ORCHARD AND VEGETABLE INTERCROPPING SYSTEMS FOR SMALL FARMS IN SOUTHEASTERN OKLAHOMA

By

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Bachelor of Science

Oklahoma Panhandle State University

Goodwell, Oklahoma

1987

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
July, 1991

ORCHARD AND VEGETABLE INTERCROPPING SYSTEMS FOR SMALL FARMS IN SOUTHEASTERN OKLAHOMA

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ACKNOWLEDGMENTS

I would like to give my thanks and appreciation to Dr. James Motes for his great deal of patience plus his advice while I was completing this thesis. I would also like to express my gratitude to the other members of my committee; Dr. Brian Kahn, Dr. Mike Smith, and Dr. Joe Schatzer for their help during my graduate program.

Special thanks goes out to Nancy Maness for her help while completing this study. Without her assistance and expertise on the computer, I would never have been able to finish this work. I would also like to thank the extension secretaries; Linda Dotter and Sandy Welch for their help at times when they had plenty of their own work to accomplish.

I owe a special thanks to my parents, Jerry and Gwen Martin, for their support during my many years of school. I would also like to thank my fellow graduate student, Bill Evans, for his help and assistance during the past years.

To the Department of Horticulture and Landscape Architecture, I owe my gratitude for the graduate assistantship, financial assistance, and scholarships I received. Also, I owe many thanks for help with the lab analysis to both Becky Cheary and Becky Carroll.

Last, but not least, I would like to thank Robert Bourne, Mike Bourne, and the rest of the staff at the Lane Research Station for their assistance in this study.

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CHAPTER I

INTRODUCTION

Southeastern Oklahoma has climatic conditions and soil types that are well suited to the production of vegetable and fruit crops. Most farmers in the area have traditional farm and ranch enterprises, but they have shown interest in diversifying into horticultural crops such as vegetables, strawberries, and peaches. Currently there is market potential in southeastern Oklahoma for these products. The cost associated in establishing a peach orchard is approximately $2,000 per acre and is prohibitive to many farmers and lenders. Since peach production does not begin until the third year after planting, financial institutions hesitate to lend money for the establishment of orchards. Intercropping the orchard for the first 3 to 5 years with vegetables and/or strawberries gives the farmer income during the establishment years and it gives the financial institution a more sound investment.

Peach production in Oklahoma has been centered around Stratford, south of Oklahoma City, and Porter, east of Tulsa. Most of Oklahoma, with the exception of the most western parts of the state, is climatically suited to the production of peaches on a favorable planting site. Although there are many non-irrigated peach orchards, irrigation is fundamental to the successful production of peaches.

Vegetable production in Oklahoma has been centered in the Arkansas River Valley, around Tulsa, and in Southwestern Oklahoma, in and around Caddo County. Southeastern Oklahoma has some vegetable operations but they have been very small and are usually operated on a relatively low input basis. With the addition of irrigation there is no reason that southeastern Oklahoma can't become a significant vegetable production area for the state.

Research on both vegetables and fruits has been conducted in Oklahoma but in areas of the state which are climatically different than southeastern Oklahoma. The soils and rainfall patterns are much different in southeastern Oklahoma compared to other areas of the state. To be of assistance to the southeastern farmer, who wants to expand and diversify his farming operation, research must be conducted in the southeastern Oklahoma area.

Data gained from this research project will be used to evaluate the potential of a peach/vegetable intercropping system in southeastern Oklahoma.

CHAPTER II

LITERATURE REVIEW

Intercropping, growing two or more crops on the same land in the same growing season (Willey, 1979) has been practiced by farmers in less developed and tropical countries for many years.

Today, the meaning of intercropping has been expanded to include many different forms of growing two or more crops together. Strip cropping, growing two or more crops together in alternate rows or in several rows of one crop then alternating to the next crop is one of the major forms of intercropping in practice today (Robinson, 1984). Polyculture (Gliessman and Altieri, 1982), mixed cropping (Willey, 1979), multiple cropping (Pearce and Edmondson, 1984), and companion cropping (Horwith, 1985) all refer to a type of intercropping where the component crops are mixed in the same row or are broadcast into the field. Alleycropping (Willey, 1979), refers to growing one crop in the alley between the rows of the main crop very much like strip cropping. Relay cropping (Willey, 1979) is very similar to intercropping but the growth periods for the component crops only overlap for a short period of time. For this study intercropping will mean the growing of one of several component crops between the permanently fixed rows of the main perennial component crop, peaches (*Prunis persica*).

In an orchard situation, there is substantial open space between the newly planted trees that would allow for the growth of an intercrop (Nijjar, 1980; Syamal and Verma, 1982). An intercrop can provide income to the farmer during the several years it takes for the main component crop to come into production (Nijjar, 1980). Some of the primary positive factors cited in intercropping research are increases in productivity per land area and better use of resources such as water, nutrients, labor, and machinery (De and Singh, 1979; Sharma, 1981). Other researchers have found that these benefits do not occur on all intercrops and that in some situations intercrops can increase inputs and decrease productivity per land area (Lamberts, 1984; Willey, 1979).

Many other benefits to orchards have been attributed to intercropping including better weed control (Nijjar, 1980), improved soil fertility and structure (Nijjar, 1980), and reductions in certain insect pests (De and Singh, 1979; Gliessman and Altieri, 1982). It has been proposed that the diverse microclimate present in the intercropped field is unfavorable to many pest species (van Emden, 1974; Gliessman and Altieri, 1982). Although this is a possibility in many intercropped fields it is just as likely that the intercropped field would provide a more favorable location for pests as some researchers have found (Cranshaw, 1984).

One advantage the small area farmer gains from intercropping is a greater production diversity and yield stability (Willey, 1979). This helps the farmer continue to maintain his income in years when some crops or portions of his crops fail to produce. There is little chance that the entire intercrop system will fail as compared to the chance of losing all of the production in a monocrop situation.

In the orchard intercrop the farmer usually will discontinue intercropping when the orchard begins producing (Nijjar, 1980). This is due to the injury that occurs to the orchard caused by cutting roots and damage to the trees canopy from machinery while conducting farming operations. The primary source of income will come from the fruit production.

In an orchard the health of the trees, the main component crop, must be considered at all times. Since the trees will eventually provide all of the income from a given area of land, the intercrops chosen to be grown must cause the least amount of permanent damage to the young orchard. Orchard spacing must be great enough to facilitate operation of cultivation and planting equipment and to provide minimum root and sunlight competition between the intercrops (Jawanda, 1978). Tall growing crops are generally not suitable as intercrops in an orchard since they provide too much competition for rooting area and sunlight (Kalra and Sarowa, 1976; Syamal and Verma, 1982).

Vegetables and/or fruit which have been suitable as orchard intercrops in the past are: radishes (*Raphanus sativus*) with pears (*Pyrus communis*) (Newman, 1986), cassava (*Manihot esculenta*) and yams (*Dioscorea* spp.) with palms (*Bactris gasipaes*) (Sparnaaij, 1957), pepper (*Piper nigrum*) with coconut (*Cocos nucifera*) (Anon., 1978; Yaacob and St. Clair-George, 1979), beans, cabbage, potatoes, and tomatoes with apples (Syamal and Verma, 1982), beans and snow peas with apples and almonds (Gliessman and Altieri, 1982), carrots, cauliflower, onions, peas, potatoes, and turnips in citrus orchards (Nijjar, 1980), strawberries with apples (Syamal and Verma, 1982), and various cucurbits with orchard crops (Jawanda, 1978).

