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Peach Flower Thinning and Possible Sites of Action of Desiccating Chemicals

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Abstract. **Airblast application of fertilizers, desiccating herbicides, or surfactants reduced fruit set and increased fruit size of 'Redhaven' peach [*Prunus persica* (L.) Batch]. The addition of the surfactant, alkylaryl polyoxyethylene glyco phosphate ester (Spray Aide), to ammonium thiosulfate (ATS) at rates from 0 ml/liter to 5 ml/liter did not increase thinning. When rates of ATS/ha remained constant, water volumes from 2338 liter/ha to 420 liter/ha did not affect thinning. Forty-six percent to 62% more flower buds developed on twigs from chemically thinned trees than on hand thinned trees. Most of this flower bud increase was on the 5 basipetal nodes of current season shoots. Treatment of the stigma, petals + anthers, peduncle, or calyx with ATS reduced fruit-set. Necrotic regions in the peduncle of some flowers could be seen under a microscope 48 hr after treatment. Flowers sprayed with DuPont WK or NH4NO3 + X-77, plus methylene blue (added as a tracer) had blue dye in the veins of the calyx, pedicle, and peduncle of some flowers after 24 hr.**

Surfactants, fertilizers, and desiccating herbicides applied to peach trees in full bloom have reduced fruit set and increased fruit size (1, 2, 3). The sprays also have reduced fruit set when applied in the early pink stage, but they have been most effective when applied in full bloom (1, 2). Sodium dinitro-o-cresylate, Elgetol, has been used as a peach bloom thinning agent, but it must be applied in full bloom so that pollination and/or stylar growth of the pollen tube is prevented (6). The economic benefit of bloom thinning has been discussed previously (3, 5).

The objectives of these studies were to determine: 1) the sites of chemical absorption and effects of localized applications of ATS to peach flower parts, 2) if surfactants increase the efficacy of ammonium thiosulfate, 3) if water rates or application method affect the thinning response, and 4) if bloom thinning influenced subsequent flower bud numbers for the next season.

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Materials and Methods

Chemicals used in these studies and their sources are listed in Table 1.

Experiment 1. Six limbs, 7.5–11.0 cm in circumference, having similar fruiting volumes and located 1.5–2.0 m in height in the outer periphery of 'Loring' trees, were selected for 6 treatments on each of 4 replicate trees prior to bloom in a randomized-block design. Test limbs were about 90% in bloom. Flower buds not yet open were removed from all test limbs. Each treatment was applied to all open flowers on each test limb regardless of the date of flower opening. A solution containing 50 ml/liter ATS + 5 ml/liter X-77 was applied to specific plant parts. One random limb on each of these trees was treated as follows: 1) control (no treatment); 2) stigma plus half the style clipped; 3) stigma plus half the style dipped in ATS solution. Treatments 4, 5, and 6 were applied with a microsyringe to petals and anther bases (100 μl ATS), peduncle (50 μl ATS), calyx outside (100 μl ATS), respectively. The amount applied was chosen by pretreating several flowers to determine an amount each structure would hold without running off. The placement of a 100 μl drop at the base of the staman (Treatment 4) caused the material to coalesce on the petal and staman bases and, in some instances, to run onto one or 2 lower petals. The placement of a single 50 ml drop on the bud scale region (Treatment 5) resulted in rapid absorption of the material between scales with very little runoff. Placement of a single 100 μl drop to the calyx, outside the cup, resulted in a portion of the material running down one side and onto the bottom of the calyx. Complete and uniform treatment of these structures would be expected from sprayer applications. Full bloom occurred 20 Apr. 1984. Fruit counts were made 42 days after full bloom.

Expt. 2. Flowers from chemically thinned trees and nontreated flowers were collected from several thinning experiments over a 3-year period and microscopically compared for injury caused by DuPont WK, NH4NO3, and/or ATS. Injury to the peduncle of a portion of treated flower buds was noticed in all 3 years. In 1984, methylene blue was added as a tracer to NH4N03 (180 g/liter) + X-77 (5 ml/liter) and DuPont WK (50 ml/liter) and these were applied with a pressurized propellent sprayer to 'Loring' peach limbs in full bloom in the field. Current season wood and flowers were examined microscopically for traces of methylene blue or necrotic areas in various tissues 24 hr after treatment.

