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Mid-Columbia Agricultural Research and Extension Center Annual Report 1999

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TABLE OF CONTENTS

Postharvest Physiology of Winter Pears
P.M. Chen, R.A. Spotts, T.J. Facteau, and E.A. Mielke 1

Pruning, Training, Rootstocks, Irrigation Systems and their Interactions for Sweet Cherries
T.J. Facteau and L.E. Long 20

Sweet Cherry Cultivar Collection
T.J. Facteau and L.E. Long 38

Evaluation of Conventional Rootstocks for Pear
E.A. Mielke, T.J. Facteau, and C.F. Seavert 43

Evaluation of Pear Interstems
E.A. Mielke 50

Evaluation of New Rootstocks of Pears
E.A. Mielke 59

Management of High-Density Pears-Tree Removal versus Containment Pruning
E.A. Mielke and C.F. Seavert 70

Red d'Anjou Failure
E.A. Mielke, F. Niederholzer, R.A. Spotts, and J. Postman 77

Effect of Training System on the Susceptibility of Cascade Pears to Hail Damage and Other Types of Fruit Marking
E.A. Mielke and T.J. Facteau 86

Effect of Rootstock and Training System on Fruit Quality and Storability of d'Anjou and Bosc Pears
E.A. Mielke, P.M. Chen, and R.A. Spotts 93

Storage Behavior and Handling of Concorde Pear as Influenced by Harvest Maturity
E.A. Mielke and P.M. Chen 101

Gala Dwarf Apple Trial
E.A. Mielke and L.A. Smith 106

TABLE OF CONTENTS, continued

Gala Semi-dwarf Apple Trial
E.A. Mielke and L.A. Smith 113

Update of Entomology Research
H. Riedl 118

Annual Report of Research in Plant Pathology
R.A. Spotts and L.A. Cervantes 131

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Clark F. Seavert, Superintendent

Welcome to the Mid-Columbia Agricultural Research and Extension Center (MCAREC). This Station is a branch of the Oregon Agricultural Experiment Station of Oregon State University's College of Agricultural Sciences. The Hood River County Extension Service is also located at the Center. There are six OSU research scientists, three Extension faculty, five adjunct, and two professor emeritus faculty residing at the MCAREC. There are also 13 classified staff with numerous visiting professors and graduate students assisting in research at the Center.

Scientists at MCAREC specialize in research important to pears, apples, and cherries. The Mid-Columbia fruit growing region in Hood River and Wasco counties accounts for 40 percent of the "winter" pears, 20 percent of the Bartlett "summer" pears, and about 20 percent of the sweet cherries produced in the United States. This fruit production has a farm gate value of approximately $75 million with an additional $75 million in gross value added.

Hood River County leads all 3,300 counties in the United States in pear production. Hood River County is also the leading Oregon county and ranks 43rd in the top 100 U.S. counties in the production of fruits, nuts, and berries.

Research at MCAREC provides growers, field-persons, and agri-businesses with answers relating to horticulture, plant pathology, post-harvest physiology, entomology, and agricultural economics. Cold storage operators in the Pacific Northwest and the rest of the world have adopted temperature and controlled atmosphere recommendations for pears developed through research at the Center. Methods for improving production efficiency and fruit quality are under study here, including research on rootstocks and interstems, tree density, training and support systems, nutrition, decay control, and integrated pest management.

Mission

The OSU-MCAREC includes research scientists and Extension faculty committed to developing a solid base of objective scientific information that addresses the needs of the fruit industry of Oregon and the Pacific Northwest.

Vision

To provide the leadership for basic and applied research relevant to the tree fruit industry. We are committed to increasing profitability, economic growth and the wise use of our natural resources.

Values

Accountability, Commitment, Integrity, and Vision are our guiding principles. Continuous learning and scholarship are keys to our on-going success.

Postharvest Physiology of Winter Pears

P.M. Chen, R.A Spotts, T.J. Facteau, and E.A. Mielke

Significant Findings

Study the flavor quality of under-chilled d'Anjou pears ripened by ethylene preconditioning during the early marketing season.

There were 11 major volatiles emitted from d'Anjou pears on day 7 of normal ripening that could be detected by gas chromatographic analysis. Two dominant volatile peaks with retention times at 1.4 and 1.6 minutes were identified as pentyle acetate and hexyl acetate, respectively. Another three volatile peaks with retention times at 0.7, 1.1, and 5.3 minutes were identified as methyl acetate, ethyle acetate, and hexanol, respectively. The remaining volatile peaks were not identified. It was evident that the aroma of ripened d'Anjou fruit was contributed mainly by pentyle acetate and hexyl acetate. Even though the normal ripening capacity of under-chilled d'Anjou pears could be promoted by external ethylene treatment, the active volatile production could not be induced until d'Anjou fruit had been stored in air at -1°C for 6 weeks. D'Anjou fruit without ethylene treatment (i.e., the control) were incapable of ripening normally if they were stored in air at -1°C for less than 8 weeks. Control fruit stored for 8 weeks generated a volatile profile upon day 7 of ripening similar to those fruit stored for 2 to 4 weeks and ripened by ethylene capsule treatment. Ripened fruit induced by the ethylene treatment developed high texture quality as early as at harvest. However, the development of aroma quality still required a sufficient period of chilling (i.e., at least 30 days at -1°C).

Identify the biochemical markers that will predict any physiological disorders of winter pears in any CA storage regimes.

Activities of pyruvate decarboxylase (PDC) and alcohol dehydrogenase (ADH) in d'Anjou pears during air storage at -1°C and different controlled atmosphere (CA) storage regimes were investigated. The normal activities of PDC and ADH in air-stored fruit were between 0.33 and 0.38 $\mu mol \cdot g^{-1} \cdot min^{-1}$ and between 0.26 and 0.31 $\mu mol \cdot g^{-1} \cdot min^{-1}$, respectively during 150 days of storage in air at -1°C. After 3 months of storage, the activities of PDC were 1.2, 0.8, 0.6, and 0.6 ($\mu mol \cdot g^{-1} \cdot min^{-1}$) in d'Anjou fruit stored in 0.5%, 1.0%, 1.5% and 2.0% O_2, respectively, while the activities of ADH were low at 0.3 (μmol $\cdot g^{-1} \cdot min^{-1}$) regardless of CA regimes. After 3 months of CA storage, d'Anjou fruit were free from skin black speck (SBS) and pithy brown core (PBC) disorders regardless of CA regimes. After 4 months of storage, the activities of PDC were 1.4, 1.1, 0.7, and 0.6 (μmol $\cdot g^{-1} \cdot min^{-1}$) in d'Anjou fruit stored in 0.5%, 1.0%, 1.5%, and 2.0% O_2, respectively, while the activities of ADH were still low at 0.4 (μmol $\cdot g^{-1} \cdot min^{-1}$) regardless of CA regimes. After 4 months of storage, fruit stored in 0.5% and 1.0% O_2 suffered 23 percent and 11 percent incidence of SBS disorder and 12 percent and 3 percent incidence of PBC disorder, respectively. The results suggested that PDC activities in d'Anjou pears were induced by low oxygen (less than 1.0 percent) prior to the development of SBS and PBC disorders. The activities of ADH in the fruit remained very low regardless of storage length and CA regimes. PDC activities might serve as a biochemical marker for early detection of SBS and PBC disorders for d'Anjou pears stored in stressful CA conditions.

Improve the model to predict the development of superficial scald in d'Anjou pears associated with growing elevations and to determine ACU in 14 orchards in the Hood River District.

D'anjou pears (Pyrus communis L.) at the first day of commercial maturity based on the flesh firmness of 64.5N (Newton) ($\pm$ 2.1N) (1N = 4.448 lb-force) were harvested from 14 orchards located at different elevations in the Hood River District, Oregon, U.S.A. in 1996, 1997, 1998, and 1999. The development of superficial scald disorder for each orchard block was standardized as "days in air storage at -1°C when 10 percent of fruit is affected with scald symptoms on day 7 of ripening at 20°C" which was denoted at DIS(10%). The accumulated cold unit (ACU) was obtained from the weather station located at the center of each orchard block and was defined as the number of hours accumulated in each orchard block when the temperature was at 10°C or lower, recorded from 42 days prior to the first date of commercial harvest. DIS(10%) (as the dependent variable) was plotted against corresponding ACU (as the independent variable) from each orchard block and subjected to the regression analyses. The regression analyses were conducted as the following functions: (1) linear; (2) exponential; (3) natural logarithmic; (4) power law; and (5) polynomial. A power law function was found to be the best fit of the regression. The equation was given as $DIS(10\%) = 62.57016*ACU^{0.07475}$ ($R^2 = 0.75779$***). The equation could be used to predict the scald development of d'Anjou pears during storage.

Study the efficacy of using starch index (SI) as a supplemental maturity index of d'Anjou pears.

In 1999, flesh firmness (FF) of d'Anjou pears grown at the lower elevation (520 ft) decreased slowly from 18.1 lb starting 4 weeks (8/25/99) prior to the predicted optimum maturity, to 14.5 lb (±0.4 lb) at commercial harvest date (9/15/99). FF changed very little for 2 weeks after the commercial harvest date and maintained at 14.5 lb in average until 9/28/99. However, starch index (SI) at the center cross-section of d'Anjou fruit changed linearly from 0.73 starting 4 weeks prior to commercial harvest date to 2.70 at the commercial harvest date, and finally to 4.10, 2 weeks after the commercial harvest date. Starch index (SI) is contributed primarily by amylose, which is stained by iodine solution to a deep blue color. Amylopectin is stained by iodine solution to a light pink color, which has little effect on SI reading. Amylose in d'Anjou fruit decreased consistently during 6 weeks of maturation period. The results indicated that changes in starch index (SI) could be used as a supplemental maturity index for the determination of harvest maturity of d'Anjou pears, especially when FF fails to change during the crucial period of fruit maturation.

Objectives

1. Study the flavor quality of under-chilled d'Anjou pears ripened by ethylene preconditioning during the early marketing season.

2. Identify the biochemical markers that will predict any physiological disorders of winter pears in any CA storage regimes.

3. Improve the model to predict the development of superficial scald in d'Anjou pears associated with the growing elevations and to determine ACU in 14 orchards in the Hood River District (the fourth year's study).

4. Study the efficacy of using starch index (SI) as a supplemental maturity index of d'Anjou pears.

Procedures

Objective 1. Study the flavor quality of under-chilled d'Anjou pears ripened by ethylene preconditioning during the early marketing season.

D'Anjou pears were harvested at commercial maturity with flesh firmness (FF) of 14 lb (±0.5 lb). Harvested fruit was stored in air at -1°C. After 0, 2, 4, 6, 8, and 10 weeks of storage, eight fruits (2.0±0.2 kg) were ripened either in a perforated bag with an ethylene capsule (designated as the ethylene group) or in a perforated bag without an ethylene capsule (designated as the control group) at 20°C for 7 days. On day 7 at 20°C, volatile profiles in one ml of atmosphere in each bag were separated by a gas chromatograph equipped with a stainless steel column (length 5 ft, O.D. 1/8", I.D. 0.085") packed with 18 percent Hallcomic W-18 on acid washed Chromosorb W (60/80 mesh). For comparative purposes, each peak with the same retention time was expressed as units of peak area count per one ml of atmosphere inside each bag. At each sampling interval, each bag was considered as an experimental unit and each treatment (i.e., ethylene bag or control bag) was replicated three times.

Objective 2. Identify the biochemical markers that will predict any physiological disorders of winter pears in any CA storage regimes.

Approximately 80 boxes (40 lb per box) of d'Anjou pears were harvested at commercial maturity with flesh firmness (FF) of 14.5 lb-force (±0.5 lb-force). Harvested fruit were drenched with TBZ fungicide solution at the labeled concentration. After fungicide treatment, fruits were packed into two types of boxes. Fruits destined for air storage were transferred into 18-kg wooden boxes with polyethylene liners. A total of 18 packed wooden boxes were stored in air at -1°C. After every 15-day storage interval, proteins from pulp tissues were extracted, and the activities of pyruvate decarboxylase (PDC) and alcohol dehydrogenase (ADH) were assayed.

Another portion of fungicide-treated fruit was transferred into 64 18-kg yellow bins with polyethylene liners. Four yellow bins with packed d'Anjou fruit were loaded into each of 16 gas-tight CA cabinets within 10 days after the commercial harvest date and cooled to equilibrate with the room temperature at -1°C. Each cabinet then was sealed and flushed with N_2 gas until the oxygen concentration in each cabinet reduced to the desired level. The CA regime of each cabinet was established within 5 days after sealing. The concentrations of O_2 and CO_2 established for each cabinet were as follows:

Cabinets 1-4	0.5% O_2 + 0.03% CO_2 (lime)
Cabinets 5-8	1.0% O_2 + 0.03% CO_2 (lime)
Cabinets 9-12	1.5% O_2 + 0.5% CO_2
Cabinets 13-16	2.0% O_2 + 1.0% CO_2

After 3, 4, 5, 6, and 7 months of storage, d'Anjou fruit in one cabinet of each CA regime were returned to air storage. The incidence of PBC and SBS disorders were assessed. Proteins from pulp tissues were extracted, and the activities of pyruvate decarboxylase (PDC) and alcohol dehydrogenase (ADH) were assayed.

Objective 3. Improve the model to predict the development of superficial scald in d'anjou pears associated with growing elevations and to determine ACU in 14 orchards in the Hood River District (the fourth year's study).

In 1999 d'Anjou pears at commercial maturity with flesh firmness (FF) of 14.5 $\pm$ 0.5 lb were harvested from mature trees in a 5-hectare orchard block located at 14 different elevation sites in the Hood River Valley District. Harvested fruit was stored in 18-kg wooden boxes with perforated polyethylene liners at -1°C in air. After 2.0, 2.5, 3.0, 3.5, and 4.0 months in storage, incidence of superficial scald disorder (Scald) was determined. At each orchard site, Optic Stow Away™ Temperature Logger (Onset Computer Corp., Pocasset, MA 02559-3450) was used to log the temperature profile from the date of full bloom to the date of commercial harvest. The accumulated hours when the temperature was equal to or below 50°F (10°C) were determined from 42 days prior to the date of commercial harvest date (denoted as accumulated cold unit, ACU). Regression analysis was used to determine the days in storage when 10 percent of fruit had developed Scald disorder [denoted as days in storage required for 10 percent fruit scald, SID(10%)]. SID(10%) and ACU determined in 1999 were added to the data obtained in 1996, 1997, and 1998 for different regression analyses.

Objective 4. Study the efficacy of using starch index (SI) as a supplemental maturity index of d'Anjou pears.

In 1999, d'Anjou pears were harvested at a weekly interval from one orchard block located at the lower (520 ft) valley of the Hood River District beginning 4 weeks prior to the commercial harvest date, except between 9/8/99 and 9/16/99, which had 5-day and 3-day intervals, until 2 weeks after the commercial harvest date. At each harvest interval, 20 fruits were picked and numbered. Flesh Firmness (FF) of each numbered fruit was determined. Starch index (SI) of each numbered fruit also was determined by a 6-point scale where "0" represents 100 percent starch (the entire surface of the central cross-section of the fruit was stained by iodine solution to a dark blue color), and "5" represents 0 percent starch (the entire surface of the cross-section is clear). The correlation analysis between FF and SI was analyzed for each orchard block, and the correlation coefficient was obtained.

A cross-section with a thickness of 0.5 cm was cut from the center of each fruit. After peeling, the section was diced further into small cubes. The combined cubes from five fruit sections were wrapped with two layers of cheesecloth and tied with a thick string. Each package of wrapped pear flesh cubes was frozen quickly in liquid nitrogen. The frozen pear flesh cubes were freeze-dried and ground into powder. The dry pear flesh powders were transferred into a vial and stored in a desiccator at room temperature. One gram of freeze-dried powder was suspended in 50 ml of 80% ethanol in a 150-ml beaker. The suspension was brought to a complete boil with constant stirring for 3 minutes. After cooling, the suspension was filtered through Whatman #1 filter paper, and the alcohol insoluble residue (AIS) was washed three times with 80% ethanel. The AIS was oven-dried at 70°C until it reached a constant weight. The dried AIS then was transferred into a mortar, and 1 gram of quartz sand was added. The dried AIS was ground into a fine powder, which then was transferred into a 50-ml beaker. Two milliliters of 18% HCI were added to the AIS fine powders and mixed well with a glass rod. After 1 hour of sitting at room temperature, 18 ml of deionized water were added to the slurry and mixed well to make the final volume of 20 ml of 1.8% HCI starch extraction. The extraction was stored at 3°C overnight. One ml of the mixed slurry was pipetted into each of four microfuge tubes and centrifuged in Beckman Microfuge E at the highest speed for 15 minutes. The clear supernatant from each tube was combined, and 2 ml of clear supernatant were used for the determination of the contents of total starch (TS), amylopectin (Ap), and amylose (Am). The correlation analyses between starch index (SI) and total starch (TS), and amylopectin (AP) and amylose (AM) were analyzed, and the correlation coefficients then were obtained.

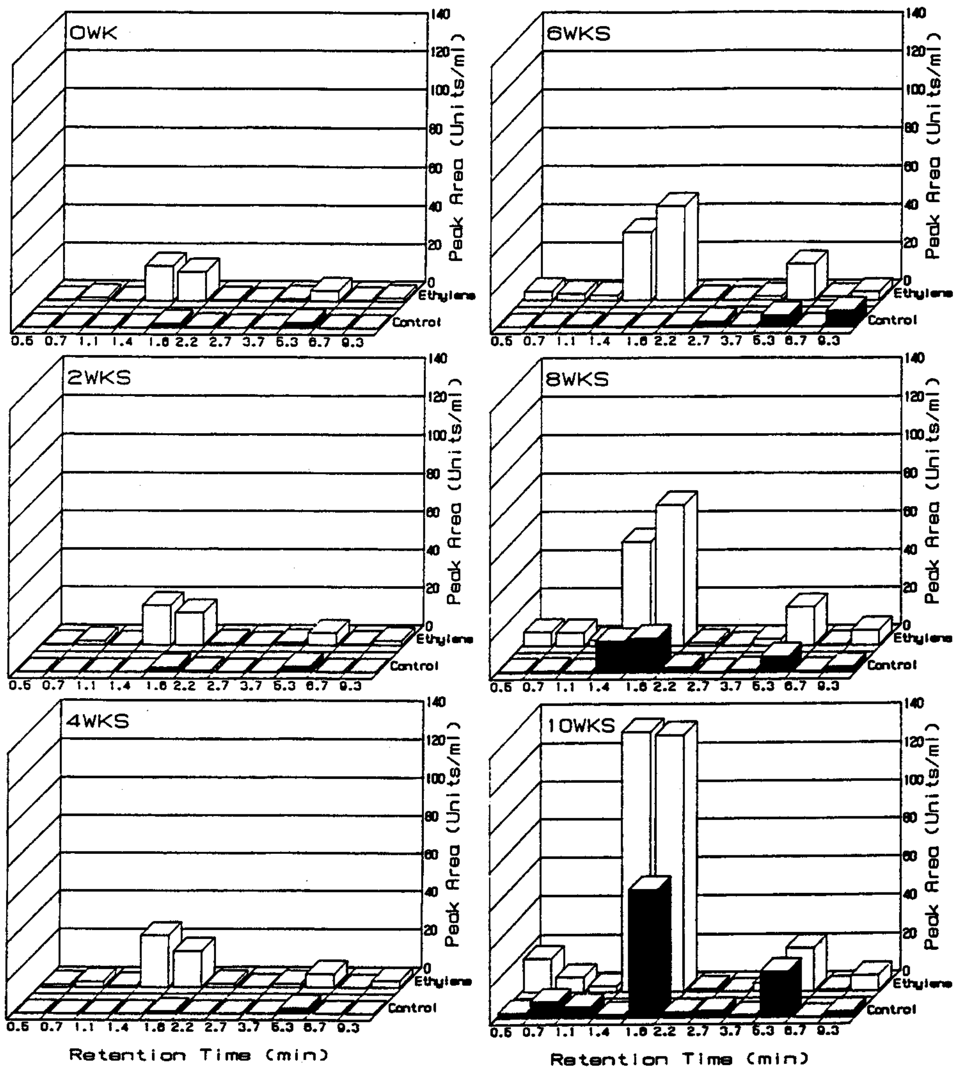
Results and Discussion

Study the flavor quality of under-chilled d'Anjou pears ripened by ethylene preconditioning during the early marketing season.

When under-chilled d'Anjou fruit was treated with an ethylene capsule in perforated bags, it ripened on day 7 at 20°C. Regardless of the storage length, ripened fruit induced by ethylene developed high buttery and juicy texture. If d'Anjou fruit were stored at -1°C for less than 30 days, ripened fruit lacked high flavor quality. There were 11 major aromatic volatiles that could be detected by gas chromatographic analysis. Two dominant volatile peaks with retention times at 1.4 and 1.6 minutes were identified as pentyle acetate and hexyl acetate, respectively. Another three volatile peaks with retention times at 0.7, 1.1, and 5.3 minutes were identified as methyl acetate, ethyle acetate, and hexanol, respectively. The remaining peaks were not identified. The aroma of ripened d'Anjou fruit was contributed mainly by pentyle acetate and hexyl acetate. Even though the normal ripening capacity of under-chilled d'Anjou pears could be promoted by external ethylene treatment (e.g., ethylene), the active volatile production could not be induced until 6 weeks of air storage at -1°C (Figure 1-1). The fundamental reason for the chilling requirement to induce aromatic volatile production in d'Anjou pears is not known, but it is worth further study.

D'Anjou fruit without the ethylene treatment (e.g., the control) were incapable of ripening normally if they were stored in air at -1°C for less than 8 weeks. Unripened d'Anjou fruit (the control) could not generate aromatic volatiles (Figure 1-1). Control fruit stored for 8 weeks generated aromatic volatile profiles similar to the fruit stored for 2 to 4 weeks followed by ethylene-capsule treatment after 7 days of ripening at 20°C (Figure 1-1). Therefore, induction of normal ripening activities of d'Anjou pears by ethylene treatment also could stimulate aromatic volatile production if the fruit had been exposed to a period of chilling for 30 days or longer. Ripened fruit induced by ethylene treatment developed high texture quality as early as at harvest. However, the development of aroma quality still required a sufficient period of chilling (at least 30 days at -1°C). A treatment of methyl jasmonate prior to the ethylene treatment might accelerate the volatile production of under-chilled d'Anjou fruit. The effect of methyl jasmonate on the induction of volatile production of d'Anjou pears will be investigated by Dr. James P. Mattheis at the USDA Tree Fruit Research Lab in Wenatchee, Washington.

Figure 1-1. Aromatic volatile profiles of d'Anjou pears treated with an ethylene capsule (Ethylene) or without an ethylene capsule (Control) in perforated bags on day 7 of ripening at 20°C. Fruit had been stored in air at -1°C for 0 (at harvest), 2, 4, 6, 8, and 10 weeks before the ripening treatment.



Identify the biochemical markers that will predict any physiological disorders of winter pears in any CA storage regimes.

Changes in the activities of pyruvate decarboxylase (PDC) in air-stored d'Anjou fruit at the level of 0.31 $\mu mol \cdot g^{-1} \cdot min^{-1}$ at harvest increased linearly to 0.37 ($\mu mol \cdot g^{-1} \cdot min^{-1}$) after 150 days of storage (Figure 2-1). The activities of alcohol dehydrogenase (ADH) in air-stored d'Anjou pears were similar to but at a little lower level than PDC activities at each corresponding storage interval (Figure 2-1). The results indicated that a low-level production of acetaldehyde and alcohol was one of the constant metabolic processes in d'Anjou pears stored in air at -1°C.

After 3 months of storage, the activities of PDC were 1.2, 0.8, 0.6, and 0.6 ($\mu mol \cdot g^{-1} \cdot min^{-1}$) in d'Anjou fruit stored in 0.5%, 1.0%, 1.5%, and 2.0% O_2, respectively, while the activities of ADH maintained a low level of 0.3 ($\mu mol \cdot g^{-1} \cdot min^{-1}$) regardless of CA regimes (Figure 2-2). After 3 months of CA storage, d'Anjou fruit were free from skin black speck (SBS) and pithy brown core (PBC) disorders regardless of CA regimes (Figure 2-3). After 4 months of storage, the activities of PDC were 1.4, 1.1, 0.7, and 0.6 ($\mu mol \cdot g^{-1} \cdot min^{-1}$) in d'Anjou fruit stored in 0.5%, 1.0%, 1.5%, and 2.0% O_2, respectively, while the activities of ADH were still at a low level of 0.4 ($\mu mol \cdot g^{-1} \cdot min^{-1}$) regardless of CA regimes (Figure 2-2). After 4 months of storage, fruit stored in 0.5% and 1.0% O_2 suffered 23 percent and 11 percent incidence of SBS disorder and 12 percent and 3 percent incidence of PBC disorder, respectively (Figure 2-3). The results suggested that PDC activities in d'Anjou pears were induced by low oxygen (less than 1.0%) prior to the development of SBS and PBC disorders. The activities of ADH in the fruit remained very low regardless of storage length and CA regimes. PDC activities, therefore, might serve as a biochemical marker for early detection of SBS and PBC disorders for d'Anjou pears stored in stressful, low oxygen CA conditions.

Figure 2-1. Changes in enzymic activities of pyruvate decarboxylase (PDC) and alcohol dehydrogenase (ADH) in d'Anjou pears during storage in air at -1°C.

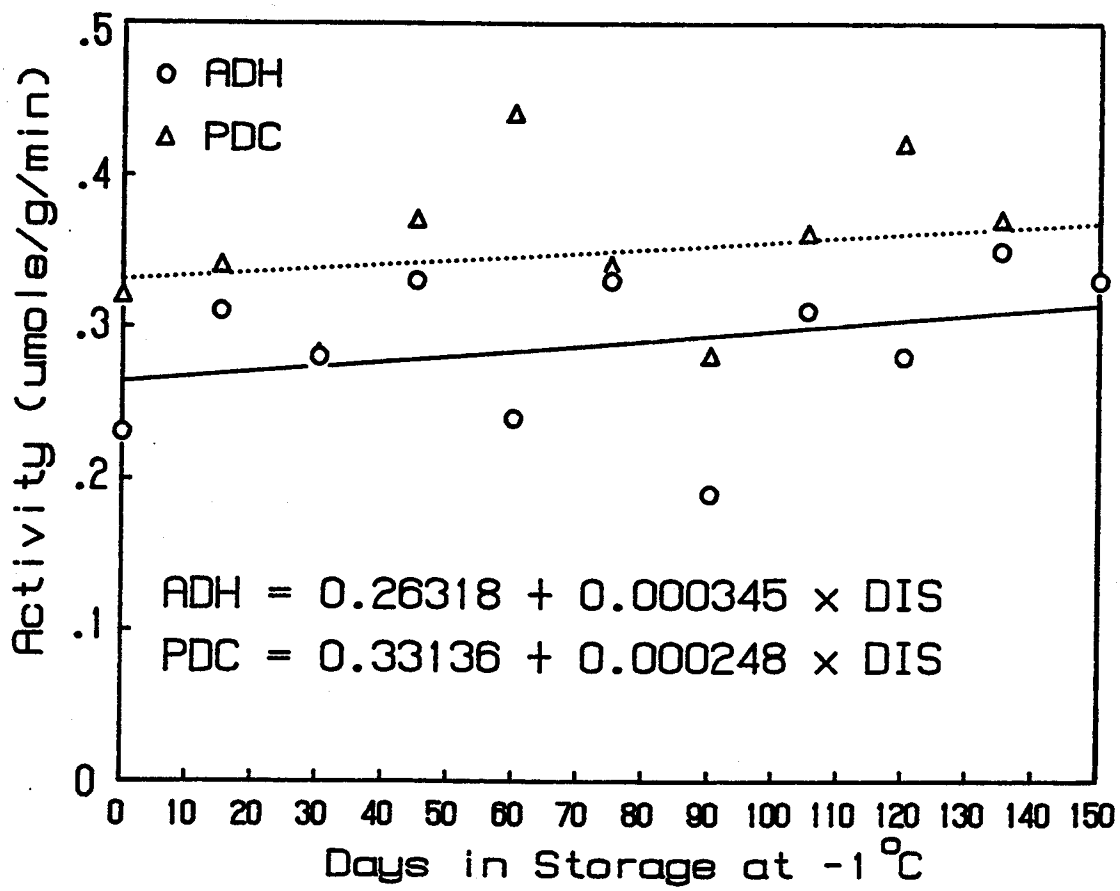


Figure 2-2. Changes in enzymic activities of pyruvate decarboxylase (PDC) and alcohol dehydrogenase (ADH) in d'Anjou pears after 3 and 4 months of storage in different controlled atmosphere (CA) regimes at -1°C.