The primary factor in choosing an intercrop is whether or not a market for the produce exists in the area. If there is no market for a particular vegetable there is no reason to intercrop with that certain vegetable no matter how well it may perform as an intercrop. Other considerations include distance between trees (Syamal and Verma, 1982), and type of tree, soil fertility, income potential and irrigation facilities (Syamal and Verma, 1982). Irrigation, if available, should include separate systems for the vegetables and for the orchard because of different water requirements for the intercrop components (Jawanda, 1978).

As the world population increases so does the need to better use the available arable land. Intercropping is being practiced more and more in the developed countries as it has always been used in the underdeveloped countries. Researchers are just beginning to scratch the surface in their investigations. Much more work needs to be done especially in the component crop interactions.

CHAPTER III

MATERIALS AND METHODS

This experiment was conducted from the fall of 1987 through the winter of 1989. The study was conducted at the Wes Watkins Agricultural Research and Extension Center at Lane, Oklahoma on a Bernow fine sandy loam on an east facing slope. Only one location was used for the study.

On 4 September 1987 the solid-set sprinkler irrigation system was put in place for the study. From a 15 cm main line two 10 cm lateral lines were laid underground running from south to north. One 10 cm line fed blocks 1 and 2 and a second 10 cm line fed blocks 3 and 4. From each 10 cm lateral line seven 5 cm side lines were buried running west to east with 4 Rainbird sprinkler heads on each of the 5 cm lines. The 56 plots in the study each had a separate sprinkler head equipped with a shut off valve. This enabled watering of any treatment separately from any other treatment on a demand basis.

Peaches

On 15 March 1988 'Loring' peach trees on Lovell rootstocks were planted on 6.7 m and 8.5 m between-row spacings. Peach trees were pruned to 76 cm tall. In-row spacing was 4.9 m for both between-row spacings.

Vegetable or fruit intercropping systems were grown on every other between-row strip to facilitate movement of equipment through the orchard for normal orchard maintenance operations. Six intercropping systems were used in the study along with a control of tall fescue mowed sod.

Peach tree growth was measured in two ways. The first method was trunk caliper diameter. Each tree trunk was measured annually at 15 cm above the soil line. The second method was canopy area. Each tree was measured from the farthest branch on one side to the farthest branch on the other side. Measurements were taken on both east-west and north-south axes, averaged, and area calculated using the appropriate geometric form. Four trees surrounding each intercropped and control plot were used as data trees. Four replications were used on each peach spacing treatment, giving 16 data trees for each of the 7 systems studied. Elemental concentration of the peach tree leaves also was measured annually. A composite sample from the 4 data trees was used for the elemental analysis. The samples were processed according to standard OSU lab procedures. Nitrogen analysis was performed by the macro-Kjeldahl process (Horowitz, 1980). Phosphorus was analyzed on a Sequoia-Turner 340 spectrophotometer. All other elements were analyzed on a Perkin-Elmer 2380 atomic absorption spectrophotometer.

Intercropping Systems

The 7 systems used in the study were: 1. control planted in tall fescue; 2. 1988 and 1989 strawberries; 3. 1988--cabbage succeeded by southern pea, 1989--spinach succeeded by cantaloupe; 4. 1988--snap bean succeeded by cabbage, 1989--spinach succeeded by cantaloupe; 5. 1988--potato succeeded by cauliflower, 1989--snap bean succeeded by cabbage; 6. 1988--cabbage succeeded by southern pea, 1989--sweet potato; 7. 1988--snap bean succeeded by cabbage, 1989--sweet potato. Strawberry and sweet potato were used as full-season intercrops while the other intercrops were used in successional intercropping systems. The intercrops were all grown on 0.9 m wide beds, with the exception of cantaloupe which was grown on 1.8 m wide beds. The 6.7 m between-row peach spacing enabled 5 of the 0.9 m beds to be maintained in intercrops while the 8.5 m between-row peach spacing enabled 7 of the 0.9 m beds to be maintained in intercrops. In the case of the cantaloupe the 6.7 m between-row peach spacing enabled intercropping two 1.8 m beds and the 8.5 m between-row peach spacing enabled intercropping three 1.8 m beds. All intercrop systems had seperate fertility tests performed yearly on which fertilizer recomendations were based.

System 1

Planted to tall fescue and mowed as required. No fertilizers or pesticides were used on this system.

System 2

On 25 February 1988 sites were prepared for the strawberries cv. 'Cardinal.' This included soil preparation and application of gramoxone herbicide (0.766 liters ha). The strawberries received 225 ml of transplant solution containing nitrogen (33.6 kg·ha^{-1}), phosphorus (29.3 kg·ha^{-1}), and potassium (27.9 kg·ha^{-1}) from a 15N-13.1P-12.4K fertilizer and diazinon at 0.65 kg·ha^{-1}. Transplanting was on 26 February 1988. On 1 March 1988 the strawberry plots were sprayed with DCPA herbicide at 2.2 kg·ha^{-1}. They were sprayed an additional time with diphenamid herbicide (0.81 kg·ha^{-1}) on 13 April 1988.

Insects and diseases were monitored periodically but no control was needed during the 1988 growing season. Weeds were also controlled throughout the year with hand-held hoes.

In December all strawberry plots were divided equally into mulch and non-mulch plots. The mulch used was wheat straw. A total of 2 treatments, 1 mulch and 1 non-mulch, were replicated 4 times on each of the peach tree spacings. The wheat straw mulch was removed prior to strawberry bloom.

On 5 May 1989 the strawberry plots were sprayed with malathion 25W (0.92 kg·ha^{-1}) to control insects before harvest.

Harvest of the strawberries began on 12 May 1989. Berries were harvested once or twice weekly depending on amounts of berries ripening and weather conditions. All fruit was graded upon picking as either marketable or unmarketable. Unmarketable fruit was not weighed.

Strawberry plots were harvested 5 times. Fungicides benomyl 50W (0.86 kg·ha^{-1}) and vinclozolin (0.28 kg·ha^{-1}) were used to control fruit diseases during the harvest period. Insects were controlled with carbaryl 50W (0.55 kg·ha^{-1}) during the same period.

System 3

On 7 March 1988 system 3 of the study was begun. Fertilizer was applied from a bulk mix of 17N-7.4P-14.1K at 56 $kg{\cdot}ha^{-1}$ N, 24.4 $kg{\cdot}ha^{-1}$ P, and 46.5 $kg{\cdot}ha^{-1}$ K. An additional 70 $kg{\cdot}ha^{-1}$ of K was also added. Before the plots were prepared for planting an application of paraquat herbicide (0.18 $kg{\cdot}ha^{-1}$) was applied to kill existing weeds.

On 10 March 1988 cabbage cv. 'Solid Blue 760' was transplanted. Row width was .9 m between-row and plant spacing was 30 cm in-row. The plants received 225 ml of transplant solution containing N (33.6 $kg{\cdot}ha^{-1}$), P (14.6 $kg{\cdot}ha^{-1}$), and K (27.9 $kg{\cdot}ha^{-1}$) from 20N-8.7P-16.6K and diazinon at 0.65 $kg{\cdot}ha^{-1}$. Replacement plants were set 17 and 24 March 1988. Replacement plants received additional transplant solution as previously applied to the initial planting.