Expt. 3. Since penetration of the material through the bud scales was thought to be important to peduncle injury and subsequent flower thinning, a rather high rate of surfactant was thought to be required to assist the penetration of fertilizer and herbicide treatments. To increase absorption, surfactant X-77 was applied at 2 rates (5 or 2.5 ml/liter) with endothall, and Spray Aide was applied at 4 rates (0, 1.5, 2.5, or 5 ml/liter) with ATS. DuPont WK and NH4NO3 + X-77 were included as standards to compare the thinning caused by the surfactants CC-42 and SN-50, 2 sources of ATS, and 1 treatment of methyl oleate with NaCO3 (used to promote water loss of grapes for raisin production) (7). Treatments were applied to 4 whole-tree replicates in a randomized complete block design on 27 Apr. when trees were in full bloom. Treatments were applied at 1590 liters/ha with a Swanson 3-point hitch airblast sprayer with both fans delivering to one side. Rows ran from north to south, and, to avoid drift, alternate trees in alternate rows were used. Thinning response was based on fruit counts taken 6 June from 3 preselected limbs on each tree. Limbs were about 7.5–11 cm in circumference, and fruit density on these limbs is expressed as fruit/cm^2 limb cross sectional area. All treatments were hand thinned on 15 June by the grower, except for 3 limbs on each of the control trees. These limbs were not thinned, but the rest of the tree was thinned to prevent tree breakage. The hand thinned treatment was not included in the analysis, since the count was taken at a date later than for the other treatments. Fruit size was taken 30 July (about 4 days before first harvest).

Expt. 4. Because penetration of these agents might be affected by water rates, 5 water rates (2338, 1590, 1170, 841, 420 liter/ha) were applied with an airblast sprayer using similar active ingredient rates per hectare. To achieve different rates, nozzle size or number was changed. Neither tractor speed nor pump pressure were altered. A hand gun treatment was included for comparison at the 1170 liter/ha water rate. Treatments were applied to 6 whole-tree replicates in a randomized complete block design on 27 Apr. when trees were in full bloom. All trees as well as the controls were hand thinned on 12 June by the grower to prevent limb breakage. Since the hand thinned treatment was counted on 15 June after the 12 June hand thinning of the control trees, these data were not included in the analysis of fruit count. Data taken for all other treatments were taken on 6 June prior to the hand thinning.

Expt. 5. In 1984, 25 shoots 8–16 cm in length were collected from each of 4 'Redhaven' trees sprayed in 1983 with 1 ml/liter Endothall (15.9% a.i.) + 5 ml/liter X-77, and 25 shoots were collected from hand thinned trees. Samples were taken 1.5–2.0 m from the ground and 1 m into the canopy. Flower buds per terminal, number of nodes, and flower buds on the basipetal 5 nodes of each terminal were recorded. These 2 treatments were a part of a larger experiment conducted in 1983 (3). The treatments were applied to 4 whole-tree replicates in a randomized complete block design on 29 Apr. 1983 when trees were in full bloom. Treatments were applied with a Swanson 3-point hitch airblast sprayer. Thinning response was based on fruit counts taken 6 June from 3 preselected limbs on each tree. Fruit density is expressed as described in Expt. 3 and 4.

Results and Discussion

Expt. 1. Application of 50 ml/liter ATS + 5 ml/liter X-77 to flowers in full bloom was as effective as removal of the stigma with half of the style for reducing fruit set of 'Loring' peach. We believe that these treatments thinned by preventing fertilization, since many button fruit developed (Table 2). The seed of these fruit did not fill the pit cavity, became brown, and abscissed by 60 days after bloom. These fruit will be referred to as button fruit in this paper, since cultivars that tend to retain unfertilized fruit might retain these fruit to harvest. The treatment of other flower parts or peduncle resulted in some flower thinning, but none was as effective as application to the stigma. We suspect that a combination of treatments to petals, anthers, peduncle, pedicle, and calyx would account for more fruit thinning than any one of these treatments alone. These results suggest that time of flower opening and conditions for fertilization could be important in thinning with desiccating chemicals.