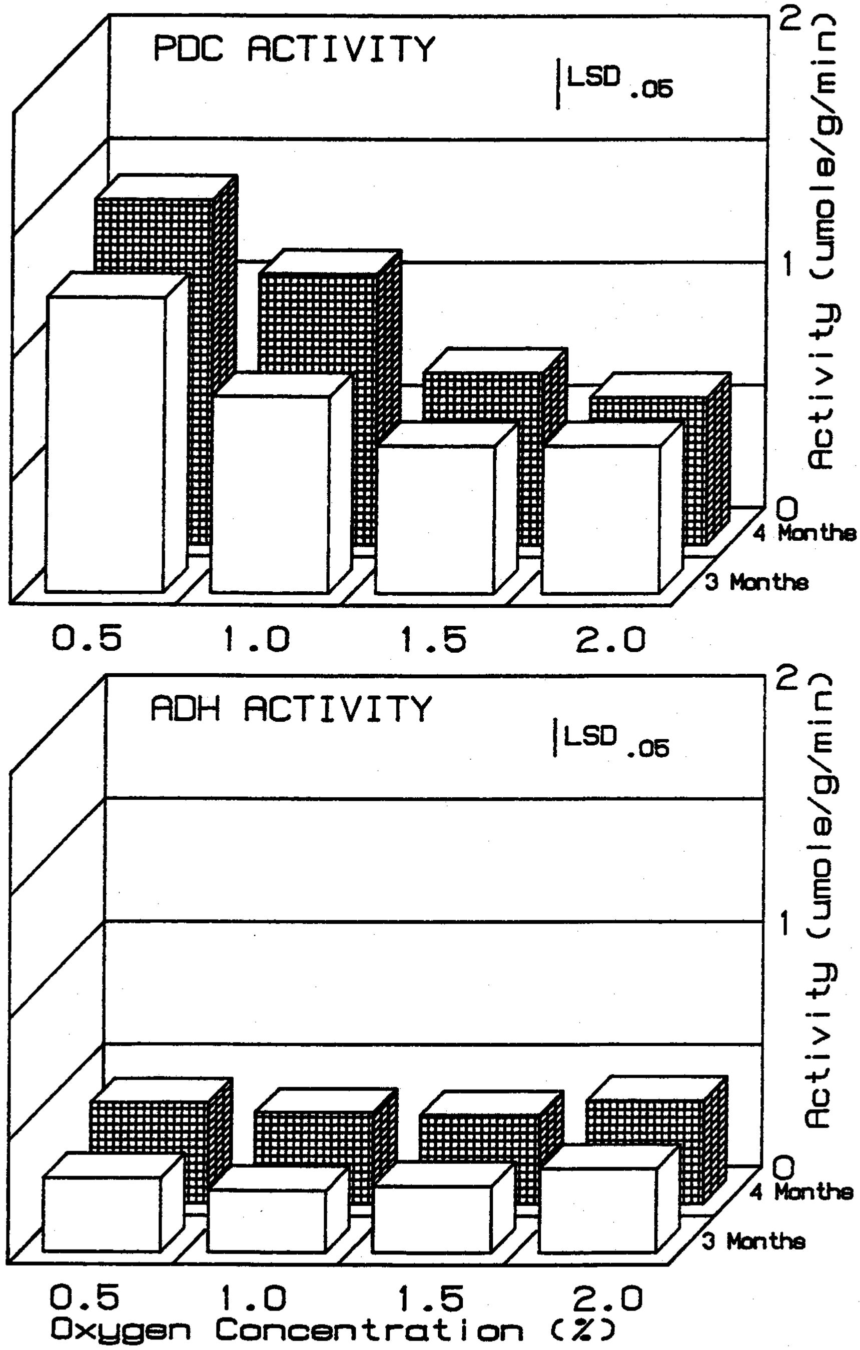
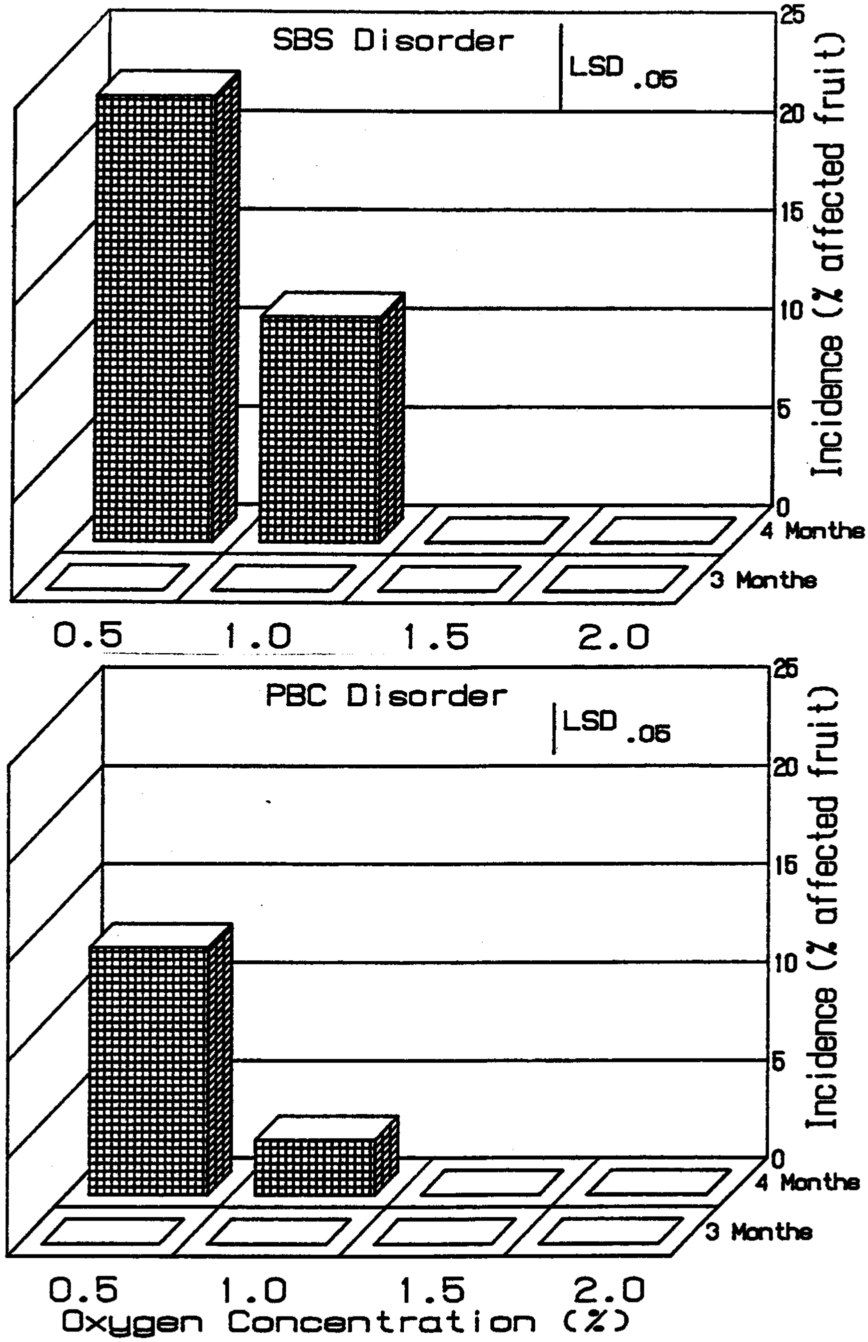


Figure 2-3. Development of skin black speck (SBS) and pithy brown core (PBC) disorders on the skin or in the core area of d'Anjou pears after 3 and 4 months of storage in different controlled atmosphere (CA) regimes at -1°C.



Improve the model to predict the development of superficial scald in d'Anjou pears associated with growing elevations and to determine ACU in 14 orchards in the Hood River District.

D'Anjou pears at the first day of commercial maturity with FF of 14.5 1b-force (±0.4 lb-force) were harvested from 14 orchards located at different elevations in the Hood River District, Oregon, U.S.A. in 1996, 1997, 1998, and 1999. Harvested d'Anjou fruit eventually developed superficial scald disorder upon 7 days of ripening at 20°C after a prolonged cold storage in air at -1°C regardless of different growing elevations. The development of superficial scald disorder for each orchard block was standardized as "days in air storage at -1°C when 10 percent of fruit is affected with scald symptoms on day 7 of ripening at 20°C," which was denoted at DIS(10%). The accumulated cold unit (ACU) was obtained from the weather station located at the center of each orchard block in 1996, 1997, 1998, and 1999. ACU was defined as the number of hours accumulated in each orchard block when the temperature was at 10°C or lower recorded from 42 days prior to the first date of commercial harvest. DIS(10%) (as the dependent variable) was plotted against corresponding ACU (as the independent variable) from each orchard block and subjected to the regression analyses. The regression analyses were conducted as the following function: (1) linear; (2) exponential; (3) natural logarithmic; (4) power law; and (5) polynomial. Table 3-1 shows the detailed statistical anlyses of each regression function. A power law function was found to be the best fit for the regression. The equation was given as: $DIS(10\%) = 62.57016*ACU^{0.07475}$ ($R^2 = 0.75779$***). Table 3-2 shows the pre-harvest and harvest information and predicted DIS(10%) of d'Anjou pears in the 1999 season. The actual DIS(10%) for each orchard block deviated from the predicted DIS(10%) between 2 to 11 days (Table 3-2). Based on the predictive equation, the actual calendar date when 10 percent of d'Anjou pears develop superficial scald disorder can be predicted at the first date of commercial harvest.

Table 3-1.

Regression analyses between DIS(10%) and ACU of d'Anjou pears grown in Hood River, Oregon in 1996, 1997, 1998, and 1999.

	Type of Regression				
	A+(B*X)	A*EXP(B*X)	A+B*LOG(X)	$A*X^B$	$A+B*X+C*X^2$
A REG COEFF	77.79067	77.66368	60.19984	62.57016	73.02160
B REG COEFF	0.07477	0.00088	6.16762	0.07475	0.18354
C REG COEFF	--	--	--	--	-0.00034
A STD ERROR	1.31920	1.27213	2.50108	1.82757	1.38770
B STD ERROR	0.00937	0.00012	0.57943	0.00677	0.02247
C STD ERROR	--	--	--	--	0.00007
A T-STAT	58.96814	265.71490	24.06952	141.61350	52.62069
B T-STAT	7.99264	7.56441	10.64425	11.04615	8.16857
C T-STAT	--	--	--	--	-5.11775
F TEST	63.88232	57.22030	113.30010	122.01740	65.66866
STD ERROR	5.57922	0.06927	4.58557	0.05355	4.34878
CORR COEFF	0.78799	0.77116	0.86251	0.87051	0.86342
R-SQUARED	0.62093	0.59468	0.74393	0.75779	0.74549

The dependent variable (Y) is DIS(10%) and the independent variable (X) is ACU.

Table 3-2.

Locations, elevations, full bloom date (FBD), commercial harvest date (CHD), days from full bloom (DFFB), accumulated cold units (ACU), and predicted days in storage at -1°C when 10 percent of fruits are affected with superficial scald disorder [PDIS(10%)] of d'Anjou trees and fruits grown in Hood River Valley in 1999.

Location	Elevation	FBD	CHD	DFFB	ACU	PDIS (10%)	*PSD	*ADIS
Exp. Stn.	158 m	19-Apr	17-Sep	15	110	89	15-Dec-1999	87
Henderson	183 m	21-Apr	18-Sep	150	135	90	17-Dec-1999	91
Rodacamar	195 m	22-Apr	20-Sep	151	238	94	23-Dec-1999	95
Merz	198 m	20-Apr	16-Sep	149	94	88	13-Dec-1999	80
Oates	244 m	22-Apr	18-Sep	149	175	92	19-Dec-1999	95
Sheppard	247 m	22-Apr	18-Sep	149	168	91	18-Dec-1999	98
Hukari	305 m	24-Apr	23-Sep	152	132	90	22-Dec-1999	93
Annala	311 m	24-Apr	23-Sep	152	134	90	22-Dec-1999	93
Dee	351 m	27-Apr	24-Sep	150	257	94	27-Dec-1999	97
Duke	354 m	25-Apr	23-Sep	151	190	92	24-Dec-1999	95
Fox	384 m	01-May	26-Sep	148	278	95	30-Dec-1999	92
Tamura	475 m	02-May	28-Sep	149	326	96	02-Jan-2000	98
Rivers	573 m	06-May	02-Oct	149	388	97	07-Jan-2000	94
Euwer	671 m	12-May	11-Oct	152	367	97	16-Jan-2000	98

ACU: The accumulated hours when the temperature is equal to or below 10°C in each orchard, calculated from 42 days prior to the commercial harvest date.

PSD: Predicted Storage Date of d'Anjou pears stored in air at -1°C when 10 percent of fruit is affected with scald symptom upon ripening at 20°C for 7 days.

ADIS: Actual Days in Storage when 10% d'Anjou pears are affected with scald symptom upon ripening at 20°C for 7 days.

Study the efficacy of using starch index (SI) as a supplemental maturity index of'Anjou pears.

In 1999, flesh firmness (FF) of d'Anjou pears grown at the lower elevation (520 ft) gradually decreased from 18.1 lb starting 4 weeks (8/25/1999) prior to commercial harvest date, to 14.5 lb at the first date of commercial harvest (9/15/1999) (Figure 4-1). Thereafter, FF did not decrease substantially for 2 weeks (9/28/1999) after the commercial harvest date and maintained at 14.6 lb in average. However, the starch index (SI) at the center cross-section of d'Anjou fruit increased linearly from 0.73 starting 4 weeks prior to the commercial harvest date to 2.70 at the first date of commercial harvest, and then to 4.10 2 weeks after the commercial harvest date (Figure 4-1).

Starch index (SI) is contributed primarily by amylose, which is stained by iodine solution a deep blue color. Amylopectin is stained by iodine solution a light pink color, which has little effect on SI reading. Amylose (Am) in d'Anjou fruit decreased consistently during 6 weeks of maturation period (Figure 4-2). Total starch (TS) also decreased gradually from the pre-mature to optimum-mature stage and then declined at a faster rate level during the post-mature stage (Figure 4-2). Amylopectin (Ap), on the other hand increased consistently from the pre-mature to optimum-mature stage and then maintained a steady level during the post-mature stage (Figure 4-2). The results indicated that the decrease in Am content in the pulp and core tissues of d'Anjou pears during fruit maturation was responsible for the increase in SI score.

The correlation analyses revealed that flesh firmness (FF) was not correlated with starch index (SI) during 6 weeks of the maturation period (Table 4-1). SI was correlated negatively with total starch (TS) and highly negatively correlated with amylose (Am), but was not correlated with amylopectin (Ap) during 6 weeks of the maturation period (Table 4-1). It was concluded that starch index (SI) and amylose (Am) could be used as a supplemental maturity index for the determination of harvest maturity of d'Anjou pears, especially when FF did not decrease consistently during the crucial period of commercial harvest.

Figure 4-1. Changes in flesh firmness (FF) and starch index (SI) of d'Anjou pears grown in the lower elevation of the Hood River Valley during 6 weeks of fruit maturation period in 1999.

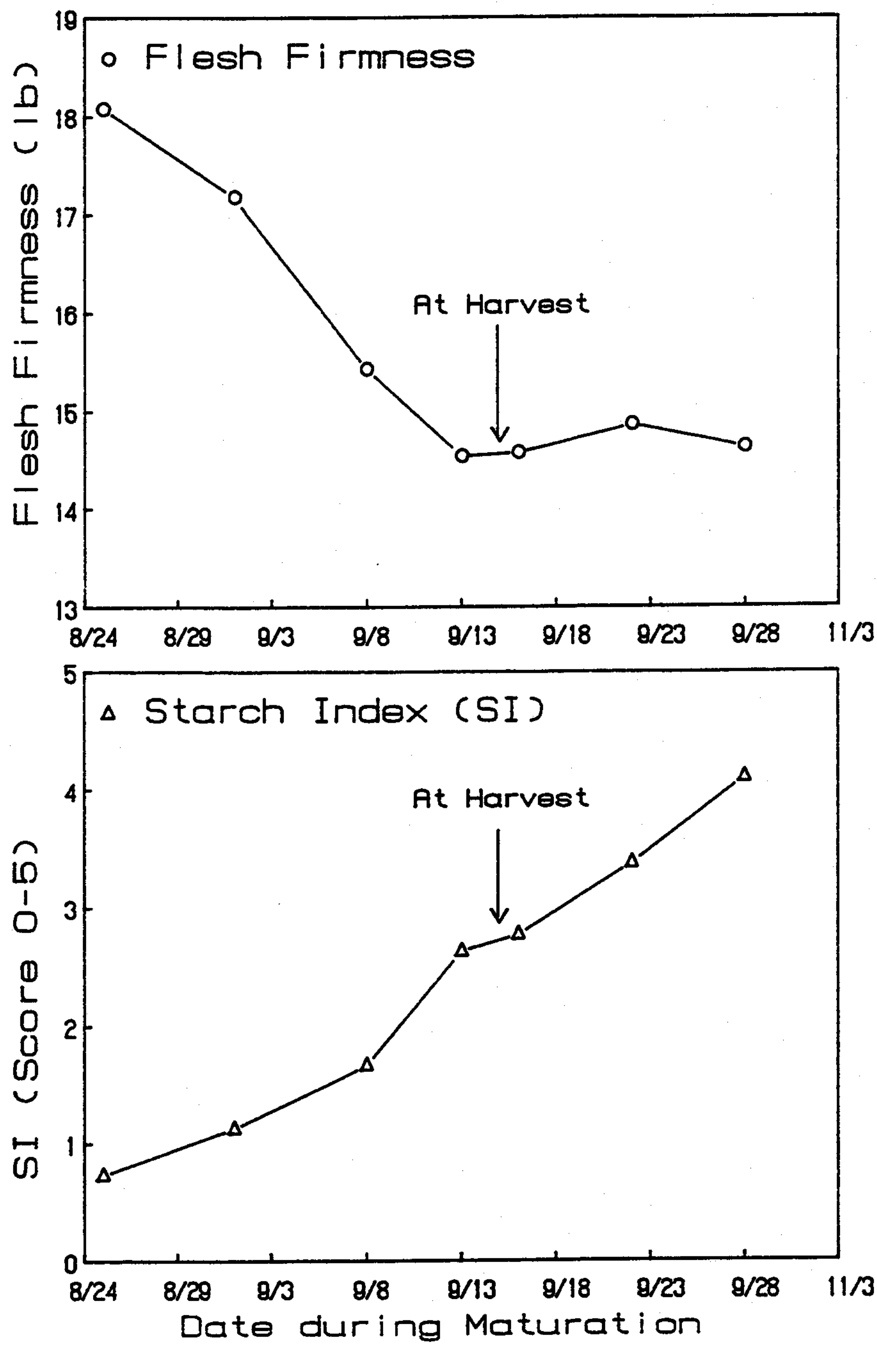


Figure 4-2. Changes in starch content (ST), amylose (AM), and amylopection (AP) of d'Anjou pears grown in the lower elevation of the Hood River Valley during 6 weeks of the fruit maturation period in 1999.

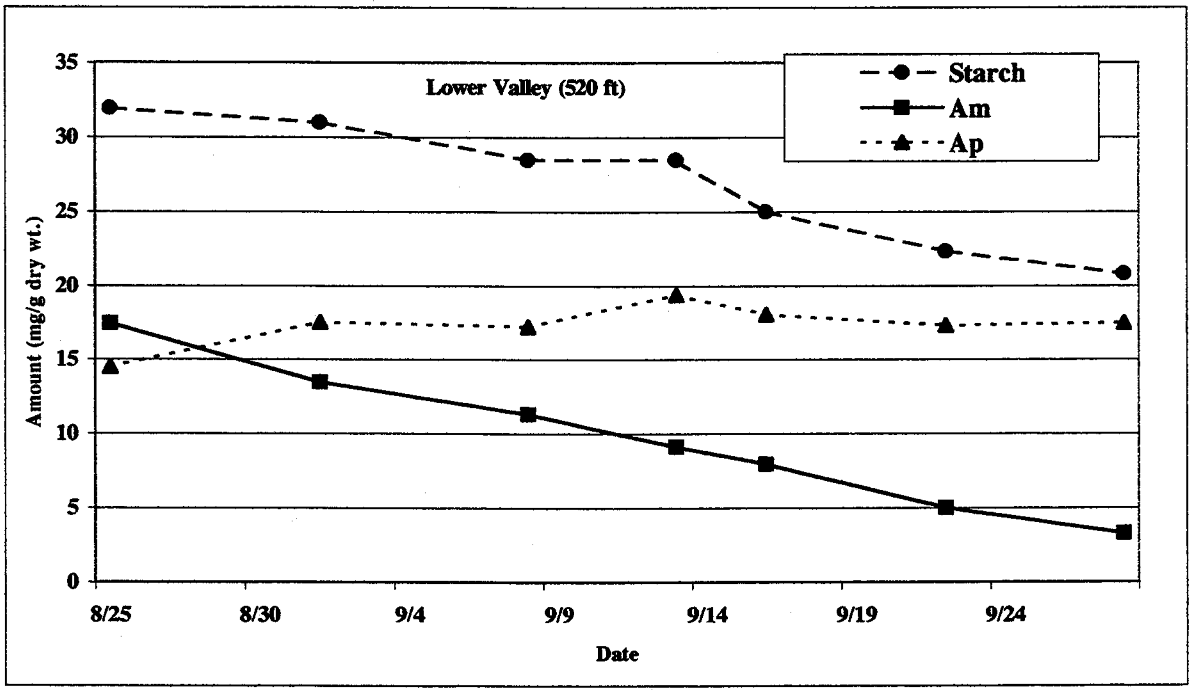


Table 4-1.

Correlations between flesh firmness (FF) and starch index (SI), starch content (ST), amylose (AM), and amylopectin (AP) of d'Anjou pears during 6 weeks of fruit maturation period in 1999.

Variables	Correlation coefficient	Significance
FF/SI	-0.7572	ns
SI/TS	-0.9608	***
SI/Am	-0.9447	****
SI/Ap	+0.5187	ns

ns = not significant
*** = significant at the 0.01% level
**** = significant at the 0.001% level

Pruning, Training, Rootstocks, Irrigation Systems, and their Interactions for Sweet Cherries

T.J. Facteau and L.E. Long

Objectives

Compare different training systems-Promalin-treated, summer pruning, multiple leader, and dormant pruned trees-as orchard management systems for sweet cherries grown on Gisela 1, 5, 6, 7, 8, 11, 12; Gi 196/4; and Mazzard rootstocks.

Compare the Spanish Bush, multiple leader, dormant pruned, and angle planted (Marchand system) growing systems on Gisela 6 and Mazzard rootstocks.

Compare Weiroot selections 53, 72, 158, 13, and 154; Tabel/Edabriz (Edabriz); Maxma Delbard 14 (Maxma 14); St. Lucia 64 (SL64); INRA Pontaleb INFEL 2845 (2845); Gisela 4; and Mazaard with Bing, Lapins, Sweetheart, and Royal Anne as the scion cultivars trained to the Spanish Bush, Vogel central leader, and open vase systems (mostly Bing and Royal Anne).

Procedures

A planting of the different rootstocks with Bing and Royal Anne as scions was established in The Dalles in spring, 1994. Trees were treated either with Promalin (7,500 ppm, spring, 1994, positioned to the horizontal and summer pruned) or as normal trees using an open vase system. Trees will be measured for growth and production annually.

In spring, 1994, Bing on Gisela 6 or Mazzard were planted in The Dalles and trained to either Spanish Bush, Marchand, or open vase training systems. There are nine blocks of each rootstock for each system. Trees will be measured for growth and fruiting annually. The Spanish Bush and Marchand systems are being deficit watered starting during the third growing season (1996).

Two separate trials were established in The Dalles to compare Weiroot 13, 158, 53, 72, and 154; Gisela 4 (planted 1997); Edabriz; Maxma 14; SL64; 2845 (planted 1998); and Mazzard with Bing and Royal Anne as scion cultivars. Trees are being trained as open vase, Spanish Bush, and central leader (Vogel) systems.

A planting was established in The Dalles (Hendricks plot) in 1994 to observe responses to several rootstocks trained to a central leader (with Promalin, 7,500 ppm applied in latex paint to 1-year wood, spring 1995), open vase, Spanish Bush, or Marchand systems on both Bing and Royal Anne cultivars. The experimental design was a split plot with training system plus deficit as the main plot and rootstocks as the sub-plot. Major scaffold limbs on central leader trees initially were spread with clothespins when growth was 5 to 8 cm. Major scaffold limbs on central leader trees were held at a nearly horizontal position with hop clips, wire, and wooden spreaders, in that order. Spreaders were applied after harvest in 1996 and 1997.

There are two sections, A and B, each with numerous smaller trials. The description of the two are as follows:

Section A.

Part 1. Royal Anne on Gisela 1, 6, and 11 trained only to a central leader.

Part 2. Bing on Mazzard comparing central leader trees to open vase where the main scaffolds were selected either in 1994 (early) or 1996 (late). Differential pruning times were started in 1998.

Part 3. Bing on Gisela's 1, 6, 7, 8, 11, and Mazzard trained only as a central leader. Differential pruning timings were started in 1997. During winter, 1998-99, root samples were analyzed for starch and soluble carbohydrate levels.

Part 4. Royal Anne on Gisela's 6, 1, 7, 11, and Mazzard planted in 1995 and trained to a central leader (Vogel, no Promalin).

Part 5. Bing on Gisela 5 trained as an open vase but with Promalin applied to the main leaders during the second growing season. All trees were summer pruned in 1996 and dormant pruned each year. Starting in 1997, rows (blocks in the experimental system) were summer pruned before harvest, after harvest, and on 1 August. Trees are irrigated by the grower cooperator.

Section B.

Part 1. Bing on Gisela 5, 6 (two nurseries), 7, 12, Gi 196/4, and Mazzard trained to either an open vase or central leader with a water deficit schedule imposed after harvest beginning in 1996. The irrigation treatments are full (1 inch per every 7 days) and deficit (1 inch per every 7 days before harvest, 1/3 inch every 7 days after harvest to 1 August, no water until 1 September, then return to a full water schedule. Only central leader trees were summer pruned in 1996. Open vase trees were dormant pruned. All dormant pruned in 1997 and 1998. All trees were summer pruned in 1999.

Part 2. Bing on Mazzard and Gisela 6 trained to a Spanish Bush, Marchand, or an open vase. The Spanish Bush and the Marchand systems receive the irrigation schedule for the reduced water scheme, whereas the open vase trees have the full irrigation schedule. The planting distance for part A is 14 ft between rows and 12 ft within a row. For part B, distances are 15 ft between rows and 12 ft within the row. Trees started to produce in 1996, and yields and fruit size are being collected along with trunk diameters yearly. Starting in 1999, stem water potentials were taken weekly the day prior to irrigation on Mazzard and Gisela 6 rootstocks for the cental leader and open vase training systems using a UC-Davis pressure bomb and techniques used by Dr. K. Shackel (mid-day stem water potential, bagged leaves).

A planting was established in spring, 1997 in The Dalles, where several rootstocks from France were trained to open vase, Spanish Bush, or central leader (Vogel) systems. The design for this trial is three Bing and three Royal Anne trees planted with each rootstock, and this sequence is repeated several times within the training systems. Because of expected differences in ultimate tree size, the planting distances for the rootstocks vary for both rootstock and training system. All rootstocks are replicated in each training system, but the design is unbalanced. Training systems are in solid rows. Another trials, started in spring, 1998, using Gisela 4 and several Weiroot rootstocks, has the same design.

A planting was established in Hood River in 1996 to compare four training systems (open vase, Spanish Bush, central leader, and Vogel [Promalin applied to all terminal growth, spring, 1997] using Lapins on Gisela 11.

A planting was established in Hood River to study the interrelationships of summer pruning and deficit irrigation. Because of the chance of lateral water movement in the Hendericks plot in The Dalles, buffer rows and trees were used in Hood River. Trees in the buffer rows are being trickle irrigated and were used for several treatments in 1999 (Table 17).

Data are being collected from the NC140 Bing rootstock planting (1998).

Significant Findings

Gisela rootstocks continued to outyield Mazzard, but differences are becoming smaller. Central leader trees continue to outyield open vase trees, but the difference is becoming smaller. Water deficit has reduced tree size (TCSA) but not influenced fruit size or yield, as a main effect. Differences in stem water potentials were seen resulting from the irrigation treatments imposed. Yield and TCSA's of several French and Weiroot clonal rootstocks are starting to show differences. Apogee reduced terminal growth.

Results

Hendricks plots, The Dalles, planted 1994

Section A, Part 1: Significant differences were found in TCSA between the three rootstocks but not for yield (Table 1). Tree losses continue to occur with Gisela 1. The Royal Anne continues to have approximately 50 percent of the yields of Bing on Gisela 6 and 11, but have similar yields on Gisela 1 (Tables 1 and 2).

Table 1. Yield, fruit size, and trunk cross sectional area for rootstock-training system trials, Section A, Part 1, Royal Anne, Hendricks (The Dalles), 1999.

Rootstock	Number of Trees	Yield kg/tree	TCSA cm^2
Gisela 6, 148/1	48	26.4	175.8 a
Gisela 11, 195/1	23	27.1	181.3 a
Gisela 1, 172/9	11	24.0	49.2 b
LSD, P=0.05	NS	NS	23.5

Section A, Part 2: Data are presented in Table 2. Central leader trained trees had significantly greater yields and larger TCSA as compared to open vase trained trees. Fruit weight was large but tended to be greater in both open vase systems. There should be no differences between the early and late treatments, because scaffold selection has not ceased. No differences were seen between the prune-timing treatments imposed starting in 1998 and continued in 1999. However, all trees were summer pruned in 1999 so that part of the trial may be discontinued.

Table 2. Yield, fruit size, and trunk cross-sectional areas for rootstock-training system trial, Section A, Part 2, Bing, Hendricks (The Dalles), 1999.

Training System	Number of Trees	Yield Kg/tree	Fruit Weight g	TCSA cm^2
Central/leader	48	9.8 a	9.6 b	187.3 a
Open vase, early	25	4.7 b	10.0 b	156.9 b
Open vase, late	26	3.7 b	10.7 b	170.3 b
LSD, P=0.05	NS	3.1	0.7	14.5
Prune timing, Started 1998				
Dormant	29	5.7	10.2	168.0
1 May	12	5.3	9.9	179.3
1 June	16	7.8	9.9	188.0
1 July	17	6.4	10.0	172.5
1 Aug.	13	8.3	10.1	188.1
Bloom, 1999	12	9.3	9.3	160.0
LSD, P=0.05		NS	NS	NS

Section A, Part 3: Data are presented in Table 3. Except for Gisela 1, all rootstocks had significantly greater yields than Mazzard. The Gisela 1 trees basically have stopped growing and have been severely pruned to try and reinvigorate them. Fruit weight was greatest with Mazzard rootstock and least with Gisela 1, probably reflecting tree vigor and cropping levels. Tree size, based on TCSA, shows the same pattern as in past years and should not change in the future. The intermeans for the different pruning times are shown, but no statistical analysis can be done because of the layout of the trial. There appears to be a large difference in Mazzard based on prune timing; however, only four trees are in each treatment. No other rootstocks show this pattern. Table 4 presents data relating to concentrations of amylose, amylopection, and reducing sugars in root tissues in the rootstocks (except for Gisela 1) and trees pruned at different timings in part 3. Roots less than 3 to 4 mm diameter) were collected during January, 1999. No differences were found between prune timings; but treatments started in 1998, and not enough time might have elapsed. Significant differences were seen between rootstocks, but what this means is not clear. The expectation was that vigorous rootstocks might have higher storage components, e.g., starch. While Mazzard did have higher levels of starch (sum of amylose and amylopectin was significantly greater in Mazzard, and there were no differences between the other rootstocks analyzed), it had lower levels of soluble sugars. No starch hydrolysis should have started, as samples were taken when trees were still dormant.

Table 3. Main effects and interactions for yield, fruit size, and trunk cross-sectional areas for rootstock-training system trial, Section A, Part 3, Bing. Hendricks (The Dalles), 1999.					
Rootstock	Prune Timing	Number of Trees	Yield kg/tree	Fruit weight g	TCSA cm^2
Gisela 6, 148/1		20	50.0	8.6	173.1
Gisela 8, 148/9		20	43.1	8.9	149.3
Mazzard		19	11.8	9.8	221.9
Gisela 11		20	49.7	8.5	166.1
Gisela 1		16	19.9	7.3	62.3
Gisela 7		19	46.1	8.2	129.0
LSD, P=0.05			7.7	0.6	14.0
	1 Jun	23	32.3	8.5	147.7
	1 Jul	23	43.6	8.7	157.6
	1 Aug	24	41.5	8.5	152.3
	Dormant, late winter	22	37.4	8.5	163.0
Gisela 6, 148/1	1 Jun	4	42.0	8.2	138.0
	1 Jul	4	52.1	9.1	163.7
	1 Aug	4	59.0	8.2	189.7
	Dormant, late winter	4	45.5	9.0	185.9
Gisela 8, 148/9	1 Jun	4	46.8	8.9	157.3
	1 Jul	4	55.1	9.1	145.2
	1 Aug	4	42.6	9.3	148.0
	Dormant, late winter	4	39.2	8.4	164.3
Mazzard	1 Jun	4	7.3	9.7	216.7
	1 Jul	4	8.8	10.1	215.5
	1 Aug	4	14.2	10.2	241.6
	Dormant, late winter	4	25.0	9.2	219.1
Gisela 11, 195/1	1 Jun	4	43.9	8.2	156.0
	1 Jul	4	60.4	8.4	194.5
	1 Aug	4	60.4	8.4	142.1
	Dormant, late winter	4	39.8	9.3	181.9
Gisela 1, 172/9	1 Jun	3	16.5	7.8	65.1
	1 Jul	3	29.7	6.6	66.6
	1 Aug	4	17.6	6.2	61.9
	Dormant, late winter	3	18.9	7.9	56.8
	1 Jun	3	36.6	8.5	114.5
	1 Jul	4	52.3	8.6	137.4
	1 Aug	4	55.4	8.2	130.2
	Dormant, late winter	4	48.0	7.1	143.4

Table 4. Effect of rootstock and prune timing on concentration of amylose, amylopectin, and soluble sugars in root tissue, mid-winter 1998-99, Section A, Part 3, Hendricks (The Dalles).					
Rootstocks	Number of Trees	Amylose, % dw	Amylopectin, % dw	Total statch, % dw	Sugar, % dw
Gisela 6, 148/1	12	3.92±0.15[z]	0.82±0.07	4.74±0.21	7.92±0.30
Gisela 8, 148/9	11	3.76±0.26	0.88±0.13	4.64±0.32	7.58±0.37
Mazzard	11	4.53±0.33	1.37±0.14	5.90±0.36	5.89±0.35
Gisela 11	8	3.95±0.33	0.97±0.09	4.92±0.31	6.05±0.38
Gisela 7	12	3.92±0.18	1.05±0.08	4.97±0.21	7.85±0.37
Prune timing, 1998-99					
1 July	16	3.89±0.21	0.92±0.09	4.81±0.22	7.33±0.35
1 Aug	20	4.35±0.20	1.13±0.09	5.48±0.25	6.55±0.29
Dormant	18	3.76±0.16	0.97±0.09	4.73±0.19	7.63±0.34
[z]± SE					

Section A, Part 4: Data are presented in Table 5. The differences between the rootstocks are similar to those seen in all of the trials to date with respect to yield and TCSA. Mazzard had the lowest yield and was the largest tree (based on TCSA).