On 5 April 1988 and 10 May 1988 additional N was sidedressed on the cabbage plots at 56 $kg{\cdot}ha^{-1}$ from urea. Cabbage loopers were controlled with sprays of fenvalerate (1.5 ml per liter of water) on 26 April, 19 May, and 14 June 1988.

Cabbage plots were harvested 4 times on 21 June, 24 June, 1 July, and 6 July 1988. Heads were weighed and graded individually as either marketable or cull. Additional measurements included solidness of head, length of core, and head diameter and height.

Succeeding the cabbage was southern peas cv.'Epoch.' N was applied at 33.6 $kg{\cdot}ha^{-1}$ from ammonium nitrate. Before planting captan was applied to the seed at the rate of 2.2 gm per kg of seed. On 12 July 1988 seeds were sown at 10 seeds per 30 cm of row.

On 14 July 1988 metolachlor herbicide (0.29 liter·ha^{-1}) was applied to the southern peas. Beet army worms were detected on the plants and methomyl insecticide (0.58 liter·ha^{-1}) was applied on both 27 July, and 15 August 1988.

Harvest of the southern peas began on 30 September 1988 for block 1 of the study, 7 October 1988 for blocks 2 and 3, and 14 October 1988 for block 4. Harvest was according to maturity with the upper portions of the orchard maturing before the lower areas. Weights were recorded on dry pods.

In 1989 the system 3 rotation began with spinach cv. 'Melody.' Plots were prepared and a bulk mix fertilizer giving 84 kg·ha^{-1} of N, 19.6 kg·ha^{-1} of P, and 92.9 kg·ha^{-1} of K was incorporated. Cycloate 6E herbicide (0.55 kg·ha^{-1}) was also incorporated for weed control.

Spinach was planted on 21 March 1989. Seeds were sown in a double-row bed with 30 seeds being sown per 30 cm of bed.

On 14 April 1989 a sidedress of nitrogen was applied at the rate of 33.6 kg·ha^{-1} from ammonium nitrate. Another sidedress was applied on 5 May 1989 at the same rate and from the same source.

Plants were monitored for insects with only one spray required. On 24 April 1989 methomyl (0.58 liter·ha^{-1}) was used for insect control. Weeds were hoed by hand periodically.

On 23 May 1989 the spinach was harvested from all plots. Grading consisted of checking for insect damage and diseases. Weights were taken on all marketable spinach.

The final crop in the system 3 rotation was planted on 1 and 2 June 1989. Cantaloupe cv. 'Magnum .45' was planted on 1.8 m between-row spacings and 30 cm in-row spacings. Plants were grown in 10 cm peat pots at the OSU research greenhouses for 3 weeks prior to planting.

Cantaloupe plants were given a 225 ml application of transplant solution containing N (33.6 $kg \cdot ha^{-1}$), P (14.6 $kg \cdot ha^{-1}$), and K (27.9 $kg \cdot ha^{-1}$) from 20N-8.7P-16.6K and diazinon at 0.65 $kg \cdot ha^{-1}$. Replacements were planted on 16 June 1989 and they were given the same transplant solution.

On 23 June 1989 trifluralin granular herbicide (0.14 $kg \cdot ha^{-1}$) was applied and watered in for weed control. On 26 June 1989 a sidedress of N at 56 $kg \cdot ha^{-1}$ was applied from ammonium nitrate.

Diseases and insects were controlled with weekly sprays of methomyl (0.17 $kg \cdot ha^{-1}$) and chlorothalonil (0.48 $liter \cdot ha^{-1}$) until harvest.

Cantaloupe plots were harvested 7 times on 8, 11, 15, 18, 25 and 29 August, and 1 September 1989. Melons were graded as being either marketable or culls and were weighed and counted.

System 4

On 14 April 1988 system 4 of the study was begun. An application of paraquat herbicide (0.77 $liter \cdot ha^{-1}$) was applied to the snap bean cv. 'Eagle' plots. The following day, 15 April 1988 an application of trifluralin herbicide

(0.19 liter·ha^{-1}) was applied. Fertilizer was applied on 19 April 1988 from a bulk mix of 13N-5.7P-10.8K giving 58 kg·ha^{-1} of N, 25.3 kg·ha^{-1} of P, and 48.1 kg·ha^{-1} of K.

Snap beans were planted on 26 April 1988. Between-row spacing was 1 m and in-row spacing was 9 seeds per 30 cm.

Insects were controlled as needed with carbaryl (0.37 kg·ha^{-1}). Weed control was supplemented with hand held hoes.

Harvest of the snap beans began with blocks 1 and 2 on 7 July 1988 and followed with blocks 3 and 4 on 8 July 1988. Data were taken on green-pod weights, number of plants per row, plant height, and pod length.

Following harvest of the snap beans, plots were prepared for the succession to cabbage cv. 'Solid Blue 760'. Fertilizer from a bulk mix 13N-5.7P-10.8K was applied at the rate of 56 kg·ha^{-1} of N, 24.4 kg·ha^{-1} of P, and 46.5 kg·ha^{-1} of K. After bedding oxyfluorfen herbicide (.09 kg·ha^{-1}) was applied for weed control.

On 18 August 1988 transplants of cabbage were planted on .9 m between-row spacings and 30 cm in-row spacings. The plants received 225 ml of transplant solution containing N (33.6 kg·ha^{-1}), P (14.7 kg·ha^{-1}), and K (27.9 kg·ha^{-1}) from 20N-8.7P-16.6K and diazinon at 0.65 kg·ha^{-1}. All plots were then sprinkler irrigated to field capacity. Replacement plants were set 2 and 9 September 1988. Replacement plants received additional transplant solution as previously applied to the initial planting.

Insects were controlled with sprays of methomyl (0.17 kg·ha^{-1}) on 6, 13, and 20 September 1988. On 27 September, 4 October, and 11 October 1988 the insects were controlled with a tank mix combination of *Bacillus thuringiensis* and permethrin (.037 kg·ha^{-1}).

Additional N was sidedressed on 23 September 1988 at 44.8 kg·ha^{-1} and again on 14 October 1988 at 33.6 kg·ha^{-1} from urea.

Cabbage was harvested 7 times on 28 October, 4, 11, 18, and 23 November, and 2 and 9 December 1988. Heads were weighed and graded either as marketable or cull. Number of heads, solidness of head, length of core, head diameter, and head height were recorded.

In 1989 the system 4 rotation was begun with spinach cv. 'Melody.' Plots were prepared and a bulk mix fertilizer giving 84 kg·ha^{-1} of N, 19.6 kg·ha^{-1} of P, and 92.9 kg·ha^{-1} of K was incorporated. Cycloate herbicide (0.55 kg·ha^{-1}) was also incorporated.

Spinach was planted on 21 March 1989. Seeds were sown in a double row bed with 30 seeds being sown per 30 cm of bed. The seeding rate was 1.8 kg·ha^{-1}.

On 14 April 1989 a sidedress of N was applied at 34 kg·ha^{-1} from ammonium nitrate. An additional sidedress was applied on 5 May 1989 at the same rate and from the same source.