Expt. 2. Microscopic examination of the peduncle, pedicle, calyx, ovary, receptacle, and supporting wood from nontreated and ammonium nitrate + X-77 (Fig. 1), DuPont WK, ATS, or endothall-sprayed branches revealed necrotic regions in the peduncle of some flowers 48 hr after treatment. Flowers sprayed with either DuPont WK, or ammonium nitrate + X-77, with methylene blue (added as a water soluble tracer) had blue dye

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Table 1. Chemicals evaluated for peach flower thinning or adjuvant activity.

Chemical name, formula, or abbreviation	Formulation used	Source
Fertilizers		
Ammonium nitrate (NH_4NO_3)	33% N	Valley Fertilizer & Chemical Corporation
Ammonium thiosulfate (ATS)	12%N, 26%S	Allied Chemical Corporation
Ammonium thiosulfate (ATS-CI)	12%N, 26%S	Chemical Enterprises, Inc.
Desiccants		
Mono N,N-dimethylalkylamine salt of endothall (Endothall)	15.9% acid equivalent 5.5%	Pennwalt Corporation
Methyl oleate	100%	Emery Industries, Inc.
Sodium carbonate (Na_2CO_3)	100%	Emery Industries, Inc.
Surfactants		
Trimethyenonylpoly-ethoxyethanol (DuPont WK)	90%	E. I. duPont deNemours & Company
Alkylaryl polyoxyethylene alcohol, glycols, fatty acids, and isopropanol (X-77)	90%	Chevron Chemical Company
Alkylaryl polyoxyethylene glyco phosphate ester (Spray-Aide)	70%	Miller Chemical & Fertilizer Corporation
Polyoxypropylene ammonium chloride (CC-42)	100%	Witco Chemical Corporation
Oxyalkylated alcohol (SN-50)	100%	Witco Chemical Corporation
Fungicides		
Zinc ethylene bisdithiocarbamate (Dithane Z-78, Zineb 75%WP)	75%WP	Rohm & Haas Company

Table 2. Effect of application site of 50 ml/liter ammonium thiosulfate + 5 ml/liter X-77 on peach fruit set and button development (1984).

Treatment	Volume of solution (µl)	No. fruit/cm² cross section of limb (FB + 42 days)	No. buttons/cm² cross section of limb (FB + 42 days)[z]
Control	---	14.1 a[y]	1.1 c
Stigma treated	Dipped	2.4 de	17.5 a
Stigma clipped	---	1.1 e	10.4 b
Petals + anthers	100	5.5 cd	0.9 c
Peduncle	50	6.1 c	0.7 c
Calyx outside	100	10.3 b	1.7 c

[z]Full bloom occurred 20 Apr. 1984. Button fruit dropped by 60 days after bloom.
[y]Mean separation in columns by Duncan's multiple range test, 5% level.

in the veins of the calyx, pedicle, and peduncle 24 hr after treatment (Fig. 2). This evidence, along with results from Expt. 1, suggest 2 sites of action: 1) interference with fertilization of the ovary when application is made during bloom to the stigma, and 2) phytotoxicity in the peduncle region by treatments during bloom or prebloom. The browning reaction in the peduncle region may have been the result of translocation and concentration of these chemicals in the peduncle from applications made to other flower parts.

Expt. 3. Preliminary laboratory and greenhouse trials (unpublished data) showed that liquid and solid fertilizers and desiccating herbicides applied to 12-day-old dwarf pea seedlings resulted in greatly enhanced caustic action when surfactant rates of 5 ml/liter were used. Rates of 0, 1.25, 2.5 ml/liter of surfactant reduced wetting and subsequent desiccation of pea seedlings.