Table 5. Yield, fruit size, and trunk cross-sectional area for rootstock-training system trial, Section A, Part 4, Royal Anne, Hendricks (The Dalles), 1999.			
Rootstock	Number of trees	Yield, kg/tree	TCSA, cm^2
Gisela 6, 148/1	13	11.8	124.1
Mazzard	19	0.3	131.3
Gisela 11, 195/1	7	14.2	113.0
Gisela 1, 172/9	16	15.6	34.8
Gisela 7, 148/8	23	12.4	79.0
LSD, P=0.05		4.6	14.3

Section A, Part 6: The purpose of this trial was to try to grow open vase trees by using Promalin and no heading cuts. The Promalin, applied in 1997, caused branching as expected. Unfortunately, because the terminal growth was so great in 1996, the branches formed too high off the ground to produce a desirable tree. All trees were reheaded in spring, 1999. In spite of this severe practice, Promalin treated trees had the highest yields between the treatments for both cultivars (Table 6). Removal of the top side buds, performed once in 1997, produced trees with the lowest yields even though they were pruned in a similar manner as the other treatments. No reason can be given for this response.

Table 6. Effect of rootstock and training system on yield and trunk cross-sectional areas of Bing and Rainier, Section A, Part 6, Hendricks (The Dalles), 1999.

Rootstock	Cultivar	Training System[z]	Number of Trees	Yield kg/tree	TCSA Cm^2
Gisela 5	Bing		46	3.1±0.6[y]	35.6±1.0
Gisela 7	Rainier		8	11.5±1.9	37.2±1.8
Gisela 5	Bing	Open vase	8	2.7±0.8	45.3±4.6
		Open vase, Promalin	23	4.0±0.8	41.2±1.4
		RTSB	7	0.7±0.5	46.0±3.3
Gisela 7	Rainier	Open vase	2	10.4±4.7	51.1±0.20
		Open vase, Promalin	5	13.6±1.7	41.7±2.6
		RTSB	1	2.8	42.5

[z]Promalin - 7,500 ppm, spring, 1997, in white interior latex paint
RTSB: remove top side buds from all leaders, spring, 1997
All trees headed below Promalin treated area, spring, 1999
[y] ± Standard error

Section B, Part 1: Data are presented in Tables 7 and 8. There were significant interactions for training system plus deficit treatments and rootstocks for yield and TCSA but only main effect differences between rootstocks for fruit weight (Table 7). The two LSD values are for comparisons within main effects where no interaction was found; and when interactions were found, to compare any two treatment means. The analysis of variance table for this is shown in Table 8. As general statements, Mazzard continued to have the lowest yields, but Mazzard trees trained to the central leader were significantly greater than open vase-trained trees. At the spacing in the plot, 8 tons/acre is equivalent to 30 kg/tree. Gisela 5 trained to central leader and deficit irrigated had the smallest TCSA. Mazzard trained to the open vase with no deficit had the largest TCSA. Fruit weight was large; but, since this represents a sub-sample from the trees, it does not give a good distribution of row sizes. As main effects, there were no differences between the two training systems and yield and fruit weight. There have been in previous years; therefore, open vase trees are catching up, as might be expected, as the trees mature and fill their allotted space. As main effects, there were no differences between deficit and irrigated trees for fruit weight and yield, but differences were found in TCSA.

Table 7. Main effects and interactions for yield, fruit size, and trunk cross-sectional area for deficit irrigation-rootstock-training system trial, Section B, Part 1, Hendricks (The Dalles), 1999.					
Training System + Deficit	Rootstock	Number of Trees	Yield kg/tree	Fruit wt g	TCSA cm^2
Central leader deficit		36	36.6	9.7	160.0
Open vase deficit		40	40.6	9.7	165.1
Open vase no deficit		39	37.7	10.0	178.7
Central leader no deficit		38	44.2	9.6	186.6
	Gisela 12	19	46.4	9.9	184.8
	Gisela 5	20	44.7	8.9	118.1
	Gisela 6 Willow Drive	39	45.5	9.6	183.6
	Gisela 6 Newark	19	47.7	10.1	176.2
	196-4	17	34.8	10.0	168.6
	Gisela 7	19	43.9	9.4	133.4
	Mazzard	20	10.4	10.2	232.1
	LSD P=0.05			0.3	
Central leader deficit	Gisela 12	5	39.7	9.7	173.5
	Gisela 5	5	24.2	9.4	80.2
	Gisela 6 Willow Drive	9	41.3	10.1	167.5
	Gisela 6 Newark	5	47.4	9.6	170.7
	196-4	4	36.1	10.3	181.8
	Gisela 7	4	39.4	9.8	123.5
	Mazzard	4	22.1	10.0	227.1
Open vase deficit	Gisela 12	5	45.5	10.0	169.3
	Gisela 5	5	57.1	8.1	138.1
	Gisela 6 Willow Drive	10	45.2	10.0	179.1
	Gisela 6 Newark	5	45.0	10.3	160.9
	196-4	5	32.7	9.5	155.7
	Gisela 7	5	50.0	9.1	121.3
	Mazzard	5	4.3	11.3	217.2
Open vase no deficit	Gisela 12	5	53.1	10.2	203.1
	Gisela 5	5	56.3	9.1	147.4
	Gisela 6 Willow Drive	10	42.3	9.8	185.3
	Gisela 6 Newark	4	44.9	11.0	192.8
	196-4	4	28.9	10.2	159.0
	Gisela 7	5	38.4	9.6	132.9
	Mazzard	6	2.0	10.8	215.2

Table 7. (continued) Main effects and interactions for yield, fruit size, and trunk cross-sectional area for deficit irrigation-rootstock-training system trial, Section B, Part 1, Hendricks (The Dalles), 1999.

Training System + Deficit	Rootstock	Number of Tree	Yield kg/tree	Fruit wt g	TCSA cm^2
Central leader no deficit	Gisela 12	4	47.8	9.6	195.6
	Gisela 5	5	41.2	9.5	106.5
	Gisela 6 Willow Drive	10	52.7	9.9	200.9
	Gisela 6 Newark	5	53.5	9.9	183.8
	196-4	4	42.1	10.0	180.9
	Gisela 7	5	47.0	9.1	153.8
	Mazzard	5	17.3	9.1	271.3
LSD, P=0.05 for rootstock comparison within training system			6.9		15.4
LSD P+ 0.05 for comparison of training system + deficit for any rootstock			7.6		15.0

Table 8. AOV summary for yield, fruit size, and trunk cross-sectional area for deficit irrigation-rootstock-training system trial, Section B, Part 1, Hendricks (The Dalles), 1999.

	Training system + Deficit (main plot)			
Variable	DF	MS	F	PR>F
Yield	3	269.8	0.8	NS
Fruit wt	3	1.3	1.09	NS
TCSA	3	4356.3	10.0	0.0014
Rootstock (sub plot)				
Yield	6	3192.6	24.7	0.0001
Fruit wt	6	3.9	4.5	0.0004
TCSA	6	27967.5	43.3	0.0001
Training system + Deficit x Rootstock				
Yield	18	334.0	2.6	0.0013
Fruit wt	18	1.3	1.6	NS
TCSA	18	1512.5	2.3	0.0037

By mid-August all trees in this section, irrigated or not, were showing signs of water stress (dull leaf color, some yellowing, and leaf drop). Section A is being watered by the grower cooperator and looked normal. Soil moisture levels were measured using a Campbell Scientific HydroSense Soil Water Content Measurement System with 20 cm probes. Data are presented as percent volumetric water content. The gap in the data was because the module was being repaired. Figure 1 shows the data and does show differences in soil moisture levels as a result of the irrigation treatments.

Stem water potentials were measured on Mazzard and Gisela 5 rootstock trees (both training systems) in Section B and on Mazzard trees (both training systems) in Section A according to methods used by K. Schackel at UC Davis. Data were taken from three single tree replicates in each group. Those results are shown in Figures 2 and 3. There were no apparent differences between the two rootstocks (data not shown), so values averaged for both rootstocks and training systems are shown in Figure 2. The deficit trees had more negative stem water potentials, so they were being stressed. Figures 3A and B give data for Mazzard for central leader and open vase systems for both sections. Section A is being irrigated by the grower cooperator and shows less negative stem water potential values, suggesting lower (or no) stress. The data suggest that there were no differences in open vase Mazzard trees, but that there were differences in the central leader trained trees. Whether this is true or was a result of the number of replicates measured cannot be determined from these data.

Section B, Part 2: Main effects for yield, fruit size, and TCSA for Section B, Part 2 are shown in Table 9, with the analysis of variance table shown in Table 10. There was no interaction between rootstock and training system for fruit weight, but there were significant main effects. There were significant interactions for yield and TCSA, but they are because of differences in magnitudes rather than opposite responses (Table 9).

Table 9. Main effects and interactions for yield, fruit size, and trunk cross-sectional area for rootstock-training system trial, Section B, Part 2, Hendricks (The Dalles), 1999.					
Training System + Deficit	Rootstock	Number of trees	Yield kg/tree	Fruit wt g	TCSA cm^2
Marchand		33	21.5	10.2	199.5
Spanish Bush		33	29.0	9.3	211.4
Open vase		36	23.2	9.5	194.1
	LSD, P=0.05			0.5	NS
	Gisela 6	52	43.2	9.1	172.4
	Mazzard	54	6.7	10.4	229.9
	LSD, P=0.05			0.3	
Marchand	Gisela 6	16	35.6	9.6	150.8
	Mazzard	18	8.9	10.8	242.8
Spanish Bush	Gisela 6	18	49.9	8.6	197.5
	Mazzard	18	8.1	10.1	225.2
Open vase	Gisela 6	18	43.3	9.1	166.6
	Mazzard	18	3.1	10.3	221.7
LSD, P=0.05 for rootstock comparison within training system			10.2		39.8
LSD, P=0.05 for training system comparison within and across rootstock			10.8		44.9

Table 10. AOV summary for yield, fruit size, and trunk cross-sectinal area for rootstock training system trial, Section B, Part 2, Hendricks (The Dalles), 1999.				
	Training system (main plot)			
Variable	DF	MS	F	PR>F
Yield	2	513.5	3.8	0.0437
Fruit wt	2	5.7	8.0	0.0038
TCSA	2	2848.4	1.1	NS
	Rootstock (sub-plot)			
Yield	1	34501.0	313.1	0.0001
Fruit wt	1	28.8	43.5	0.0001
TCSA	1	92679.1	58.0	0.0001
	Training system x Rootstock			
Yield	2	611.2	5.6	0.0056
Fruit wt	2	0.769	1.2	NS
TCSA	2	9930.1	6.2	0.0032

French rootstocks, The Dalles, planted 1997

Data from the third growing season are shown in Tables 11 and 12 for Bing and Royal Anne cultivars, respectively. For Bing, significant differences were found in TCSA, fruit weight, and yield for the different rootstocks and training systems. The proper statistical test for the interaction has not been conducted as yet, but data are shown. In general, higher yielding rootstocks had smaller fruit, but all fruit size was small. Edabriz had the smallest TCSA and fruit weight and the highest yield. SL 64 had the largest TCSA. Mazzard and P50 had the lowest yields. In 1999, *Pseudomonas*-like symptoms (trunk gumming) developed on many trees. Trees on the rootstock 2845 had the highest number of suspect trees, and that rootstock trained to a central leader had the largest number. Trees trained to a central leader had significantly higher yields as compared to the Spanish Bush or open vase systems. Trees trained to the central leader also had the highest number of trees with *Pseudomonas*-like symptoms (Table 11).

Results were similar for Royal Anne (Table 12). Yield was expressed as number of fruit per tree. Edabriz had the smallest TCSA and the most fruit. SL 64 had the largest

TCSA. Mazzard and P50 had the lowest number of fruit. Trees trained to the central leader had the highest number of fruit per tree.

Weiroot and Gisela 4 rootstocks, The Dalles, planted 1998

Data for the Weiroot-Gisela 4 planting started in 1998 are shown in Tables 13 and 14 for Bing and Royal Anne, respectively. The intermeans comparisions have not been completed, but the means are shown without analysis. Differences were found between rootstocks for initial TCSA and after 1 and 2 years' growth, and also for yield (expressed as number of fruit per tree). Differences between training systems were found after 1 and 2 years' growth and also for yield. Weiroot 72 was the smallest tree and had the most fruit. Similar patterns were found with Royal Anne.

Lapins on Gisela 11 trial, Hood River

Results are presented in Table 15. Trees trained to the central leader system had greater yields in the third growing season as compared to the open vase or Spanish Bush systems. Central leader Promalin-treated trees had the highest yields. Trees growing in rows covered with the Dewitt Sunbelt ground cover were larger (accepting $P > 0.10$) and had higher yields (Table 15). An attempt was made to examine fruit size as a function of harvest date. The trial was established with four blocks. One block was harvested on 7/7/99 and another on 7/20/99, and all fruit was row sized. The expectation was to see an increase in percentage of fruit in larger row sizes in the later harvest. The data show that time was not the important factor. Because of unexplained differences in yield, the early harvested block had larger fruit size as shown by the average fruit weight and the pattern of row size distribution (Table 16).

Table 15. Yield and trunk cross-sectional area for Lapins on Gisela 11 on four different training systems, with and without landscape cloth soil cover, 1999.			
Training system	Cover[z]	Yield, kg	TCSA, cm^2
Open vase		4.4	81.3
Central leader (Vogel)		14.8	85.7
Central leader (Promalin)[y]		23.1	87.2
Spanish Bush		6.6	88.2
LSD, P=0.05		3.7	NS
	Cover	12.2	90.2
	None	10.0	77.4
P value		NS	0.0681
Open vase	Cover	4.5	84.0
	None	4.2	76.0
Central leader (Vogel)	Cover	15.4	90.1
	None	14.3	78.8
Central leader (Promalin)	Cover	24.7	90.5
	None	19.4	79.1
Spanish Bush	Cover	7.5	94.1
	None	4.8	76.3
Interaction		NS	NS

[z]Dewitt Sunbelt
[y]Promalin applied 7,500 ppm, March, 1997

Table 16. Fruit size and yield of Lapins on Gisela 11 in relation to time of harvest and yield, 1999. Trees were planted in 1996.		
	Harvest date	
	Percent in row size	
Row size	7/7	7/20
13	0.6	1.6
12	2.7	10.5
11	23.9	39.0
10	58.2	44.3
>10	14.6	4.5
Yield, kg	6.7	13.8
Fruit weight, g	10.6	9.0

Apogee, horizontal training, pinching, and irrigation effects on tree growth, Hood River

Several treatments (see Table 17) were applied to trees in the buffer rows in the Lapins on the Mazzard irrigation-summer pruning block established at Hood River (1999). There were 10 single tree replicates per treatment. The purpose of those treatments was to examine various ways of controlling growth. Trees were measured for total extension growth and trunk cross-sectional areas. Results suggest that increasing rates of foliar-applied Apogee reduced growth, and that a single pinch (removal of the terminal after about 6 inches of growth) increased extension growth. There was a great deal of variation within the trees, hence a large LSD value. Apogee also was applied at the 250 ppm rate of five Kordia on Mazzard rootstock trees on 6/7/99 (6 to 8 inches growth) with five non-treated trees serving as controls. Ten terminals per tree were measured on 9/22/99. Average terminal growth was 57.3 and 85.2 cm for the Apogee-treated and controls, respectively, a statistically significant reduction.

Table 17. Effect of Apogee, limb angle, and irrigation system on terminal growth and trunk cross-sectional areas of Lapins on Mazzard rootstock on trees planted in 1999, 1999 data year.

Treatment[z]	Total extension growth cm	Trunk cross sectional area cm^2
Apogee, 500 ppm	184.9	4.4
Apogee, 250 ppm	234.7	6.4
Horizontal	255.9	4.7
Pinched one[w]	376.9	6.0
Control, trickle irrigated[x]	321.9	6.6
Control, micro irrigated[y]	257.4	4.9
LSD, P=0.05	120.8	2.5

[z]Apogee applied 6/8/99
[w]Pinched 6/7/99
[x]Trickle-2, 1 ghp/tree
[y]Micro-Toro, VI-PC series, 9.5 gph, brown, 14.8 ft wetted diameter

Sweet Cherry Cultivar Collection

T.J. Facteau and L.E. Long

Significant Findings

Most of the Canadian selections had good flavor and were large. The best were Sonata, Cristaline, and 13S-21-1, based on size, flavor, and firmness. Trees planted in 1996 started to bear fruit, and, in general, fruit characteristics were similar to those found with the grafted limbs. Three selections from Zaiger's Genetics had good size and fair firmness (23W29, 104EB90, and 90LA132). They were supposed to ripen 4 to 10 days before Bing, but they appeared to be mature about 21 days before Bing.

Objectives

Evaluate sweet cherry cultivars for the Mid-Columbia area with respect to fruit size, quality, incidence of disease, and susceptibility to rain cracking.

Procedures

As many cultivars as possible will be collected and grown in a site in The Dalles and at MCAREC in Hood River. Observations will be made on vigor, cropping, and fruit quality. Selections will be evaluated as to which ones to discontinue and which new selections to add.

Results

Data were collected from limbs grafted on mature Bing trees (Table 1) as well as from trees planted in 1996 (Table 2). Bing firmness values were not taken in 1999 but are usually approximately 7 N/cm with fruit weights around 8 to 10 g. The whole tree data shown in Table 2 are preliminary, in that samples were not taken over as large a range as with the limb data. Three of the four selections from Zaiger's Genetics (104EB90, 23W29, and 90LA132) had fair size and firmness and ripened about 2 to 3 weeks before Bing. They were larger than Chelan but softer.

Table 3 gives ratings for number of flowers and amount of open bloom for a single date (4/21/99) for the Canadian whole tree plot at site K. It also provides a general idea of tree shape in the open vase type of pruning system. The data are preliminary, because the trees are just beginning to bear fruit.

Table 1. Fruit weight and firmness of sweet cherry selections from limbs grafted onto mature Bing trees at the Kelsey site in The Dalles, OR, 1999. Commercial harvest for Bing was 7/6.

	6/23		6/29		7/2		7/6		7/20		7/30		8/5	
Selection	N/cm[z]	g	N/cm[z]	g	N/cm[z]	g	N/cm[z]	g	N/cm[z]	g	N/cm[z]	g	N/cm[z]	g
13s-8-33	4.3±0.33[y]	8.1												
13s-10-40			6.3±0.25	9.3	4.6±0.19	10.5								
13s-3-13			4.8±0.11	10.2	4.6±0.15	10.4	4.2±0.11	10.3						
Newstar			7.2±0.33	8.1	6.2±0.48	10.4								
Sylvia			4.8±0.15	8.7	4.6±0.17	8.4								
Sonata					6.3±0.32	8.1								
13s-18-15					4.1±0.28	10.0								
13s-21-7					4.7±0.32	8.6	4.5±0.08	8.5	5.8±0.40	8.9			5.7±0.23	9.4
13s-49-24					6.0±0.22	10.2			4.3±0.45	11.2			5.2±0.22	10.9
Cristalina					4.9±0.16	8.9	4.8±0.26	7.7	5.1±0.25	11.1			6.9±0.56	10.0
13s-21-1									11.3±0.49	7.9	8.7±0.70	9.3	6.9±0.30	9.1
13s-42-49									7.1±0.84	10.5	6.9±0.51	12.0	8.0±0.63	12.0
Symphony									5.4±0.08	10.3	4.0±0.31	10.0	7.1±0.04	11.8

[z]Measured with an Instron Model 1000, 5 kg weigh beam, range 20 kg, crosshead speed 20.
[y]±SE

Table 2. Fruit weight (g) and firmness (N/cm) of sweet cherry selections from trees planted in 1996 in The Dalles, OR, 1999. Commercial Bing harvest was 7/6 at site K.														
	6/17		6/21		6/23		6/28		7/23		7/30		8/5	
Selection[z]	N/cm[y]	g	N/cm[y]	g	N/cm[y]	g	N/cm[y]	g	N/cm[y]	g	N/cm[y]	g	N/cm[y]	g
Chelan	6.6±0.29[y]	6.4												
104EB90 H			5.4±0.51	9.1										
23W29 H			6.2±0.30	7.8										
6HB486 K			3.5±0.20	8.3										
90LA132 B			5.5±0.42	8.3			5.0±0.48	8.9						
13s-8-33 K					5.8±0.40	11.0								
11w-26-58 K									3.3±0.25	10.7				
13n-7-19 K									4.3±0.20	15.7				
13s-16-29 K									7.4±0.45	7.5				
13s-18-15 K									4.1±0.34	13.0				
13s-21-1 K									8.0±0.36	9.5			6.9±0.30	9.1
13s-21-7 K									6.2±1.01	9.3				
13s-24-21 K									4.1±0.43	9.7				
13s-42-49 K									7.4±0.42	11.9				
13s-49-24 K									5.1±0.12	11.7				
133-20-9 K									8.3±1.25	9.8				
Cristlina K									5.2±0.20	11.4				
Newstar K									4.1±0.32	14.3				
Sandra Rose K									3.3±0.31	12.2				
Sonata K									5.9±0.24	11.9				
Sylvia K									5.2±0.48	10.8			4.3±0.19	10.4
Symphony K									6.8±0.54	9.0			8.2±1.13	8.3
Lapins K											4.6±0.40	10.7		
Sweetheart K											6.6±0.38	10.2		
Sweetheart H											8.0±0.62	10.1		
Sweetheart/G6													8.7±0.51	8.2
Sweetheart/Mz													9.2±1.00	11.1

[z]B – Byers site; K – Kelsey site, The Dalles, OR; H – Hendricks site, The Dalles, OR; G6 – Giesla 6 rootstock; Mz – Mazzard rootstock

[y]±SE

Table 3. Ratings of number of flowers, amount of open bloom (scale 1 to 10, 10 most), and tree vigor and shape for Canadian selections at the Kelsey site, The Dalles, for trees planted in 1996. Data were taken 4/21/99.

Selection	Number of flowers	Amount of open bloom	Shape, vigor
4W-11-8	2.4	0	spreading
13S-17-40	1.8	1	
13S-18-15	1	0	
Sylvia	1	0	spreading
13S-10-40 Sandra Rose	0	0	upright
13N-6-59 Sonata	2.6	0	
3S-25-25 Symphony	1.4	3.4	upright
13S-21-7	1.4	2	upright
13S-21-1	6	0	spreading
13S-8-33	1	3	weak, little branching
13S-49-24	3.4	3.8	
13N-7-19	4	5.6	not much branching
2C-61-22 Cristalina	1.6	0	
13S-24-21	0.8	0.8	very upright
Newstar	2.4	0	
13S-42-49	1	0	
8S-3-13	2	1.8	much less vigorous
Bing		3.5	

Evaluation of Conventinal Rootstocks for Pear

E.A. Mielke, T.J. Facteau, and C.F. Seavert

Significant Findings

Old Home by Farmingdale rootstocks delayed the onset of bloom, but not full bloom, in 10-year-old Golden Russet Bosc pears as compared to trees with Bartlett seedling rootstocks. Golden Russet Bosc OHxF 18 and 40 rootstocks exhibited significantly more fruit than Bosc on trees with Bartlett seedling or OHxF 97 roots. This resulted in 30 percent more yield in 1999 (with larger fruit size) and 50 percent more yield over the 10-year life of the planting. With 10-year-old Comice, trees with BA29C quince roots had 4 times the number of fruit and 3 times the yield of trees with Bartlett seedling roots. Comice on OHxF 40 rootstock was over 2 times as productive as the control.

In a 9-year-old planting in Parkdale, Bosc trees with OhxF 18, 40, or 69 roots had 30 to 60 percent more fruit and yield than did the controls (OhxF 97 roots). Fruit size was smallest on the trees with OhxF 97 roots, with 40 to 70 percent lower cumulative yields on the control. Columbia Red d'Anjou trees with OhxF 69 and 87 roots were 50 percent more productive than trees with OhxF 40 roots. The 9-year cumulative yield on trees with OhxF 87 rootstocks was greater than the cumulative yield on trees with OhxF 69 rootstocks by 11 tons per acre. Columbia Red d'Anjou trees on OhxF 69 roots experienced the greatest tree mortality.

Objectives

Determine the optimum rootstocks and the appropriate management system for inducing dwarfing character, precocity, production, and fruit quality under varying soil and climatic conditions in the Pacific Northwest.

Continue to work with breeders around the world to select and identify rootstocks, which would be potentially valuable to the Pacific Northwest.

Import, propagate, and test rootstocks identified in Objectives 1 and 2 for test under local or regional trials.

Propagate common scion cultivars and potential dwarfing rootstocks as interstems for test under local or regional conditions.

Procedures

Maintain existing Bosc, Comice, and Columbia Red d'Anjou pear plantings with a variety of rootstocks. Evaluate each plot annually for growth, flowering, productivity, and winter survival. Evaluate fruit for production, size, quality, and storability. The following trials will be maintained:

a. 1990 Bosc
b. 1990 Comice
c. 1991 Bosc (Parkdale)
d. 1991 Columbia Red d'Anjou (Parkdale)

Results and Discussion

1990 Bosc

This is the 10th and final year of this trials. A comprehensive final report will be available later in the year. No significant differences in growth (as measured by TCSA) were observed (Table 1). Fruit numbers and yield were increased significantly on Bosc trees where OHxF 18 and 40 rootstocks were used, in comparison to trees with either Bartlett seedling or OHxF 97 rootstocks (Table 1). Fruit size was significantly lower where Bartlett seedling roots were utilized. Old Home by Farmingdale rootstocks delayed the onset of bloom, but not full bloom, in 10-year-old Bosc pears (data not shown).This is a continuation of results observed in previous years. The use of OHxF 40 rootstocks resulted in 30 percent more yield in 1999 (with larger fruit size) and approximately 50 percent more yield over the 10-year life of the plant (Table 2). The use of either OHxF 40 or OHxF 97 rootstocks significantly increased fruit size.

1990 Comice

This was the 10th and final year for this trial also. With 10-year-old Comice, trees with BA29C quince roots had 4 times the number of fruit and 3 times the yield of trees with Bartlett seedling roots (Table 3). Comice with OHxF 40 roots were over 2 times as productive as the control. Trees with Bartlett seedling roots produced the greatest fruit size in 1999 (Table 3); however, over the 10-year trial life, fruit size was significantly larger on trees with OHxF 40 roots and significantly smaller on trees with BA29C roots (Table 4). The cumulative yield efficiency was greatest on trees with BA29C roots.

1991 Bosc

In a 9-year-old planting in Parkdale, the differences that were observed in both tree survival and TCSA were not significant (Table 5). While there were no significant difference in TCSA between the rootstocks, Bosc on OHxF 18 rootstocks increased at a significantly slower rate in 1999. This possible is due to the fact that the combination has produced the greatest yield in 1999 and previous years, or it could indicate that a potential problem is starting to become apparent. Bosc trees with OHxF 18, 40, or 69 roots had 30 to 60 percent more fruit and yield than did the controls (OHxF 97 roots). Bosc on OHxF 18 roots had significantly more fruit than Bosc on any of the other rootstocks. Bosc on OHxF 97 roots yield significantly less fruit than Bosc on any of the OHxF rootstocks. This was due to both a reduction in fruit numbers and fruit size on trees with OHxF 97 roots.

1991 Columbia Red D'Anjou

Columbia Red d'Anjou trees on OHxF 69 roots experienced the greatest tree mortality (Table 6); however, some mortality existed with all of the rootstocks. No significant differences were observed in growth as measured by TCSA. However, Columbia Red d'Anjou with OHxF 87 roots exhibited the smallest percentage increase in growth. This may be due simply to the fact that the trees have produced heavily the past two seasons. It also may be the first indication that the trees are beginning to collapse with Red d'Anjou failure. Columbia Red d'Anjou trees with OHxF 69 and 87 roots were 40 percent more productive than trees with OHxF 40 roots (Table 6). The increase in yield on Columbia Red d'Anjou with OHxF 87 roots was accompanied by a significant reduction in fruit size (Table 6). Cumulative yield on trees with OHxF 87 roots was greater than on trees with OHxF 40 roots by 11 tons per acres.

Table 1. Effect of rootstock on the growth, yield, fruit weight, and yield efficiency of 10-year-old Golden Russet Bosc pears. Data are means for four individual trees.

			1999 Yield			
Rootstock	Trunk Cross-sectional area (cm^2)	Fruit Number	pounds/tree	tons/acre	Fruit Weight (g)	Yield Efficiency (kg/cm^2)
Bartlett	121.2 a	136.5 b	55.5 b	7.6 b	175.8 b	0.200 ab
OHxF 18	129.4 a	170.8 a	71.5 a	9.7 a	192.1 ab	0.252 a
OHxF 40	132.3 a	172.5 a	74.5 a	10.2 a	195.3 a	0.253 a
OHxF 97	139.7 a	100.7 b	45.7 b	6.2 b	206.4 a	0.149 b

Means within a column followed by the same letter are not significantly different.

Table 2. Effect of rootstock on the cumulative yield, fruit weight, and yield efficiency of 10-year-old Golden Russet Bosc pears. Data are means for four individual trees.

Rootstock	Cumulative fruit number	Cumulative Yield (pounds/tree)	(tons/acre)	Average Fruit Weight (g)	Cumulative Yield Efficiency (kg/cm^2)
Bartlett	535.5 b	121.3 b	36.4 b	223.7 b	0.989 a
OH xF 18	631.8 a	151.4 ab	45.5 ab	240.1 b	1.175 a
OHxF 40	678.0 a	188.0 a	56.4 a	276.6 a	1.419 a
OHxF 97	545.7 b	160.2 ab	48.0 ab	296.3 a	1.150 a

Means within a column followed by the same letter are not significantly different.

Table 3. Effect of rootstock on the growth, yield, fruit weight, and yield efficiency of 10-year-old Comice pears. Data are means for four individual trees.

			1999 Yield			
Rootstock	Trunk Cross-sectional Area (cm^2)	Fruit Number	(pounds/tree)	(tons/acre)	Fruit Weight (g)	Yield Efficiency (kg/cm^2)
Bartlett	120.4 b	29.0 c	18.5 c	2.5 c	289.4 a	0.070 c
OHxF 40	161.8 a	81.0 b	44.7 b	6.1 b	247.7 b	0.123 b
OHxF 97	137.9 b	43.3 c	22.2 c	3.0 c	229.3 b	0.071 c
BA29C	129.5 b	120.7 a	63.1 a	8.6 a	244.9 b	0.227 a

Means within a column followed by the same letter are not significantly different.

Table 4. Effect of rootstock on the sumulative yield, fruit weight, and yield efficiency of 10-year-old Comice pears. Data are means for four individual trees.