Plants were periodically monitored for insects and only one spray was needed. On 24 April 1989 methomyl insecticide (0.58 liter·ha^{-1}) was applied. Additional weed control was provided by hand hoeing.

On 23 May 1989 the spinach was harvested from all plots. Grading consisted of monitoring for insect and disease damage. Weights were taken on all marketable spinach.

The final crop in the system 4 rotation was cantaloupe cv. 'Magnum .45.' Prior to transplanting in the field on 1 and 2 June 1989, the cantaloupe were grown in 10 cm peat pots in a commercial greenhouse mix for 3 weeks at the OSU research greenhouses. Between-row spacing was 2 ms and in-row spacing was 30 cm. At the time of transplanting the plants were given an application of transplant solution containing N (33.6 $kg \cdot ha^{-1}$), P (14.7 $kg \cdot ha^{-1}$), and K (27.9 $kg \cdot ha^{-1}$) from 20N-8.7P-16.6K and diazinon at 0.65 $kg \cdot ha^{-1}$. Replacements were planted on 16 June 1989 and they were given the same transplant solution as previously applied.

On 23 June 1989 trifluralin granular herbicide (0.14 $kg \cdot ha^{-1}$) was applied then irrigated in for weed control.

On 26 June 1989 a sidedress of N was applied at 56 $kg \cdot ha^{-1}$ from ammonium nitrate.

Diseases and insects were controlled with weekly sprays of methomyl (0.17 $kg \cdot ha^{-1}$) and chlorothalonil (0.48 $liter \cdot ha^{-1}$) as needed up until harvest.

Cantaloupe plots were harvested 7 times on 8, 11, 15, 18, 25, and 29 August, and 1 September 1989. Melons were graded either as marketable or cull and were weighed and counted.

System 5

On 7 March 1988 the system 5 rotation was begun with spring potatoes cv. 'Viking.' Plots were treated with paraquat herbicide (0.14 kg·ha^{-1}) to kill emerged grasses and broadleaf weeds.

On 15 March 1988 fertilizer was applied from a bulk mix of 13N-5.7P-10.8K at 336 kg·ha^{-1} giving a total of 44 kg·ha^{-1} of N, 19.2 kg·ha^{-1} of P, and 36.5 kg·ha^{-1} of K. Aldicarb insecticide (0.55 kg·ha^{-1}) was placed in the potato furrow for insect control. Between-row spacing was 1 m and in-row spacing was 30 cm.

Potato seed pieces were cut from whole potatoes and were 28 to 42 gm each. The potatoes were planted to a depth of 10 cm on the same day they were cut. On 20 May 1988 a sidedress of N was applied at 45 kg·ha^{-1} from urea. Another sidedress of N was applied on 3 June 1988 at 45 kg·ha^{-1} from urea.

Potatoes were harvested on 14 and 15 July 1988. Tubers were graded as A's (greater than 4.8 cm in diameter) and B's (less than 5.7 cm but greater than 3.8 cm in diameter). Over 40 percent of grade A potatoes must be larger than 6.4 cm in diameter. Potatoes not fitting either of those categories, but still being of marketable quality, were designated grade C potatoes. Tubers with defects were graded as culls. Counts and weights were taken on all categories.

Succeeding the potatoes in the system 5 rotation was cauliflower cv. 'Early Glacier.' On 27 July 1988 plots were prepared and fertilizer was applied from a bulk mix 13N-5.7P-10.8K giving 56 kg·ha^{-1} of N, 24.4 kg·ha^{-1} of P, and 46.5 kg·ha^{-1} of K. After the beds were made oxyfluorfen herbicide (.07 kg·ha^{-1}) was applied as an annual broadleaf weed control.

On 18 August 1988 transplants were planted on 1 m between-row spacings and 45 cm in-row spacings. The plants received 225 ml of transplant solution containing N (33.6 $kg{\cdot}ha^{-1}$), P (14.7 $kg{\cdot}ha^{-1}$), and K (27.9 $kg{\cdot}ha^{-1}$) from 20N-8.7P-16.6K and diazinon at 0.65 $kg{\cdot}ha^{-1}$. All plots were then watered with sprinkler irrigation to field capacity.

Replacement plants were planted on 2 and 9 September 1988. They received the same transplant solution as applied to the initial planting.

Insects were controlled with sprays of methomyl insecticide (0.17 $kg{\cdot}ha^{-1}$) on 6, 13, and 20 September 1988. On 27 September, 4 October, and 11 October 1988 the insect control changed to a combination of *Bacillus thuringiensis* and permethrin (0.037 $kg{\cdot}ha^{-1}$).

Fertilizer was sidedressed on 23 September, at 45 $kg{\cdot}ha^{-1}$ of N from urea and on 14 October 1988 at 34 $kg{\cdot}ha^{-1}$ of N from urea.

Cauliflower plots were harvested 7 times on 28 October, 4, 11, 18 and 23 November, 2 and 9 December 1988. Heads were weighed and graded as either marketable or culls.

The 1989 system 5 rotation began with snap bean cv. 'Eagle.' Before planting fertilizer was incorporated into the plots from a bulk mix giving 28 $kg{\cdot}ha^{-1}$ of N, and 46.5 $kg{\cdot}ha^{-1}$ of K. Trifluralin herbicide (.09 $kg{\cdot}ha^{-1}$) was incorporated for weed control.

Snap beans were planted on 28 April 1989. Between-row spacing was 1 m and in-row spacing was 10 seeds per 30 cm of row. The seeding rate was 112 $kg{\cdot}ha^{-1}$. On 20 June 1989 a sidedress of N at 28 $kg{\cdot}ha^{-1}$ was applied from urea.

Harvest of the snap beans began on 6 July 1989 for blocks 1 and 2 and ended on 7 July 1989 for blocks 3 and 4. Data were taken on green pod weights, number of plants per row, plant height, and pod length.

Succeeding the harvest of the snap beans, the plots were prepared for cabbage cv. 'Solid Blue 760,' the final crop in the system 5 rotation. On 11 August 1989 plots were fertilized with a bulk mix of 17N-7.4P-14.1K giving 48 $kg{\cdot}ha^{-1}$ of N, 21 $kg{\cdot}ha^{-1}$ of P, and 39.8 $kg{\cdot}ha^{-1}$ of K. An additional 69.7 $kg{\cdot}ha^{-1}$ of K was added. The fertilizer was tilled in and the beds were prepared. One week later, after weed seeds had time to germinate, oxyfluorfen (.069 $kg{\cdot}ha^{-1}$) and glyphosate (0.37 $kg{\cdot}ha^{-1}$) were applied to the plots for weed control.

On 25 August 1989 cabbage was transplanted into the plots with 1 m between-row spacings and 30 cm in-row spacings. The plants received 225 ml of transplant solution containing N (33.6 $kg{\cdot}ha^{-1}$), P (14.7 $kg{\cdot}ha^{-1}$), and K (27.9 $kg{\cdot}ha^{-1}$) from 20N-8.7P-16.6K and diazinon at 0.65 $kg{\cdot}ha^{-1}$. All plots were then irrigated by sprinkler irrigation to field capacity.

On 8 September 1989 dead plants were replaced with new ones. The newly planted cabbage received transplant solution as applied to the initial planting.

