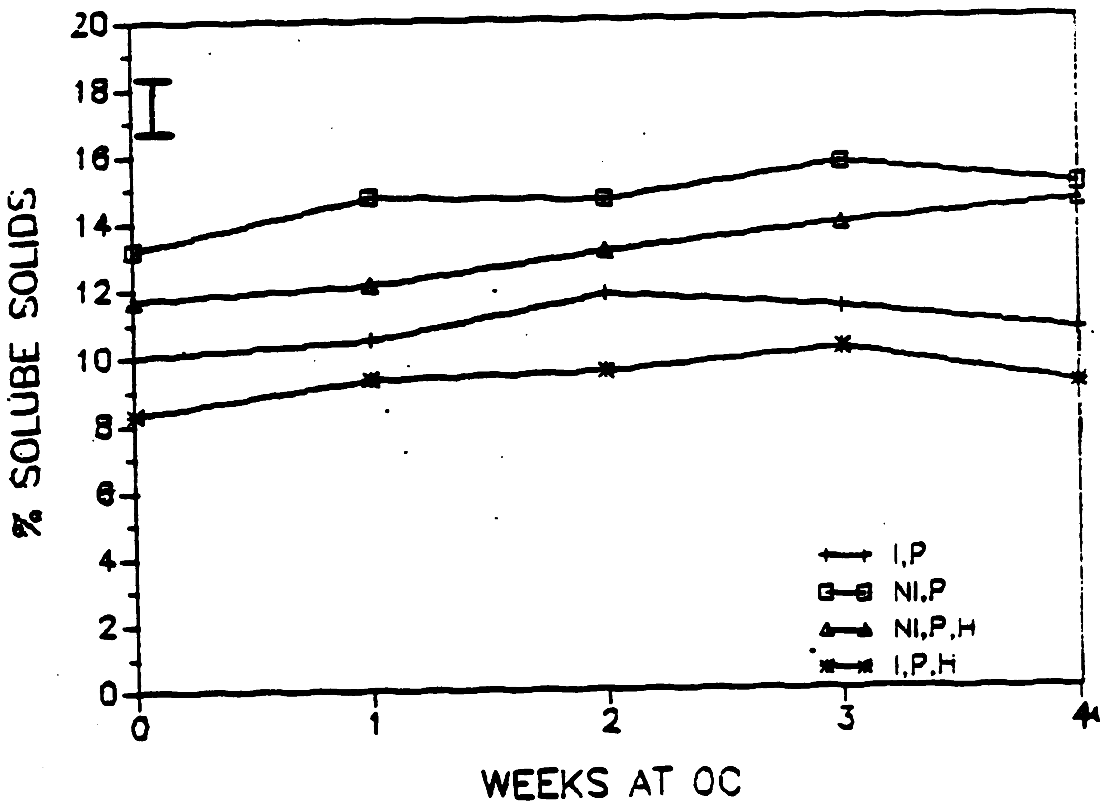



Figure 11. Effect of irrigation and hedging on palmette trained trees at 0°C storage. (I= irrigated, NI= non-irrigated, P= palmette, CL= central leader, H= hedged)

for all treatments. This was evident because there was no time x temperature, time x treatment, temperature x treatment or time x temperature x treatment interaction.

Incidence of Disorders for the First Harvest Date.

At 0°C fruits did not spoil for all treatments during the four weeks of storage. Irrigated trees produced fruit of advanced maturity by the first harvest date. These fruits from irrigated trees appeared to have a higher incidence of spoilage after one week of storage at 20°C (Table 3). Generally, the occurrance of spoilage increased with prior storage time at 0°C. Fruits were considered spoiled after they had broken down or rotted (green mold, Alternaria spp). This data strongly suggests that evaluations of storage quality should be evaluated for a series of harvest dates in order to determine if irrigation has an adverse effect on storage quality when the fruit was harvested at differing maturities.

Table 3. Effect of training system, irrigation and hedging on occurrence of spoiled fruit for fruits stored for one week at 20°C after 0, 1, 2, 3, or 4 weeks storage at 0°C.

% of Spoiled Fruit (internal breakdown, green mould, or both)

| | Total Storage Time (Weeks) | | | | |
|---|---|---|---|---|---|
| Treatment | 1 | 2 | 3 | 4 | 5 |
| No irrigation, central leader | 3 | 3 | 2 | 10 | 12 |
| No irrigation, palmette | 0 | 0 | 3 | 10 | 7 |
| No irrigation, palmette hedged | 0 | 0 | 0 | 3 | 7 |
| Irrigation, central leader | 17 | 35 | 17 | 42 | 82 |
| Irrigation, palmette | 20 | 6 | 37 | 70 | 100 |
| Irrigation, palmette, hedged | 10 | 6 | 17 | 30 | 67 |

Discussion

Cultural practices during crop growth are known to affect fruit quality at harvest (Ballinger, et. al., 1963; Morris, et. al., 1961; Haller, 1952; Leuty and Pree, 1980) and postharvest conditions generally do not improve quality. The results obtained in this study indicated that the effects of cultural practices on fruit quality are not clear and inconsistent with harvest dates. It has been shown that single harvest date data is misleading since quality varied differently with successive harvest dates. Therefore, successive harvests are important in attempting to elucidate the variation in maturity caused by the different cultural practices. Maturation is more variable among peaches than among other fruit (Marini and Trout, 1984). this makes it difficult to separate fruit variation quality not associated with treatments from variation actually due to the treatments. The researcher then needs to seek methods that reduce experimental variation and maximize variation due to treatments.

Single harvest date postharvest data is limited in that successive harvests yield variable data. However, important information on changes of maturity indices with time and temperature of storage is obtained. The importance of storing fruit of certain characteristics is reiterated by storage data which revealed consistency of differences at the beginning of storage.