		Cumulative Yield			
Rootstock	Cumulative fruit number	(pounds/tree)	(tons/acre)	Average Fruit Weight (g)	Cumulative Yield Efficiency (kg/cm^2)
Bartlett	130.0 c	42.1 c	6.4 c	323.7 b	0.349 c
OHxF 40	231.3 b	83.4 b	12.6 b	352.8 a	0.504 b
OHxF 97	145.3 c	47.0 c	7.1 c	323.6 b	0.335 c
BA29C	431.3 a	123.0 a	18.6 a	288.0 c	0.966 a

Means within a column followed by the same letter are not significantly different.

Table 5. Effect of rootstock on tree survival, growth, yield, fruit weight, and yield efficiency of 9-year-old Golden Russet Bosc pears growing in Parkdale, Oregon.

					1999 Yield	
Rootstock	Percent Alive	Trunk Cross-sectional Area (cm^2)	Increase in Trunk Cross-sectional Area (%)	Fruit Number	(pounds/tree)	(tons/acre)
OHxF 18	90 a	59.0 a	16.5 c	105.5 a	40.2 a	7.3 a
OHxF 40	100 a	53.3 a	19.3 ab	80.8 b	30.1 bc	5.5 bc
OHxF 69	80 a	57.9 a	20.2 ab	92.0 ab	33.3 ab	6.0 ab
OHxF 97	70 a	49.1 a	24.4 a	61.7 c	22.0 c	4.0 c
OHxF 18	174.6 a	0.293 a	376.5 a	165.4 a	30.1 a	199.6 ab
OHxF 40	171.8 a	0.279 a	309.5 b	139.7 b	25.4 b	201.4 a
OHxF 69	164.0 ab	0.259 a	340.4 ab	150.7 ab	27.4 ab	199.8 ab
OHxF 97	157.3 b	0.196 b	238.0 c	97.9 c	17.8 c	182.6 b

Table 6. Effect of rootstock on tree survival, growth, yield, fruit weight, and yield efficiency of 9-year-old Columbia Red d'Anjou pears growing in Parkdale, Oregon.

					1999 Yield	
Rootstock	Precent Alive	Trunk Cross-sectional Area (cm^2)	Increase in Trunk Cross-sectional Area (%)	Fruit Number	(pounds/tree)	(tons/acre)
OHxF 40	0.9 a	52.5 a	20.4 a	86.3 b	38.7 b	7.0 b
OHxF 69	0.6 b	53.0 a	11.4 ab	117.0 a	49.5 a	9.0 a
OHxF 87	0.8 ab	50.1 a	7.1 b	129.3 a	47.5 a	8.6 a
OHxF 40	204.3 a	0.317 b	298.3 b	140.7 b	25.6 b	216.6 a
OHxF 69	190.4 ab	0.394 ab	428.0 a	183.0 a	33.3 a	193.6 b
OHxF 87	164.9 c	0.420 a	459.3 a	201.8 a	36.7 a	199.8 ab

Means within a column followed by the same letter are not significantly different.

Evaluation of Pear Interstems

E.A. Mielke

Significant Findings

D'Anjou and Bartlett trees on OHxF 97 rootstocks with Conference interstems were the shortest, narrowest, and had the smallest canopy of all interstem combinations in the 1993 planting. Both d'Anjou and Bartlett trees with the BP interstems had significantly more fruit, with significantly larger fruit size, than did trees with no interstems. Fruit size on trees with BP-1 roots averaged 30 percent larger than fruit on the controls over the length of the trial. Trees with the Brossier roots experienced significantly higher tree mortality.

D'Anjou, Bartlett, Bosc, and Comice trees on Bartlett seedling rootstocks with Conference interstems (1994 trial) produced trees with canopy volumes 50 percent less than that of the control (1-year root with no interstem). Trees with Bosc interstems were more productive than the controls. Trees with Bartlett interstems had smaller fruit size. Significant interactions in tree volume efficiency occurred between the four cultivars and the interstems.

Objectives

Determine the effect of interstems in inducing dwarfing character, precocity, production, and fruit quality under varying soil and climatic conditions in the Pacific Northwest.

Procedures

Maintain existing green d'Anjou, Bartlett, Bosc, and Comice plantings. Evaluate each plot annually for growth, flowering, productivity, and winter survival. Evaluate fruit for production, size, and quality. The following trials will be maintained:

a. 1993 Brossier/BP interstems
b. 1994 *Pyrus communis* interstems

Results and Discussion

Brossier/BP Interstems

Interstems influenced tree survival. Overall, 7-year-old trees with both Brossier interstems experienced 50 percent mortality (Table 1). Growth, as measured by TCSA, was significantly less in both green d'Anjou and green Bartlett trees with Conference interstems. This was observed both at 15 cm (in the interstem) and 35 cm above ground. Trees with the South African interstems (BP-1 and BP-2) had the largest canopy volumes, and trees with Conference interstems had the smallest canopy volumes (Table 1). The values were not significantly different from the control (no interstem). The differences observed in initial and full bloom were not significant. Fruit number and yield were over twice as great when trees had BP-2 interstems as compared to the non-interstemmed control. Fruit size was 25 percent larger when BP-1 interstems were utilized (Table 2) as compared to the control. Average fruit weight over the life of the planting was 50 grams greater on trees with BP-1 interstems as compared to the control. Although trees with Conference interstems did not have significantly more production than did the control, its smaller canopy volume made it the most yield efficient.

Communis Interstems

The main effect of *P. communis* interstems on 6-year-old d'Anjou, Bartlett, Bosc, and Comice trees is shown in Table 4. Trees with both Bartlett and Conference interstems were shorter, narrower, and had significantly smaller canopy volumes (Table 4). First and full bloom were significantly advanced where 2-year-old rootstocks were used. Trees with Bartlett interstems experienced significantly greater tree mortality.

D'Anjou trees with either 2-year-old seedling roots or Bartlett interstems had greater tree mortality than did the control (Table 5). With the exception of trees with Bosc interstems, the canopy volume of all interstemmed trees was significantly less than that of the control (1-year roots). These interstemmed trees also were significantly less productive than the controls, had significantly smaller fruit size, and were less yield efficient.

The effect of the interstems on 6-year-old green Bartlett pears is shown in Tables 6 and 7. Trees with Bartlett interstems had a significantly lower tree survival than the non-interstemmed control (Table 6). Canopy volumes were significantly smaller when Bartlett or Conference interstems were used (Table 6). Trees with Bosc and 2-year-old roots had significantly more fruit and yield than did the controls. With the exception of

Bartlett trees with d'Anjou interstems, interstemmed trees were significantly more yield efficient than the controls in 1999 (Table 6) and over the life of the plant (Table 7). The control trees exhibited the smallest average cumulative fruit weight and lowest yield efficiency over the life of the planting (Table 7).

The effect of interstems on 6-year-old Golden Russet Bosc is shown in Tables 8 and 9. Golden Russet Bosc with d'Anjou, Bartlett or Bosc interstems experienced significantly greater tree mortalities than did the control. Trees with Conference interstems were the shortest, narrowest, and had the least canopy volume (Table 8). With the exception of trees with Bosc interstems, interstemmed trees had significantly smaller canopy volumes as compared to the control. Trees with Conference interstems significantly advanced initial and full bloom as compared to the control (Table 8). Trees with d'Anjou interstems produced significantly more fruit, greater yields, and slightly larger fruit size than the controls (Table 9).

The effect of interstems on 6-year-old Comice trees is shown in Tables 10 and 11. Comice with Bartlett interstems experienced greater tree mortality than did the control (Table 10). Comice trees with Bartlett, Bosc, or Conference interstems were significantly smaller than the non-interstemmed controls (Table 10). Comice trees with d'Anjou and Bosc interstems produced significantly more fruit and yield than did the control. Comice trees with d'Anjou and Conference interstems had significantly larger fruit than the control over the life of the planting (Table 11).

Table 1. Effect of interstem on survival, growth, and size of 7-year-old trees. Data are means for six individual tree replicates for green d'Anjou and green Bartlett.

		Trunk Cross-sectional Area				
Interstem	Percent Alive	15 cm (cm^2)	35 cm (cm^2)	Height (ft)	Width (ft)	Canopy Volume (m^3)
None	70 ab	62.5 cd	58.9 bc	12.8 ab	9.4 ab	8.2 ab
d'Anjou	90 a	77.9 bc	74.0 ab	13.7 a	9.9 a	9.8 a
BP-1	100 a	82.2 ac	80.7 a	12.8 ab	10.0 a	9.2 a
BP-2	80 a	73.2 bcd	65.7 ab	13.0 ab	9.6 a	8.6 a
Conference	90 a	58.2 d	44.9 c	12.4 b	8.4 b	6.1 ab
PYR2144	50 b	83.6 ab	75.0 ab	13.5 a	9.3 ab	8.4 ab
PYR2146	50 b	99.1 a	69.8 ab	12.8 ab	9.4 ab	8.1 ab

Means within a column followed by the same letter are not significantly different.

Table 2. Effect of interstem on bloom, yield, and fruit weight of 7-year-old trees. Data are means for six individual tree replicates for green d'anjou and green Bartlett.

	Julian Date			1999 Yield		
Interstem	First Bloom	Full Bloom	1999 Fruit Number	(pounds/tree)	(tons/acre)	Fruit Weight (g)
None	105.6 ab	110.7 ab	28.0 b	12.8 b	1.7 b	215.2 b
d'Anjou	106.3 a	111.8 ab	32.0 b	13.1 b	1.8 b	205.4 b
BP-1	105.0 b	109.5 b	25.8 b	14.8 b	2.0 b	256.2 a
BP-2	106.1 a	112.5 a	64.1 a	29.9 a	4.1 a	219.1 b
Conference	105.8 ab	110.8 ab	35.5 b	16.5 b	2.2 b	216.6 b
PYR2144	105.9 ab	111.3 ab	41.8 ab	19.8 ab	2.7 ab	229.6 ab
PYR2146	105.9 ab	110.8 ab	47.7 ab	21.3 ab	2.9 ab	220.3 a

Means within a column followed by the same letter are not significantly different.

Table 3. Effect of interstem on tree size, fruit number, yield, fruit weight, and yield efficiency on 7-year-old green d'Anjou trees. Data are means for six single tree replicates.

			Cumulative Yield			
Interstem	Canopy Volume (m^3)	Cumulative Fruit Number	(pounds/tree)	(tons/acre)	Average Fruit Weight (g)	Cumulative Yield Efficiency (kg/m^3)
None	8.0 ab	44.0 b	24.7 b	3.4 b	249.7 b	1.394 c
d'Anjou	12.0 a	83.7 ab	47.7 ab	6.5 ab	266.5 ab	1.704 bc
BP-1	9.2 ab	94.3 ab	64.4 ab	8.8 ab	309.8 a	3.351 abc
BP-2	9.4 ab	139.0 a	86.8 a	11.9 a	288.4 ab	3.777 ab
Conference	6.3 b	118.2 ab	58.0 ab	7.9 ab	226.8 b	4.126 a
PYR2144	6.9 b	59.8 ab	39.3 ab	5.4 ab	285.7 ab	2.532 abc
PYR2146	7.8 b	120.6 ab	62.3 ab	8.5 ab	240.5 b	3.572 ab

Within a column, means followed by the same letter are not significantly different.

Table 4. Main effect of interstem on survival, tree size, and bloom date of 6-year-old d'Anjou, Bartlett, Golden Russet Bosc, and Comice pears. Data means for six replicate trees for each of the four cultivars.

					Julian Date	
Interstem	Percent Alive	Height (ft)	Width (ft)	Canopy Volume (m^3)	First Bloom	Full Bloom
1-Year	96 a	13.7 ab	7.8 ab	6.4 ab	108.3 a	113.4 a
2-Year	88 ab	12.5 bc	7.1 b	5.0 b	102.6 b	107.3 b
d'Anjou	92 a	12.9 a	7.2 ab	5.8 ab	108.6 a	113.8 a
Bartlett	74 b	10.4 c	5.5 c	3.0 c	108.0 a	112.8 a
Bosc	92 a	12.6 ab	8.1 a	6.8 a	108.7 a	113.2 a
Conference	100 a	10.6 c	5.9 c	3.1 c	107.3 a	112.5 a

Means within a column followed by the same letter are not significantly different.

Table 5. Effect of interstem on survival, canopy volume, yield, fruit weight, and yield efficiency of 6-year-old d'Anjou pears. Data are means for six replicate trees.						
			1999 Yield			
Interstem	Percent Alive	Canopy Volume (m^3)	(pounds/tree)	(tons/acre)	Fruit Weight (g)	Yield Efficiency (kg/m^3)
1-Year	100 a	7.4 a	22.7 a	3.1 a	238.8 a	1.267 a
2-Year	80 b	5.8 b	13.8 b	1.9 b	216.4 a	1.190 a
d'Anjou	100 a	6.1 b	9.1 c	1.2 c	193.6 b	0.902 c
Bartlett	80 b	3.4 d	5.3 c	0.7 c	189.9 b	0.981 b
Bosc	100 a	8.0 a	23.2 a	3.2 a	236.0 a	1.194 a
Conference	100 a	5.2 c	10.7 b	1.5 b	193.7 b	0.975 b
Means within a column followed by the same letter are not significantly different.						

Table 6. Effect of interstem on survival, canopy volume, yield, and yield efficiency of 6-year-old Bartlett trees. Data means for six replicate trees.						
				1999 Yield		
Interstem	Percent Alive	Canopy Volume (m^3)	Fruit Number	(pounds/tree)	(tons/acre)	Yield Efficiency (kg/m^3)
1-Year	100 a	7.0 a	63.5 b	22.5 b	3.1 b	1.434 c
2-Year	80 ab	6.2 a	79.4 a	34.6 a	4.7 a	2.531 a
d'Anjou	80 ab	6.4 a	46.9 c	20.8 b	2.8 b	1.482 c
Bartlett	70 b	2.4 b	37.2 c	11.5 c	1.6 c	2.309 ab
Bosc	80 ab	8.3 a	80.4 a	34.7 a	4.7 a	2.258 b
Conference	100 a	2.6 b	32.7 b	12.7 c	1.7 c	2.478 a
Means within a column followed by the same letter are not significantly different.						

Table 7. Effect of interstem on cumulative yield, fruit weight, and yield efficiency of 6-year-old Bartlett pears. Data are means for six replicate trees.

		Cumulative Yield			
Interstem	Fruit Number	(pounds/tree)	(tons/acre)	Average Fruit Weight (g)	Cumulative Yield Efficiency (kg/m^3)
1-Year	154.5 b	46.3 b	6.3 b	131.3 c	3.041 e
2-Year	217.7 a	73.6 a	10.0 a	152.5 b	5.202 b
d'Anjou	139.6 b	47.1 b	6.4 b	166.1 a	3.254 e
Bartlett	68.5 c	19.5 c	2.7 c	139.5 c	3.463 d
Bosc	238.3 a	82.0 a	11.2 a	161.1 a	4.778 c
Conference	85.3 c	28.2 c	3.9 c	151.2 b	5.837 a

Means within a column followed by the same letter are not significantly different.

Table 8. Effect of interstem on survival, tree size, canopy volume, and bloom of 6-year-old Golden Russet Bosc pears. Data are means for six replicate trees.

					Julian Date	
Interstem	Percent Alive	Height (ft)	Width (ft)	Canopy Volume (m^3)	First Bloom	Full Bloom
1-Year	100 a	13.3 ab	9.0 ab	8.2 b	111.3 a	115.5 a
2-Year	100 a	11.6 c	6.6 b	3.7 e	110.5 ab	114.7 ab
d'Anjou	80 b	11.5 c	6.8 b	6.1 c	111.2 a	115.3 a
Bartlett	80 b	12.7 bc	7.0 b	4.7 d	111.5 a	114.9 a
Bosc	80 b	13.7 a	9.8 a	9.3 a	112.7 a	116.0 a
Conference	100 a	9.8 d	5.2 c	2.4 e	108.9 b	113.7 b

Means within a column followed by the same letter are not significantly different.

Table 9. Effect of interstem on yield, fruit weight, and yield efficiency of 6-year-old Golden Russet Bosc pears. Data are means for six replicate trees.

		1999 Yield				
Interstem	Fruit Number	(pounds/tree)	(tons/acre)	Fruit Weight (g)	Yield Efficiency (kg/m^3)	Cumulative Yield Efficiency (kg/m^3)
1-Year	35.8 b	17.6 b	2.4 b	211.4 a	1.071 b	2.361 b
2-Year	16.8 c	7.2 c	1.0 c	180.5 b	0.850 c	1.443 b
d'Anjou	50.7 a	25.1 a	3.4 a	224.5 a	1.827 ab	2.555 b
Bartlett	23.9 c	10.8 c	1.5 c	197.9 b	1.208 b	2.163 b
Bosc	44.4 ab	21.4 a	2.9 a	214.2 a	1.044 bc	2.019 b
Conference	21.7 c	10.5 c	1.4 c	205.6 ab	2.808 a	5.123 a

Means within a column followed by the same letter are not significantly different.

Table 10. Effect of interstem on survival, tree size, and yield of 6-year-old Comice pears. Data are means for six replicate trees.

Interstem	Percent Alive	Height (ft)	Width (ft)	Canopy Volume (m^3)	Fruit Number	1999 Yield (pounds/tree)
1-Year	80 b	14.1 a	5.2 ab	3.0 b	8.4 b	5.3 c
2-Year	80 b	12.3 b	5.8 a	3.9 a	5.7 d	3.7 c
d'Anjou	100 a	13.8 a	5.8 a	4.0 a	16.3 a	11.3 a
Bartlett	70 b	8.0 c	3.2 c	1.7 c	11.1 bc	7.5 b
Bosc	100 a	10.7 b	4.3 c	2.0 c	14.8 a	9.7 ab
Conference	100 a	11.0 b	4.8 bc	2.2 c	7.2 cd	4.8 c

Means within a column followed by the same letter are not significantly different.

Table 11. Effect of interstem on yield, fruit size, and yield efficiency of 6-year-old Comice pears. Data are means for six replicate trees.						
Interstem	1999 Yield (tons/acre)	1999 Fruit Weight (g)	1999 Yield Efficiency (kg/m^3)	Cumulative (tons/acre)	Average Fruit Weight (g)	Cumulative Yield Efficiency (kg/m^3)
1-Year	0.7 c	298.7 ab	0.638 b	1.0 c	268.3 b	1.095 b
2-Year	0.5 c	297.4 ab	0.493 b	1.4 c	261.7 b	1.492 b
d'Anjou	1.5 a	314.6 a	0.954 b	2.6 a	290.2 a	1.577 b
Bartlett	1.0 b	234.5 c	1.969 a	2.2 b	231.9 c	2.796 a
Bosc	1.3 ab	283.0 b	1.259 ab	2.8 a	241.1 bc	2.680 a
Conference	0.7 c	310.6 a	0.787 b	1.1 c	292.8 a	1.301 b
Means within a column followed by the same letter are not significantly different.						

Evaluation of New Rootstocks of Pears

E.A. Mielke

Significant Findings

Green d'Anjou trees on Horner (OHxF by OHxF crosses) rootstocks planted in 1995 had tree volumes in the range of 25 to 85 percent of trees with the control (OHxF 97) rootstocks. Rootstock affected the dates of both onset of bloom and full bloom. Trees with the H-1, H-4, and H-10 roots produced more fruit and a greater yield than did the controls. This was due primarily to a higher percentage of fruit set.

The 1995 planting of d'Anjou trees budded at 15 inches on OHxF 97 rootstocks were shorter, narrower, and had a significantly small canopy volume than trees budded at either 9 inches or 3 inches (the control). Trees budded at 9 inches had significantly more flower clusters. Yield was reduced on trees budded at 15 inches. A contributing factor may be that the original buds were cut off in the summer at the nursery, and the trees had to be rebudded.

In 1998, an initial evaluation trial and nursery with rootstock material propagated by Bill Proebsting were established utilizing the English 708 series, Pyronia, Fox, and Retuzier rootstocks with OHxF 87 controls. Four Cultivars (d'Anjou, Bartlett, Bosc, and Comice) were established on the rootstocks to test rootstock scion interactions. In 1999, two additional Fox, Pyrodwarf, and Pyro II (2-33) rootstocks were added. Nursery liners were budded in fall, 1999 for 2001 planting at sites in the Northwest.

Objective

Determine if new rootstock material or different propagation means can induce dwarfing character, precocity, production, and fruit quality under varying soil and climatic conditions in the Northwest.

Procedures

Maintain existing Horner block. Evaluate for growth, flowering, productivity, defoliation, and winter survival. Evaluate fruit for production, size, quality, and storability.

Maintain existing budding height plot. Evalue as above.

Establish a planting with Pyrodwarf rootstocks in Hood River. Cultivars utilized will be Bartlett, Bosc, and Concorde. Evaluate as above.

Propagate trees and establish a planting with the 708 series of English rootstocks. Evaluate as above.

Results and Discussion

Field evaluation of 13 of the more than 600 seedling selections of the Horner collection (OHxF by OHxF crosses) began in 1995. Based on previous information, only clones were selected that had been shown to have 100 percent rooting in a softwood cutting rooting test. Clones were selected which exhibited a range of size differences in the mother plants. For an initial screening, d'Anjou was budded onto the rootstock liners and planted in a completely randomized design planting (with 4 to 10 single tree replicates). Two of the 13 selections (H-36 and H-79) had less than 100 percent survival (Table 1). Tree growth (as measured by trunk cross-sectional area) varied by a factor of four-fold. One selection (H-1) was similar to the control (d'Anjou with OHxF 97), one (H-4) was significantly larger than the control, and the remaining 11 had TCSAs which were smaller than the control. On a percentage basis, growth increases were fairly uniform across the selections. Tree size, as measured by height, spread, and canopy volume, was not well related to TCSA. Trees with H-6 and H-14 roots were the shortest and narrowest (Table 1), and trees with H-14 roots had the significantly smallest canopy valume (Table 2). The canopy volumes of all trees with Horner rootstocks were smaller than the controls, ranging from 86 to 25 percent of trees with OHxF 97 roots. Eleven of the 13 selections tested had canopy volumes significantly smaller than the control.

D'Anjou trees with H-6 roots were delayed significantly in both the onset of bloom and reaching full bloom (Table 2). The average number of flower clusters ranged from 12 to 132. Trees with H-6 and H-10 roots had significantly more flower clusters. Initial fruit set varied from almost no fruit to over 60 fruit per 100 flower clusters (Table 3). Seven of the 13 selections set significantly more fruit than did the control. Due to a great deal of variability in fruit weight (Table 3), only three of the selections (H-1, H-4, and H-10) had yields that were significantly greater than the control. In addition to high yields, trees with H-4 roots also bore fruit that was significantly larger than fruit on the control (Table 3). Due to wide variations in TCSA, fruit numbers, fruit size, and canopy size, no significant differences were observed in yield efficiency when referenced to TCSA (kg/cm^3) provides a more accurate representation of the crop density (Table 4). Trees with H-4 roots had the greatest yield efficiency. Due to the fact that the trees are only in their fifth leaf (second year of production), cumulative yields and fruit weights were similar to those observed in 1999 Table 4).

Budding height of green d'Anjou on OHxF 97 roots significantly affected tree growth (Table 5). Trees budded at 15 inches were about one-half the size of those budded at a standard height of 3 inches. Higher budded trees were shorter with a narrower spread and had smaller canopy volumes. Part of this may be explained by the fact that the original buds inadvertently were cut off in the nursery, and the trees had to be rebudded. Based on our previous experience with rebudded trees, they were, under the worst conditions, only 1 year behind trees that did not have to be rebudded. In this case, the rebudded trees act as if they are 3 years behind the controls.

The highest budding dramatically reduced the number of flower clusters (Table 6). As initial and final fruit set values were similar for the different budding heights, fruit number was related directly to the number of clusters. As fruit size was not affected by budding height (Table 7), 1999 yields were correlated well with fruit numbers (Table 6). As this was only the second year of production, cumulative yield and yield efficiency were similar to 1999 yield and yield efficiency (Table 7).

Due to the efforts of Bill Proebsting, a number of the new rootstock materials are available for testing. The selections include members of the English 708 series, the French Retuzier series, the Italian Fox series, and Pyronia. The original material was delivered in the fall of 1998 as either small, budded trees in pots, or rootstock liners. Additional liners were delivered in the spring and fall of 1999. These rootstocks have been established in an initial planting to evaluate basic characteristics of the rootstocks, and to look at any potential for cultivar interaction with the four most common cultivars in the Pacific Northwest.

The unbudded trees were field budded in the fall of 1999. Due to a source mix-up between Pyrodwarf and its sister (Pyro II or Pyro 2-33), budded trees were not available for spring, 1999 planting. Liners were planted in spring of 1999 and field budded in the fall of 1999. Commercially produced Pyrodwarf and Pyro II 2-33 will be established in spring, 2000 (Table 9). Two additional Fox series liners were established in the nursery in fall, 1999 (Table 10). Larger numbers of some of the liners were available (Table 11). These were budded in the fall of 1999 to either green d'Anjou or green Bartlett. These will be available to plant in a number of grower trials in the Pacific Northwest.

Table 1. Effect of Horner rootstock on tree survival, growth, and canopy size of 5-year-old d'Anjou trees. Data are means for 4 to 10 individual tree replicates.

			Increase Trunk Cross-sectional Area		Canopy Size	
Rootstock	Percent Alive	Trunk Cross-sectional area (cm^2)	(cm^2)	(%)	Height (ft)	Width (ft)
H-1	100 a	43.3 b	15.8 b	56.5 ab	11.1 abc	8.0 ab
H-3	100 a	35.5 bcd	13.4 b	63.8 ab	10.5 abcde	7.9 abc
H-4	100 a	61.6 a	29.0 a	86.6 ab	12.0 a	8.0 abc
H-6	100 a	20.9 de	7.4 b	55.0 ab	8.9 ef	5.9 cd
H-9	100 a	24.3 cde	11.3 b	88.4 a	10.1 bcdef	6.5 bcd
H-10	100 a	35.9 bcd	12.5 b	53.3 b	11.3 abc	6.9 abcd
H-14	100 a	14.9 e	6.8 b	81.9 ab	8.7 f	5.0 d
H-18	100 a	30.7 bcde	10.8 b	55.7 ab	9.7 cdef	6.6 abcd
H-19	100 a	28.7 bcde	11.8 b	72.7 ab	10.5 abcde	6.4 bcd
H-36	80 ab	40.6 bc	17.2 b	74.3 ab	11.7 ab	7.7 abc
H-51	100 a	27.7 bcde	10.9 b	67.7 ab	10.3 bcdef	5.9 cd
H-53	100 a	21.7 de	8.1 b	58.9 ab	9.3 def	6.1 bcd
H-79	70 b	35.4 bcd	16.5 b	87.1 a	10.6 abcd	7.1 abc
OHxF 97	100 b	44.5 b	16.2 b	57.7 ab	12.0 a	8.6 a

Means within a column followed by the same letter are not significantly different.

Table 2. Effect of Horner rootstock on canopy volume, bloom, number of flower clusters, and initial fruit set on 5-year-old d'Anjou trees. Data are means for 4 to 10 individual tree replicates.

			Julian Date			
Rootstock	Canopy Volume (m^3)	Percent of OHxF 97	First Bloom	Full Bloom	Number of Clusters	Initial Fruit Number
H-1	5.1 abc	80.5 abc	104.0 c	108.0 b	93.3 ab	23.0 ab
H-3	4.6 bcde	72.0 bcde	106.3 bc	108.3 b	33.8 bcd	5.0 cd
H-4	5.5 ab	85.7 ab	106.0 c	108.4 b	131.8 a	36.6 a
H-6	2.3 hij	36.2 hij	107.8 a	110.0 a	11.8 d	0.2 e
H-9	3.4 fghi	52.4 fghi	106.0 c	108.0 b	25.0 cd	11.0 cd
H-10	3.8 defg	58.7 defg	106.5 abc	108.8 ab	102.5 a	25.3 a
H-14	1.6 j	25.6 j	106.7 abc	108.7 b	10.0 d	7.0 cd
H-18	3.1 fghi	48.3 fghi	106.1 c	108.6 b	85.4 abc	8.0 cd
H-19	3.4 efgh	53.2 efgh	106.5 abc	108.5 b	15.0 d	3.5 de
H-36	4.8 bcd	75.5 bcd	106.3 bc	109.0 ab	22.3 cd	8.3 cd
H-51	2.8 fghij	44.0 fghij	106.8 abc	108.5 b	17.9 cd	2.1 de
H-53	2.5 hij	39.1 hij	106.5 abc	109.0 ab	19.0 cd	7.5 cd
H-79	3.8 def	59.5 def	107.5 ab	109.0 ab	13.5 d	1.5 e
OHxF 97	6.4 a	100.0 a	106.3 bc	108.8 ab	70.3 bcd	12.3 cd

Means within a column followed by the same letter are not significantly different.

Table 3. Effect of Horner rootstock on fruit set, yield, and fruit weight on 5-year-old d'Anjou trees. Data are means for 4 to 10 individual tree replicates.

Rootstock	Fruit per 100 Clusters: Initial	Fruit per 100 Clusters: Final	1999 Fruit Number	1999 Yield (pounds/tree)	1999 Yield (tons/acre)	1999 Fruit Weight (g)
H-1	21.9 cd	20.8 cd	23.0 ab	13.6 ab	2.1 ab	272.0 bc
H-3	25.0 bcd	21.2 bc	4.3 cd	2.6 cd	0.4 cd	282.1 ab
H-4	29.5 bcd	31.2 bc	37.6 a	24.9 a	3.8 a	306.1 a
H-6	0.4 d	0.0 e	0.0 e	0.0 d	0.0 d	--
H-9	62.2 a	58.3 a	10.5 cd	5.0 cd	0.8 cd	210.5 h
H-10	24.7 bcd	25.6 bc	26.0 ab	15.4 ab	2.3 ab	266.6 bcd
H-14	43.8 abc	34.4 bc	5.5 cd	2.5 cd	0.4 cd	206.2 h
H-18	8.1 d	7.5 de	8.1 cd	4.4 cd	0.7 cd	242.2 efg
H-19	23.6 bcd	12.5 d	2.0 de	1.1 d	0.2 d	257.1 cde
H-36	54.6 ab	78.5 a	8.5 cd	4.9 cd	0.8 cd	254.2 cde
H-51	18.3 cd	18.3 cd	2.1 de	1.2 d	0.2 d	249.5 cdef
H-53	31.2 abcd	29.7 bc	7.0 cd	4.0 cd	0.6 cd	242.5 defg
H-79	5.8 d	5.8 e	1.5 e	0.8 d	0.1 d	226.8 fgh
OHxF 97	14.1 d	14.9 d	12.3 cd	7.1 cd	1.1 cd	273.7 bc

Means within a column followed by the same letter are not significantly different.

Table 4. Effect of Horner rootstock on yield efficiency, cumulative yield, and cumulative fruit weight on 5-year-old d'Anjou trees. Data are means for 4 to 10 individual tree replicates.