On 29 September and 20 October 1989 additional N was sidedressed on the plots giving 45 and 56 $kg{\cdot}ha^{-1}$ respectively from urea. On 21 November 1989 another sidedress of N was applied giving 45 $kg{\cdot}ha^{-1}$ from ammonium nitrate.

Cabbage plots were harvested on 17 November and on 1 December 1989. Heads were weighed and graded as marketable or cull. Due to low yields no additional data were taken for this cabbage harvest.

System 6

On 7 March 1988 system 6 of the study was begun. Fertilizer was applied from a bulk mix of 17N-7.4P-14.1K at the rate of 56 $kg \cdot ha^{-1}$ of N, 24.4 $kg \cdot ha^{-1}$ of P, and 46.5 $kg \cdot ha^{-1}$ of K. An additional 69.784 $kg \cdot ha^{-1}$ of K was also added. The plots were bedded and on 9 March 1988 an application of gramoxone herbicide (0.14 $kg \cdot ha^{-1}$) was applied to the beds to kill the existing weeds.

On 10 March 1988 cabbage cv. 'Solid Blue 760' was transplanted into the plots. Between-row spacing was 1 m and in-row spacing was 30 cm. The plants received 225 ml of transplant solution containing N (33.6 $kg \cdot ha^{-1}$), P (14.7 $kg \cdot ha^{-1}$), and K (27.9 $kg \cdot ha^{-1}$) from 20N-8.7P-16.6K and diazinon at 0.65 $kg \cdot ha^{-1}$. Replacement plants were set 17 and 24 March 1988. The replacement plants received additional transplant solution as applied to the initial planting.

On 5 April and 10 May 1988 a sidedress of N was applied at 56 $kg \cdot ha^{-1}$ on both dates from urea. Cabbage loopers were controlled with sprays of fenvalerate (1.5 ml per liter of water) on 26 April, 19 May, and 14 June 1988.

Cabbage plots were harvested 4 times on 21 and 24 June and 1 and 6 July 1988. Heads were weighed and graded individually as either marketable or cull. Additional measurements included solidness of head, length of core, head diameter, and head height.

Succeeding the cabbage in system 6 was southern pea cv. 'Epoch.' Plots were prepared and fertilizer was incorporated at 34 $kg{\cdot}ha^{-1}$ of N from ammonium nitrate. Captan was applied to the seeds before planting at the rate of 2.2 gm per kg of seed. On 12 July, 1988 seeds were sown at 10 seeds per 30 cm of row. The between-row spacing was 1 m.

On 14 July 1988 metolachlor herbicide (0.29 $liter{\cdot}ha^{-1}$) was applied to the plots for weed control. Beet army worms were detected on the plants and methomyl insecticide (0.58 $kg{\cdot}ha^{-1}$) was applied for control on both 27 July and 15 August 1988.

Harvest of the southern peas began on 30 September 1988 for block 1 of the study, 7 October 1988 for blocks 2 and 3, and 14 October 1988 for block 4. Harvest was according to maturity with the upper portions of the study reaching mature stages before the lower areas. Measurements were taken on dry pod weights.

In 1989 the last part of the system 6 rotation, sweet potatoes cv. 'Jewel,' was planted. On 19 June 1989 plots were prepared for the sweet potatoes. Fertilizer from a bulk mix giving 34 $kg{\cdot}ha^{-1}$ of N, 24.4 $kg{\cdot}ha^{-1}$ of P, and 92.9 $kg{\cdot}ha^{-1}$ of K was incorporated along with diazinon insecticide (0.74 $kg{\cdot}ha^{-1}$) for control of soil insects.

On 22 June 1989 sweet potato slips were transplanted with between-row spacings of 1 m and in-row spacings of 36 cm. The plants received 225 ml of transplant solution containing N (33.6 $kg \cdot ha^{-1}$), P (29.3 $kg \cdot ha^{-1}$), and K (27.9 $kg \cdot ha^{-1}$) from 15N-13.1P-12.4K. EPTC herbicide (0.46 $kg \cdot ha^{-1}$) was applied post-transplant for weed control. The plots were then watered in with sprinkler irrigation to field capacity.

On 26 October 1989 the sweet potato vines were mowed to facilitate harvest on 27 October 1989. The sweet potato roots were divided into 4 groups (U.S. #1, canner, jumbo, and culls) and weighed.

<u>System 7</u>

On 14 April 1988 system 7 of the study was begun with an application of gramoxone herbicide (0.77 $liter \cdot ha^{-1}$). The following day, 15 April 1988 trifluralin herbicide (0.19 $liter \cdot ha^{-1}$) was applied. Fertilizer was applied on 19 April 1988 from a bulk mix of 13N-5.7P-10.8K giving 58 $kg \cdot ha^{-1}$ of N, 25.3 $kg \cdot ha^{-1}$ of P, and 48.1 $kg \cdot ha^{-1}$ of K.

Snap beans cv. 'Eagle' were planted on 26 April 1988. Between-row spacing was 1 m and in-row spacing was 9 seeds per 30 cm of row.

Insects were controlled with carbaryl (0.368 $kg \cdot ha^{-1}$) as needed. Additional weed control was provided with hand held hoes.

Harvest of the snap beans began with blocks 1 and 2 on 7 July 1988 and followed with blocks 3 and 4 on 8 July 1988. Data were taken on green pod weights, number of plants per row, plant height, and pod length.

Following the harvest of snap beans plots were prepared for the succession to cabbage cv. 'Solid Blue 760.' Fertilizer from a bulk mix 13N-5.7P-10.8K was applied at the rate of 56 kg·ha^{-1} of N, 24.4 kg·ha^{-1} of P, and 46.5 kg·ha^{-1} of K. After bedding oxyfluorfen herbicide (.092 kg·ha^{-1}) was applied.

On 18 August 1988 transplants of cabbage were planted on 1 m between-row spacings and 30 cm in-row spacings. The plants received 225 ml of transplant solution containing N (33.6 kg·ha^{-1}), P (14.7 kg·ha^{-1}), and K (27.9 kg·ha^{-1}) from 20N-8.7P-16.6K and diazinon at 0.65 kg·ha^{-1}. All plots were then watered to field capacity with sprinkler irrigation. Replacement plants were set on both 2 and 9 September 1988. Replacement plants received additional transplant solution as previously applied to the initial planting.

Insects were controlled with sprays of methomyl (0.17 kg·ha^{-1}) on 6, 13, and 20 September 1988. On 27 September 4 and 11 October 1988 the insects were controlled with a tank mix combination of *Bacillus thuringiensis* and permethrin (.037 kg·ha^{-1}). A N sidedress was applied on 23 September 1988 at 45 kg·ha^{-1} from urea. Another sidedress application was applied on 14 October 1988 at 34 kg·ha^{-1} of N also from urea.

Cabbage was harvested 7 times on 28 October, 4, 11, 18 and 23 November, 2 and 9 December 1988. Heads were weighed and graded either as marketable or culls. Number of heads, solidness of head, length of core, head diameter, and head height were also recorded.

In 1989 the last half of the system 7 rotation was begun. On 19 June 1989 plots were prepared for sweet potatoes cv. 'Jewel.' Fertilizer from a bulk mix giving 34 $kg{\cdot}ha^{-1}$ of N, 24.4 $kg{\cdot}ha^{-1}$ of P, and 92.9 $kg{\cdot}ha^{-1}$ of K was incorporated along with diazinon insecticide (0.74 $kg{\cdot}ha^{-1}$) for control of soil insects.