On peach trees, we found "Spray-Aide" surfactant levels of 0, 1.25, 2.5, or 5 ml/liter did not influence thinning by ATS (Table 3). In addition, 5 ml/liter X-77 did not increase thinning by endothall when compared to endothall + 2.5 ml/liter X-77. Even though the pedicle and peduncle appear to be well protected by bud scales at full bloom, normal surfactant rates apparent are adequate to facilitate thinning by endothall, and no surfactant is needed to obtain thinning with ATS. These results also support the idea that application to all the floral structures (petals, staymans, calyx) may be involved.

No thinning difference was found between the 2 sources of ATS (Allied Chemical Corporation or Chemical Enterprises, Inc.) (Table 3). Methyl oleate + NaCO3 did not thin at the rates used. DuPont WK surfactant was more effective than SN 50 or CC-42 surfactants. Some leaf burning was evident with all chemicals used, but this was not thought to be important, since these first small leaves usually drop early. Leaf injury appeared to be less from ATS and the surfactant, DuPont WK, than from NH_4NO_3 treatment. Leaf injury ratings did not show differences among the ATS, Endothall, and SN-50 treatments. The ATS treatments overthinned at the rates used, but the grower hand thinned all trees including controls that needed to be thinned on 15 June. A subsequent fruit count on June 15 showed a fruit density of 5 fruit/cm² cross sectional area for typical grower hand thinning. Most of the treatments that caused thinning increased fruit size more than did hand thinning. Havis (5) reported that thinning in bloom increased fruit size more than did thinning at later stages. Fruit from treated trees were normal, but matured somewhat earlier than did hand thinned checks due to the reduced crop load.

Expt. 4. Bloom thinning and fruit diameter were not changed when a constant rate of ATS/ha was applied in water rates from

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Table 3. Effect of airblast spray applications of several flower thinning agents on 'Redhaven' peach fruit set (1984).

Treatment	Formulation rate	No. fruit/cm^2 cross sectional area of limb	Fruit diameter (cm)
Control	0	16.2 a[z]	4.80 a
Hand thinning	0	5.0	5.13 ab
NH_4NO_3	120 g/l	2.3 e	6.38 e
+ X-77	5 ml/l		
DuPont WK	25 ml/l	1.0 e	6.32 e
CC-42	25 ml/l	11.7 bc	5.54 bc
SN-50	25 ml/l	6.7 d	6.02 cde
Endothall	0.75 ml/l	9.7 cd	5.44 b
+ X-77	5 ml/l		
Endothall	0.75 ml/l	9.5 cd	5.61 bcd
+ X-77	2.5 ml/l		
Methyl oleate	20 ml/l	14.8 ab	5.13 ab
+ Na CO_3	38.4 g/l		
ATS-Cl	30 ml/l	2.0 e	6.48 e
+ X-77	5 ml/l		
ATS	30 ml/l	2.8 de	6.60 e
+ X-77	5 ml/l		
ATS	30 ml/l	3.7 de	6.20 e
+ Spray-Aide	5 ml/l		
+ Dithane Z-78	9.6 g/l		
ATS	30 ml/l	2.7 de	6.50 e
+ Spray-Aide	5 ml/l		
ATS	30 ml/l	2.7 de	6.45 e
+ Spray-Aide	2.5 ml/l		
ATS	30 ml/l	3.7 de	6.12 de
+ Spray-Aide	1.25 ml/l		
ATS + no surfactant	30 ml/l	3.8 de	6.32 e

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

Table 4. Effect of application method and water volume on ammonium thiosulfate (ATS) thinning of peach fruit (1984).

Treatment	Application method	Water rate liter/ha	Conc (a.i.)	No. fruit/cm^2 limb cross sectional area	Fruit diameter (cm)
Control	---	---	---	20.9 a[y]	---
Hand thinned	---	---	---	6.3	5.11 a
ATS[z]	airblast	2,338	15 ml/l	5.2 b	6.05 b
ATS[z]	airblast	1,590	20 ml/l	4.0 b	6.20 bc
ATS[z]	airblast	1,170	30 ml/l	5.5 b	5.89 b
ATS[z]	airblast	841	42 ml/l	2.8 bc	6.20 bc
ATS[z]	airblast	420	84 ml/l	4.1 b	6.17 bc
ATS[z]	handgun	1,170	30 ml/l	0.8 c	6.48 c

[z]The adjuvant Spray-Aide (5 ml/liter) was added to promote uniform coverage. ATS rate was 35 liters/ha.
[y]Mean separation within columns by Duncan's multiple range test, 5% level.