Size Effects

As the size of the fruit increased, the more blush was associated with such fruit irrespective of treatment. The correlation was strong (r = 0.9). Flesh firmness was found to be negatively correlated (r = -0.7) to size implying that there was a tendency of smaller fruit being firmer than large. Size, therefore, further confounds the effects of treatments. In some instances, treatment effects are thus indirect via size. However, in this study, fruit soluble solids content were found to be independent of size. To find out conclusive information about size effects, there is need to extensively investigate how maturity indices vary for the different size categories.

## Size Categories

The different treatments due to cultural practices did not affect fruit quantities in the different size categories. This was so because of the large variation among the experimental units receiving the same treatments. However, the trend of larger fruit with irrigation compared to no irrigation is important since this might be significant if variation among experimental units receiving the same treatment is controlled. Furthermore, the trend toward more fruit in the larger size categories could be of commercial importance to the grower (Loreti, et. al., 1980). Ballinger, et. al. (1963) found similar trends of increase in size with irrigation over three years. Morris, et. al. (1961) reported that the percentage of peaches with a minimum diameter of 2.25 cm increased by a combination of all-season irrigation, severe pruning and heavy thinning during the dry season.

Harvest Dates

Maturity indices of peach fruits were affected by harvest dates. Similar findings have been reported (Stembridge, et. al, 1972; Marini and Trout, 1984). The importance of successive harvests have been demonstrated in this study since data from single harvests is inconclusive. Variation of some maturity indices may occur with years (Ballinger, et. al, 1963) tree age and peach cultivars used (Layne, et. al, 1976). Maturity indices vary with harvest dates because with time the stage of maturity advances. Successive harvests introduce variation due to fruit selection, less mature fruit remain on the tree with each harvest. This further makes treatment differences elusive.

Training Systems

Training systems did not influence fruit yields in the different size categories over four harvest dates. Chalmers and van den Ende (1988) found no yield differences for the palmette and central leader hedge with "Loring" peaches using several intensive planting systems. However, they found the Tatura trellis outyielding the palmette and central leader hedge. Couvillon (1986) reported yield variation with training systems: central leader system outyielding the palmette system and sometimes the opposite. Ferree and Hall (1980) found the central leader system outyielding the trellis and interstem hedge row. Differences in the amount of light received by a tree canopy and the hedge row appear to be the primary causal agent in yield differences of training systems (Chalmers and van den Ende, 1988; Sansavini et. al., 1980; Ferree and Hall, 1980; Kappel et. al, 1983; and Baroni and

Bergioni, 1988). The total dry-matter production of an orchard is determined by the amount of light energy the orchard can intercept and the efficiency with which it can convert that intercepted energy into dry matter (Palmer, 1980).

It is necessary to control variation among experimental units receiving the same treatment to detect treatment differences if any. Fruit color and firmness were not affected by training systems studied but the central leader system produced fruit with higher soluble solids content than palmette trees over the harvests. The higher soluble solids content of fruit harvested from the central leader may be due to the system intercepting more sunlight energy.

Practically there is need to select a training system which maximizes light utilization and offers the best quality characteristics depending on fruit destiny, i.e., whether for dessert, processing or long distance shipping.

## Irrigation

Irrigation based on 75% EPAN resulted in a trend towards more fruit in the larger size categories for all treatments compared to no irrigation. Though this trend was not significant in the particular season studied, it is important and may be more pronounced in the drier seasons. Increase in fruit yields by irrigation has been widely reported for peach (Layne et. al, 1981; Chalmers and van den Ende, 1988; Mitchell and Chalmers, 1982; Chalmers et. al., 1987; and Westwood, 1978). However there is a dearth of information regarding the effect of irrigation on peach quality.

In this study, the effects of irrigation on fruit color and firmness were unclear and inconsistent with successive harvests. At the first harvest date, fruit from irrigated treatments were less firm than fruit from non-irrigated trees. With the second harvest date, the firmness of irrigated fruits increased. Such an increase was unusual and unexpected and could be due to less mature, firmer fruit having been left on irrigated trees. With successive harvests, fruit firmness decreased as the fruits ripened. Similar findings of fruit becoming less firm with successive harvests have been reported (Haller, 1952; Rood, 1957; and Marini and Trout, 1984).

These were minor trends of more colored fruit with irrigation and inconsistency with successive harvests. It was found difficult to isolate color differences due to irrigation and those due to other factors and/or variation in the experimental units themselves. The amount of fruit blush generally remained constant or tended to increase with successive harvests. Marini and Trout (1984) found a gradual red color increase with four successive harvests but a decrease with the last harvest. This might help explain the selection effect. The fact that larger fruits were found to be more colored makes size a confounding factor. However, it appears that irrigation may indirectly result in larger, more colored fruit.

The effect of irrigation on fruit soluble solids was more consistent with successive harvests than for the other maturity indices. Soluble solids content of fruit decreased with harvest dates for all treatments. Decreases of soluble solids content of fruit with successive harvests have been reported (Hall, 1952; Romani, et. al, 1962; Marini and Trout, 1984; and Martin, et. al, 1987). Increases and decreases have also been reported (Martin, et. al., 1987). The decrease in fruit soluble solids content of peach may be due to fruits of higher percent soluble solids having been harvested on prior harvests. Possibly with increased time on the tree fruit water content increases accompanying the ripening process since the storage data revealed minor increases in percent soluble solids possibly due to water loss of the detatched fruits. Weather during the final days of harvest may be important as Haller (1952) reported that soluble solids in peach are lowered by cool, cloudy and humid conditions while a dry spell before harvest was found to increase percent soluble solids of fruit.

It was interesting that differences in percent soluble solids due to treatments were maintained over the three harvests (Fig. 5 and 6). Non-irrigated trees produced fruit of higher soluble solids than fruit from non-irrigated treatments. Morris, et. al, (1961) found that percentage of soluble solids increased with lighter fruit loads, and decreased with irrigation. Chalmers (1986) reported that fruit with higher water content had lower soluble solids.