On 22 June 1989 sweet potato slips were transplanted with between-row spacings of 1 m and in-row spacings of 36 cm. The plants received transplant solution containing N (33.6 $kg{\cdot}ha^{-1}$), P (29.3 $kg{\cdot}ha^{-1}$), and K (27.9 $kg{\cdot}ha^{-1}$) from 15N-13.1P-12.4K. EPTC herbicide (0.46 $kg{\cdot}ha^{-1}$) was applied post transplant for weed control. The plots were then watered by sprinkler irrigation to field capacity.

On 26 October 1989 the sweet potato vines were mowed to facilitate harvest on 27 October 1989. The roots were divided into 4 groups (U.S. #1, canners, jumbos, and culls) and weighed.

CHAPTER IV

RESULTS

In 1988 and 1989 tree measurements were taken to determine the growth of the intercropped and the non-intercropped peaches. These measurements were also taken at the time of planting for initial trunk caliper and canopy sizes.

In 1989 trunk caliper increases from the previous year's measurements were significantly greater on the 8.5 m between-row spacings than on the 6.7 m between-row spacings (Table 1). The trunk caliper increases in 1988 also tended to be larger on the 8.5 m between-row spacings than on the 6.7 m between-row spacings but they were not significant. Although they were not compared statistically, trunk caliper increases in 1988 appeared to be greatest in systems 1 and 7 on both between-row spacings. There were no significant interactions between spacing and treatments in either the 1988 or the 1989 trunk caliper increase data.

In 1988 and 1989 total trunk caliper sizes were compared on both between-row spacings. These measurements do not consider previous growth or size of the trees at planting. The 8.5 m between-row spacings had larger total trunk caliper sizes in 1989 than the 6.7 m between-row spacings (Table 1). Differences were not significant in 1988. There were no

Table 1. Effects of spacing and intercrop systems on 'Loring' peach trunk caliper and canopy.

Spacing and intercrop system	Caliper increase (mm)		Total caliper (mm)		Canopy area increase (m^2)		Total canopy area (m^2)
	1988	1989	1988	1989	1988	1989	1989
6.7 m x 4.9 m							
System 1[z]	18	38	28	56	0.8	2.3	3.1
System 2[y]	13	36	24	50	0.7	2.0	2.7
System 3[x]	13	44	24	57	0.7	2.7	3.4
System 4[w]	12	36	22	48	0.6	1.7	2.2
System 5[v]	14	35	24	49	0.7	1.9	2.6
System 6[u]	14	44	24	59	0.7	2.8	3.5
System 7[t]	16	32	26	49	0.8	2.0	2.7
MEAN	14a	38a	25a	53a	0.7a	2.2a	2.9a
Interaction Spacing x System	NS	NS	NS	NS	NS	NS	NS
8.5 m x 4.9 m							
System 1[z]	18	46	27	64	0.8	2.7	3.6
System 2[y]	16	39	27	56	0.8	2.5	3.3
System 3[x]	16	44	27	60	0.8	2.8	3.6
System 4[w]	16	40	26	56	0.8	2.3	3.0
System 5[v]	17	44	27	61	0.8	3.0	3.8
System 6[u]	15	36	25	52	0.8	1.9	2.6
System 7[t]	20	46	30	67	0.8	3.5	4.6
MEAN	17a	42b	27a	59b	0.8b	2.7b	3.5b
Interaction Spacing x System	NS	NS	NS	NS	NS	NS	NS

[z]System 1 -- Control/Fescue
[y]System 2 -- Strawberries
[x]System 3 -- 1988 cabbage succeeded by southern pea. 1989 spinach succeeded by cantaloupe.
[w]System 4 -- 1988 snap bean succeeded by cabbage. 1989 spinach succeeded by cantaloupe.
[v]System 5 -- 1988 potato succeeded by cauliflower. 1989 snap bean succeeded by cabbage.
[u]System 6 -- 1988 cabbage succeeded by southern pea. 1989 sweet potato.
[t]System 7 -- 1988 snap bean succeeded by cabbage. 1989 sweet potato.

statistically significant interactions in total caliper between spacing and treatments in either 1988 or 1989.

Canopy area increase and total canopy area were also measured at planting and in 1988 and 1989. In 1988 canopy area increase over the initial planting canopy area (zero for all trees) was significantly greater in the 8.5 m between-row spacings than the 6.7 m between-row spacings (Table 1). In 1989 the results were similar with the 8.5 m between-row spacings showing significantly greater canopy increases than the 6.7 m between-row spacings.

Total canopy area in 1989 was also significantly greater on the 8.5 m between-row spacings than on the 6.7 m between-row spacings (Table 1). Total canopy area for 1988 was not shown because it was identical to the 1988 canopy area increase values.

There were no significant interactions between spacings and treatments in either the canopy area increase data or the total canopy area data in 1988 and 1989.

Elemental concentrations from peach leaf samples were taken in both 1988 and 1989. There were no interactions in elemental concentrations between spacing and treatments so the two spacings were pooled. Nitrogen concentrations in 1988 showed system 2 to be significantly higher than system 3 with all other systems being intermediate in N concentration. In 1989 there were no statistical differences between any of the systems with regard to N concentration (Table 2). Phosphorus concentrations in 1988 were significantly greater in system 2 than in systems 1, 4, or 5. System 1 had

Table 2. Influence of intercrop on peach leaf elemental concentration. Means over two spacings.

Intercropping system	Dry weight (%)										Dry weight (μ/g)					
	N		P		K		Ca		Mg		Zn		Fe		Mn	
	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989	1988	1989	1988[z]	1989	1988	1989
System 1 Fescue	3.79ab[y]	3.43a	0.208b	0.15b	1.44a	1.78de	1.73a	1.43a	0.55a	0.36a	27ab	18.6ab	635	159ab	172a	309b
System 2 Strawberries	3.88a	3.38a	0.217a	0.16b	1.58a	2.01bc	1.87a	1.50a	0.51a	0.33ab	27ab	18.0b	579	152ab	185a	391ab
System 3 1988:Cabbage/southernpea 1989·Spinach/cantaloupe	3.70b	3.46a	0.209ab	0.17ab	1 56a	1.77e	1.87a	1.57a	0.52a	0.35ab	29a	20.6ab	647	143b	243a	305b
System 4 1988:Snapbean/cabbage 1989:Spinach/cantaloupe	3.76ab	3 48a	0.186c	0.19a	1.47a	2.32a	1.79a	1.38a	0.51a	0.32b	25b	19.1ab	657	142b	132a	375ab
System 5 1988:Potato/cauliflower 1989:Snapbean/cabbage	3 77ab	3.41a	0.195bc	0.17ab	1.49a	2.00bcd	1.78a	1.50a	0.51a	0.34ab	26ab	19.1ab	622	160ab	143a	430a
System 6 1988:Cabbage/southernpea 1989:Sweet potato	3 76ab	3.43a	0.205abc	0.16b	1.47a	1.80cde	1.90a	1.41a	0.53a	0.34ab	28ab	18.4b	612	167a	196a	351ab
System 7 1988:Snapbean/cabbage 1989:Sweet potato	3.80ab	3.48a	0.209ab	0.17ab	1.62a	2.06b	1.83a	1.51a	0.53a	0.34ab	27ab	21.1a	626	150ab	149a	400ab

[z] Interaction of spacing x system was significant at 5% level.