2338 liter/ha to 420 liter/ha with an airblast sprayer (Table 4). However, the application of 1170 ml/liter with a hand gun caused more thinning than 4 of the 5 airblast treatments. This increase may have occurred because droplets were large, but we believe increased thinning occurred because of thorough coverage of the blooms and less "blow-by" to adjacent rows from hand gun application.

Expt. 5. Hand thinned and nonthinned 'Cresthaven' trees produced a 10-times difference in flower bud production (4). To investigate further the time of thinning on flower bud production, shoots from 1983 plots were collected from the control (hand thinned) and endothall bloom thinned treatments (3). Shoots of 8–15 cm in length were selected throughout the bearing canopy. Production of flower buds per cm, per node, and per terminal were about 46% to 62% greater on bloom-thinned than on hand-thinned trees (Table 5).

The basipetal nodes of the bloom-thinned trees had 2.7 times as many flower buds as did hand thinned trees (Table 5). These results suggest that peach flower buds are secondary to the fruit as sinks early in the season. These additional flower buds on bloom-thinned trees are located mostly at the basipetal 5 nodes, and because they generally opened a few days later than acropetal buds, additional spring frost protection would be expected. The increased number of buds produced also might improve bud survival from critical winter temperatures. Investigations into the cold hardiness of these buds should be pursued.

Even though desiccating chemicals will reduce fruit set if applied in the pink stage of development (1, 2), they also reduce

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Table 5. Effect of Endothall applied at bloom in 1983 on 'Redhaven' peach flower bud numbers in 1984.

Treatment	No. fruit/cm^2 limb cross sectional area	Terminal length (cm)	Nodes cm	Flower bud production in 1984			
				Buds/cm	Buds/ node	Buds/ terminal	Buds/ basipetal 5 nodes
Unthinned	22.0 a^z						
Hand thinned	5.4	12.8 a	1.20 a	0.63 a	0.75 a	8.0 a	2.04 a
Endothall (1 ml/liter) + X-77 (5 ml/liter)	5.9 b	11.4 a	1.18 a	1.02 b	1.21 b	11.7 b	5.33 b

^{z}Mean separation within columns by Duncan's multiple range test, 5% level.