The results reported in this paper indicate that irrigation may be used to manipulate fruit size and the accompanying fruit quality depending on the harvest date and the desired goal, e.g., whether fruit is for fresh market or processing. A compromise can be made to obtain the desired quality characteristics at a given harvest date using the concept of reduced drip irrigation (RDI) which has been widely investigated by Chalmers. It would be interesting to find out how fruit quality varies with the amount of water applied during the growing season and during different stages of fruit growth.

## Hedging

The effects of hedging on fruit maturity were varied, inconsistent with harvest dates and difficult to understand. Data presented from a single harvest is misleading and inconclusive since variation and inconsistently was observed with successive harvests. Marini (1985) reported that pruning treatment had no consistent effect on yield, fruit size, or date of maturity. Red color and soluble solids of 'Loring' fruit were not affected by pruning treatment, but flesh firmness was increased for fruit from summer topped trees. He also found that harvest date influenced aspects of fruit quality though the effects were not consistent for the two years studied. Hedging, although containing the growth of the tree satisfactorily, has depressing effects on the fruitfulness of trees (Chalmers, et. al., 1981). Hedging invigorates vegetative growth and this may compete with fruit growth. It is important that physiological balance between roots and vegetative parts be maintained.

## Chances of Maturity Indices After Harvest

Generally, the treatment differences at harvest between irrigated and non-irrigated treatments persisted in storage at $0^{o}C$. At $0^{o}C$ ripening and senescence were slowed down compared to $20^{o}C$. Typical findings have been reported by Haller (1952). The results obtained provide evidence of the importance of temperature in maintaining quality of peaches. Thus it is recommended to store peaches between -0.5° and 0°C (Haller and Harding, 1939). Blush did not change at 0°C or 20°C irrespective of time of storage. This indicates that blush formation ceases at harvest (Haller, 1952).

At 0°C, ground color of stored fruit increased after the third week of storage. This may mean that fruit ripening takes place at 0°C after three weeks of storage. These fluctuations of ground color at 0°C are inconsistent and difficult to explain. The hedging effect of lowering ground color appears more pronounced for the irrigated treatments stored at 0°C. After one week at 20°C fruit from all treatments attained maximum yellow color irrespective of storage time at 0°C. These results suggested an increase in metabolism at 20°C compared to 0°C. Practically higher temperatures like 20°C should be used to ripen peach fruits (turning them yellow). Peaches ripen satisfactorily at temperatures between 18 and 29°C (Hardenburg et. al, 1986).

At 0°C flesh color increased slowly and became pronounced after the fourth week of storage. This may be because fruit metabolized at 0°C and gradually acquired enough energy to change the flesh color like the ground color, i.e., turning fruit flesh yellow. The flesh color differences at harvest were maintained for the irrigated treatments though gradually all fruit turned yellow. No flesh color differences were evident for the non-irrigated treatments though all fruits gradually turned yellow.

No flesh firmness was recorded after one week at 20°C irrespective of prior time of storage at 0°C for all treatments. These results indicate that 20°C is a high enough temperature to accelerate metabolic reactions associated with cell wall softening. Therefore, fruit stored at 20°C should be utilized as soon as possible because the rate of senescence is higher at such a temperature compared to 0°C. Flesh firmness gradually decreased with time for all treatments at 0°C. Flesh firmness decrease was gradual, implying that 0°C was effective to some extent in minimizing metabolic rates. These results suggest that tangible physiological changes are possible at 0°C especially after one week of storage. Flesh firmness changed together with ground color and flesh color, implying a maturity change with cold storage for all treatments. However, Horton and Hopfinger (1987) found minor decreases in flesh firmness for fruit stored at 0°C for two weeks with decrease in flesh firmness being more pronounced as temperatures were increased. Peach sensitivity to low temperature emphasizes the need to rapidly cool them followed by maintaining cold temperatures after harvest.

Soluble solids did not change after harvest irrespective of storage time or temperature. Haller (1952) noted that no appreciable changes in percentage of soluble solids has been found during ripening after harvest.

From the results presented (Fig. 10, 11, 12), manipulation of soluble solids can only be done prior to harvest. At 20°C physiological disorders and pathological activities are promoted compared to 0°C. Therefore, 0°C is effective in minimizing or preventing disorder occurrence compared to 20°C.

## CONCLUSIONS

1. Size had a confounding effect on maturity indices except for fruit soluble solids content. It is important to measure fruit maturity indices for various size categories and do a correlation analysis.
2. Training systems alone did not significantly affect fruit yield in the different size categories, fruit color and flesh firmness. Fruit harvested from central leader trained trees had higher soluble solids content.
3. Irrigation lowered fruit soluble solids content and this was persistent with successive harvests. The effect of irrigation on peach fruit yield, color and firmness was inconsistent with successive harvests. It is possible to manipulate fruit quality through irrigation control.
4. The effects of hedging on fruit quality were found to be unclear.
5. Harvest dates were demonstrated to be important in studying variation due to treatments. Fruit maturity varied inconsistently with successive harvests.
6. The amount of fruit blush and soluble solids did not change with time and temperature of storage.
7. There is need for thorough research to control variation which may mask the effects of training systems, irrigation and summer hedging on fruit quality. The concept of reduced drip irrigation (RDI) is very promising since Chalmers (1988) found that at a

certain RDI level maximum yields were obtained and this might be true with certain quality characteristics at various stages of harvest.

Information obtained from these studies will facilitate making compromises for the maximum and efficient utilization of resources leading to profit maximization by the grower.

# LITERATURE CITED

## 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.

Baroni, G. and G. Bargioni. 1988. Performance of the "Stark Redgold" nectarine variety in cultivation of different planting densities. International Peach Symposium, June 19-23, 1988, Clemson University, Clemson, SC, USA.

Bourne, M.C. 1980. Texture evaluation of horticultural crops. HortSci. 15:51-57.

Brown, G.E. 1972. The pruning of trees, shrubs and conifers. Faber and Faber - London.