Rootstock	1999 Yield Efficiency (kg/cm^2)	1999 Yield Efficiency (kg/m^3)	Cumulative Fruit Number	Cumulative Yield (pounds/tree)	Cumulative Yield (tons/acre)	Average Fruit Weight (g)
H-1	0.164 abc	1.413 abc	27.3 c	15.7 b	2.3 b	262.3 bc
H-3	0.038 abc	0.305 c	6.3 cd	3.5 cd	0.5 cd	268.3 b
H-4	0.203 a	2.185 a	40.6 a	26.8 a	4.2 a	302.2 a
H-6	--	--	0.0 e	0.0 d	0.0 d	--
H-9	0.132 abc	1.291 abc	10.5 cd	5.0 cd	1.0 cd	210.0 ef
H-10	0.198 ab	1.903 ab	35.5 a	19.5 ab	3.0 ab	254.0 bcd
H-14	0.171 abc	1.422 abc	7.0 cd	3.0 cd	0.5 cd	188.0 f
H-18	0.079 abc	0.888 abc	12.3 cd	6.0 cd	0.9 cd	217.7 ef
H-19	0.022 c	0.302 c	2.0 de	1.5 d	0.0 d	257.0 bcd
H-36	0.057 abc	0.491 bc	8.5 cd	5.0 cd	0.5 cd	254.0 bcd
H-51	0.028 bc	0.471 bc	2.6 de	1.4 d	0.0 d	238.7 bcde
H-53	0.070 abc	0.544 bc	9.0 cd	5.0 cd	0.5 cd	229.5 de
H-79	0.016 c	0.136 c	1.5 e	1.0 d	0.0 d	227.0 def
OHxF 97	0.096 abc	0.637 bc	18.8 cd	10.0 c	1.4 c	235.2 cde

Means within a column followed by the same letter are not significantly different.

Table 5. Effect of budding height on growth, tree size, and canopy volume of 5-year-old d'Anjou trees. Data are means for four three-tree plots.

			Canopy Size		
Budding Height (inches)	Trunk Cross-sectional Area (cm^2)	Percent Increase Trunk Cross-sectional Area	Height (ft)	Width (ft)	Canopy Volume (m^3)
3	44.5 a	16.1 a	12.0 a	8.6 a	6.4 a
9	46.6 a	17.5 a	12.7 a	9.1 a	7.5 a
15	22.8 b	11.8 b	10.6 b	6.0 b	2.9 b

Means within the same column followed by the same letter are not significantly different.

Table 6. Effect of budding height on flowering, fruit set, and yield of 5-year-old d'Anjou pear trees. Data are means for four three-tree plots.

		Fruit per 100 Clusters			1999 Yield	
Budding Height (inches)	Number of Flower Clusters	Initial	Final	1999 Fruit Number	(pounds/tree)	(tons/acre)
3	70.2 b	17.1 a	17.4 a	12.2 ab	7.1 a	1.1 a
9	93.2 a	19.6 a	19.8 a	16.0 a	9.3 a	1.4 a
15	12.2 c	19.9 a	25.5 a	3.1 b	1.7 b	0.3 b

Means within the same column followed by the same letter are not significantly different.

Table 7. Effect of budding height on fruit size, yield efficiency, cumulative yield, and cumulative yield efficiency of 5-year-old d'Anjou trees. Data are means for four three-tree plots.

				Cumulative Yield		
Budding Height (inches)	1999 Fruit Weight (g)	1999 Yield Efficiency (kg/m^3)	Cumulative Fruit Number	(pounds/tree)	(tons/acre)	Cumulative Yield Efficiency (kg/m^3)
3	272.7 a	0.853 a	18.8 b	9.9 b	240.2 a	0.735 a
9	265.9 a	0.621 a	26.4 a	13.8 a	238.4 a	0.924 a
15	265.1 a	0.321 b	3.2 c	1.7 c	253.7 a	0.287 b

Means within the same column followed by the same letter are not significantly different.

Table 8. New rootstock scion combinations added to rootstock trials[z]. Material provided by Bill Proebsting.				
Rootstock	d'Anjou	Bartlett	Golden Russet Bosc	Comice
Seedling Bartlett	F98/FB99	F98/FB99	F98/FB99	F98/FB99
708-2	F98/FB99	F98/FB99	F98/FB99	F98/FB99
708-12	F98/FB99	F98/FB99	F98/FB99	F98/FB99
708-36	F98/FB99	F98/FB99	F98/FB99	F98/FB99
OH11	F98/FB99	F98/FB99	F98/FB99	F98/FB99
96FI13 (Fox 11)	FB99	FB99	-	-
96FI14 (Fox 16)	FB99	FB99	-	-
Pyronia	FB99	-	-	-
Pyro II (2-33)	-	FB99	FB99	-
Pyrodwarf	FB99	FB99	FB99	FB99

[z]F98 = Budded liner planted fall, 1998. FB99 = Liner planted in place fall, 1998 or spring, 1999, and field budded fall, 1999.

Table 9. Commercially propagated trees to be planted spring, 2000.			
Rootstock	Bartlett	Comice	Concorde
Pyrodwarf	X	X	X
Pyro II (2-33)	X	X	X
OHxF 97	X	X	X

Table 10. Rootstocks added to nursery.	
Rootstock Liner	Year to Bud
96FI12 (Fox)	Fall 00
96FI15 (Fox)	Fall 00

Table 11. Combinations available for grower trials, spring, 2001.		
	Scion	
Rootstock	d'Anjou	Bartlett
708-2	48	46
708-12	139	150
708-36	28	32
96FI13 (Fox 11)	39	39
96FI14 (Fox 16)	20	-
OHxF 40	34	34
OHxF 87	132	134

Management of High-Density Pears-Tree Removal Versus Containment Pruning

E.A. Mielke and C.F. Seavert

Significant Findings

Due to problems with tree loss due to fire blight, and the difficulty in reforming fruiting wood, a great deal of variability has been introduced into the experimental plot. The non-uniformity and variability is such that even large differences between treatments would not be statistically significant. Therefore, it was decided to terminate the research plot before the answer to our original question was found. That question was whether it was better to remove every other tree when plantings become too dense, or to prune every tree heavily in an attempt to obtain the maximum production and highest quality possible. With this in mind, all the experimental trees within a spacing were pooled for yield and graded and sized as one lot. Therefore, a statistical analysis is not possible.

An overall observation to be made is that it is not desirable to wait until production had begun to drop to take corrective action. If tree removal had begun at an earlier time, when there was still active fruiting and vegetative wood in the lower portions of the trees, it would have been easier to reestablish a bearing canopy.

Objectives

The objective of this 4-year project was to determine the effects of tree removal versus tree containment pruning on production, fruit size and quality, and grower returns.

Procedures

A block of higher density d'Anjou and Bartlett pears with between-row spacings of 14, 16, and 18 feet and in-row spacings of 6 and 8 feet were utilized for the experiment. One-half of the trees at each density were pruned to encourage regeneration of the lower fruiting wood and allow better light penetration. The other half of each planting would have every other tree removed, with the remaining trees pruned to maximize the use of the newly available space. The range of spacings should have allowed for the determination of when it is better to remove than prune.

At harvest, production on individual trees was determined, and the fruit from individual treatments was run over the new packing line to determine size and grade and to allow for uniform inoculation of the fruit with decay organisms. Random samples of fruit from each treatment were stored for a minimum of 6 months to determine if the management system had an effect on fruit quality. Economic models were constructed to determine which treatments provide the greatest grower returns.

Results and Discussion

The effect of the heavy pruning versus tree removal on the production in green d'Anjou pears is shown in Table 1. In all cases where trees were removed, the yield on the remaining trees increased. This was evident even the first year after the removal was performed. The yield increased on a per tree basis was very dramatic in the second year. Yields on the remaining trees where every other tree had been removed approached twice that of where all the trees had been left and pruned heavily. Greater increases in yield on the remaining trees was observed where the trees had started out at the lower densities, and not as much of the lower fruiting and vegetative wood had been "shaded out." This was very encouraging; however, in the third year, per tree yields took a dramatic decline in both the "pruned" and "removed" plots.Yield increases on the "removed" as compared to the "pruned" plots ranged from almost nothing to almost double. The average increase on the "removed" plots was about 45 percent. The cumulative yield on a per tree basis increased about 55 percent where every other tree hasd been removed.

When yields are compared on a per acre basis, the picture becomes somewhat different. In the first year after tree removal was performed, per acre yields on green d'Anjou were decreased in all cases where trees were removed (Table 1). This had been expected, as it was anticipated that it would take several years to rebuild the remaining trees. Per acre yield in the second year of the trial ranged from 80 to 100 percent of the yields where trees had not been removed. The average increase was about 90 percent. The greater increases occurred where the trees had started out at the higher densities. In the third year, per acre yields were reduced greatly where the trees had been removed. Overall, when trees had been removed, per acre yields were only about 70 percent of the yields where the trees were "pruned."

Fruit size and quality were affected by the tree removal versus pruning. This was expressed by placing a gross packing house value on the crop based on its size and grade (Table 2). This resulted in a $13 to $25 per ton increase in the first year of the trial where trees had been "removed." The overall average increase was $20 per ton. In the second year of the trial, the difference in the average increase had dropped to $9 per ton where trees had been "removed," with the range being -$1 to $18 per ton. In the third year, the average price differential dropped to -$14 per ton where trees had been "removed," with a range of -$2 to -$23 per ton. This was due primarily to an increase in the percentage of smaller fruit where trees had been "removed." If we translate the gross packing house income to a per acre basis, the per acre loss where trees were "removed" was $4,000, $900, and $2,500, respectively for the 1st 2nd, and 3rd year of the trial. The overall loss where trees were "removed" was $7,450 per acre and ranged from $5,200 to $10,000 per acre. The picture was very similar for Bartlett (Tables 3 and 4). Per tree yield increase where trees were "removed" was 30 percent, 100 percent, and 55 percent, respectively for the 1st, 2nd, and 3rd years of the trial. The average increase was 50 percent (Table 3). This resulted in per acre yields of 65 percent, 100 percent, and 80 percent, respectively for the 1st, 2nd, and 3rd years of the trial, where trees were "removed" versus "pruned." The cumulative yield where trees were "removed" was only 75 percent compared to where the trees were "pruned."

The average value of the crop increased by $40 per ton gross packing house return in the first year of the trial (Table 4). This was due primarily to a shift to larger fruit sizes. By the second year of the trial, the difference was only $12 per ton where the trees were "removed." In the third year of the trial, the value was approximately $14 per ton less where the trees were "removed," primarily due to a higher percentage of small fruit. The per acre value of the crop was an average of $3,500, $700, and $2,350 less per acre gross packing house returns, respectively, for the 1st, 2nd, and 3rd years of the trial, where trees had been "removed." This resulted in a cumulative average gross packing house loss of approximately $6,550 per acre for the 3 years of the trial.

The data presented does not provide an answer to the question that we originally set out to answer. The data strongly suggests that it is better to leave all the trees and "prune" heavily rather than "remove" every other tree. A valid criticism is that we waited too long to begin the experiment: waiting 10 years until production actually had begun to drop was too long. If tree removal had begun at an earlier time, when yield overall were still increasing, and the active fruiting and vegetative wood in the lower portions of the trees was beginning to decline and/or "die out," it would have been easier to reestablish a bearing canopy. Likewise, canopy loss to fireblight was not anticipated originally. However, this made it more difficult to rebuild the trees.

Table 1. Effect of tree removal vs. pruning and spacing on the annual and cumulative production on green d'Anjou pears.

			Annual Yield (pounds per tree)				Annual Yield (tons/acre)			
Spacing (ft)	Pruned vs. Removed	Trees Per acre	1997	1998	1999	Total	1997	1998	1999	Total
14x6	Pruned	519	85.9	90.2	74.1	250.2	22.3	23.4	19.2	64.9
14x12	Removed	259	99.0	161.0	140.2	400.2	12.8	20.9	18.2	51.8
14x8	Pruned	389	108.4	120.6	80.8	309.8	21.1	23.4	15.7	60.3
14x16	Removed	194	157.0	195.6	86.9	439.5	15.2	19.0	8.4	42.6
16x6	Pruned	454	119.2	112.6	70.5	302.4	27.1	25.6	16.0	68.6
16x12	Removed	227	143.2	213.8	112.4	469.4	16.3	24.3	12.8	53.3
16x8	Pruned	340	129.8	140.4	93.0	363.2	22.1	23.9	15.8	61.7
16x16	Removed	170	184.2	237.6	143.1	564.9	15.7	20.2	12.2	48.0
18x6	Pruned	403	79.9	123.0	57.0	259.9	16.1	24.8	11.5	52.4
18x12	Removed	202	105.7	246.6	73.8	426.1	10.7	24.9	7.5	43.0
18x8	Pruned	303	112.0	147.4	91.9	351.3	17.0	22.3	13.9	53.2
18x16	Removed	151	130.7	302.5	122.5	555.7	9.9	22.8	9.2	42.0

Table 2. Effect of tree removal vs. pruning and spacing on the gross packing house value per ton and per acre for green d'Anjou pears.

			Gross Value (dollars/ton)				Gross Value (dollars/acre)			
Spacing (ft)	Pruned vs. Removed	Trees per acre	1997	1998	1999	Average	1997	1998	1999	Total
14x6	Pruned	519	559.09	587.27	616.22	587.53	12,463	13,746	11,843	38,052
14x12	Removed	259	580.00	599.09	614.06	597.72	7,436	12,494	11,148	31,078
14x8	Pruned	389	570.00	584.55	603.68	586.08	12,018	13,707	9,492	35,217
14x16	Removed	194	582.73	591.82	595.10	589.88	8,874	11,228	5,017	25,118
16x6	Pruned	454	568.18	587.27	606.49	587.32	15,374	15,016	9,712	40,102
16x12	Removed	227	589.09	604.55	601.02	598.22	9,575	14,673	7,667	31,915
16x8	Pruned	340	567.27	586.36	610.09	587.91	12,517	13,991	9,650	36,158
16x16	Removed	170	591.82	600.91	599.91	597.55	9,266	12,136	7,297	28,699
18x6	Pruned	403	569.09	573.64	577.02	573.25	9,162	14,215	6,631	30,008
18x12	Removed	202	588.18	578.18	549.47	571.94	6,279	14,402	4,094	24,775
18x8	Pruned	303	572.73	583.64	609.27	588.54	9,718	13,033	8,479	31,231
18x16	Removed	151	591.82	582.73	576.99	583.84	5,840	13,309	5,336	24,485

Table 3. Effect of tree removal vs. pruning and spacing on the annual and cumulative production on green Bartlett pears.

			Annual Yield (pounds per tree)				Annual Yield (tons/acre)			
Spacing (ft)	Pruned vs. removed	Trees per acre	1997	1998	1999	Total	1997	1998	1999	Total
14x6	Pruned	519	85.9	75.5	74.5	235.9	22.3	19.6	19.3	61.2
14x12	Removed	259	98.8	108.5	100.2	307.5	12.8	14.0	13.0	39.8
14x8	Pruned	389	108.5	72.2	76.6	257.2	21.1	14.0	14.9	50.0
14x16	Removed	194	157.7	106.5	139.6	403.8	15.3	10.3	13.5	39.2
16x6	Pruned	454	118.9	92.2	88.4	299.5	27.0	20.9	20.1	68.0
16x12	Removed	227	142.7	159.3	115.0	417.0	16.2	18.1	13.1	47.3
16x8	Pruned	340	130.0	111.8	85.7	327.5	22.1	19.0	14.6	55.7
16x16	Removed	170	184.7	168.1	161.8	514.6	15.7	14.3	13.8	43.7
18x6	Pruned	403	79.9	37.6	82.9	200.4	16.1	7.6	16.7	40.4
18x12	Removed	202	105.9	103.6	168.0	377.6	10.7	10.5	17.0	38.1
18x8	Pruned	303	111.6	56.8	73.3	241.6	16.9	8.6	11.1	36.6
18x16	Removed	151	131.1	165.2	64.4	360.7	9.9	12.5	4.9	27.2

Table 4. Effect of tree removal vs. pruning and spacing on the annual and cumulative production on green Bartlett pears.

			Gross Value (dollars/ton)				Gross Value (dollars/acre)			
Spacing (ft)	Pruned vs. removed	Trees per acre	1997	1998	1999	Average	1997	1998	1999	Total
14x6	Pruned	519	505.45	561.82	616.22	561.16	11,272	11,001	11,913	34,186
14x12	Removed	259	557.27	587.27	614.06	586.20	7,133	8,249	7,968	23,350
14x8	Pruned	389	547.27	573.64	603.68	574.86	11,547	8,051	8,994	28,593
14x16	Removed	194	567.27	579.09	595.10	580.49	8,679	5,981	8,058	22,719
16x6	Pruned	454	518.18	563.64	606.49	562.77	13,991	11,794	12,170	37,955
16x12	Removed	227	598.18	599.09	601.02	599.43	9,691	10,831	7,845	28,366
16x8	Pruned	340	543.64	576.36	610.09	576.70	12,014	10,950	8,888	31,853
16x16	Removed	170	595.45	598.18	599.91	597.85	9,349	8,546	8,251	26,145
18x6	Pruned	403	566.36	568.18	577.02	570.52	9,118	4,307	9,639	23,064
18x12	Removed	202	586.36	565.45	549.47	567.10	6,274	5,918	9,323	21,515
18x8	Pruned	303	582.73	596.36	609.27	596.12	9,848	5,128	6,766	21,742
18x16	Removed	151	594.55	583.64	576.99	585.06	5,886	7,280	2,805	15,972

Red d'Anjou Failure

E.A. Mielke, F. Niederholzer, R.A. Spotts, and J. Postman

Significant Findings

The issue involving the presence or absence of pear decline still has not been resolved, as concerns involving the test procedure and the ability to determine if decline is present have not been resolved. Two attempts to root cuttings directly to form own-rooted plants have failed. Materials has been placed into tissue culture to develop the own-rooted plants.

Carbohydrates (sugar, starch, amylose, and amylopectin) have been analyzed partially from the roots of Columbia Red and green d'Anjou. Carbohydrate levels are lower (starch is significantly lower) in the roots of the Columbia Red d'Anjou trees. Starch levels were correlated with 1998 and 1999 yields.

Crop limitation, via hand removal of 25, 50, 75, or 100 percent of the crop by summer thinning, caused a reduction in yield. While thinning reduced the crop, fruit size was not increased significantly until 50 percent of the crop had been removed. Removal of 75 percent or more of the crop significantly increased shoot length and diameter. Root samples collected from each of the trees have yet to be analyzed. During root collection, it was noted that no roots were found under the Columbia Red d'Anjou trees closer than 16 to 18 inches from the surface, while roots were found within 6 inches of the surface on other red and green cultivars adjacent to the Columbia Red d'Anjou. This suggests that the roots under Columbia Red d'Anjou may be more sensitive to low temperatures. Crop limitation reduced the amount of "redness" observed in the trees at harvest.

An attempt was made to impose irrigation stress by installing smaller rotators in the existing irrigation system. Water reduction levels were 25, 40, and 50 percent of the standard application. No differences were noted in production, fruit number, or fruit size. Water application rates of 2.98, 3.49, 4.24, and 5.74 inches were applied every 2 weeks.

The red-green trees have been established. Production occurred on both the green d'Anjou and Bartlett "bottoms," but not the Columbia Red d'Anjou tops. While no significant differences in growth have occurred as yet on the young trees, there is a trend to reduced growth where the trees have red tops. No significant differences were observed in root carbohydrates. High variability existed between replicates. As very small root samples were collected to minimize the stress on the small trees, they may not have been representative.

Objectives

Determine the presence or absence of pear decline or other virus or virus-like conditions in Columbia Red d'Anjou trees exhibiting collapse.

Determine the effect of crop load in causing the collapse of Columbia Red d'Anjou trees or in the severity of the collapse.

Determine the effect of water stress in causing the collapse or in the severity of the collapse.

Determine if own-root trees can prevent the development of Columbia Red d'Anjou failure by the elimination of the propagation union or any incompatibility between the scion and rootstock.

Determine if combination green/red trees can alleviate the condition or prevent its development.

Procedures

Collect shoot samples from trees exhibiting early, mid-, and severe stages of collapse as well as asymptomatic controls. This will be done as soon as the problems in determining the presence or absence of pear decline have been resolved.

Thin heavy bearing young trees to 0, 25, 50, or 75 percent of crop with a non-thinned control.

Subject trees to 25, 40, and 50 percent water reduction. Cropping level, fruit size, and color were determined at harvest. The level of shoot and root carbohydrates will be determined in all treatments.

Once own-rooted red d'Anjou trees are available, they will be planted in at least three locations where collapse symptoms have been noted. The trees will be followed for the development of collapse. If decline or other virus or virus-like organisms are determined in procedure 1, the own-rooted trees will be inoculated with decline to determine if they are resistant to the collapse.

Develop Red d'Anjou trees with a permanent lower whorl of either green Bartlett or green d'Anjou. Determine the effect on tree growth and development of the disorder. Determine the level of root carbohydrates in all treatments.

Results and Discussion

Carbohydrates (sugar, starch, amylose, and amylopectin) have been analyzed partially from the root of Columbia Red and green d'Anjou on OHxF 40 rootstocks. Carbohydrate levels are lower (starch is significantly lower) in the roots of the Columbia Red d'Anjou trees (Table 1). Average starch levels from the OHxF 40 roots under green and Columbia Red d'Anjou were correlated positively with both 1998 and 1999 yields.

Crop limitation, removal of 25, 50, 75, or 100 percent of the crop by summer thinning, caused a reduction in yield. No significant differences were observed in trunk cross-sectional areas (TCSAs) (Table 2); however, as the thinning was not imposed until mid-summer, no differences were expected at this point. While thinning reduced the crop, fruit size was not significantly increased until 50 percent of the crop had been removed. A greater effect on fruit size was expected. It is possible that by June to July, maximum fruit size has already been determined: and, thinning at, or after, this time would have little, if any, effect on fruit size. No significant differences in shoot length were noted between the non-thinned control and any of the crop removal levels in early July, just shortly before thinning had been performed (Table 3). Removal of 75 percent or more of the crop significantly increased shoot length and diameter by the end of the growing season.

Root samples collected from each of the trees have yet to be analyzed. During root collection, it was noted that no roots were found under the Columbia Red d'Anjou trees closer than 16 or 18 inches from the surface, while roots were found within 6 inches of the surface on other red and green cultivars adjacent to the Columbia Red d'Anjou. This suggests that the roots under Columbia Red d'Anjou may be more sensitive to low temperatures. Crop limitation reduced the amount of "redness" observed in the trees at harvest (data not shown).

Smaller rotators were installed in an existing irrigation system in an attempt to impose irrigation stress. The nozzles were selected to reduce water applications 25, 40, and 50 percent of the grower's standard application. This resulted in the application of 2.98, 3.49, 4.24, or 5.74 inches of water at each application (Table 4). No differences were observed in fruit number, yield, or fruit weight. Either the lowest application adequately met the needs of the trees and crop, or it takes more than one season for water stress to become apparent. In future years, tree water potential will be assessed utilizing a pressure bomb to determine the degree of stress being imposed.

The red/green combination trees have been established. Production occurred on both the green d'Anjou and Bartlett "bottoms," but not the Columbia Red d'Anjou tops. No significant differences in growth (as measured by TCSA) have occurred as yet on the young trees (Table 5). There is, however, a significant reduction in the rate of TCSA increases where Bartlett trees have red tops, along with a significant reduction in tree height. While no significant differences in fruit number, yield, or fruit size were observed in 1999 (Table 6), or in the cumulative data (Table 7), green Bartlett trees with Columbia Red d'Anjou tops were slightly more yield efficient. No significant differences were observed in root sugar (Table 8). With the exception of amylose, there were no differences in carbohydrates from the combination trees with green d'Anjou bottoms. There were, however, significant differences in the levels of starch, amylose, and amylopectin when green Bartlett bottoms were utilized. High variability existed between replicates. As very small root samples were collected to minimize the stress on the small trees, they may not have been representative.

Table 1. Effect of Columbia Red or green d'Anjou scions on root carbohydrates and yields on 9-year-old trees. Data are means for 36 trees.

Component	Green d'Anjou	Red d'Anjou
Sugar (%)	8.3 a	8.03 a
Starch (%)	1.53 a	1.41 b
Amylose (%)	1.23 a	1.14 a
Amylopectin (%)	0.29 a	0.27 a
Yield - 1998 (kg/tree)	51.4 a	41.9 b
Yield - 1999 (kg/tree)	31.2 a	27.8 a

Means within a row followed by the same letter are not significantly different.

Table 2. Effect of crop removal on tree growth, fruit number, yield, and fruit weight on young, mature Columbia Red d'Anjou pear trees growing in Parkdale, Oregon. Data are means for 6 individual trees.

Percent of Crop Removal by Hand Thinning	Trunk Cross-sectional Area (cm^2)	Fruit Number	1999 Yield (pounds per tree)	1999 Yield (tons/acre)	Fruit Weight (g)
100	162.7 a	0.8 d	0.5 d	0.1 d	277.8 ab
75	149.4 a	81.0 c	53.3 c	7.3 c	300.3 a
50	172.9 a	228.7 b	140.2 c	19.1 b	278.4 ab
25	143.6 a	250.2 b	145.0 b	19.8 b	264.7 bc
0	151.7 a	411.0 a	223.1 a	30.4 a	248.2 c

Means within a column and parameter followed by the same letter are not significantly different.

Table 3. Effect of crop removal on shoot growth on young, mature Columbia Red d'Anjou pear trees growing in Parkdale, Oregon. Data means are for three individual shoots on each of six trees.

			Increase in Shoot Length		
Percent of Crop Removal by Hand Thinning	Shoot Length in July (cm)	Shoot Length in October (cm)	(cm)	(%)	Shoot Diameter (cm)
100	51.8 ab	93.4 a	41.6 a	80.3 a	0.43 a
75	49.0 ab	88.5 a	39.5 ab	82.5 a	0.39 b
50	45.4 b	76.9 c	31.4 c	70.9 a	0.35 c
25	51.8 a	86.1 abc	34.2 abc	66.3 a	0.35 c
0	49.1 ab	80.7 bc	31.6 bc	65.3 a	0.35 c

Means within a column and parameter followed by the same letter are not significantly different.

Table 4. Effect of water reduction on fruit number, yield, and fruit weight of young, mature Columbia Red d'Anjou pears. Data are means for six individual trees.

Percent Water Reduction	Inches per Irrigation	Fruit Number	1999 Yield (pounds/tree)	1999 Yield (tons/acre)	Fruit Weight (g)
0	5.74	204.4 a	108.9 a	21.2 a	242.2 a
25	4.24	177.2 a	96.2 a	18.8 a	246.8 a
40	3.49	189.8 a	100.9 a	19.6 a	241.6 a
50	2.98	222.8 a	116.2 a	22.6 a	237.1 a

Means within a column followed by the same letter are not significantly different.

Table 5. Effect of the presence of a Columbia Red d'Anjou "top" and a green d'Anjou or green Bartlett "bottom" on growth and tree size of 4-year-old trees. Data are means for six individual tree replicates.

				1999 Tree Size		
Bottom Whorl	Top	Trunk Cross-sectional Area (cm^2)	Increase in Trunk Cross-sectional Area (%)	Height (ft)	Width (ft)	Volume (m^3)
d'Anjou	None	27.7 a	60.4 a	7.4 bc	7.2 ab	2.8 ab
d'Anjou	Columbia	26.8 a	56.8 a	7.9 b	7.5 a	3.2 a
Bartlett	None	20.9 b	45.1 b	9.2 a	6.1 b	2.4 ab
Bartlett	Columbia	20.7 b	35.8 c	6.8 c	6.4 b	2.1 b

Table 6. Effect of the presence of a Columbia Red d'Anjou "top" and a green d'Anjou or green Bartlett "bottom" on the 1999 yield and fruit size of 4-year-old trees. Data are means for siz individual tree replicates.

		1999 Yield				
Bottom Whorl	Top	Fruit Number	(pounds/tree)	tons/acre)	Fruit Weight (g)	Yield Efficiency (kg/cm^2)
d'Anjou	None	5.8 b	3.1 b	0.5 b	246.4 a	0.056 c
d'Anjou	Columbia	5.0 b	2.7 b	0.4 b	250.3 a	0.066 c
Bartlett	None	16.3 a	7.4 a	1.1 a	202.8 b	0.148 b
Bartlett	Columbia	21.3 a	10.1 a	1.5 a	214.2 b	0.221 a

Means within a column followed by the same letter are not significantly different.

Table 7. Effect of the presence of a Columbia d'Anjou "top" and a green d'Anjou or green Bartlett "bottom" on the cumulative yield and fruit size of 4-year-old trees. Data are means for six individual tree replicates.

		Cumulative Yield				
Bottom Whorl	Top	Fruit Number	(pounds/tree)	Tons/acre)	Average Fruit Weight (g)	Cumulative Yield Efficiency (kg/cm^2)
d'Anjou	None	7.8 b	4.1 b	0.6 b	237.5 a	0.074 c
d' Anjou	Columbia	8.1 b	4.1 b	0.6 b	231.3 a	0.088 c
Bartlett	None	25.7 a	10.9 a	1.7 a	186.0 b	0.226 b
Bartlett	Columbia	31.6 a	14.1 a	2.1 a	203.1 c	0.305 a

Means within a column followed by the same letter are not significantly different.

Table 8. Effect of the presence of a Columbia Red d'Anjou "top" and a green d'Anjou or green Bartlett "bottom" on the root carbohydrates in 4-year-old combination trees. Data are means for six individual trees.

Bottom	Top	Percent Sugar	Percent Starch	Percent Amylose	Percent Amylopectin
d'Anjou	None	8.10 a	1.79 a	1.73 a	0.270 b
d'Anjou	Red d'Anjou	8.66 a	1.91 a	1.44 b	0.262 b
Bartlett	None	8.31 a	1.42 b	0.96 c	0.764 a
Bartlett	Red d'Anjou	7.53 a	1.80 a	1.56 ab	0.241 b

Means within the same column followed by the same letter are not significantly different.

Effect of Training System on the Susceptibility of Cascade Pears to Hail Damage and Other Types of Fruit Marking

E.A. Mielke and T.J. Facteau

Introduction

Hail damage is a problem with which growers in some areas have to contend with every year. Insurance is available to protect a grower from losses. National Crop Insurance Service, which underwrites most of the policies, has raised questions concerning the amount of damage suffered by different types of training systems. This project was designed to evaluate the amount of damage induced by artificial hail on pears trained on six different systems.

Cascade pears on six training systems were exposed to artificial hail conditions for period of 0, 30, or 60 seconds. The hail damage was imposed 3 weeks prior to harvest. The fruit was held in storage at -1°C for 2 months and ripened at 20°C for 5 days prior to evaluation. The training systems included: Marchand, Mid-Columbia Central Leader (MCL), MIA, Palmate, Slender Spindle, and Standard Central Leader (CL). Central Leader trees suffered the most total hail damage, with the MCL and Marchand suffering the least tree damage. Little difference in hail damage was noted between the 30- and 60-second treatments. The majority of the damage was caused by cuts and surface abrasion due to sharp edges on the ice, which is not typical of natural hail, and was an artifact of the way the synthetic hail was produced. In the second year, when more "typical" hail was used, significant differences in hail damage existed only with the MIA at the 30-second timing. At the 60-second timing, no significant differences in damage were apparent. Significant differences existed in the percentage of damage differences in damage were apparent. Significant differences existed in the percentage of damage between the 0- and 15-second timings; these were evident for all systems except the Central Leader and Spindle. Between the 15- and 30-second timings, significant differences were apparent for all systems except the Palmate and Marchand. Between the 30- and 60-second timings, significant differences existed for all systems except the Spindle, with the Mid-Columbia Central Leader experiencing the greatest increase between the 30- and 60-second timing.

Procedures

To evaluate the hail potential, a 6-year-old Cascade pear block was selected, as Cascade fruit is very prone to show any type of mechanical injury. The block was part of a training system trial with six training systems. They are: standard central leader (CL), Mid-Columbia Leader (central leader-spindle hybrid) (MCL), Palmate, Marhand, Spindle, and MIA. The planting distance for the central leader, Mid-Columbia Leader, and Spindle was 4.9 x 2 m (850 trees/ha). The planting distance for the Marchand distance was 4.3 x 2.4 m (969 trees/ha) and the planting distance for the MIA was 4.3 x 1.2 x 2.4 m (1,543 trees/ha).