[y] Mean separation, within columns by Duncan's Multiple Range Test, 5% level.

significantly greater concentrations of P than system 4 in 1988. System 4 had significantly less P concentrations in 1988 than systems 1, 2, 3, and 7. In 1989 P concentrations were significantly different between system 4 and systems 1, 2, and 6 with system 4 having greater concentrations than the others (Table 2). Potassium concentrations were not significantly different in 1988. In 1989 the concentrations fluctuated greatly with system 4 having significantly greater amounts of K than any of the other systems. System 3 had the lowest K concentrations of any of the systems, although it was only significantly different from systems 2, 4, 5, and 7 (Table 2). Calcium concentrations were not significantly different between any of the systems in either 1988 and 1989 (Table 2). Magnesium concentrations among the systems were not different in 1988. In 1989 system 1 had the highest level of Mg and system 4 had the lowest. In 1988 Zn concentrations among the systems were significantly different only between systems 3 and 4. System 3 had significantly higher Zn concentrations. In 1989 the Zn concentrations among the systems were significantly different only between system 7 and systems 2 and 6. System 7 had the higher concentrations (Table 2). Iron concentrations were not significantly different in 1988 among the systems because there was a significant interaction between spacings and treatments. The 6.7 m spacings had much higher levels of iron than did the 8.5 m spacings. In 1989 significant differences in Fe concentration were noted between system 6 and systems 3 and 4 with system 6 having the higher concentration (Table 2). Manganese concentrations were not statistically different in 1988. In 1989 there were significant differences between system 5 and systems 1 and 3 with system 5 having the highest levels of Mn (Table 2). Although there were many significant differences among the elemental concentrations in both 1988 and 1989, there was no perceivable pattern in the differences found.

Individual crops grown in 1988 were evaluated on various yield parameters appropriate to each crop. In almost all cases yields trended higher in the 8.5 m between-row spacings than on the 6.7 m between-row spacings (Tables 3 through 14). These differences were significant only in the number of grade "B" potatoes (Table 6), weight of southern pea pods (Table 7), number and weight of cauliflower cull heads (Table 9), and plant height of snap beans (Table 11). Yields were calculated not on actual land area occupied by each crop, but by the land area occupied by the crops and the trees.

Due to excessively wet soils and perched water tables at the orchard site during 1987 and 1989 many of the peach trees were lost. Because of this, fruit production data from the peach trees could not be taken. The fruit production from the various systems would have made the yield data of the intercrops much more useful. At the termination of the project losses of trees were too great to determine orchard production and longevity.

Table 3. Effects of peach row spacing on the yield[z] of mulched and non-mulched strawberries[y] in an intercropped orchard in 1989.

Orchard spacing	Yield ($kg \cdot ha^{-1}$) non-mulched	Yield ($kg \cdot ha^{-1}$) mulched
6.7 m x 4.9 m	2393	2159
8.5 m x 4.9 m	2762	2610
F-test	NS	NS

[z]Yields are per hectare of orchard.

[y]System 2 -- 1988 and 1989 strawberries.

Table 4. Effect of peach row spacing on the yield[z] of spring cabbage in an intercropped orchard in 1988.

Intercrop system	Marketable heads·ha^{-1}		Cull heads·ha^{-1}	
	Number	Weight (kg)	Number	Weight (kg)
System 3[y]				
6.7 m x 4.9 m	403	2750	230	1382
8.5 m x 4.9 m	463	3220	303	1726
F-test	NS	NS	NS	NS
System 6[x]				
6.7 m x 4.9 m	520	3401	311	1832
8.5 m x 4.9 m	442	3012	263	1428
F-test	NS	NS	NS	NS

[z]Yields are per hectare of orchard.

[y]System 3 – 1988 cabbage succeeded by southern pea. 1989 spinach succeeded by cantaloupe.

[x]System 6 – 1988 cabbage succeeded by southern pea. 1989 sweet potato.

Table 5. Effect of peach row spacing on snap bean growth and yield[z] in an intercropped orchard in 1988.

Intercrop system	Length of 25 pods (cm)	Plant height (cm)	Number of plants ($1000 \cdot ha^{-1}$)	Weight of green pods ($kg \cdot ha^{-1}$)
System 4[y]				
6.7 m x 4.9 m	267	40	61.4	1992
8.5 m x 4.9 m	264	41	65.0	2224
F-test	NS	NS	NS	NS
System 7[x]				
6.7 m x 4.9 m	254	40	70.8	1811
8.5 m x 4.9 m	254	40	64.0	1448
F-test	NS	NS	NS	NS

[z]Yields are per hectare of orchard.

[y]System 4 – 1988 snap bean succeeded by cabbage. 1989 spinach succeeded by cantaloupe.

[x]System 7 – 1988 snap bean succeeded by cabbage. 1989 sweet potato.

Table 6. Effect of peach row spacing on the growth and yield[z] of potatoes[y] in an intercropped orchard in 1988.

Orchard spacing	Grade "A"[x]		Grade "B"[w]		Grade "C"[v]	
	$1000 \cdot ha^{-1}$	Wt.($kg \cdot ha^{-1}$)	$1000 \cdot ha^{-1}$	Wt.($kg \cdot ha^{-1}$)	$1000 \cdot ha^{-1}$	Wt.($kg \cdot ha^{-1}$)
6.7 x 4.9 m	38.4	4545	79.3	352	17.0	631
8.5 x 4.9 m	49.5	5940	10.6	457	20.9	757
F-test	NS	NS	*[u]	NS	NS	NS

[z]Yields are per hectare of orchard.

[y]System 5 – 1988 potato succeeded by cauliflower. 1989 snap bean succeeded by cabbage.

[x]Grade "A" - Tubers with a minimum diameter of 4.8 cm and no maximum diameter. Forty percent of tubers must be greater than 6.4 cm in diameter.

[w]Grade "B" - Tubers with a minimum diameter of 3.8 cm and a maximum diameter of 5.7 cm.

[v]Grade "C" - Tubers with a maximum diameter of 3.8 cm.

[u]Significantly different at the 5% level using Fisher's F-test.

Table 7. Effect of peach row spacing on yield[z] of southern pea in an intercropped orchard in 1988.

Intercrop system and spacing	Number of plants $(1000 \cdot ha^{-1})$	Weight of pods $(kg \cdot ha^{-1})$
System 3[y]		
6.7 m x 4.9 m	34.5	552
8.5 m x 4.9 m	75.8	864
F-test	NS	*[x]
System 6[w]		
6.7 m x 4.9 m	50.9	687
8.5 mx 4.9 m	63.7	853
F-test	NS	NS

[z]Yields are per hectare of orchard.

[y]System 3 -- 1988 cabbage succeeded by southern pea. 1989 spinach succeeded by cantaloupe.

[x]Significantly different at 5% level using Fisher's F-test.

[w]System 6 -- 1988 cabbage succeeded by southern pea. 1989 sweet potato.

Table 8. Effects of peach row spacing on the yield[z] of fall cabbage in an intercropped orchard in 1988.