Bucks, D.A. and S. Davis. 1986. Historical development in trickle irrigation for crop production design, operation and management. Ed. F.S. Nakayama and D.A. Bucks Elsevier, 1-5.

Chalmers, D.J. 1988. An analysis of growth and productivity of peach trees. Paper presented at International Peach Symposium, June 19-23, 1988, Clemson, SC.

Chalmers, D.J. 1988. Personal communication.

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 P.H. Jerie. 1984. The physiology of growth control of peach and pear trees using reduced irrigation. Acta Hort. 146:143-149.

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 B. Van den Ende. 1988. Paper presented at International Peach Symposium, Clemson University, Clemson, SC, June 19-23, 1988.

Couvillon, G.A. 1986. High density peach plantings mean management and dollars. National Peach Council Proceedings 23-28. Asheville, NC, USA.

Dann, I.R. and P.H. Jerie. 1988. Gradients in maturiy and sugar levels of fruit within peach trees. J. Amer. Soc. Hort. Sci. 113(1):27-31.

Delwiche, M.J. 1987. Grader performance using a peach ground color maturity chart. HortSci. 22:87-89.

Delwiche, M.J. and Baumgardner. 1985. Ground color as a peach maturity index. J. Amer. Soc. Hort. Sci 110(1):53-57.

DeSalvador, F.R. and T.M. DeJong. 1988. Observations of sunlight interception and penetration into the canopies of peach trees in different planting densities and pruning configurations. International Peach Symposium, June 19-23, 1988, Clemson University, Clemson, SC, USA.

Doorenbos, J. and W.O. Pruitt. 1977. Guidelines for predicting crop water requirements FAO and UN, 62-65.

Erez, A. and J.A. Flore. 1986. The quantitative effect of solar radiation on 'Redhaven' peach fruit skin color. HortSci. 21:1424-1426.

Feree, D.C. and F.R. Hall. 1980. Canopy development, light and spray penetration in Golden Delicious trees in four management systems. Acta Horticulturae, 114, 1 Orchard Plantation Systems, 91-96.

Francis, F.J. 1980. Color quality evaluation of horticultural crops. HortSci. 15:14-15.

Frecon, J.L. 1983. Ed. by J. Hull, Jr. Peach production in New Jersey and the middle Atlantic states. Michigan State Horticultural Society. 113th Annual Report, 49-60.

Gentry, J.P., F.G. Mitchell, and K.E. Nelson. 1963. Weight loss of grapes and nectarines as related to humidity and air velocity of storage. Amer. Soc. Agr. Engin. Trans. 6:254-256.

Gerdts, M. 1987. Training and pruning for maximum production and quality. p. 122-124. Joint National Peach Council and Southeastern Convention Proceedings, 46th NPC Annual Convention, Atlanta, Georgia.

Grappadelli, L.C. 1985. Effects of flower bud position and canopy light environment on time of flowering and fruit quality in peach (Prunus persica (L.) Batsch). MS Thesis, Clemson University, Clemson, SC, 1-70.

Haller, M.H. 1952. Handling, transportation, storage and marketing of peaches. Bibliographical Bulletin 21, USDA.

Haller, M.H. and P.L. Harding. 1939. Effect of storage temperature on peaches. U.S. Dept. Agr. Tech. Bul. 680, 1-32.

Hardenburg, R.E., A.E. Watada, and C.Y. Wang. 1986. The commercial storage of fruits, vegetables, and florist and nursery stocks. USDA Agric. Handbook #66.

Heinicke, D.R. 1966. Characteristics of McIntosh and Red Delicious apples as influenced by exposure to sunlight during the growing season. Proc. Amer. Soc. Hort. Sci. 89:10-13.

Heinicke, D.R. 1963. The micro-climate of fruit trees. II Foliage and light distribution patterns in apple trees. Proc. Amer. Soc. of Hort. Sci. 83:1-11.

Horton, D. and T. Hopfinger. 1987. Harvesting and packing quality peaches. Joint National Peach Council and Southeastern Convention Proceedings, 46th NPC Annual Convention. Feb. 1-4, 1987. Atlanta, GA, 7-10.

Jackson, J.E. 1980. Theory of light interception by orchards and a modeling approach to optimizing orchard design. Acta Hort. 114:60-79.

Jackson, J.E., R.O. Sharples, and J.W. Palmer. 1971. The influence of shade and within tree position on apple fruit size, color, and storage quality. J. Amer. Soc. Hort. Sci. 46:277-287.

Kader, A.A. 1983. Postharvest quality maintenance of fruits and vegetables in developing countries. In Post-Harvest Physiology and Crop Preservation. Ed. M. Lieberman. 455-470.

Kader, A.A. 1985. Postharvest biology and technology: An overview in postharvest technology of horticultural crops. Univ. of California. Special Publication 3311, 3-7.

Kappel, F., J.A. Flore, and R.E.C. Layne. 1983. Characterization of the light microclimate in four peach hedgerow canopies. J. Amer. Soc. Hort. Sci. 108:102-105.

Layne, R.E.C., C.S. Tan, and J.M. Fulton. 1981. Effect of irrigation and tree density on peach production. J. Amer. Soc. Hort. Sci. 106:151-156.

Layne, R.E.C., G.M. Weaver, H.O. Jackson, and F.D. Stroud. 1976. Influence of peach seedling rootstock on growth, yield and survival of peach scion cultivars. J. Amer. Soc. Hort. Sci. 101:568-572.

Leuty, S.J. and D.J. Pree. 1980. The influence of tree population and summer pruning on productivity, growth and quality of peaches. J. Amer. Soc. Hort. Sci. 105:702-705.

Loreti, F., S. Marini, and D. Stefanelli. 1980. Some observations on sunlight interception and distribution by peach trees at different planting densities. Acta Hort. 114. 1980 Orchard and Plantation Systems.