A hail machine constructed by the National Crop Insurance Services was utilized to impart the damage. It was elevated on a fortlift to provide the hail stream outlet at 6 m. The nozzle was hand directed over the top of the tree at a downward angle of 10 degrees from vertical. Replicate trees were hailed for either 30 or 60 seconds. Adjacent non-hailed trees were used as controls. Ice pellets (1 cm diameter) were obtained from a commercial ice machine, and stored in polyethylene bags at -4°C until use. Just prior to use, the bags with the amount of ice needed to hail an individual tree were removed from storage, bounced on the tailgate of a pickup to loosen the material, and then fed into the hopper. The artificial hail was imposed 3 weeks prior to harvest.

The fruit was harvested at commercial maturity and stored at -1°C for 2 months. The fruit was removed from storage, ripened for 5 days at 20°C, and then evaluated for hail injury. At the same time, the fruit also was examined for storage rot, limb rub, scab, and russet.

Results and Discussion

Hail Injury

The results of the hail injury are shown in Table 1. Central Leader trees suffered the most total hail damage, with the Palmate and Marchand suffering the least tree damage (data not shown). With regards to fruit, the MIA and Spindle systems suffered the most damage, and fruit from the MCL suffered the least damage. Little difference in total hail damage was noted between the 30- and 60-second treatmens; however, the longer treatment resulted in less fruit without damage. Fruit from the Spindle and MIA systems exhibited the least amount of fruit with no damage, and fruit from MCL system had the greatest amount of fruit with no damage. The majority of the damage was caused by cuts and surface abrasion due to sharp edges on the ice. This is not a typical natural hail, and was an artifact of the way the synthetic hail was produced. Storing the ice at -4°C prior to use caused the ice pellets to freeze together. When the bags were bounced to loosen the material prior to us, the sharp edges were formed. Therefore, the degree of hail damage may not be indicative of natural hail. In the second year, when more typical hail was used, the Central Leader trees suffered the least total hail damage at the 15- and 30-second timings, and had similar damage to the Spindle system at the 60-second timing. This is in contrast to 1996, when the Central Leader experienced the greatest damage. With the exception of the Spindle system, all the other systems experienced more damage than the Central Leader at the 15-second timing, with the MIA and the Palmate exhibiting the most damage. Significant differences in hail damage existed only with the MIA at the 30-second timing. At the 60-second timing, no significant differences in damage were apparent.

Significant differences existed in the percentage of damage between the 0- and 15-second timings; these were evident for all systems except the Central Leader and Spindle. Between the 15- and 30-second timings, significant differences were apparent for all systems except the Palmate and Marchand. Between the 30- and 60-second timings, significant differences existed for all systems except the Spindle, with the Mid-Columbia Central Leader experiencing the greatest increase between the 30- and 60-second timing.

Storage Rot

Post-storage rot was greatest in fruit from the Palmate and CL systems and was not observable in fruit from the other systems (Table 2). Rot data was presented only for the control trees as the hail wounds would allow for easier entry of the decay organisms. There was a greater degree of rot in fruit from the hailed trees. The principal rot and decay organism present was *Mucor* sp., and it would have infected the fruit prior to harvest. There is no explanation at this time as to why fruit from only two of the systems became infected.

Limb Rub

Fruit from the MIA and Palmate systems exhibited the greatest amount of fruit without limb rub (Table 3). Fruit from the Marchand exhibited the greatest amount of limb rub, while Marchand fruit exhibited the greatest damage. Fruit from the CL and Spindle systems while having intermediate amounts of fruit without limb rub, exhibited the most fruit with severe limb rub. The degree of injury is related to the fruit-bearing branches, freedom to move, and the site is exposed to frequent winds.

Scab

Fruit from the MIA system exhibited the greatest amount of scab, while the Marchand fruit exhibited the least scab; however, differences were not significant. The site is adjacent to an apple block which has been used to produce processing fruit.

Strict scab control is not practiced in that block, and the 1996 season was the worst in recent time. No scab was observed in 1997.

Russet

The climate of the Mid-Columbia region is such that russet does occur in most years. The spring of 1996 was cool and wet and favored the development of non-specific russet. However, fruit from the CL and Palmate systems was free of russet. Fruit from the MIA, MCL, and Spindle systems had the least amount of clean fruit. These differences were not significant.

Summary

This preliminary study has shown that some systems may be more prone to hail damage, and that some of the systems may be more or less prone to other fruit marking defects. The study will be repeated for at least 2 more years, with changes in the ice manufacture to get more natural hail particles. This preliminary study has shown that some systems may be more prone to hail damage at relatively short intervals of hail exposure; however, with 60-second exposures, no significant differences between systems were observed.

Additionally, red and green d'Anjou, Bosc, and Starkrimson pears may be added to study the effect of training system on fruit marking.

Table 1. Effect of training system and length of hail period on fruit damage in 6-year-old Cascade pears.

		Percentage of fruit with hail damage			
System	Hail Time (sec)	None	Light	Moderate	Severe
Central Leader	0	100.0	0.0	0.0	0.0
	30	46.8	32.4	11.5	9.3
	60	23.9	39.2	21.9	15.0
Mid-Columbia Leader	0	100.0	0.0	0.0	0.0
	30	78.1	5.1	2.5	14.3
	60	60.0	14.3	9.8	18.9
Palmate	0	100.0	0.0	0.0	0.0
	30	51.1	37.2	10.0	1.7
	60	26.8	40.5	19.2	13.5
Marchand	0	100.0	0.0	0.0	0.0
	30	64.8	19.9	9.2	6.1
	60	34.9	38.0	14.9	12.2
Spindle	0	100.0	0.0	0.0	0.0
	30	30.0	19.9	18.9	8.1
	60	15.0	38.0	12.5	10.0
MIA	0	100.0	0.0	0.0	0.0
	30	32.6	30.0	11.8	25.6
	60	11.3	34.6	23.3	30.8

Table 2. Effect of training system on fruit with storage rot on 6-year-old Cascade pears.				
	Percentage of fruit with storage rot			
Training system	None	Light	Moderate	Severe
Central Leader	95.9	2.0	2.0	0.0
Mid-Columbia Leader	100.0	0.0	0.0	0.0
Palmate	92.4	6.3	1.3	0.0
Marchand	100.0	0.0	0.0	0.0
Spindle	100.0	0.0	0.0	0.0
MIA	100.0	0.0	0.0	0.0

Table 3. Effect of training system on fruit with limb rub on 6-year-old Cascade pears.				
	Percentage of fruit with limb rub			
Training system	None	Light	Moderate	Severe
Central Leader	59.2	14.3	20.4	9.1
Mid-Columbia Leader	49.5	29.6	19.0	1.8
Palmate	61.9	28.6	7.1	2.4
Marchand	38.0	33.0	24.1	4.9
Spindle	50.0	33.3	8.3	8.3
MIA	67.9	10.7	17.9	3.6

Table 4. Effect of training system on fruit with scab on 6-year-old Cascade pears.				
	Percentage of fruit with scab			
Training System	None	Light	Moderate	Severe
Central Leader	75.5	20.4	4.1	0.0
Mid-Columbia Leader	68.6	18.0	13.4	0.0
Palmate	76.2	16.7	4.8	2.4
Marchand	80.3	16.9	2.8	0.0
Spindle	73.2	16.2	10.6	0.0
MIA	62.8	22.3	14.8	0.0

Table 5. Effect of training system on fruit with russet on 6-year-old Cascade pears.				
	Percentage of fruit with russet			
Training System	None	Light	Moderate	Severe
Central Leader	100.0	0.0	0.0	0.0
Mid-Columbia Leader	80.1	11.5	7.5	0.9
Palmate	100.0	0.0	0.0	0.0
Marchand	93.0	5.6	1.4	0.0
Spindle	83.3	8.3	8.3	0.0
MIA	78.6	13.3	7.1	1.0

Table 6. Effect of training system and length of hail exposure on percent injury to fruit from 7-year-old Cascade pear trees in Hood River, Oregon.				
	Hail Time (seconds)			
Training System	0	15	30	60
Central Leader	0.0	0.4	2.3	8.0
Mid-Columbia Leader	0.0	2.6	4.4	15.6
Palmate	0.0	5.6	4.2	9.9
Marchand	0.0	3.4	4.9	9.3
Spindle	0.0	0.8	6.4	7.9
MIA	0.0	4.6	8.2	11.8
$LSD_{(.05)}$ – System	0.0	1.5	4.1	7.9
$LSD_{(.05)}$ – Time	0.0	1.1	1.8	2.3

Effect of Rootstock and Training System on Fruit Quality and Storability of d'Anjou and Bosc Pears

E.A. Mielke, P.M. Chen, and R.A. Spotts

Significant Findings

This project is due to terminate at the end of this year. The 1999-2000 samples are in storage, and will not be removed for analysis until May. The OSU laboratory normally processes tissue samples during the late summer; therefore, the final report will not be completed until next year. The data presented here is for the crop year 1998-1999.

Total fruit defects were greater in fruit from the 1998 crop season as compared with fruit from the 1997 crop season. Differences were noted between rootstocks and training systems in all of the defects examined in both Bosc and d'Anjou pears. The 1998 crop rootstock data is similar in the pattern of defects with respect to data from the 1997 crop season. While some overall relationships existed in nutrient levels (particularly N, P, K, Ca, S, and Cu) and defects, they are weak and cannot explain the differences that were observed between either rootstocks or training systems. This was true for both the d'Anjou and Bosc cultivars.

Fruit samples from the 1999 crop year were collected in the field and are in CA storage at -1°C. they will be evaluated for quality in May, after they are returned to regular storage for 1 month, then ripened for 5 days at 20°C, and reevaluated. Tissue samples have been collected and will be evaluated.

Objectives

The objective of this project is to determine the effect of rootstock and training system on the development of storage disorders and decay on d'Anjou and Bosc pears.

Procedures

D'Anjou and Bosc pears growing on a minimum of eight rootstocks were harvested at proper maturity. Four replicate boxes of fruit were collected at random from each rootstock-cultivar combination. The fruit was stored at -1°C in CA and regular refrigerated cold storage. The fruit was evaluated for the type and degree of storage disorder and decay after 8 months of storage. Ten additional fruits were collected at random from each lot at harvest, and the peels were analyzed for mineral content in the Plant Analysis Laboratory at Oregon State University.

D'Anjou and Bosc pears growing on a minimum of 10 training systems were harvested at proper maturity. Four replicate boxes of fruit were collected at random from each rootstock-cultivar combination. The fruit was stored at -1°C in CA and regular refrigerated cold storage. The fruit was evaluated for the type and degree of storage disorder and decay after 8 months of storage. Ten additional fruits were collected at random from each lot at harvest, and the peels were analyzed for mineral content in the Plant Analysis Laboratory at Oregon State University.

Results and Discussion

This project is due to terminate at the end of this year. The 1999-2000 samples are in storage, and will not be removed for analysis until May. The OSU laboratory will process the tissue samples in the late summer. Therefore, the final report will not be completed until next year. The data presented here is for the crop year 1998-1999.

Thirty d'Anjou and 28 Bosc training system-rootstock combinations were evaluated in 1998-1999 as in 1997-1998. The 198 fruit samples were evaluated for 18 parameters covering physical, insect, physiological, storage problems, disorders, and 12 mineral elements. To present this data and the 216 potential regression plots for each of the two cultivars would require approximately 250 pages. Therefore, data will be presented for the five "best" combinations and the five "worst" combinations. The summary report to be prepared after the completion of the analysis of the 1999 crop will provide all of the information over the 4-year life of the project. With the exception of the parameters where a large number of the combinations were "tied" for the top positions, the "best" five combinations were significantly different from the "worst" five combinations.

The "best" and "worst" combinations for each of the parameters for both cultivars are shown in Tables 1, 2, 3, 4, and 5. No single combination consistently appears as either "best" or "worst." Overall, the numerical values of the physical parameters were similar to the 1997 crop year. The numerical values for weather related, storage, and physiological parameters were somewhat higher in the 1998 crop than in the 1997 crop year. Physiological disorders were generally higher in Bosc as compared to d'Anjou. A number of relationships existed between fruit nutrient levels and the pre- and post-ripening defects. Similar relationships existed between the two cultivars. This was particularly true of N, P, K, Ca, S, and Cu; however, the peel nutrient levels do not explain the difference in defects which were found between rootstocks and/or training systems. The relationships were similar to those found in previous years. The correlations are weak, with R^2 values in range of -0.2 to +0.2.

Table 1. Effect of training system and rootstock on various parameters in d'Anjou and Bosc pears.

	Bosc				d'Anjou			
	Best Combinations		Worst Combinations		Best Combinations		Worst Combinations	
Parameter	System	Rootstock	System	Rootstock	System	Rootstock	System	Rootstock
Clear	CSPN	BET	CSPN	BAR	CPAL	OHxF217	MAR	OHxF040
	MIA	OHxF069	CLDR	OHXF217	CPAL	OHxF513	MCL	OHxF361
	CPAL	QC	CLDR	BAR	PAL	OHxF040	CLDR	OHxF040
	PAL	OhxFF069	CPAL	BAR	CLDR	OHxF333	CLDR	OHxF097
	MCL	OHxF040	CLDR	OHXF097	MAR	OHxF097	MCL	OHxF040
Russet		No apparent damage			CLDR	OHxF339	MCL	OHxF361
					CSPN	OHxF513	MIA	OHxF097
					CLDR	OHxF217	MAR	OHxF097
					CSPN	OHxF217	SPN	OHxF097
					CLDR	OHxF333	TAT	OHxF097
Limb Rub	MAR	OHxF069	CLDR	OHxF513	MCL	BAR	MCL	OHxF361
	MIA	OHxF069	CLDR	OHxF333	CLDR	BET	MCL	OHxF069
	MCL	OHxF069	CLDR	BAR	PAL	OHxF040	MIA	OHxF097
	MCL	OHxF040	CSPN	BET	CLDR	OHxF217	MCL	OHxF040
	CPAL	OHxF513	CPAL	QC	MAR	OHxF040	CSPN	OHxF333
Frost Marking	13 combinations		MIA	OHxF040	CLDR	OHxF513	CSPN	OHxF217
	tied as best		CSPN	BET	CSPN	OHxF333	MCL	OHxF051
			CPAL	QC	MCL	OHxF087	CPAL	CAL
			CLDR	OHxF069	PAL	OHxF040	CSPN	OHxF513
			PAL	OHxF040	MCL	BAR	CLDR	OHxF339

CLDR = Central Leader (Standard); CPAL = Central Palmate; CSPN = Central Spindle; MAR = Marchand; MCL = Mid-Columbia Leader; MIA = MIA; PAL = Palmate; SPN = Slender Spindle; TAT = Tatura; BAR = Bartlett; BET = Betulaefolia; CAL = Calleryana; and QC = BA29C Quince.

Table 2. Effect of training system and rootstock on various parameters in d'Anjou and Bosc pears.

	Bosc				d'Anjou			
	Best Combinations		Worst Combinations		Best Combinations		Worst Combinations	
Parameter	System	Rootstock	System	Rootstock	System	Rootstock	System	Rootstock
Sun Discoloration	PAL	OHxF040	CSPN	BET	CSPN	OHxF217	MAR	OHxF040
	CLDR	OHxF097	SPN	OHxF069	MCL	OHxF361	MIA	OHxF040
	CLDR	OHxF040	CSPN	BAR	MCL	OHxF051	SPN	OHxF040
	MIA	OHxF040	MIA	OHxF069	SPN	OHxF097	PAL	OHxF040
	CLDR	OHxF069	PAL	OHxF069	MCL	OHxF040	CSPN	OHxF513
Rust Mite		No apparent damage			MAR	OHxF097	MIA	OHxF097
					MCL	OHxF069	MCL	OHxF087
					MCL	OHxF361	MCL	OHxF051
					CLDR	OHxF040	MAR	OHxF040
					SPN	OHxF097	MIA	OHxF040
Pear Psylla		No apparent damage			CLDR	OHxF333	MAR	OHxF040
					CLDR	OHxF217	MCL	OHxF040
					CSPN	OHxF217	CLDR	OHxF097
					CPAL	OHxF513	PAL	OHxF097
					CLDR	OHxF339	SPN	OHxF097
Other Insect	CLDR	BAR	CLDR	OHxF069	CLDR	BET	CSPN	OHxF513
	CPAL	OHxF513	CLDR	OHxF018	PAL	OHxF097	MCL	OHxF069
	CSPN	BAR	CLDR	OHxF333	CLDR	OHxF513	MCL	OHxF361
	CSPN	BET	MIA	OHxF069	CPAL	OHxF217	CLDR	OHxF333
	MCL	OHxF069	SPN	OHxF069	PAL	OHxF040	MAR	OHxF097

CLDR = Central Leader (Standard); CPAL = Central Palmate; CSPN = Central Spindle; MAR= Marchand; MCL =Mid-Columbia Leader; MIA = MIA; PAL = Palmate; SPN = Slender Spindle; TAT = Tatura; BAR = Bartlett; BET = Betulaefolia; CAL = Calleryana; and QC = BA29C Quince.

Table 3. Effect of training system and rootstock on various parameters in d'Anjou and Bosc pears.

	Bosc				d'Anjou			
	Best Combinations		Worst Combinations		Best Combinations		Worst Combinations	
Parameter	System	Rootstock	System	Rootstock	System	Rootstock	System	Rootstock
Decay	CLDR	OHxF040	CPAL	OHxF513	SPN	OHxF040	TAT	OHxF097
	PAL	OHxF069	CPAL	BAR	CLDR	OHxF333	CLDR	BET
	CLDR	BAR	CLDR	OHxF513	MIA	OHxF097	CPAL	CAL
	CLDR	OHxF339	CSPN	BAR	MCL	OHxF097	CLDR	OHxF097
	MCL	OHxF069	CLDR	OHxF333	MCL	OHxF040	MCL	OHxF361
Scald		No damage apparent			CLDR	BET	MIA	OHxF097
					TAT	OHxF097	CLDR	OHxF333
					CPAL	CAL	SPN	OHxF040
					CLDR	OHxF097	PAL	OHxF040
					MCL	OHxF051	CPAL	OHxF513
Scab		No damage apparent			SPN	OHxF040	CSPN	OHxF513
					SPN	OHxF097	MCL	OHxF051
					CLDR	OHxF040	CLDR	OHxF339
					MCL	OHxF361	MCL	OHxF087
					MCL	OHxF097	CLDR	OHxF513
Physiological Spot	7 combinations		CPAL	QC	MIA	OHxF097	CLDR	OHxF333
	tied as best		CSPN	QC	MAR	OHxF097	MCL	BAR
			CLDR	OHxF040	CSPN	OHxF217	CLDR	OHxF217
			CLDR	BET	CLDR	BET	MCL	OHxF087
			CLDR	QC	CSPN	OHxF333	CSPN	OHxF513

CLDR - Central Leader (Standard); CPAL = Central Palmate; CSPN = Central Spindle; MAR = Marchand; MCL = Mid-Columbia Leader; MIA = MIA; PAL = Palmate; SPN = Slender Spindle; TAT = Tatura; BAR = Bartlett; BET = Betulaefolia; CAL = Calleryana; and QC = BA29C Quince.

Table 4. Effect of training system and rootstock on various parameters in d'Anjou and Bosc pears.

	Bosc				d'Anjou			
	Best Combinations		Worst Combinatins		Best Combinations		Worst Combinations	
Parameter	System	Rootstock	System	Rootstock	System	Rootstock	System	Rootstock
Shrivel	CPAL	OHxF513	CPAL	BAR	10 combinations		CSPN	OHxF217
	CLDR	OHxF513	PAL	OHxF040	tied as best		CPAL	CAL
	CLDR	BET	MIA	OHxF040			CLDR	OHxF339
	CLDR	OHxF339	CSPN	BAR			CLDR	OHxF333
	MCL	OHxF040	CLDR	BAR			CLDR	OHxF217
Internal cork	25 combinations		MCL	OHxF069	MCL	OHxF097	CLDR	BET
	tied as best		CLDR	OHxF069	MCL	OHxF051	SPN	OHxF097
			CPAL	BAR	MAR	OHxF040	PAL	OHxF097
					CLDR	OHxF339	MCL	OHxF069
					CLDR	OHxF097	MCL	OHxF361
External Cork	17 combinations		SPN	OHxF069	CLDR	OHxF040	CLDR	BET
	tied as best		SPN	OHxF040	MCL	OHxF097	PAL	OHxF097
			PAL	OHxF069	CPAL	OHxF333	MCL	OHxF361
			PAL	OHxF040	MCL	OHxF087	SPN	OHxF097
			MIA	OHxF069	PAL	OHxF040	CPAL	OHxF217
Flesh Browning	22 combinations		PAL	OHxF040	24 combinations		CLDR	OHxF097
	tied as best		MIA	OHxF069	tied as best		CLDR	BET
			CLDR	BET			MCL	OHxF361
			MIA	OHxF040			SPN	OHxF040
			CPAL	OHxF513			MCL	OHxF069

CLDR = Central Leader (Standard); CPAL = Central Palmate; CSPN = Central Spindle; MAR = Marchand; MCL = Mid-Columbia Leader; MIA = MIA; PAL = Palmate; SPN = Slender Spindle; TAT = Tatura; BAR = Bartlett; BET = Betulaefolia; CAL = Calleryana; and QC = BA29C Quince.

Table 5. Effect of training system and rootstock on various parameters in d'Anjou and Bosc pears.

	Bosc				d'Anjou			
	Best Combinations		Worst Combinations		Best Combinations		Worst Combinations	
Parameter	System	Rootstock	System	Rootstock	System	Rootstock	System	Rootstock
Core Browning	24 combinations		CLDR	OHxF069	16 combinations		CPAL	OHxF513
	tied as best		CLDR	BET	tied as best		CPAL	CAL
			CLDR	OHxF018			CLDR	OHxF217
			CPAL	OHxF513			CSPN	OHxF513
							CLDR	OHxF513
Pithy Brown Core	26 combinations		CLDR	OHxF069	25 combinations		CLDR	BET
	tied as best		CPAL	QC	tied as best		MCL	OHxF069
							CLDR	OHxF339
							CPAL	CAL
							MCL	OHxF097

CLDR = Central Leader (Standard); CPAL = Central Palmate; CSPN = Central Spindle; MAR = Marchand; MCL = Mid-Columbia Leader; MIA = MIA; PAL = Palmate; SPN = Slender Spindle; TAT = Tatura; BAR = Bartlett; BET = Betulaefolia; CAL = Calleryana; and QC = BA29C Quince.

Storage Behavior and Handling of Concorde Pear as Influenced by Harvest Maturity

E.A. Mielke and P. M. Chen

Significant findings

Concorde pears were harvested at two times, just prior to the onset of commercial CA d'Anjou harvest and 2 weeks later in the Hood River, Peshastin, and Lake Chelan areas. At initial harvest, fruit from the Lake Chelan area were slightly less firm (0.6 pounds) than the fruit from the Peshastin and Hood River areas. Fruit from the Peshastin area was 0.4 pounds less firm than the first from the other two areas at the second harvest. Fruit was placed in either conventional air storage or CA storage at −1°C. CA conditions were 0.7% O_2 and <0.1% CO_2 for the first 100 days, then 2% O_2 and 1% CO_2 for the remainder of the storage period.

Fruit from all areas at harvest was incapable of ripening normally, in that it did not soften or develop a smooth texture; however, after 2 months of conventional storage, fruit from all areas was able to ripen properly. Fruit from the two harvests did not ripen significantly different. Fruit was placed on a brush bed using a combination 0.050 Peck/horsehair brush for 30, 60, 120, and 240 seconds at a speed of 60 rpm (60 seconds previously had shown damage to Comice and was twice the speed normally used for pears). Harvest and 2-month storage samples exhibited no scuffing damage at any of the scuffing times. Additional samples from conventional storage and the samples from CA storage will be evaluated following the prescribed storage intervals. We wish to thank Robert Peterson and Randy Smith for their cooperation with this project.

Objectives

Determine the storage life, chilling requirement, and ripening quality of Concorde pears as influenced by harvest maturity, storage conditions, and production region.

Determine the resistance to handling-induced scuffing of Concorde pears as influenced by harvest maturity and production region.

Procedures

Fruit from the Hood River and Wenatchee Valleys was harvested two times: (1) at onset of commercial CA green d'Anjou harvest; and (2) two weeks later.

At each harvest in each location, 19 boxes of fruit were harvested and packed into boxes with polyliners. Nine boxes of fruit were stored in conventional refrigerated storage at -1 °C, and nine boxes were stored in controlled atmosphere conditions. One box from each harvest was utilized to determine the initial flesh firmness (FF), total acidity (TA), and soluble solids (SS).

After 1, 2, or 4 months conventional storage, or 4, 6, or 8 months CA storage, three boxes of fruit was or will be transferred to a ripening room at 68°F. After day 1, 3, 5, and 7 of ripening at 20°C, FF, TA, and SS are evaluated. On day 7 of ripening, the dessert quality of the ripened fruit is assessed.

At harvest and following each storage cycle, fruit from each location will be utilized to determine the sensitivity to skin scuffing. The fruit from each sample lot will be divided into four lots and each lot placed on a brush bed operating at 60 rpm for 1, 2, or 4 minutes. The control will consist of non-scuffed fruit. The fruit will be transferred to a ripening room at 20°C for 7 days and the degree of scuffing evaluated.

Results and Discussion

The effect of location, harvest date, and length of storage for the initial and 1- and 2-month conventional storage periods are shown in Table 1. As the experiment has not been completed, a statistical evaluation of the data has not been performed. At the initial harvest date, the fruit from location 2 (Lake Chelan) was slightly lower in flesh firmness (0.6 pounds). At the second harvest date, the fruit from location 3 (Peshastin) was slightly less firm (0.4 pounds). Fruit from the second harvest date was 1.1 and 2.0 pounds softer than fruit from the first harvest date.

Over the 7-day ripening period, the flesh firmness of the fruit evaluated at harvest dropped an average of 2.7 pounds for harvest 1 and 3.0 pounds for harvest 2. This indicated that the fruit did not have the ability to ripen immediately after harvest. During the 1 or 2 months of storage, the fruit dropped approximately ½ pound of pressure. During the 7-day ripening period following 1 month of storage, fruit from harvest 1 dropped 8.3 pounds in firmness, and fruit from harvest 2 dropped 6.7 pounds in firmness. Following 2 months of storage, fruit from harvest 1 dropped 8.4 pounds in firmness, and the fruit from harvest 2 dropped 6.7 pounds in firmness. The large drops in pressure indicate that the fruit has the basic ability to ripen. While the data has not yet been analyzed statistically, previous experience has indicated that the small differences between locations (less than 1 pound) would not be statistically significant.

Total acid in unripened and ripened fruit is shown in Table 2. Total acid was lower in harvest 2 fruit as compared to harvest 1 fruit after 1 month of storage. Within the same harvest period, total acid was also lower in fruit stored for 2 months as compared to fruit stored for 1 month. Soluble solids were similar between locations and storage length in unripened fruit. The soluble solid content of ripened fruit was higher than that found in the unripened fruit.

After 7 days of ripening, fruit texture was more desirable in fruit from harvest 2 as compared to fruit from harvest 1. The length of storage (through 2 months) slightly improved fruit texture, but it is highly unlikely that the differences will be significant. Fruit flavor improved between harvest 1 and harvest 2, and between 1 and 2 months of storage.

Based on the data collected so far, it has been determined that Concorde pears need at least 30 days of cold storage before they have the ability to ripen. The later (post-d'Anjou) harvest date ripens slightly faster with higher flavor and better texture. The later harvest provides higher quality under short-term conventional storage conditions.

Table 1. Effect of harvest date, length of storage, and days of ripening on flesh firmness in Concorde pears.

				Flesh Firmness (lb) Day of Ripening			
Location	Harvest	Storage Month	Flesh Firmness at Harvest (lb)	1	3	5	7
1	1	0	15.2	15.1	14.8	13.9	12.2
		1	-	14.9	12.3	8.6	6.3
		2	-	14.7	12.1	6.4	5.9
	2	0	13.4	13.5	12.7	11.6	10.7
		1	-	13.1	11.5	8.1	5.9
		2	-	13.2	10.9	6.5	6.0
2	1	0	14.6	14.7	14.6	13.7	12.5
		1	-	14.5	12.1	8.2	6.4
		2	-	14.1	10.9	6.3	6.0
	2	0	13.5	13.4	12.5	11.5	10.1
		1	-	13.1	12.2	8.3	6.1
		2	-	12.9	11.1	6.4	6.1
3	1	0	15.1	14.9	14.9	13.3	12.1
		1	-	14.4	11.9	8.4	6.2
		2	-	14.2	11.2	6.6	5.8
	2	0	13.1	13.0	12.3	10.9	10.3
		1	-	12.2	12.1	8.2	6.3
		2	-	11.9	10.8	6.4	5.7

Table 2. Effect of harvest date, length of storage, and days of ripening on total acid, soluble solids, texture, and flavor of Concorde pears.

			Total Acid (meq/100 ml)		Soluble Solids			
Location	Harvest	Storage Month	Unripe	Ripe	Unripe (%)	Ripe (%)	Texture	Flavor
1	1	0	-	-	-	-	-	-
		1	4.97	4.93	12.9	13.5	5.3	4.7
		2	4.11	4.12	13.2	13.4	5.4	4.9
	2	0	-	-	-	-	-	-
		1	4.68	4.61	12.6	13.7	7.3	5.3
		2	4.57	4.52	12.9	13.8	7.8	6.1
2	1	0	-	-	-	-	-	-
		1	4.89	4.81	13.1	13.4	5.1	4.3
		2	4.03	4.74	13.2	13.6	5.5	4.9
	2	0	-	-	-	-	-	-
		1	4.71	4.69	12.9	13.5	7.9	5.4
		2	4.51	4.73	12.8	13.7	7.9	6.4
3	1	0	-	-	-	-	-	-
		1	4.87	4.79	12.8	13.1	5.0	5.1
		2	4.10	4.68	13.3	13.3	5.6	5.4
	2	0	-	-	-	-	-	-
		1	4.62	4.64	12.5	13.6	7.6	5.3
		2	4.49	4.61	12.6	13.8	8.1	6.2

Gala Dwarf Apple Trial

E.A. Mielke and L.A. Smith

Introduction

New apple rootstocks are being developed continually in the United States and other countries around the world. Generally, growers have progressed from conventional full-sized trees to smaller semi-dwarf and finally to full dwarfing rootstocks. Apples make up a small percentage of the tree fruits grown in the Mid-Columbia Region, and growers generally have progressed from full-sized trees on seedling rootstocks to smaller semi-dwarfing or full dwarfing rootstocks. The purpose of this project is to examine some of the newer dwarfing rootstocks that have shown superior performance around the world.

The initial (4-year) results indicate that a number of the rootstocks appear to be better than the standard EMLA 9 and EMLA 27 rootstocks with regards to productivity and fruit size in the dwarfing class. These initial findings, while informative, should be viewed with caution until more experience is gained with these rootstocks.

Procedures

In 1994, a dwarf Gala apple planting was established on 19 dwarfing rootstocks (M26 to EM 27 size). The trial included six Malling 9 selections. The rootstocks included: B-9, B-469, B-491, CG 65, EMLA26, EMLA27, Mark, Ottawa 3, P-2, P-16, P-22, V-605-1, and V-605-3. It has been determined that one rootstock was not true to type, and it is being maintained as an unknown (UNK 3). Malling 9 rootstock selections included: EMLA9, Fleuren, Nic 29, Pajam 1, Pajam 2, and T337. The plot was established as a randomized complete block design with 10 replicates. Tree spacing was 11.5 x 16 ft. The trees were trained to a modified Central Leader/Spindle system. Annually, the trees are measured for trunk circumference, height, width, and yield. The trees are harvest three times.