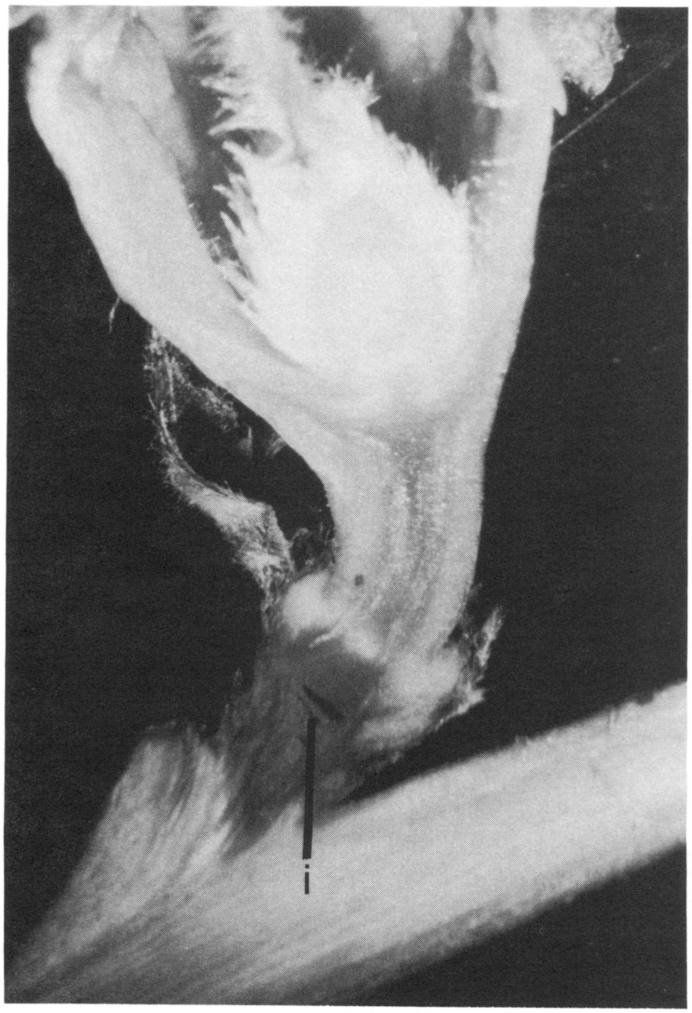

Fig. 1 Severe injury (**i**) of 'Loring' flower peduncle 48 hr after air-blast spraying with NH_4NO_3 + X-77.

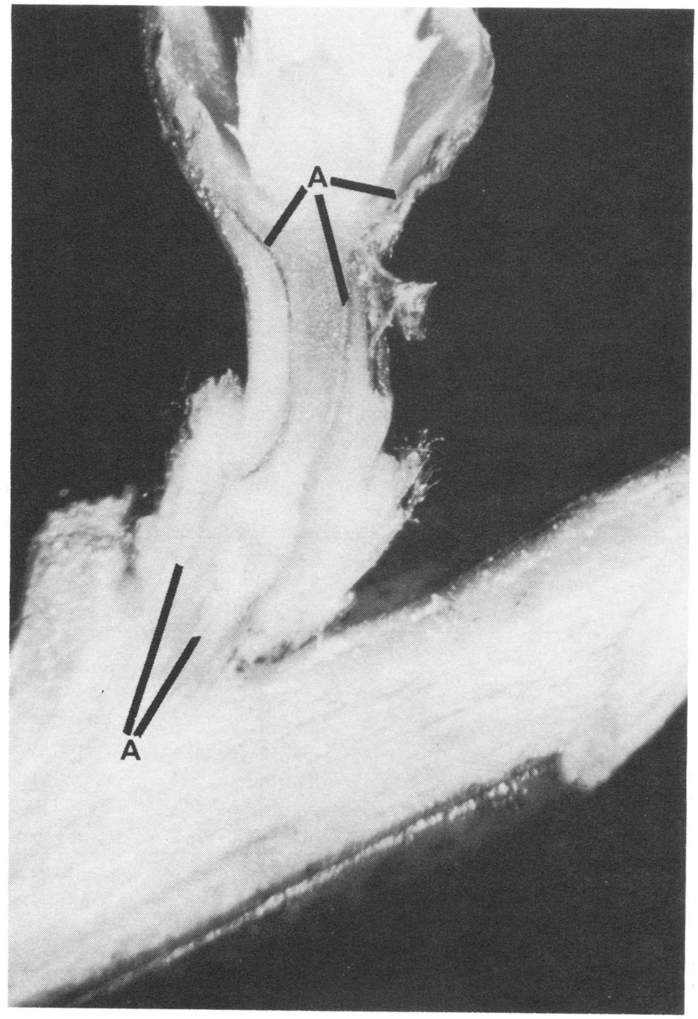

Fig. 2 Stained vascular bundles (**A**) of 'Loring' peach flower peduncle, pedicle, and calyx cup 24 hr after spraying with DuPont WK + methylene blue.

fruit set, if applied at bloom, by interfering with ovule fertilization (Table 2). Therefore, maximum thinning would be expected from applications made in the early full-bloom stage. Addition of surfactants or high water rates per hectare did not influence the amount of thinning by ATS in these experiments. If low water volumes are used, however, the chance of calibration errors or high deposits near sprayer nozzles when rows are close together could become additional risk factors. Bloom thinning greatly increased the number of flower buds produced on the basipetal portion of shoots the following year. When selecting a chemical rate of a bloom thinner, the number of flower buds per length of terminal might need consideration, since various cultivars produce different flower numbers and since the previous season's crop may affect greatly flower bud production.