Luckwill, L.C. 1969. Control of growth and fruitfulness of apple trees. p. 238. In L.C. Luckwill and C.V. Eulfing (Ed.) Physiology of Tree Crops. Academic Press, New York.

Marini, R.P. 1985. Vegetative growth, yield, and fruit quality of peach as influenced by dormant pruning, summer pruning, and summer topping. J. Amer. Soc. Hort. Sci. 110:133-139.

Marini, R.P. and Trout, J.R. 1984. Sampling procedures for minimizing variation in peach fruit quality. J. Amer. Soc. Hort. Sci. 109:361-364.

Martin, G.C., F. Yoshikawa, and J.H. La Rue. 1987. Effect of soil applications of paclobutrazol on vegetative growth, pruning time, flowering, yield and quality of 'Flavorcrest' peach. J. Amer. Soc. Hort. Sci. 112:915-921.

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. 1986. Cooling horticultural commodities. In postharvest technology of horticultural crops. Univ. of California Special Publication 3311. 35-43.

Morris, J.R., A.A. Kattan, and E.H. Arrington. 1961. Response of Elberta peaches to interactive effects of irrigation, pruning and thinning. Proc. Amer. Soc. Hort. Sci. 80:177-189.

Mowry, Indy. 1986. Michigan Agricultural Statistics. Ed. Mowry Indy. 1986. Michigan Department of Agriculture. p. 41.

Palmer, J.H. 1980. Computed effects of spacing on light interception and distribution within hedgerow trees in relation to productivity. Acta Hort. 114, Orchard and Plantation Systems, 80-88.

Palmer, J.W. and S.J. Wertheim. 1980. Effects of tree density on fruit quality. Acta Hort. 114:1189.

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

Ridley, J.D. 1984. Peach production and marketing in South Carolina. Michigan State Horticultural Society. 115th Annual Report. Ed. J. Hull, Jr. East Lansing, MI. 24-30.

Romani, R.J., F.C. Jacob, and C.M. Sprock. 1961. Studies on the use of light transmission to assess the maturity of peaches, nectarines and plums. Proc. Amer. Soc. Hort. Sci. 80:220-229.

Rood, P. 1957. Development and evaluation of objective maturity indices for California freestone peaches. Proc. Amer. Soc. Hort. Sci. 70:104-112.

Ryall, A.L. and W.T. Pentzer. 1974. Handling, transportation and storage of fruits and vegetables. Vol. 2, AVI Publishing Company, Inc.

Salunke, D.K. and B.B. Desai. 1984. Postharvest biotechnology of fruits. Vol. 1, 149-155.

Sansavini, S., D. Bassi, and L. Giunchi. 1980. Tree efficiency and fruit quality in high density apple orchards. Acta Hort. 114:114-123.

Stebbins, R.L. and M. MacCasky. 1983. Pruning. How to guide for gardeners. H.P. Books. 55-61.

Stembridge, G.E., R.A. Baumgardner, W.E. Johnston, and L.O. Van Blaricon. 1972. Measuring uniformity of peach maturity. HortScience 7:387-189.

Upshall and J.R. Van Haarlem. 1947. Quantity and quality of fruit, fresh and processed, as affected by stage of maturity at picking time. Ontario Hort. Expt. Stn. Rpt. 1945-46:6-27. In Handling Transportation and Marketing of Peaches Biblio Bulletin 21, U.S. Dept. of Agriculture.

Vigouroux, A. 1988. Importance of water alimentation for calcium content and protection of peaches predisposed to bacterial die back by growing in acid soils. Poster presented at International Peach Symposium. Clemson University, June 19-23, 1988. Clemson, SC, USA.

Watada, A.E., J.A. Abbott, and E.E. Finney, Jr. 1976. Firmness of peaches measured nondestructively. J. Amer. Soc. Hort. Sci. 101:404-406.

Watada, A.E., R.C. Herner, A.A. Kader, R.J. Romani, and G.L. Staby. 1984. Terminology for the description of developmental stages of horticultural crops. HortSci. 19:20-21.

Watkins, R. 1976. Cherry, plum, peach, apricot, and almond. p. 242-246. In Evolution of Crop Plants.

Westwood, M.N. 1978. Temperate - Zone Pomology. W.H. Freeman and Company. San Francisco.

Westwood, M.N., M.H. Chaplin, and A.N. Roberts. 1978. Effects of rootstock on growth, bloom, yield, maturity, and fruit quality of prune (*Prunus domestica* L.). J. Amer. Soc. Hort. Sci. 98:352-357.

# APPENDICES

# APPENDIX A

## The Effect of Fruit Position on Tree on Maturity Indices

Fruits were harvested on the 15th of August, 1988. Maturity indices were measured for fruit harvested from irrigated and non-hedged palmette and central leader trained trees. Fruit from the top half of the canopy was comapred to fruit from the bottom half.

## RESULTS

### Fruit Position on Tree

Maturity indices were influenced by position of fruiton the tree, i.e., whether fruit occupied the top half of the tree or the bottom half (Table 4) (P  0.05). Larger fruit (Fig. 1) with a high blush rating (Fig. 2) more yellow ground color (Fig. 3) and flesh color (Fig. 4) and % soluble solids when harvested were from the top half of the tree compared to fruit harvested from the bototm half of the tree. Flesh firmness was lower for fruit from the top hal fof the tree than fruit from the bottom half (Fig. 5).

Table 4. Effect of fruit position on tree on maturity indices.

| Tree Position | Weight (g) | Blush | Ground Color | Flesh Color | Flesh Firmness (kg) Blush | Flesh Firmness (kg) Non-Blush | % Soluble Solids |
|---|---|---|---|---|---|---|---|
| Top | 223.9a[z] | 4.3a | 4.6a | 4.7a | 0.5a | 0.5a | 9.3a |
| Bottom | 184.0b | 3.4b | 3.4b | 3.5b | 1.5b | 1.5b | 8.5b |
| (SE) | +3.99 | +0.09 | +0.09 | +0.08 | +0.17 | +0.17 | +0.1 |

[z] Values are means of 320 fruit, separated by F test P - 5%.