Results and Discussion

Survival

The effect of dwarfing rootstocks on tree survival is shown in Table 1. Two of 10 trees with Ottawa 3 roots failed to survive, as did 1 of 10 trees with EMLA 27 and V-605-1 roots.

Growth

Based on either trunk cross-sectional area (TCSA) or canopy volume, trees with P-22 roots were the smallest, and trees with UNK 3 roots were the largest (Table 1). TCSA gives a measure of the total biomass of the tree. Within a single compound genetic system (rootstock and scion), TCSA can reflect tree size accurately; however, it is not a particularly good measure of tree size when comparing different compound genetic systems. Differences in relative size occurred with the two systems. The Fleuron clone of M.9 was the least vigorous M.9 selection, with the Pajam 2 clone being the largest. Significant differences in tree height, spread, and volume were noted, both between the rootstocks and between the Malling 9 selections. While root suckering was a minor problem generally, trees with UNK 3 rootstocks produced almost 20 times the number of suckers as compared to any other trees. Differences in root suckers were noted in the M.9 clones. Trees with Mark rootstocks exhibited significant amounts of the root proliferation callusing for which it is noted.

Flowering and Fruiting

Rootstock slightly affected first bloom, and significantly affected the date of full bloom (Table 1). There was a 3-day variation in both first and full bloom dates. The period between first and full bloom ranged from 4 to 6 days in 1997. Nine of the 19 selections required only 4 days, 5 of the 19 selections required 5 days, and the remaining 5 selections required 6 days. The Nic 29 and Fleuron clones of M.9 demonstrated the latest full bloom dates. The Malling 9 selections generally had a longer time interval between first and full bloom. Only one of the selections (Pajam 2) required 4 days, while the remaining selection required 5 or 6 days.

Yield was least on trees with P-22 roots, and greatest on trees with Nic 29 and Ottawa 3 roots (Table 2). The dwarfing rootstocks affected fruit maturity (Table 3). Trees with the T337 clone of M-9 matured the latest, and trees with EMLA 27 roots matured the earliest. Approximately a two and one-half fold difference was noted in cumulative production (Table 4). The smallest trees generally had the lowest yield, and the largest trees generally had the greatest yield; however, the relationship is not significant, as a great deal of variability existed in yield efficiencies (Table 4). Relative differences were noted between the volume based system and trunk cross-sectional area based systems. Fruit size was the largest on the first harvest date with two-thirds of the rootstocks (Table 3). Average fruit size was the largest on trees with B-9 roots, and smallest on trees with B-469 and Pajam 1 roots.

Summary

The initial (4-year) results indicate that a number of the rootstocks appear to be better than the standard EMLA 9 and EMLA 27 rootstocks with regards to productivity and fruit size in the dwarfing class. These initial findings, while informative, should be viewed with caution until more experience is gained with these rootstocks.

Acknowledgment

This program was begun as part of the Regional Strategy Program.

Table 1. Effect of rootstock on trunk cross-sectional area, bloom date, and tree size in 4-year-old Gala dwarf apples.

			Increase in TCSA 96-97		Bloom Dates		1997 Tree Size		% Increase		Tree Volume (m^3) (.2454*d2*h)	
Rootstock	Percent Survival	Fall 97 TCSA (cm^2)	(cm^2)	%	First	Full	Height (m)	Spread (m)	Height	Spread	97	% Incrs.
P-22	100	12.2	3.6	40.4	4-28	5-1	2.28	1.8	6.2	20.5	1.9	56.2
EMLA 27	90	15.3	5.5	56.5	4-27	5-1	2.41	2.0	8.7	14.3	2.4	41.6
B-469	100	17.8	5.3	42.3	4-27	5-2	2.42	2.0	-1.0	3.1	2.5	5.5
P-16	100	12.3	3.8	45.8	4-27	5-1	2.44	2.0	0.0	13.4	2.5	30.4
B-491	100	14.8	6.1	69.9	4-27	5-1	2.69	2.1	3.8	22.3	3.1	56.7
V-605-3	100	17.5	6.4	57.5	4-28	5-1	2.74	2.1	5.3	8.8	3.2	25.6
Mark	100	22.4	5.7	34.1	4-28	5-1	2.58	2.4	6.1	13.0	3.7	38.5
M.9 (Fleuren)	100	20.0	7.0	55.1	4-28	5-3	2.80	2.4	-3.0	5.5	3.9	9.4
M.9 (T337)	100	21.5	8.1	61.9	4-27	5-2	2.87	2.4	-0.5	5.8	4.2	11.5
EMLA 9	100	22.9	8.1	58.7	4-28	5-2	3.01	2.4	4.6	4.3	4.6	17.0
P-2	100	26.3	9.5	56.3	4-28	5-1	2.85	2.6	-2.2	6.9	4.6	12.5
M.9 (Pajam 1)	100	26.5	9.5	56.6	4-28	5-2	3.09	2.6	2.0	2.5	5.1	9.1
EMLA 26	100	30.1	11.5	62.3	4-28	5-1	3.15	2.7	2.9	9.9	5.1	24.9
M.9 (Nic 29)	100	26.4	8.7	50.1	4-28	5-3	3.05	2.6	0.6	9.6	5.3	22.9
Ottawa #3	80	28.0	10.7	62.4	4-28	5-1	3.09	2.8	5.9	16.2	5.3	44.0
B-9	100	26.7	9.4	54.9	4-26	5-1	3.30	2.8	9.0	14.4	6.3	42.6
M.9 (Pajam 2)	100	29.3	10.5	55.7	4-28	5-1	3.16	2.8	0.5	5.9	6.4	13.9
V-605-1	90	32.2	11.6	56.6	4-28	5-1	3.36	2.9	1.6	11.6	7.0	27.2
CG 65	100	54.3	21.9	67.3	4-28	5-2	3.95	3.4	4.4	6.4	11.4	24.0

Table 2. Effect of rootstock on harvest date, fruit number, and yield in 4-year-old Gala dwarf apples.

			Harvest Date			Fruit Number			Yield (kg)			
Rootstock	Vol/TCSA (m^3/cm^2) 97	Number of Root Suckers	1st[t]	2nd	3rd	1st	2nd	3rd	1st[t]	2nd	3rd	Total
P-22	0.1	1.3	8-23	8-29	9-3	4.5	17.3	11.9	0.7	3.0	1.6	5.4
EMLA 27	0.2	0.0	8-23	8-29	9-3	6.7	18.2	11.1	1.2	3.3	1.4	5.8
B-469	0.1	0.9	8-23	8-29	9-3	7.1	25.0	23.9	1.2	4.3	3.7	8.8
P-16	0.2	0.6	8-23	8-29	9-3	5.9	25.9	14.1	1.2	4.7	1.9	7.8
B-491	0.2	0.7	8-23	8-29	9-3	5.5	19.4	18.7	1.0	3.6	2.7	7.3
V-605-3	0.2	0.0	8-23	8-29	9-3	6.5	30.4	20.5	1.3	5.3	2.7	9.3
Mark	0.2	0.9	8-23	8-29	9-3	7.0	35.8	30.9	1.2	6.3	4.3	11.8
M.9 (Fleuren)	0.2	0.3	8-23	8-29	9-3	3.2	23.2	28.2	0.5	4.2	4.1	8.8
M.9 (T337)	0.2	0.4	8-21	8-29	9-3	2.8	31.9	31.4	0.5	6.2	4.5	11.1
EMLA 9	0.2	0.6	8-23	8-29	9-3	7.6	37.3	22.5	1.5	7.5	3.8	12.8
P-2	0.2	0.2	8-23	8-29	9-3	5.9	31.4	37.0	1.1	5.9	6.0	12.9
M.9 (Pajam 1)	0.2	0.4	8-23	8-29	9-3	4.9	33.2	29.8	1.0	6.4	4.9	12.3
EMLA 26	0.2	0.1	8-21	8-29	9-3	9.6	25.3	34.8	1.8	4.7	5.3	11.7
M.9 (Nic 29)	0.2	1.3	8-23	8-29	9-3	6.0	40.4	35.9	1.2	7.8	5.7	14.7
Ottawa #3	0.2	0.3	8-23	8-29	9-3	7.6	38.5	45.0	1.4	6.9	6.5	14.7
B-9	0.2	3.0	8-23	8-29	9-3	3.3	34.4	31.4	0.7	6.9	5.2	12.7
M.9 (Pajam 2)	0.2	3.3	8-23	8-29	9-3	7.3	37.9	28.0	1.5	7.8	4.5	13.8
V-605-1	0.2	0.4	8-23	8-29	9-3	6.9	31.7	18.4	1.3	5.7	2.6	9.6
CG 65	0.2	20.1	8-23	8-29	9-3	7.3	32.2	20.2	1.4	6.0	3.1	10.5

Table 3. Effect of rootstock on distribution of harvest and fruit weight in 4-year-old Gala dwarf apples.

		Percent of Fruit by Number Harvest			Percent of Fruit by Weight Harvest			Fruit Weight (g) Harvest			
Rootstock	Tons per Acre	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	Average
P-22	2.1	15.2	54.2	30.6	15.5	57.9	26.6	178.0	185.0	146.4	169.5
EMLA 27	2.3	21.8	51.3	26.9	23.6	54.3	22.1	182.2	183.1	145.7	171.8
B-469	3.5	7.8	46.6	45.6	8.1	48.8	43.1	173.2	169.0	145.0	160.6
P-16	3.1	14.2	56.8	29.0	15.4	62.5	22.0	186.2	182.6	118.6	162.4
B-491	2.9	13.0	47.6	39.4	14.6	50.8	34.6	186.0	188.4	150.4	174.7
V-605-3	3.7	12.3	54.3	33.4	15.1	56.7	28.2	209.4	174.3	130.6	171.4
Mark	4.7	10.4	49.0	40.6	11.0	53.8	35.2	174.7	178.5	138.9	164.0
M.9 (Fleuren)	3.5	6.0	46.0	48.1	6.4	53.1	40.5	171.2	183.5	130.3	161.7
M.9 (T337)	4.4	3.1	50.3	46.6	3.3	57.5	39.2	191.6	186.5	134.4	163.3
EMLA 9	5.0	12.9	53.7	33.5	14.0	56.3	29.8	196.1	195.5	154.2	182.0
P-2	5.1	9.2	43.6	47.2	9.9	46.8	43.3	182.6	184.6	157.6	174.8
M.9 (Pajam 1)	4.9	10.8	53.0	36.2	12.3	55.3	32.4	202.9	190.2	162.6	184.8
EMLA 26	4.6	15.5	32.2	52.3	17.7	35.4	47.0	193.9	190.3	148.2	177.5
M.9 (Nix 29)	5.8	6.4	50.2	43.4	7.0	54.8	38.2	200.4	193.7	155.0	180.0
Ottawa #3	5.8	8.0	40.4	51.7	8.9	44.7	46.4	192.9	185.6	145.4	172.6
B-9	5.0	4.7	50.7	44.6	5.6	55.0	39.3	220.4	204.6	161.6	193.7
M.9 (Pajam 2)	5.5	10.1	50.2	39.7	10.7	54.4	34.9	205.9	203.7	164.8	191.5
V-605-1	3.8	10.7	53.1	36.1	12.4	54.5	33.1	198.1	171.8	147.2	170.7
CG 65	4.2	14.8	56.3	28.8	17.2	57.2	25.6	199.2	175.9	154.9	178.7

Table 4. Effect of rootstock on accumulated yield and yield efficiency in 4-year-old Gala apples.

	Accumulated Yield 1995-97			Yield Efficiency 1997 Yield (kg)/	
Rootstock	Lb Fruit	Wt (kg)	Tons/Acre	(m^3) of Tree Volume	(cm^2) of TCSA
P-22	75.5	12.3	4.9	3.067	0.434
EMLA 27	98.7	15.3	6.0	2.497	0.386
B-469	118.9	17.9	7.1	3.744	0.500
P-16	106.3	16.8	6.6	3.303	0.604
B-491	95.4	15.0	5.9	2.460	0.494
V-605-3	130.8	20.0	7.9	2.997	0.529
Mark	176.9	25.9	10.2	3.366	0.527
M.9 (Fleuren)	133.3	21.7	8.6	2.385	0.443
M.9 (T337)	141.8	23.0	9.1	2.523	0.505
EMLA 9	150.3	25.5	10.1	2.887	0.542
P-2	194.0	30.3	12.0	2.801	0.482
M.9 (Pajam 1)	162.3	27.0	10.7	2.373	0.468
EMLA 26	147.0	23.7	9.4	2.201	0.405
M.9 (Nic 29)	180.9	30.0	11.9	2.810	0.552
Ottawa #3	186.6	28.2	11.2	2.590	0.537
B-9	171.4	28.4	11.2	2.055	0.488
M.9 (Pajam 2)	191.5	32.4	12.8	2.339	0.487
V-605-1	175.6	26.5	10.5	1.349	0.301
CG 65	205.9	29.7	11.7	0.832	0.183

Gala Semi-Dwarf Apple Trial

E.A. Mielke and L.A. Smith

Introduction

New apple rootstocks are being developed continually in the United States and other countries around the world. Generally, growers have progressed from conventional full-sized trees to smaller semi-dwarf and finally to full dwarfing rootstocks. Apples make up a small percentage of the tree fruits grown in the Mid-Columbia Region, and growers generally have progressed from full-sized trees on seedling rootstocks to smaller semi-dwarfing or full dwarfing rootstocks. The purpose of this project is to examine some of the newer semi-dwarfing rootstocks that have shown superior performance around the world.

The initial (4-year) results indicate that G.30 and V.2 rootstocks appear to be better than the standard M.26 EMLA rootstocks with regards to productivity in the semi-dwarfing class. These initial findings, while informative, should be viewed with caution until more experience is gained with these rootstocks.

Procedures

In 1994, a semi-dwarf Gala planting was established on six semi-dwarfing rootstocks (M26 to EM 7a size). The rootstocks included M.26 EMLA, P.1, V.2, CG.13, G.11, and G.30. The plot was established as a randomized complete block design with 10 replicates. Tree spacing was 10 x 16 ft. The trees were trained to a modified Central Leader/Spindle system. It was determined in 1997 that two of the Cornell-Geneva combinations were not true to type (CG.13 and G.11), and though they were unknown, data was collected on them initially. By the end of 1997, it was apparent that the two selections were excessively large in size and relatively non-fruitful. These trees were removed in the winter 1998-1999. Annually, the trees are measured for trunk circumference, height, width, and yield. The trees are harvested three times.

Results and Discussion

Growth

The effect of semi-dwarfing rootstocks on growth and tree size of 4-year-old Gala apples is shown in Table 1. Because data was collected on the two unknown rootstocks, it is presented here. Based on trunk cross-sectional area (TCSA), M.26 EMLA rootstocks produced the smallest trees and UNK 1 the largest trees. Based on tree volume, P.1 produced the largest trees, and V.2 the smallest trees. There is little correlation between tree volume and TCSA as shown by the variability in volume to TCSA ratio. Little differences are seen in height, as the trees have nearly reached their allowable height. Trees with M.26 EMLA roots had the smallest branch spread, and trees with V.2 had the greatest branch spread.

Flowering and Fruiting

First bloom was delayed slightly on the trees with P.1 and V.2 rootstocks; however, full bloom was not affected (Table 2). Trees on G.30 roots produced the greatest number of fruits and the greatest yield. With the exception of the two unknown stocks, trees on P1 roots produced the least number of fruit and the least production. Slight differences were seen in harvest maturity (Table 3). Trees on M.26 EMLA and V.2 roots matured earlier than the other trees, while trees on G.30 matured later. Fruit size was smallest on trees with G.11 roots, and largest on trees with V.2 roots (Table 3). Fruit size was not related to yield. Fruit size generally was largest at the first harvest date and least at the last harvest date. Accumulated yield was greatest in trees with G.30 roots, and least in trees with G.11 roots (Table 4). Yield efficiency was best in trees with M.26 EMLA roots (Table 4).

Summary

The initial (4-year) results indicate that G.30 and V.2 rootstocks appear to be better than the standard M.26 EMLA rootstocks with regards to productivity in the semi-dwarfing class. These initial findings, while informative, should be viewed with caution until more experience is gained with these rootstocks.

Table 1. Effect of rootstock on trunk cross-sectional area, bloom date, and tree size in 4-year-old Gale semi-dwarf apples.

						1997 Tree Size						
		Increase in TCSA 96-97						% Increase		Tree Volume (m^3) (0.2454*d2*h)		
Rootstock	Fall/97 TCSA (cm^2)	(cm^2)	% Incrs.	First	Full	Height (m)	Spread (m)	Height	Spread	97	% Incres.	Vol.TCSA (m^3/cm^2) 97
P.1	49.4	20.5	75.3	4-28	5-2	3.74	3.36	3.1	15.9	10.60	40.2	0.210
V.2	35.5	11.2	52.2	4-28	5-2	3.25	3.20	-1.1	15.5	8.20	32.2	0.231
G.11	49.9	24.4	101.3	4-27	5-2	3.87	3.04	13.4	26.5	9.02	82.8	0.179
CG.13	52.7	25.2	95.5	4-27	5-2	3.92	3.13	7.6	19.8	9.49	56.0	0.180
G.30	35.3	12.0	54.2	4-27	5-2	3.60	3.27	3.6	15.6	9.57	38.7	0.269
M.26 EMLA	31.7	11.9	59.9	4-27	5-2	3.28	2.86	5.3	16.6	6.68	43.6	0.211

Table 2. Effect of rootstock on harvest date, fruit number, and yield in 4-year-old Gala semi-dwarf apples.

		Harvest Date			Fruit Number				Yield (kg)			
Rootstock	Number of Root Suckers	1st	2nd	3rd	1st	2nd	3rd	Total	1st	2nd	3rd	Total
P.1	0.5	8-23	8-29	9-3	1.3	17.4	27.2	45.9	0.3	3.3	4.1	7.7
V.2	1.4	8-23	8-29	9-3	6.2	29.4	26.9	62.5	1.3	5.9	4.5	11.8
G.11	2.7	8-23	8-30	9-3	2.3	14.3	19.8	35.9	0.3	2.4	2.7	5.4
CG.13	1.2	8-23	8-29	9-3	1.2	16.3	27.7	42.3	0.2	3.1	3.8	7.1
G.30	2.4	8-23	8-29	9-3	5.0	37.8	81.2	124.0	0.9	7.6	13.1	21.6
M.26 EMLA	0.2	8-21	8-29	9-3	10.4	29.3	57.3	84.4	1.7	4.3	7.8	13.8

Table 3. Effect of rootstock on distribution of harvest and fruit weight in 4-year-old gala semi-dwarf apples.

	Percent of Fruit by Number Harvest			Percent of Fruit by Weight Harvest			Fruit Weight (g) Harvest			
Rootstock	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	Average
P.1	2.8	38.3	59.0	3.4	43.7	52.9	221.8	196.4	150.3	184.5
V.2	11.0	47.2	41.8	13.1	49.3	37.6	209.0	194.7	161.8	188.5
G.11	5.3	38.2	56.5	5.9	42.9	51.2	173.7	173.1	134.1	157.3
CG.13	3.9	43.4	52.7	4.4	47.2	48.4	177.7	181.8	151.9	169.5
G.30	4.7	32.5	62.8	5.0	36.5	58.5	176.6	200.2	158.8	178.8
M.26 EMLA	12.5	28.9	58.5	13.9	30.8	55.3	183.5	174.3	150.7	168.3

Table 4. Effect of rootstock on accumulated yield and yield efficiency in 4-year-old Gala semi-dwarf apples.					
	Accumulated Yield 1995-97			Yield Efficiency 1997 Yield (kg)/	
Rootstock	lb Fruit	Wt (kg)	Tons/Acre	(m^3) of Tree Vol.	(cm^2)of TCSA
P.1	142.2	20.9	4.8	0.7	0.2
V.2	147.0	23.7	5.5	1.4	0.3
G.11	76.9	10.9	2.5	0.6	0.1
CG.13	89.6	13.1	3.0	0.7	0.1
G.30	225.0	37.0	8.6	2.3	0.6
M.26 EMLA	166.9	25.6	5.9	2.2	0.4

Update of Entomology Research at the Mid-Columbia Agricultural Research and Extension Center

H. Riedl

Research Activities

As in the past, the entomology research program at the Center strives to provide the fruit industry with safe and effective control tools for the insect and mite problems they face every year. The overall goal has been to develop and implement integrated pest management (IPM) programs for tree fruits in the Mid-Columbia area, which are less reliant on broad-spectrum pesticides and emphasize the use of selective, less harmful control alternatives. The main themes in our research have been: selective control tactics for major and minor fruit pests; monitoring and management of insecticide and acaricide resistance in tree fruit pests; pesticide effects on natural enemies; prediction of pest phenology; cultivar susceptibility to pest attack; and pest management under conventional, organic, and integrated fruit production (IFP) systems.

Evaluation of New Insecticides/Miticides and Other Control Technologies

The food Quality Protection Act (FQPA) is threatening the continued use of broad-spectrum pesticides, especially the organophosphates (OPs), which have been the backbone of pest control programs on tree fruits for many years. At the very least, use requirements for many organophosphate insecticides are expected to change and make the use of these products more difficult. Fortunately, there are several new pesticide chemistries which are being developed by the agricultural chemical industry as replacements, among them several neonicotinoids, insect growth regulators such as the ecdysone agonists, Success (spinosad), and indoxacarb. In addition, alternative control technologies are becoming available as replacements for old pesticides.

A large number of registered and experimental compounds, microbials, and non-chemical control methods are being tested annually as part of an on-going effort to evaluate controls for various pests on apples, pears, and sweet cherries and to determine potential problems (e.g., disruptiveness to natural enemies, phytotoxicity) and fir with integrated control programs. Most of this research is conducted with support from the agricultural chemical industry and is summarized every year in the Annual Report of Research in Entomology. This report is available free of charge. The following are some of the highlights of the research which was conducted in 1999.

Neonicotinoids

Provado (imidacloprid) was the first insecticide of this new class which received registration for use on apples and pears. Recently, we have tested two additional neonicotinoids, Actara (thiamethoxam) and Calypso (thiacloprid), for control of several pest species on apples and pears. Similar to Provado, Actara is active primarily against sucking insects and has shown activity in our tests against white apple leafhopper and aphids. A large pear psylla trial will be conducted with Actara this season. Calypso has been effective against codling moth, tentiform leafminer, and white apple leafhopper. At high rates or with repeated applications, some neonicotinoids at times have caused a build-up of spider mites.

Insect growth regulators (IGRs)

The major group of IGRs we have investigated over the last 10 years are the ecdysone agonists. These are insect growth regulators which interfere with the moulting process. One characteristic of this insecticide chemistry is its selectivity to natural enemies, since it is active primarily against lepidopterous pests. The two ecdysone agonists we have worked with are Confirm (tebufenozide) and Intrepid (methoxyfenozide; RH-2485). Confirm is registered now and controls leafroller, but it is somewhat weak on codling moth. It performs adequately against codling moth as part of a seasonal program with OP insecticides. Due to its selectivity, Confirm has a good fit with mating disruption. Intrepid is under development and is as selective as Confirm to natural enemies. Intrepid has shown better performance than Confirm against codling moth on apples and has been as effective as *Bt* sprays or Success (spinosad) against obliquebanded leafroller on sweet cherries.

Esteem (pyripoxyfen) is an IGR which mimics the activity of juvenile hormone-a key hormone in insect development. In our tests on apple, Esteem has controlled San Jose scale and has provided suppression of leafroller and codling moth. In 1999, we evaluated three different timings of Esteem for pre-bloom pear psylla control. Applications at the "pink" stage gave better control than a "delayed dormant" or "petal fall" timing. In the same test we also evaluated **Dimilin** (diflubenzuron), and IGR which inhibits the formation of chitin in the insect cuticle, for pre-bloom pear psylla control. However, control was not any better than with Esteem.We repeated the timing study this season to confirm these results. Esteem is registered fully now on apples and pears. Prior to 1998, we have done extensive field-testing of **Comply** (fenoxycarb), another juvenile hormone mimic, on apples and pears. However, our research with Comply has come to a halt, since the company has stopped all research and development activity with this product. **Neemix** is a botanical insecticide with insect growth regulator activity. It is labeled for tree fruits and can be used by organic growers. We tested Neemix in 1998 and 1999 for leafroller control on pears in combination with *Bt*. Performance in our tests was weak.

Other insecticide and miticides

In a leafroller trial, **Success** (spinosad) has controlled second-generation larvae on cherries and has been effective, especially in combination with oil, against codling moth, leafminer, and leafroller on apples. In laboratory tests, Success has shown larvicidal but little ovicidal activity against codling moth. Last year's data suggest that it may be possible to use Success as part of a seasonal codling moth control program. Success is registered for use on apples and cherries. A pear label still is pending.

DuPont's **indoxacarb** (Avaunt) was tested at the Center for the first time in 1999. In field trials on apples and pears, this experimental insecticide controlled codling moth, leafroller, and white apple leafhopper. Work this season with indoxacarb will focus on defining field rates and on laboratory studies to determine stage susceptibility of codling moth.

In field trials with registered pear psylla insecticides, **Provado** and **Mitac** controlled adults while **Pyramite** has no activity against this stage. Provado and Mitac were detrimental to natural enemies, in particular predatory plant bugs. The selectivity of Pyramite still needs to be investigated. Pyramite had better ovicidal activity against pear psylla then either Provado or Mitac. **AgriMek** had no effect on pear psylla eggs but was very effective against young nymphs. Pyramite, Provado, and Mitac also had activity against pear psylla nymphs. Oil did not enhance the activity of Pyramite against pear psylla. Similar studies will be conducted this season with Probado to determine if the addition of oil improves performance.

Several miticide trials were conducted in 1999 at the Center. The only experimental miticides we tested was **binfenazate** (UC-D2341), which performed well against twospotted spider mite and European red mite on apple. In tests with registered miticides, Pyramite was effective on pear at the "pink" stage to reduce a high overwintering population of twospotted spider mites (85 percent control). A subsequent treatment of **Savey plus Vendex** was applied when spider mites began to build up again in June, and this maintained control through harvest.

Evaluation of alternative control technologies

Several alternative control technologies have been under study at the Center over the last 10 years. Two projects which were conducted in 1998/99 should be highlighted. Both projects involved the use of the codling month pheromone.

In one project, mating disruption with Isomate C Plus pheromone dispensers at a rate of 200/acre (half the label rate) was combined with a single supplemental spray of the organophosphate Imidan to achieve seasonal control of codling moth in a large d'Anjou pear block. Three different rates of Imidan were compared in this program. One block was treated with a full rate of Imidan, another with ½ rate, and a third with ¼ the rate. All three programs provided codling moth control. The major difference between the three blocks was biological pear psylla control, which was much better where the lower Imidan rates were used. We intended to continue this test this season to demonstrate first, that low rates of an organophosphate provide adequate supplemental codling moth control in combination with mating disruption; and second, that improved biological control of pear psylla can be a major benefit of such a program.

The other interesting new control technology we tested last year against codling moth was an "attract & kill" formulation with the trade name **"Last Call".** This control method works by attracting male codling moth adults to small droplets which contain pheromone (the attractant) and a knock-down insecticide as killing agent (a pyrethroid). A special hand-held applicator was used to apply small droplets of uniform size to the bark of trees. About 1,500 droplets/acre have to be applied with this method. No organophosphate insecticides were used in this block for insect control between bloom and harvest. As a result, biological control of pear psylla was very effective, thanks to numerous natural enemies which were not eliminated by broad-spectrum sprays. Although biological pear psylla control was very successful, there was some codling moth damage due to moths immigrating from an adjacent pear block where no insecticides were used. Lack of protection from immigrating female moths is one of the drawbacks of this control method.

Other research projects

In addition to the field tests at the Experiment Station and grower field trials, the entomology program at MCAREC is involved in a number of other projects, which are summarized briefly here. Please contact Helmut Riedl at the Mid-Columbia Agricutlrual Research and Extension Center if you would like to have more detailed information about any of the projects listed.

Susceptibility testing of pear psylla to pyrethroid and other insecticides

The status of resistance to several insecticides is being monitored in pear psylla populations in northern Oregon using an adult bioassay. Pyrethriod resistance monitoring will continue at selected sites to determine possible reversion after use of these products was discontinued in 1994, and growers shifted to materials with different modes of action. Resistance to pyrethriods has been stable, but resistance to abamectin (AgriMek) has not been detected so far.

Acaricide susceptibility and resistance management of spider mites on pear

Previous studies have shown that McDaniel spider mite, the predominant mite pest on pear in the Mid-Columbia area, has become resistant to organotin acaricides. AgriMek (abamectin) has been used since 1988 for mite control on most of the pear acreage in the Hood River Valley with exceptional results providing season-long control with single applications. However, field observations supported by evidence from laboratory bioassays indicate that populations are becoming less susceptible as a result of 10 years of continuous abamectin use. A regional project was initiated in 1995 to survey susceptibility patterns in spider mites on pears to abamectin, hexythiazox (Savey), and fenbutatin oxide (Vendex), and to compare resistance development in commercial orchards with continuous abamectin use versus alternative abamectin with fenbutatin, hexythiazox, and other acaricides. This is a cooperative project with TFRC/Wenatchee and the SOES/Medford and was supported initially by the HRGSA; presently, the project is supported by the Agricultural Research Foundation. No completion date has been set.

Biology and control of pear rust mite

With recent changes in pest management programs on pears and the increased use of more selective insecticides and miticides, secondary pests such as pear rust mite (PRM) have become more troublesome. The objective of this project is to develop a seasonal strategy for pear rust mite control. Work includes: evaluations of post-harvest and pre-bloom sulfur sprays; studies of the environmental conditions (e.g., rain, temperature) which influence sulfur performance against rust mite; effect of additives such as oil on field performance of sulfur sprays; evaluation of foliar rust mite materials; and biological studies to improve timing of pre-bloom and foliar rust mite sprays.

Results to date: Pear rust mite has become a serious problem in recent years, especially on smooth-skinned cultivars (e.g., d'Anjou, Bartlett). Growers have relied primarily on sulfur sprays for post-harvest and pre-bloom control. Although sulfurs provide better control of overwintering rust mites than other materials, they may not be sufficient by themselves, and additional materials may have to be applied during the post-bloom period for seasonal suppression.

Pear rust mite emergence begins in late winter and coincides with bud swell. Under Hood River conditions, the emergence period covers about 4 to 6 weeks from the end of February until the beginning of April. Sulfur treatments applied at bud swell were more effective than later treatments when buds were already open (scales still attached). We have not found a major difference in the performance of different types of sulfurs against PRM, although liquid lime sulfur may perform better in some situations than dry flowable sulfur. Monitoring PRM on leaves and fruit is key to making control decisions. Control in mid- to late summer is critical to prevent high overwintering populations which can cause damage the following spring. AgriMek at the low label rate is still very effective for PRM control after bloom. Pyramite can be used close to harvest due to its short PHI. This is a multi-year project and was supported initially by the HRGSA; presently, the project is supported by the Agricultural Research Foundation. No completion date has been set.

Effect of environmental conditions and host factors on the reproductive success of field-collected and laboratory-reared codling moth

To monitor resistance and cross-resistance to IGRs, eggs and larvae must be reared from field-collected moths. Wild codling moths collected in the field do not adapt easily to laboratory conditions, and often only a small proportion of individuals reproduce. Genetic variability and possibly important resistance traits may be lost during colony establishments, thus creating a genetic bottleneck effect. Our objective was to improve our understanding of the reproductive biology of field-collected and laboratory-reared codling moths. It was hoped that by defining the optimal conditions for mating and egg-laying, it would be possible to increase the proportion of reproducing pairs and maintain the genetic traits typical for a field population in the F1 generation.