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Changes in Water Soluble Polyuronides in the Pulp Tissue of Ripening 'Bosc' Pears following Cold Storage in Air or in 1% Oxygen

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Abstract. **'Bosc' pears (*Pyrus communis* L.) harvested at an optimum maturity, based on flesh firmness (about 62 N), were stored either in air or 1% O_2 (plus <0.03% CO_2) at −1°C. Fruit stored in air for 1 to 3 months softened rapidly after 2 days of ripening at 20°C and reached ripeness with flesh firmness of 20 N or lower by the 9th day. Ripening was associated with a reduction in extractable juice (EJ) and an apparent increase in water soluble polyuronides (WSP). Fruit stored in air for 4 to 5 months also softened rapidly after 2 days of ripening, but flesh firmness was still between 26 and 30 N after 9 days; however, EJ and WSP of fruit did not change appreciably during 9 days of ripening. The WSP content in fruit stored in either air or 1% O_2 increased substantially during 6 months of storage at −1°C. Increased WSP content during storage did not affect the quantity of EJ. Fruit stored at 1% O_2 showed a reduction in EJ and an increase in WSP during the 9-day ripening period, whereas, in long-term air-stored fruit, EJ did not decline while WSP was degraded. Correlation of EJ and WSP during each ripening period provided an estimation of storage life. Increased WSP after ripening might be responsible for the increase in hygroscopic binding capacity of the ripened pulp tissue.**

Winter pears stored in air at −1°C for a proper period of time (usually 3 and 5 months for 'Bosc' and 'd'Anjou' pears, respectively) or in low-O_2 atmosphere for 6 to 8 months, respectively, are capable of ripening at 20° with desirable dessert quality upon removal from cold storage (5, 6, 15). Pear fruit with this quality have good flavor and a juicy, buttery texture. However, fruit stored in air at −1° for a prolonged period of time (usually 4 months for 'Bosc' and 6 months for 'd'Anjou) tend to have a dry, coarse texture and poor flavor upon ripening (5, 6, 15). Development of the juicy, buttery texture is associated with a reduction in extractable juice, which probably results from an increase in solubility of pectic substances in the pulp (8). Polyuronide is the major component of pectic substances in fruit pulp (16); changes in its solubility are related closely to the texture modifications. The main purpose of this study was to investigate the changes in flesh firmness, extractable juice (EJ), and water soluble polyuronides (WSP) in 'Bosc' pear fruit during a 9-day ripening period after monthly removal of fruit from a 5-month air-storage, or after 6 months of storage in 1% O_2 at −1°C.

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Materials and Methods

Plant material, types of storage, and sampling periods. 'Bosc' pears at optimum maturity with an average flesh firmness of 62 N (14 lbf) were harvested from 3 separate uniform, mature trees in an orchard at the Mid-Columbia Experiment Station. After harvest, all fruit were drenched with benomyl (600 ug · liter^{-1}).

Fifty benomyl-treated fruit from each tree were divided into 5-fruit lots which were placed into perforated polyethylene snack bags. Ten bags of fruit from each tree were placed into a 19-liter wide-mouth glass jar in a cold room at −1°C. Each jar was equipped with a gas-tight lid having inlet and outlet ports fitted with Tygon tubing. After sealing, each jar was flushed with prepurified N_2 gas (about 99.995% purity, with C_2H_4 and C_2H_2 below 0.05 ppm) for 24 hr. One percent O_2 in each jar was obtained by mixing synthetic air (which is made of 79% N_2 and 21% O_2) and prepurified N_2 with the aid of 2 flowmeters and a mixing tube. The flow rate was maintained at about 50 ml · min^{-1}. The CO_2 concentration in each jar was maintained below 0.03% by the use of 5 packages of 100 gL of hydrated lime in each jar. The O_2 level was maintained at 1.0% ± 0.2% throughout the 6 months of storage. Another set of 50 fruit/tree received synthetic air at about 50 ml · min^{-1}, provided as air storage under an identical flow-through system. The relative humidity (RH) in each jar was not monitored.

The remainder of the fruit were transferred at random into 20-kg wooden boxes with perforated poly liners and stored in air at −1°C until used. One box of fruit (about 100 fruit) per tree was removed from air storage at monthly intervals for 5