## DISCUSSION

### Fruit Position

At harvest larger, more colored fruit with higher % soluble solids but less firm fruit were obtained from top halves of trees compared to fruit which came from bottom halves of the tree. Similar findings have been reported in apple by Sansavini et. al. (1980) and Ferree and Hall

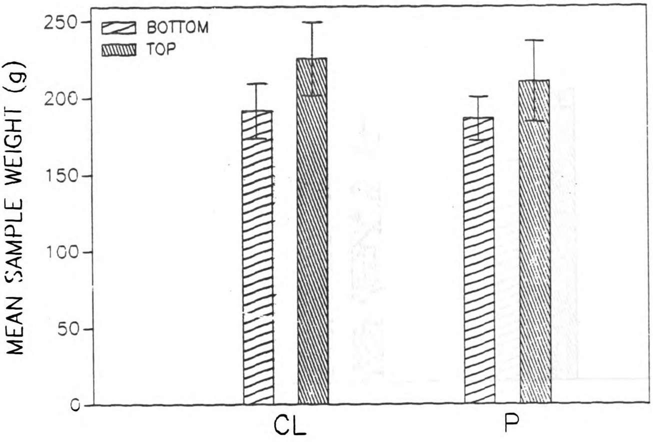



Fig. 1. Effect of fruit canopy position on mean fruit weight for central leader (CL) and palmette (P) trained Newhaven peach trees. Means separated by LSD at P = 5%. Bars ± SE.

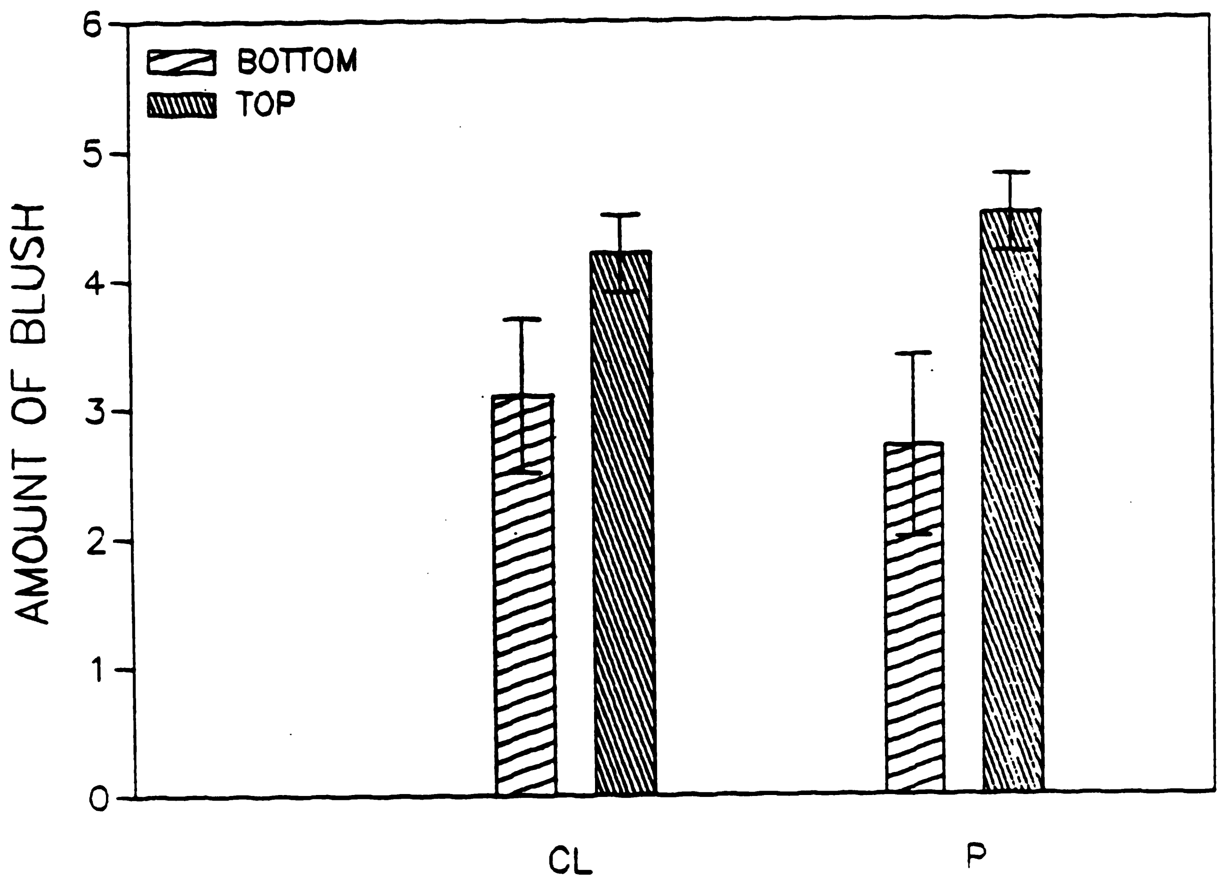



Fig. 2. Effect of fruit canopy position on blush for central leader (CL) and palmette (P) trained Newhaven peach trees. Means separated by F test at P = 5%. Bars ± SE.