Intercrop system and spacing	Weight of marketable heads ($kg \cdot ha^{-1}$)	Number of marketable heads$\cdot ha^{-1}$
System 4[y]		
6.7 m x 4.9 m	2964	2656
8.5 m x 4.9 m	3516	2929
F-test	NS	NS
System 7[x]		
6.7 m x 4.9 m	2560	2184
8.5 mx 4.9 m	3548	3007
F-test	NS	NS

[z]System 4 -- 1988 snap bean succeeded by cabbage. 1989 spinach succeeded by cantaloupe.

[y]System 7 -- 1988 snap bean succeeded by cabbage. 1989 sweet potato.

Table 9. Effect of peach row spacing on the yield[z] of fall cauliflower[y] in an intercropped orchard in 1988.

Orchard spacing	Marketable heads·ha^{-1} Number	Marketable heads·ha^{-1} Weight (kg)	Cull heads·ha^{-1} Number	Cull heads·ha^{-1} Weight (kg)
6.7 x 4.9 m	1312	2322	624	804
8.5 x 4.9 m	1272	2229	1486	2064
F-test	NS	NS	*[x]	*

[z]Yields are per hectare of orchard yield.

[y]System 5 – 1988 potato succeeded by cauliflower. 1989 snap bean succeeded by cabbage.

[x]Significantly different at the 5% level using Fisher's F-test.

Table 10. Effect of peach row spacing on the yield[z] of spring spinach in an intercropped orchard in 1989.

Intercrop system and spacing	Yield marketable spinach ($kg \cdot ha^{-1}$)
System 3[y]	
6.7 x 4.9 m	2654
8.5 x 4.9 m	4025
F-test	NS
System 4[x]	
6.7 x 4.9 m	1963
8.5 x 4.9 m	1565
F-test	NS

[z]Yields are per hectare of orchard.

[y]System 3 -- 1988 cabbage succeeded by southern pea. 1989 spinach succeeded by cabbage.

[x]System 4 -- 1988 snap bean succeeded by cabbage. 1989 spinach succeeded by cantaloupe.

Table 11. Effect of peach row spacing on the growth and yield[z] of snap bean[y] in an intercropped orchard in 1989.

Orchard spacing	Length of 25 pods (cm)	Plant ht. (cm)	Number of plants ($1000 \cdot ha^{-1}$)	Yield green pods($kg \cdot ha^{-1}$)
6.7 x 4.9 m	262	42	174	3669
8.5 x 4.9 m	254	45	178	4510
F-test	NS	*[x]	NS	NS

[z]Yields are per hectare of orchard.

[y]System 5 -- 1988 potato succeeded by cauliflower. 1989 snap bean succeeded by cabbage.

[x]Significantly different at the 5% level using Fisher's F-test.

Table 12. Effects of peach row spacing on the growth and yield[z] of sweet potatoes in an intercropped orchard in 1989.

Intercrop system and spacing	U.S. No. 1's		Canners		Jumbo's		Cracks	
	$1000 \cdot ha^{-1}$	Wt.($kg \cdot ha^{-1}$)	$1000 \cdot ha^{-1}$	Wt.($kg \cdot ha^{-1}$)	$1000 \cdot ha^{-1}$	Wt.($kg \cdot ha^{-1}$)	$1000 \cdot ha^{-1}$	Wt.($kg \cdot ha^{-1}$)
System 6[y]								
6.7 x 4.9 m	43.2	11667	80.0	6223	4.3	1997	7.0	1397
8.5 x 4.9 m	44.0	10541	87.6	6677	2.4	1073	5.7	1112
F-test	NS	NS	NS	NS	NS	NS	NS	NS
System 7[x]								
6.7 x 4.9 m	39.3	10742	70.4	5321	2.9	1446	8.1	1728
8.5 x 4.9 m	42.3	11611	76.5	5985	2.9	1407	11.0	9184
F-test	NS	NS	NS	NS	NS	NS	NS	NS

[z]Yields are per hectare of orchard.

[y]System 6 -- 1988 cabbage succeeded by southern pea. 1989 sweetpotato.

[x]System 7 -- 1988 snap bean succeeded by cabbage. 1989 sweetpotato.

Table 13. Effect of peach row spacing on the yield[z] of cantaloupe in an intercropped orchard in 1989.

Intercrop system and spacing	Marketable fruit Number	Marketable fruit Weight ($kg \cdot ha^{-1}$)
System 3[y]		
6.7 x 4.9 m	1465	1634
8.5 x 4.9 m	1448	1668
F-test	NS	NS
System 4[x]		
6.7 x 4.9 m	1670	2009
8.5 x 4.9 m	1821	2184
F-test	NS	NS

[z]Yields are per hectare of orchard.

[y]System 3 -- 1988 cabbage succeeded by southern pea. 1989 spinach succeeded by cabbage.

[x]System 4 -- 1988 snap bean succeeded by cabbage. 1989 spinach succeeded by cantaloupe.

Table 14. Effect of peach row spacing on the yield[z] of fall cabbage[y] in an intercropped orchard in 1989.

Intercrop spacing	Marketable heads·ha^{-1}	
	Number	Weight (kg)
6.7 x 4.9 m	2580	2688
8.5 x 4.9 m	2412	2508
F-test	NS	NS

[z]Yields are per hectare of orchard.

[y]System 5 -- 1988 potato succeeded by cauliflower. 1989 snap bean succeeded by cabbage.

CHAPTER V

DISCUSSION

From this study it appears that intercropping peach orchards in the first 3 to 5 years with supplemental income crops is possible without causing significant detrimental effects on the orchard as long as precautions are taken against erosion and orchard tree damage. It is probable that the added value of the intercrops would offset the losses caused by yield reductions to the peach crop.

Intercrop selections need not be the crops used in this study. At any given location, the farmer would need to choose compatible intercrops which would be marketable in his area.

From a management standpoint, intercrops which are perennial, such as the strawberry system used in this study, are much easier to maintain than the annual vegetable systems. Perennial crops require much less cultivation, aside from the initial planting, and other machine operations than do the annual crops. Some perennial intercrops which might be suitable, other than the strawberries, are grasses for hay and herbs.

Soil erosion as it relates to intercropping has not been discussed in the literature. Visual indications noticed while conducting this study point to soil erosion as a major drawback to intercropping. It is very probable that the more slope to the orchard, the more erosion potential there would be. Since peach orchards need to have air drainage to prevent frost damage to the fruit, slope on the orchard site is desirable. The annual cropping systems appeared to sustain the most erosion during the study, while the constant cover provided by the strawberry crop prevented erosion loss of soil. With the annuals, there are many periods in the year that the soil is bare or just partially covered. It is during these times that the erosion potential would be the greatest.

Much more work needs to be done on intercropping before any large investment intercropping systems are established. Long term effects on the trees need to be studied in a location where the trees can be maintained over a much longer time period. Also, monthly growth measurements on the trees might give a better indication when the growth decreases seen in this study occur. Since we took yearly growth data it is impossible to determine if the decreases occurred gradually over the entire year or if they occurred in certain periods of the year.

Other areas which need more study are root-zone interactions, water relations, light and nutrient competitions, and possible allelopathic interactions between the intercrops themselves or between crops in the rotational systems.

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