Results to date: Thermoperiod did not affect mating success or egg-laying of field or laboratory moths. Natural photoperiod seemed to be important for the reproductive success of field moths, but less so for laboratory moths. Both strains laid eggs on all three surfaces, but leaves were preferred. Only ca.30 percent of the field moths oviposited under laboratory conditions (artificial light, constant temperature), whereas 90 to 100 percent oviposited in outdoor cages with natural light and constant temperature. This research was funded by grants to E. Palevsky from the apple grower association of the Upper Galilee in Israel, the Baron De Hirsch Fund in New York, and the Agricultural Research Foundation. The project was completed in 1998.

Host selection, reproductive biology, and host-specific mortality of codling moth on pear and apple

In contrast to apple, there are large differences to codling moth attack among *Pyrus* species and cultivars. Bartlett pears are more susceptible than any of the winter pears such as d'Anjou and Bosc. Differences in codling moth infestation levels may be a manifestation of host preference by the moth stage, and/or they may arise because of differential mortality on different hosts. The effects of food quality (e.g., apple vs. pear) also may play a role. This project focuses on several key aspects of the relationship between codling moth and its hosts: host selection and selection of oviposition sites by the adult female moth; egg-laying behavior on different cultivars; host-specific mortality factors affecting immature stages; and relationship between larval food source, rate of development, and reproduction.

Results to date: The number of eggs per fruit cluster is correlated with the number of fruit per cluster, suggesting non-random distribution of eggs between clusters. In controlled experiments, there was also a preference for clusters with more fruit. More than 95 percent of eggs are laid within ten cm of a fruit. Egg distribution varies through the season depending on cultivar. Eggs on woody tissue were found only during the first generation. On d'Anjou and Red Delicious, the upper leaf surface is the preferred oviposition site; on Bartlett, it is the underside of the leaf.

As pears mature, the fruit surface becomes the preferred oviposition site. Whether or not a fruit was infested did not affect its selection as an oviposition site. Moth avoided fruit clusters where the fruit began to yellow (e.g., Bartlett). This possibly is related to a chemical factor such as ethylene. For instance, mature Bartlett pears produce 1,500 times more ethylene than green immature fruit. Moths caged on host plants (apple, pear) mated more readily and produced more eggs than moths caged on a non-host (maple). When fruit was added to a cage on a non-host tree (maple), mating and egg-laying increased. Experiments with artificial fruit suggest that visual stimiuli may play a minor role in attracting moths to a fruit cluster. Choice tests suggested that pear is preferred over apple for oviposition for most of the season. Preference may be related to higher alpha farnesene concentrations in pear. Moths avoided pubescent apple and smooth non-host leaves (maple) as oviposition sites but readily laid eggs on smooth host leaves.

Neonates penetrated to the fruit interior more readily on Red Delicious and on Bartlett than on d'Anjou. There were no differences in penetration rates when pears were close to maturity. Once larvae were inside the fruit, there were no differences in terms of larval mortality between cultivars.

This project is supported by the Spanish Ministry of Science and Education (INIA) through a scholarship to Santiago Marti (Ph.D. student). It was initiated in 1996; anticipated completion is in 2000.

Insecticide resistance of South African and Oregon codling moth populations

Resistance levels in South African codling moth populations are among the highest in the world. Studies will be conducted to improve on available resistance monitoring methods, document resistance levels, investigate cross-resistance patterns, and develop resistance management strategies. This project is supported by Unifruco Research Services, South Africa, through a grant to Matthew Addision (Ph.D. student). It was initiated in 1997; anticipated completion is in 2001.

Prediction of obliquebanded leafroller activity on sweet cherries for improved timing of control measures

The goal of this project is to develop host-specific information on the seasonal phenology and development of obliquebanded leafroller on sweet cherries. Work conducted under this project will include; development of a predictive capability for leafroller activity; collection of phonological data on overwintering larvae, moth flight, and summer larvae for validation purposes; studies on larval feeding behavior on sweet cherries; control studies with pre- and post-bloom applications; and development of appropriate Extension literature and software to facilitate information transfer to growers.

Results to date: The majority of the overwintering generation larvae emerge from their hibernacula between stages 2 (side green) and 5 (open cluster). Results thus far suggest that larvae are distributed evenly throughout the top and bottom sections of the tree through bloom. OBLR larvae prefer to inhabit the south and east sides of the tree over the west and north sides. Overwintering larvae begin to pupate in mid-May with peak pupation towards the end of May. Adult flight of the overwintering generation began around mid- to late May at 847 degree-days (43°F lower, 85°F upper threshold) from January 1.

The first moths caught in pheromone traps were used as a Biofix point. The first flight peaked (50 percent catch) at 156 degree-days after Biofix and was 95 percent complete at 546 degree-days. Oviposition of the overwintering flight began 119 degree-days after Biofix. Most of the egg masses had been laid, and their larvae emerged at 995 degree-days, coinciding with the end of Bing harvest in The Dalles area. The overwintering flight began at pit hardening for The Dalles cherry district. The summer generation flight (second flight) peaked at 1,841 degree-days after Biofix and was 95 percent complete by 2,259 degree-days. The first summer generation larvae were detected at 612 degree-days, during Royal Anne harvest. After 1,140 degree-days, a majority of the summer generation larvae had reached a size where they could be detected easily in the bins, about the time of Lapin and freezer/canner harvest in The Dalles.

This is a Master's thesis project (M. Omeg, graduate student) and is funded by the Oregon Sweet Cherry commission and the Agricultural Research Foundation. The project was initiated in 1998; anticipated completion is in the fall of 2000.

Effects of horticultural spray oil on pear tree productivity and fruit quality

Summer use of oil, a selective pesticide, has considerable pest management benefits for codling moth, pear psylla, and mite control. The purpose of this project is to examine the horticultural implications of oil use during the foliar period. In field tests begun in 1996, sprays were applied by hydraulic handgun. A second field experiment was started in 1997 to examine the impact of oil sprays applied by commercial airblast equipment.

Results to date: Horticultural spray oil, Orchex 796E, was applied at a 1 percent v/v concentration three times a year during the foliar season to mature pear trees over a 3-year period (1996-1998). Four pear cultivars were examined: d'Anjou, Bartlett, Bosc, and Comice. Applications were made with a high pressure handgun sprayer with the spray volume adjusted to apply 3,785 liter/ha.

Significant responses to repeated treatment with Orchex 796E were observed in a number of fruit characteristics and productivity paramenters. Significant effects varied with pear cultivar. The most consistent and economically important effects were seen in d'Anjou, where fruit size and yield efficiency both were reduced. Reduced yields also were seen in Comice and, to a lesser degree, in Bartlett. A consistently significant increase in fruit russet was observed in Bartlett treated with Orchex 796E, but the amount of fruit russet was not increased to economically damaging levels. Bosc exhibited the fewest significant responses of the cultivars tested.

In a subsequent study, the handgun application method was compared to the air-carrier sprayer method currently used in commercial orchards, with lower spray volumes used with the air-carrier sprayer. While this subsequent study, initiated in 1997, is still in progress, few significant effects have been observed to date with commercial air-carrier application.

This is a join project with the Southern Oregon Experiment Station (R. Hilton, P. VanBuskirk, and D. Sugar). It was supported initially by the Areawide Codling Moth Program (USDA/ARS) and Exxon Company; currently, it is supported only by Exxon. The project was initiated in 1996; anticipated duration is 5 years.

Extension activities and extension research

In addition to research, the entomology program also is involved in a number of Extension activities, such as assisting the tree fruit industry with pesticide registrations (label expansions, state local need labels, emergency registrations such as "Section 18s"), and providing advice on pest control to growers and the general public. A major Extension effort of the entomology program at the Center has been its involvement with the Integrated Fruit Production (IFP) Program. Entomology has played a leading role in developing this program for the tree fruit industry in the Mid-Columbia area. Two Extension activities of the entomology program at the Center are highlighted below.

Pesticide registrations

Since 1987, we have petitioned for 22 "Section 18" emergency registrations on behalf of Oregon's tree fruit industry. The majority of the "Section 18" petitions we submitted were for pears. The Environmental Protection Agency (EPA) granted all submitted requests. This activity has involved the preparation of petitions and use reports as well as research trials to develop data in support of "Section 18" petitions.

Research demonstration and implementation of Integrated Fruit Production (IFP) on pears in northern Oregon

With the 1997 season, the 3-year IFP demonstration project was concluded. This project was funded by the Center for Applied Agricultural Research (CAAR) and the Hood River Grower-Shipper Association (HRGSA). In 1998, a permanent IFP site was established at the Mid-Columbia Agricultural Research and Extension Center to continue with IFP research and to demonstrate IFP-compatible production practices. The IFP demonstration site consists of a 2.2 acre mixed pear block (d'Anjou, Bartlett). It was used in 1999 to evaluate IFP practices including selective codling moth control with "attract & kill", augmentation of biological control of pear psylla by providing habitat for predatory insects, irrigation scheduling based on soil moisture monitoring, and ground cover management practices. The IFP demonstration site also served as an outdoor laboratory to train orchard scouts in monitoring techniques, pest identification, and pest management decision-making. Limited funds were available in 1999 thought a special allocation from the HRGSA and were used for supplies and orchard monitoring.

Recent publications from the entomology program

Please contact Helmut Riedl at the Mid-Columbia Agricultural Research and Extension Center for copies.

Giliomee, J.H. and H. Riedl. 1998. A century of codling moth control in South Africa. I. Historical perspectivie. J. South African Soc. Hort. Sci. 8(2):27-31.

Riedl, H., T.L. Blomefield, and J.H. Giliomee. 1998. A century of codling moth control in South Africa. II. Current and future status of codling moth management. J. South Afican Soc. Hort. Sci. 8(2):32-54.

Niederholzer, F., C.F. Seavert, and H. Riedl. 1998. Demonstration and implementation of Integrated Fruit Production (IFP) on pears in northern Oregon: Introduction. *In*: Proc. VIIth Intern. Symp. Pear Growing, J.B. Retamales et al. (eds.); Acta Hort. 475:59-66.

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Pons, S., J. Avilla, and H. Riedl. 1998. Efecto del momento de aplicación, utilización de coadyuvantes y volumen de tratamientos en la efectividad de tebufenocida para el control de *Cydia pomonella* (L.) (Lepidoptera: Tortricidae). Boletin de Sanidad Vegetal-Plagas. 24(4):921-934.

Riedl, H. 1998. Pflanzenschutz im Obstbau in Europa und Nordamerika - ein Vergleich. Obstbau Weinbau 35 (10):308-309.

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Beers, E.H., H. Riedl, and J.E. Dunley. 1998. Resistance to abamectin and reversion to susceptibility to fenbutatin oxide in spider mite (Acari: Tetranychidae) populations in the Pacific Northwest. J. Econ. Entomol. 91:352-360.

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Riedl, H. and F. Niederholzer. 1997. Secondary pests: the up- and down-side of selective pest management on tree fruits. Proceed. 111th Ann. Mtg. Oregon Hort. Soc. 88:93-106.

Riedl, H. 1997. Integrated Fruit Production (IFP), selective pest management, and pesticide resistance. Proceed. 111th Ann. Mtg. Oregon Hort. Soc. 88:81-85.

Tree Fruit Entomology, MCAREC 1998

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"The preceding report includes information concerning experimental use of unregistered pesticides or unregistered uses of pesticides. Experimental results should not be interpreted as recommendations for us. Use of unregistered materials or use of any registered pesticide inconsistent with its label is against both Federal Law and State Law".

Annual Report of Research in Plant Pathology

R.A. Spotts and L.A. Cervantes

Several major preharvest and postharvest diseases of apple, pear, and sweet cherry were studied. Below is a summary of the methods used in this research and the results and discussion of each project. Most of this research was conducted in the last 2 years. The pear fire blight and sweet cherry brown rot research was completed prior to this time, but it was not included in prior station reports.

Resistance of Pear Cultivars in Oregon to Natural Fire Blight Infection

Joint project of R.A. Spotts and E.A. Mielke.

Introduction

Fire blight is one of the most serious and destructive diseases of pear in the United States and in many other countries of the world. The disease is caused by the bacterium *Erwinia amylovora*. Many reports of resistance of pear cultivars to fire blight appeared in the last 1960s and 1970s. Many of these reports included observations of natural infections in pear cultivars as well as studies using artificial inoculation.

In 1990, a pear cultivar trial was established at the Oregon State University Mid-Columbia Agricultural Research and Extension Center (MCAREC) in Hood River. Approximately 119 cultivar/rootstock combinations from several sources are part of the planting. During pear bloom in 1994, the fire blight risk level was extremely high from 18 to 21 April, according to the Courgarblight model developed in Washington and used successfully in the Pacific Northwest for several years. Degree hours exceeded 500 for 4 consecutive days, and rain occurred on 18 and 21 April. Although streptomycin was applied on 20 April, considerable fire blight infection was observed in the cultivar planting in early May. Because there appeared to be considerable differences in the severity of fire blight among the cultivars, quantitative data were collected and are reported herein.

Results and Discussion

Over 80 percent of all fire blight strikes were visible by 9 May, the first date of removal of infected tissue. Of the 119 cultivar/rootstock combinations, 34 had no fire blight strikes in any of the four replicate trees. Another 34 combinations had only one tree with fire blight infection. Thirty-four combinations had two trees infected, including California, Glou-Morceau, and Sensation Red Bartlett on OHxF333, all with more than nine strikes per tree. Fifteen cultivar/rootstock combinations had three of the four trees infected, including Red pear 6-67, Dr. J. Guyot, Red Spot on OHxF333, and Best Ever on OHxF97 with more than 10 strikes per tree. Two cultivars, Jules d'Airolles and Worden Seckel on OHxF333, had fire blight strikes in all trees and an average of 6.7 and 5.0 strikes per tree, respectively. All trees of these two cultivars had to be removed in 1994.

Although each study on pear cultivar resistance includes many cultivars not tested in other rankings, some common cultivars often appear. California and Glou-Morceau, which were susceptible in our trial, also are considered susceptible by others. Cultivars with no fire blight in our trial and also listed as resistant by others include Bantam, Dawn, Magness, Maxine, Moonglow, Shinko, and Waite. Resistance of a few cultivars differed from previous reports. Eldorado, which we found susceptible,was considered resistant by Aldwinckle and van der Zwet. Dana Hovey and Passe Crassane were resistant in our study but susceptible in other studies.

Considerable variability occurred among replicates. For example, the four Fame replicates had 0, 0, 0, and 50 strikes per tree. Although many of the more severely infected trees were in the same general area of the orchard, highly infected trees were seldom adjacent to one another. The pattern in the orchard showed a general "band" running in an east-west direction and may be related to spread of inoculum by the prevailing west wind.

In this and other plantings at MCAREC, trees on OHXF18 appeared most resistant, while the same cultivars on OHxF40 appeared most susceptible. Also, 9 of the 11 IRP cultivars on Bartlett seedling roots were more resistant than when the cultivars were on *Pyrus betulaefolia* roots, and the rootstock difference was highly significant ($P = 0.01$) according to a paired "t" test. *P. betulaefolia* is considered a very vigorous rootstock.

Most of the highly infected cultivars were at full bloom between 16 and 20 April, the time that coincided with extreme risk weather conditions. Cultivars showing no infection were at full bloom over a wider time period, from 11 to 19 April. Thus, while some of these noninfected cultivars were well past full bloom when risk was high and may have escaped infection, others were in full bloom and may possess genetic resistance. Because of the diversity of bloom dates of the cultivars in this trial, caution must be used when evaluating the results. The study is most valuable in sorting out highly susceptible cultivars, since those without blight may be resistant but also may have escaped infection.

Biological Control of Decay of Pear

Survival of Cryptococcus infirmo-miniatus (CIM) in thiabendazole and stability of a WDG formulation

Methods. Mertect 340F was added to CIM suspensions to produce the following final concentrations of TBZ: 0, 100, 264, and 528 ppm a.i. Flasks containing the yeast plus TBZ suspensions were mixed on a rotary shaker during the day (8:00 AM to 5:00 PM) or mixed constantly and sampled after 0, 8, 24, 48, 72, and 96 hours. Yeast populations were determined by standard dilution plating, and survival was determined by comparing populations with the initial population.

Results. The concentration of viable cells of the yeast CIM decreased from 3-4 x 10^8 colony forming units per ml to about 1 x 10^8 cfu/ml after 1 day in either water or any of the TBZ suspensions. The yeast concentration remained stable for the next 3 days in all three TBZ suspensions and in water. There were no significant differences in survival in any of the TBZ suspensions compared with survival in water at any of the assay times. Based on these results and previous studies with inoculated pear fruit, CIM is compatible with TBZ, including the full labeled rate of Mertect 340F (528 ppm a.i.).

Methods. For stability (survival of yeast cells in the WDG formulation), product was held at 0, 5, 20°C, and a lab refrigerator (3°C). After 1 week, then monthly for 5 months, cells per gram of product were determined by dilution plating on YMDA. Populations were calculated from plate colony counts and compared with the original population.

Results. The viable cell concentration of CIM increased during the first month at all temperatures, then began to decline. After 5 months, the viable cell concentration decreased 11, 8, 24, and 78 percent at 0, 3, 5, and 20°C, respectively.

Experiments with a formulation of Cryptococcus infirmo-miniatus

Methods. A WDG formulation of *C. infirmo-miniatus* has been produced by Ecogen, Inc. and was evaluated for efficacy at rates up to 2.5 X 10^8 cfu/ml.

Fruit were puncture-wounded, and spores of *Penicillium expansum* or *Botrytis cinerea* were added to each biocontrol treatment to produce a final concentration of 3,975 and 675 spores/ml, respectively. The control was spores of *P. expansum* or *B. cinerea* in sterile distilled water. Treated fruit were stored on fiberboard trays in cardboard fruit boxes lined with polybags. Fruit stored at 20°C were evaluated for decay incidence and severity after 7 days. Decay of fruit stored at -1°C was evaluated after 2 or 3 months for gray mold and blue mold, respectively. A second efficacy trial was done using only CIM at 0, 0.5, 1.0, 1.5, and 2.0 x 10^8 cfu/ml.

Results. In a test of the effectiveness of the new WDG formulation of CIM, the relationship between percent decay and CIM cell concentration was highly significant ($P = 0.01$). Rates of CIM of 1.6 and 2.5 x 10^8 cfu/ml resulted in 91 of 100 percent control of blue mold, respectively. In a second test using five rates of formulated CIM, the relationship between percent decay and CIM cell concentration was highly significant ($P = 0.01$). Rates of CIM above 1 x 10^8 cfu/ml resulted in 80 to 95 percent control of blue mold.

Chemical Control of Decay of Pear

Use of thiram on pears

Methods. This trial, which is similar to one conducted last year, determined the effectiveness of orchard applications of thiram and ziram for contol of postharvest decay. The trial also provided information necessary for the registration of thiram on pears.

Bosc and d'Anjou trees were sprayed at pink, petal fall, first cover, and second cover with Procure (12 oz/a) alone or combined with thiram (3 lb/a) or Dithane (3 lb/a). Unsprayed trees were used as controls. Preharvest treatments applied to trees in the above four treatments included thiram at 3.5 lb/a at a 7 day PHI, ziram at 5 lb/a at a 14 day PHI, or unsprayed. One box of fruit from each of four replicates was harvested and stored in air at -1°C. Decay was evaluated after 3 and 6 months.

Results. Gray mold (*Botrytis cinerea*), blue mold (*Penicillium expansum*), Alternaria rot (*Alternaria* spp.), and bull's-eye rot (*Pezicula malicorticis*) developed in stored fruit. Decay data were analyzed with two-way analysis of variance to determine the effects of the spring and the preharvest treatments and their interactions.

For d'Anjou pear, total decay in the spring treatments ranged from 0.2 to 1.6 percent. The Procure plus Thiram treatment had significantly less total decay than the unsprayed control for d'Anjou, but none of the other treatments gave significant control. The Procure plus Thiram treatment also gave significant control of total gray mold. Other differences of spring treatments on other pathogens were not significant. None of the preharvest fungicides gave significant control of any of the decays. There were no significant interactions between the spring and preharvest fungicide treatments.

For Bosc, total decay in the spring treatments ranged from 1.4 to 5.1 percent. Neither spring nor preharvest fungicide applications significantly reduced decay compared to the unsprayed control. In addition, there wre no significant interactions between the spring and preharvest fungicide treatments.

Decay levels in this trial were low, with almost all individual decays at less than 1 percent. Under these conditions, it is difficult to demonstrate a significant decay reduction, even with an effective fungicide program. In addition, it should be noted that Thiram Granuflo is labeled at up to 6.8 lb per acre on apple, well above the 3.5 lb rate used in this test. The Ziram label for preharvest application on pear is 8 lb per acre, well above the 5.0 lb used in this test. Future trials for decay control should be conducted at maximum label rates.

Fungicide control and timing of bull's-eye rot

Methods. Based on historic weather records, three probable infection windows (early June, mid-August, and early September) were identified. Limbs on Bosc pear trees were flagged and fruit was inoculated at each of these times with *Pezicula malicorticis*, the casual agent of bull's-eye rot. Inoculated fruit were covered with aluminum foil for 3.5 h, then uncovered to attain a wetness period of about 4 h. At 3, 2, and 1 weeks before inoculation and 1 week after inoculation, fruit were sprayed with mancozeb, ziram, or thiram at maximum label rates. Control fruit remained unsprayed. At harvest, half of the unsprayed fruit was drenched with thiabendazole (Mertect 340F) at 528 μg/ml. Each treatment was applied to three replicate limbs of 10 fruits per limb. Fruit was harvested in September at commercial harvest, placed in cold storage in cardboard boxes lined with perforated polyethylene bags, and held at -1°C. The incidence and severity of bull's-eye rot was evaluated after 3, 5, and 7 months.

This study will provide information on the optimum timing of those commercial fungicides that are known to provide some level of bull's-eye rot control. In addition, the fungicides will be compared for efficacy with each other and with the postharvest thiabendazole treatment. The inoculum concentration and wetness period selected here are based on previous studies.

Results. No infection occurred from the June inoculation, and the August inoculation resulted in only low levels of infection that appeared unrelated to the fungicide or timing. The September inoculation, early on the day of harvest, resulted in 78.7 percent infection of the control (no fungicide) fruit after 6 months in cold storage. Thiram, applied 3, 2, or 1 weeks before harvest, gave significant control of bull's-eye rot (12 to 32 percent infection). Ziram, applied 3 and 2 weeks before harvest, also gave significant bull's-eye rot control (36 to 39 percent infection), but the 1 week preharvest application did not control the disease. A Mertect drench of unsprayed, inoculated fruit at harvest gave control (20 percent infection) equivalent to the most effective preharvest fungicide treatments. There is no explanation for the failure of ziram applied 1 week before harvest to control decay. The experiment should be repeated and should include promising new fungicides.

Large Scale Packing Line Studies

Bin sanitation

Methods. Tests similar to last year were repeated. Several bins of fruit from MCAREC orchards were prewashed with nonrecirculating water and an equal number of bins of fruit were run through the packing line without prewashing. After each bin was run (washed bins first), the populations of pathogens in the dump and flume water was monitored.

Results. Twelve bins of d'Anjou pear fruit were used in this test, with half of the bins not washed and the other half washed before entering the dump tank. Prewashing bins before immersion significantly reduced the sport load of *Penicillium* spp. and *Alternaria* spp. in the dump tank water. These results are similar to last year and demonstrate the benefit of bin and dump tank sanitation.

Evaluation of UV system for decay control

Methods. A high intensity, ultraviolet light with a water-cooled disinfection unit and pneumatic safety shields was tested for control of blue mold, gray mold, and mucor rot of pear. Surface-sterilized d'Anjou pears were wound-inoculated with *B. cinerea*, *P. expansum*, or *M. piriformis*. In addition, some fruit inoculated with *P. expansum* was inoculated with dry spores in a settling tower. Inoculated fruit were divided into two groups. The first group was run through the system with UV light off, followed by the second group with the light on. In addition to the three pathogens, other variables included rotation speed of the rollers and speed of fruit moving along the line under the UV light.

In addition to decay control, the effect of the UV exposure on fruit quality was determined. Exposed fruit was ripened and evaluated for quality. Also, treated fruit was placed back in cold storage and evaluated periodically for quality and ability to ripen acceptably.

Results. Operating conditions similar to a commercial packing house include a roller rotation of 20 and an exposure time of 8 seconds. The slow (15) and fast (25) roller rotations and long exposure time (24 seconds) were included to vary exposure of fruit to the UV light. The UV system, including the pneumatic safety shields, appeared to operate satisfactorily. The system produced ozone, which had an obvious odor in the packing line area.

Incidence of gray mold (*B. cinerea*) and Mucor rot (*M. piriformis*) was reduced 5 percent when inoculated fruit was exposed to the UV treatment. Reduction in the incidence of blue mold (*P. expansum*) with UV varied from 24 to 40 percent and averaged 35 percent in five of the size blue mold tests. In one test, decay of fruit exposed to the UV was greater than the control fruit. Incidence of blue mold was higher in fruit inoculated with the dry spores in the tower, and UV treatment of this fruit reduced decay by 24 percent. Altering roller speed or speed of fruit movement across the packing line did not appear to affect the level of decay control. UV treatment did not affect decay severity (size of decay lesions). Because this was a nonreplicated trial, statistical analyses of the data were not done. None of the fruit quality parameters (extractable juice, soluble solids, titratable acids, and flesh firmness) were affected by the UV treatment. UV-treated fruit ripened acceptably and had a slightly more yellow appearance than nontreated fruit.

The positive effect on the blue mold is encouraging for this preliminary trial. It may be possible to improve decay control in the future by modification of the system and combining UV with other types of treatments. Replicated trials will be done next year.

Studies of Decay Pathogens

Germination of decay pathogens at selected temperatures

Methods. Spores of decay pathogens contaminate wounds during harvest and in the packing house. The spores germinate and cause decay of fruit. The process is temperature- and moisture-dependent. Information on how much time is required for germination at temperatures from -1° to 20°C, combined with information on the moisture and termperature status of fruit surfaces in cold storage, will help determine where infection is occurring.

Germination of *B. cinerea* spores in pear juice was done first, and future studies will be done with germination of spores on slices of pear tissue. The study will be repeated with *P. expansum, M. piriformis,* and *Pezicula malicorticis*.

Results. Prior to determination of germination on pear "wafers," a series of experiments measuring germination in pear juice, are being done to obtain estimates of the time required for germination at several temperatures. This will enable the "wafer" research, which is difficult, to be done with fewer time/temperature combinations. Results with pear juice are complete for *Botrytis cinerea,* and experiments with *Mucor* and *Penicillium* are in progress. For *B. cinerea*, germination in pear juice begins at about 4, 5, 12, and 40 hours at 20, 10, 5, and -1°C, respectively.

Air and fruit surface Penicillium spore levels

Methods. This epidemiological study was initiated last year to begin collecting data on the concentrations of spores of *Penicillium expansum* in orchard air and on fruit surfaces during harvest. This study will be continued to determine these concentrations in several pear orchards. In a closely linked study, a range of air and fruit surface spore concentrations will be produced in a 7-foot-high spore inoculation tower, and spore levels will be correclated with the amount of decay that develops in fruit with dry surfaces and surfaces covered with dew. Fruit will be puncture-wounded before or after inoculation. These relationships will be used as standards to determine the decay risk in orchards at the time of harvest based on abundance of inoculum. Similar studies are in progress for *Botrytis*.

Results. Spores of *B. cinerea* and *Penicillium* spp. were monitored monthly and on the day of harvest in an orchard with a history of decay. Samples included air, litter, and fruit surface washes. In addition, the stems of 50 to 100 fruits per month were tested for infection. At harvest, the spore concentrations per cubis meter of air of *B. cinerea* and *P. expansum* were 220 and 950, respectively. Air from close to the limb at the moment of picking contained 125 and 1,450 spores per cubic meter of *B. cinerea* and *P. expansum*, respectively. These levels are very high compared with previous years. *B. cinerea* spores adhere tightly when wet with dew; thus, shaking the limbs while harvesting did not increase the spore levels in the air.

Populations of spores of *B. cinerea, M. piriformis,* and *Penicillium* spp. up to 253, 957, and 4,384 per gram of dry litter were found in 1999. These levels are high compared with those in previous years.

The numbers of spores of *B. cinerea* on the fruit surface increased through the season and reached a level of 1,987 per fruit at harvest. *Penicillium* spore levels were highest in July, dropped in August and early September, then increased again at harvest to 960 per fruit.

Stem end infection caused by *B. cinerea* and *Penicillium expansum* reached 38 and 24 percent, respectively, at harvest. These levels were higher than in preceding years. Twenty boxes of fruit from this orchard were placed in cold storage and will be monitored for decay for 8 months. Commercial fruit from this block also will be monitored for decay.

Application of monoclonal antibodies for rapid identification of postharvest fungal pathogens

Methods. Monoclonal antibodies (MABs) are highly specific proteins that selectively bind to an antigen, in this case molecules in the spores or mycelium of a fungus. A large collection of these antibodies that react with several important postharvest pathogens of pear and apple has been developed by Dr. Molly Dewey and her colleagues at the University of Oxford, UK. Monoclonal antibodies have the advantages of being specific, sensitive, easy to use, quick, and low in cost.

Several MABs were tested for practical applications such as rapid identification of *B. cinerea* and *P. expansum*. The MABs were used to identify which fungus is causing decay of fruit. The current method for doing this is to plate pieces of infected tissue on agar media. The pathogenic fungus grows from the infected tissue and can be identified in about 5 to 7 days. Results with the MAB method will be available in 24 hours. Similar techniques were used to identify *B. cinerea* and *P. expansum* in pear stem tissue and in orchard air.

Results. The development of *Botrytis cinerea* in pear stems from six orchards in Oregon and Washington after 6 and 8 months of cold storage in air was studied. The fungus was detected by plating stem tissue halves on selective media and by ELISA using the *Botrytis*-specific monoclonal antibody BC-12.CA4. Both methods showed an increase in incidence between 6 and 8 months, but ELISA had greater sensitivity than plating. Quantitative ELISA tests in stems, with or without stem end rot, indicated that a critical biomass of *B. cinerea* in the stems is needed for development of stem end rot of fruit to occur. Because the ELISA technique detects both viable and nonviable *B. cinerea*, the usefulness of ELISA may be limited.

Control of Brown Rot and Blue Mold of Sweet Cherry Fruit with Combinations of Preharvest Iprodione, Postharvest *Cryptococcus infirmo-miniatus*, and Modified Atmosphere Packaging

(joint project of R.A. Spotts, L.A. Cervantes, T.J. Facteau, and T. Chand-Goyal)

Methods. The effectiveness of preharvest iprodione and postharvest *Cryptococcus infirmo-miniatus* treatments alone and in combination for control of decay of sweet cherry fruit was studied. Also, the effect of a modified atmosphere on brown rot control was evaluated as a part of the iprodione-*C. infirmo-miniatus* combinations.

Results. A single preharvest application of iprodione (Rovral 50WP) at 2 pounds per acre reduced brown rot in stored sweet cherry fruit in both years of this study. Significantly better control of brown rot was obtained when cherry fruit that received a preharvest iprodione application also was treated with a postharvest dip in a suspension of *C. infirmo-miniatus* containing 0.5-1.5 x 10^8 cfu/ml. Brown rot was reduced by modified atmosphere packaging (MAP) alone and further reduced as a result of a *C. infirmo-miniatus*-Map synergism. Incidence of brown rot was reduced from 41.5 percent in the control to 0.4 percent by combining preharvest iprodione and postharvest *C. infirmo-miniatus* treatments with MAP.