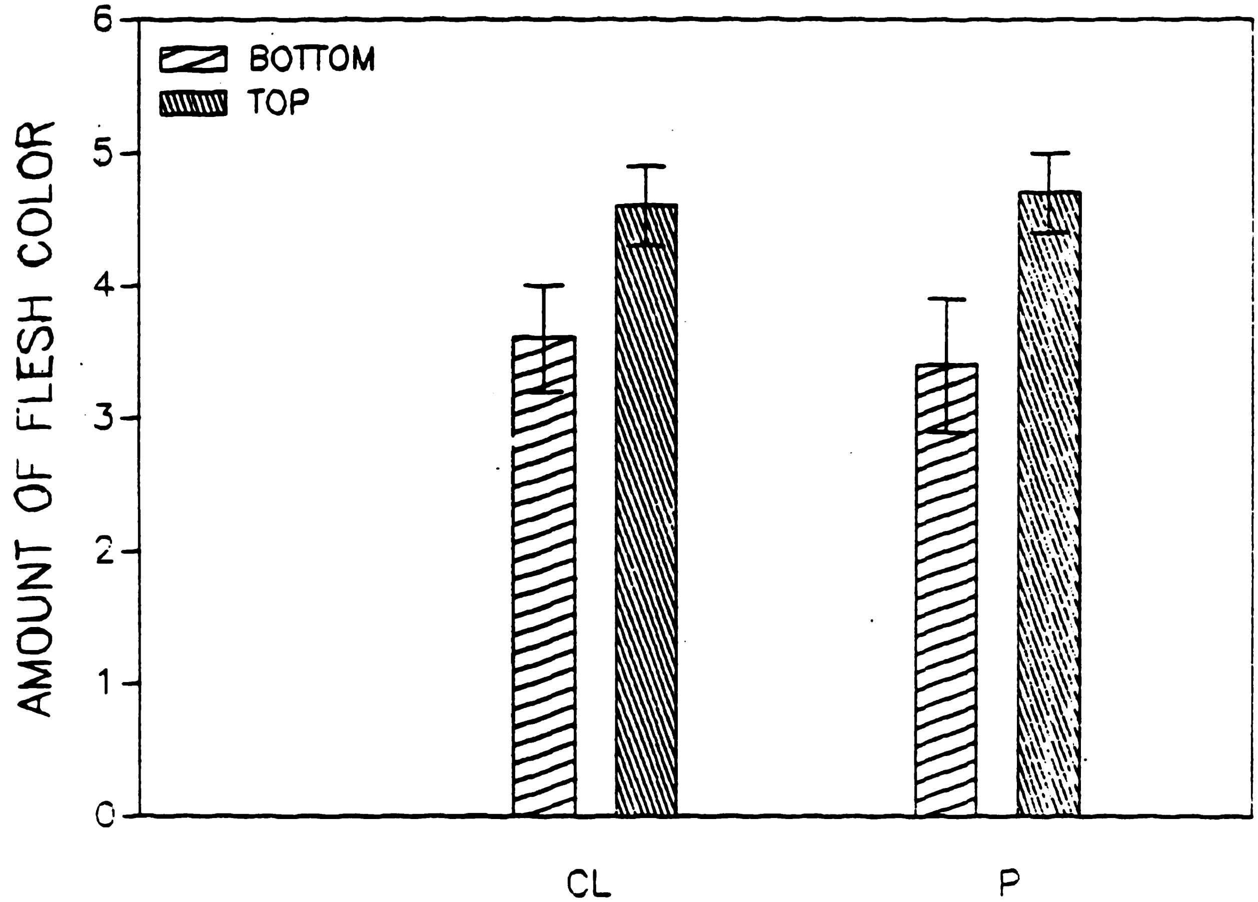



Fig. 3. Effect of fruit canopy position on flesh color for central leader (CL) and palmette (P) trained Newhaven peach trees. Differences by F test at P = 5%. Bars ± SE.

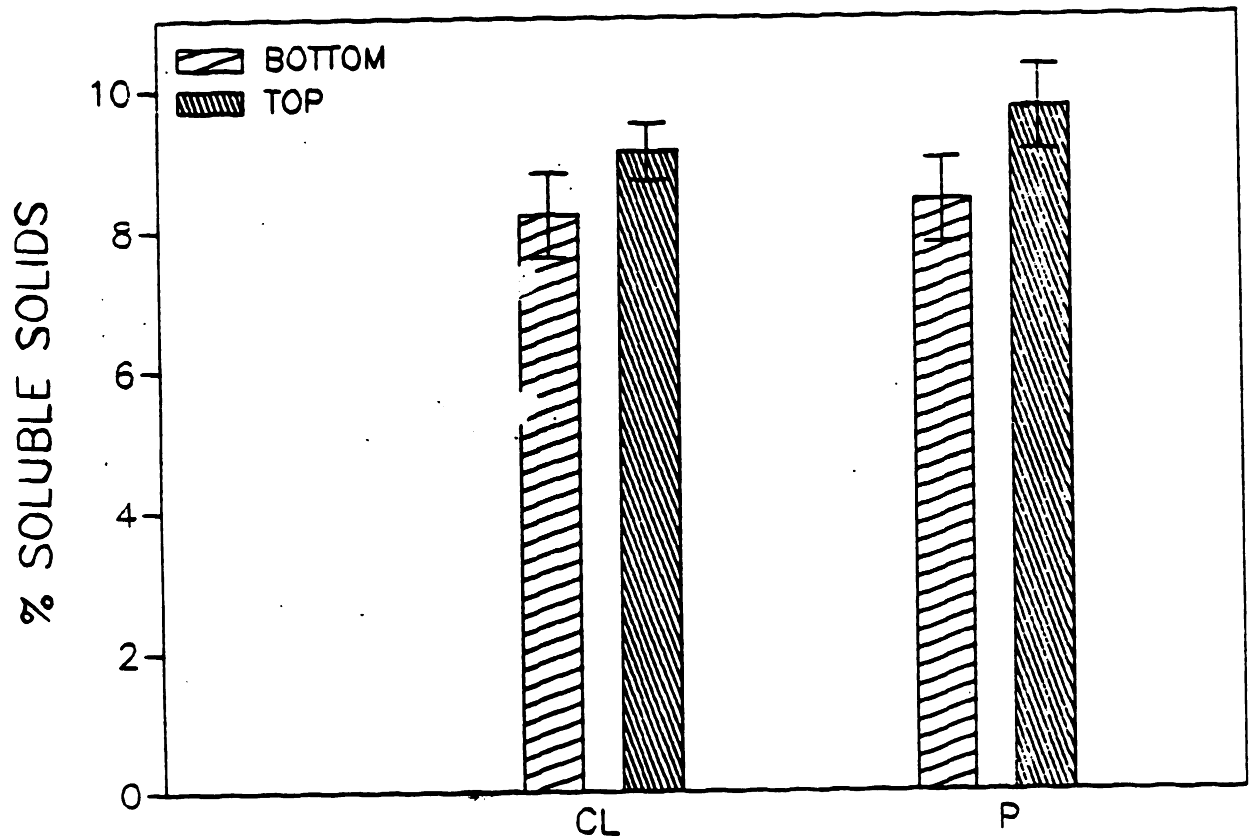



Fig. 4. Effect of fruit canopy position on % soluble solids for central leader (CL) and palmette (P) trained Newhaven peach trees. Differences by F test at P = 5%. Bars ± SE.

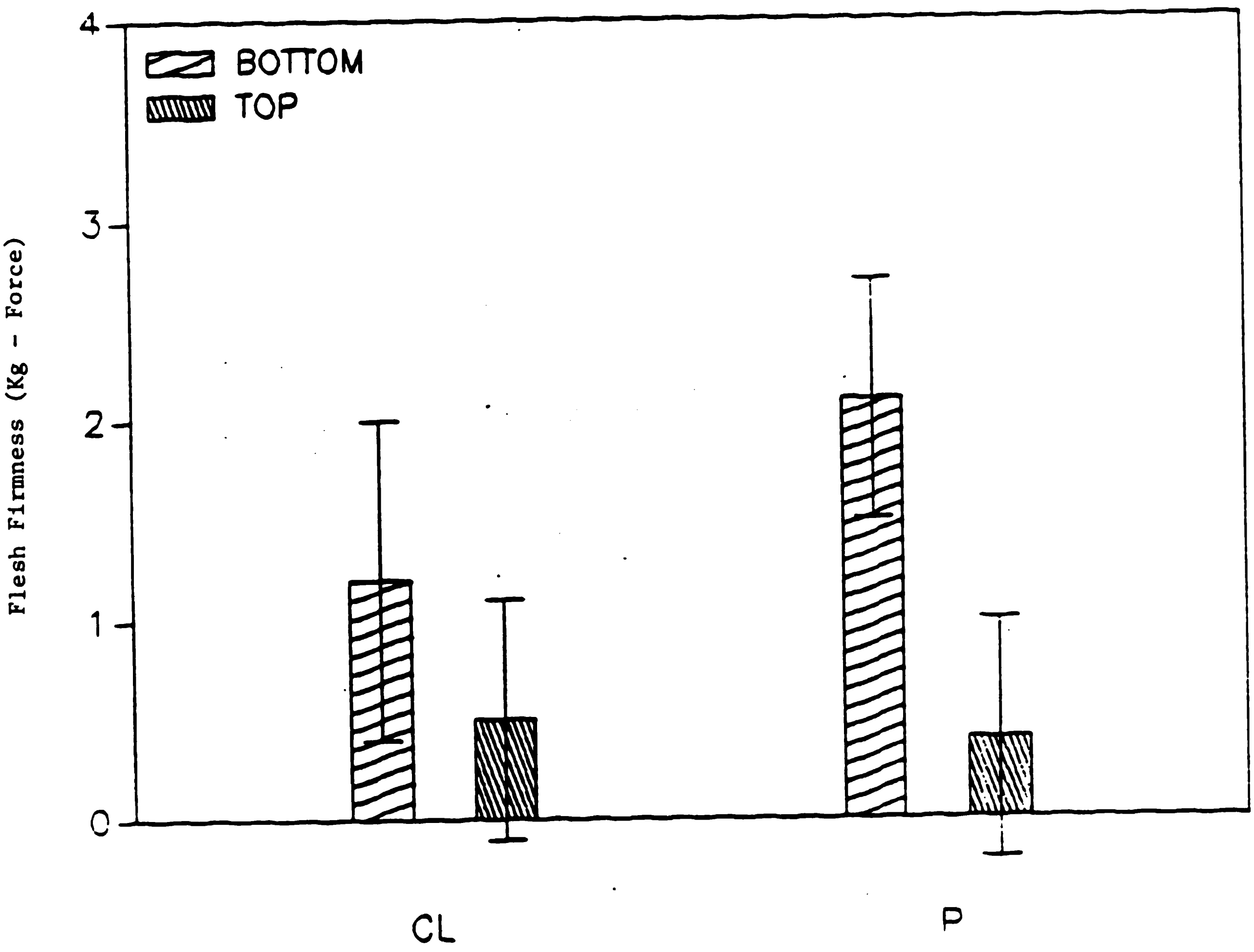



Fig. 5. Effect of fruit canopy position on flesh firmness for central leader (CL) and palmette (P) trained Newhaven peach trees.

(1980). In peach, Dann and Jerie (1988) found that fruit ripened first and were larger at the top of tree and at the tips of laterals. The current concept is that the upper half of the canopy receives more sunlight energy than the lower half (Loreti et. al., 1980; Ferree and Hall, 1980; Heinicke, 1963; Kappel and Flore, 1983; and Dann and Jerie, 1988). Loreti et. al. (1980) found that fruit form the upper half of the peach tree canopy had higher soluble solids and fruit weight and that fruit color was also influenced. However, Erez and Flore (1986) did not find weight differences with varying light intensity exposure but found more colored fruit at 40% full sun compared to 10%. The results reported in this paper suggested that fruit from the upper half of the canopy matured earlier and was more colored than that from the lower half. This may be due to the top half of the tree receiving more sunlight energy. In practice operations that maximize light utilization like the top half of the tree canopy should be sought.

## CONCLUSION

Fruit from the top half of peach trees matured earlier than fruit from the bottom half.