Fruit Notes

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Fruit Notes

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Cover: Primocane-fruiting blackberries at the UMass Cold Spring Orchard Research & Education Center, Belchertown, Massachusetts. Photo by Wesley R. Autio.

Preliminary Results with a Vacuum Assisted Harvest System for Apples

James Schupp, Tara Baugher, Edwin Winzeler, and Melanie Schupp
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The harvest of specialty crops for the fresh market is labor intensive, and attempts at automation have been less successful than with field crops. Apple harvest is particularly difficult to automate because fruit suffer bruise damage easily. Nevertheless, market, social, and political forces have converged to make mechanical augmentation of harvest essential for the survival of the specialty crop industry in the U.S.

The challenges are enormous, as the constraints on candidate technologies include high performance, low cost, robustness, simplicity, and ease of repair. The opportunities and rewards, on the other hand, are commensurately great. Merely addressing these challenges is already inspiring a new generation of engineers and students to think creatively about problems in agriculture and related fields and to bring engineers and growers together (Kliethermes et al., 2010; Leslie et al., 2008; http://www.cascrop.com/index.php?option=com_content&view=article&id=1521&Itemid=666). Successful development technologies could reinvigorate the specialty crop industry, make it competitive in international markets, and employ segments of the population that have largely been excluded from the labor pool due to physical constraints.

The total value of U.S. specialty crops—$49 billion in sales—now exceeds the combined value of the five major program crops—$45.8 billion in sales (Schmoldt, 2007). However, despite the specialty crop industry's major contribution to the U.S. economy and the finding that "a secure domestic food supply is a national security imperative," U.S. specialty crop producers remain vulnerable to the real possibility of being eliminated within the next ten years (Schmoldt, 2007). This crisis stems in large part from dependency on a large seasonal workforce, coupled with increasing labor costs and decreasing availability of agricultural employees. In a socioeconomic technology adoption survey of growers conducted by members of our research team, harvesting was among the highest rated areas of need for advanced technologies to improve precision and efficiency in tree fruit production (Ellis et al., 2010).

Prior Approaches to Addressing Harvest Labor Inputs

Mechanical harvesting machines that utilized mass removal techniques were widely tested in the U.S. in the 1970s and 1980s. The machines were unsuccessful in harvesting fruit for the fresh market due to excessive fruit damage caused during fruit detachment, contact with limbs or other fruit while falling through a three-dimensional tree canopy, and bulk collection procedures (Peterson, 2005b).

Mechanical engineering efforts for specialty crops declined in the 1990s, and the focus shifted to the development of labor platforms for use with planar tree architectures. Fruit were still picked and placed in the bin by hand, but harvest efficiency was increased and fruit quality was similar to that which was conventionally harvested (Baugher et al., 2009a; Schupp et al., 2007). In the late 1990s, engineers began looking at automated bin filling technologies, but early designs resulted in excessive bruising of fruit (Peterson, 2005a). The complex fruit handling and equipment/operator interface was a major obstacle to developing semi-automated harvest systems.

Significant progress has been made on robotic harvest. However, insufficient fruit recovery and difficulties in developing both an end effector and a vision system that performs equal to the human hand and human visual system avert commercialization in the near future (Bulanon and Kataoka, 2010; Sarig, 1993).

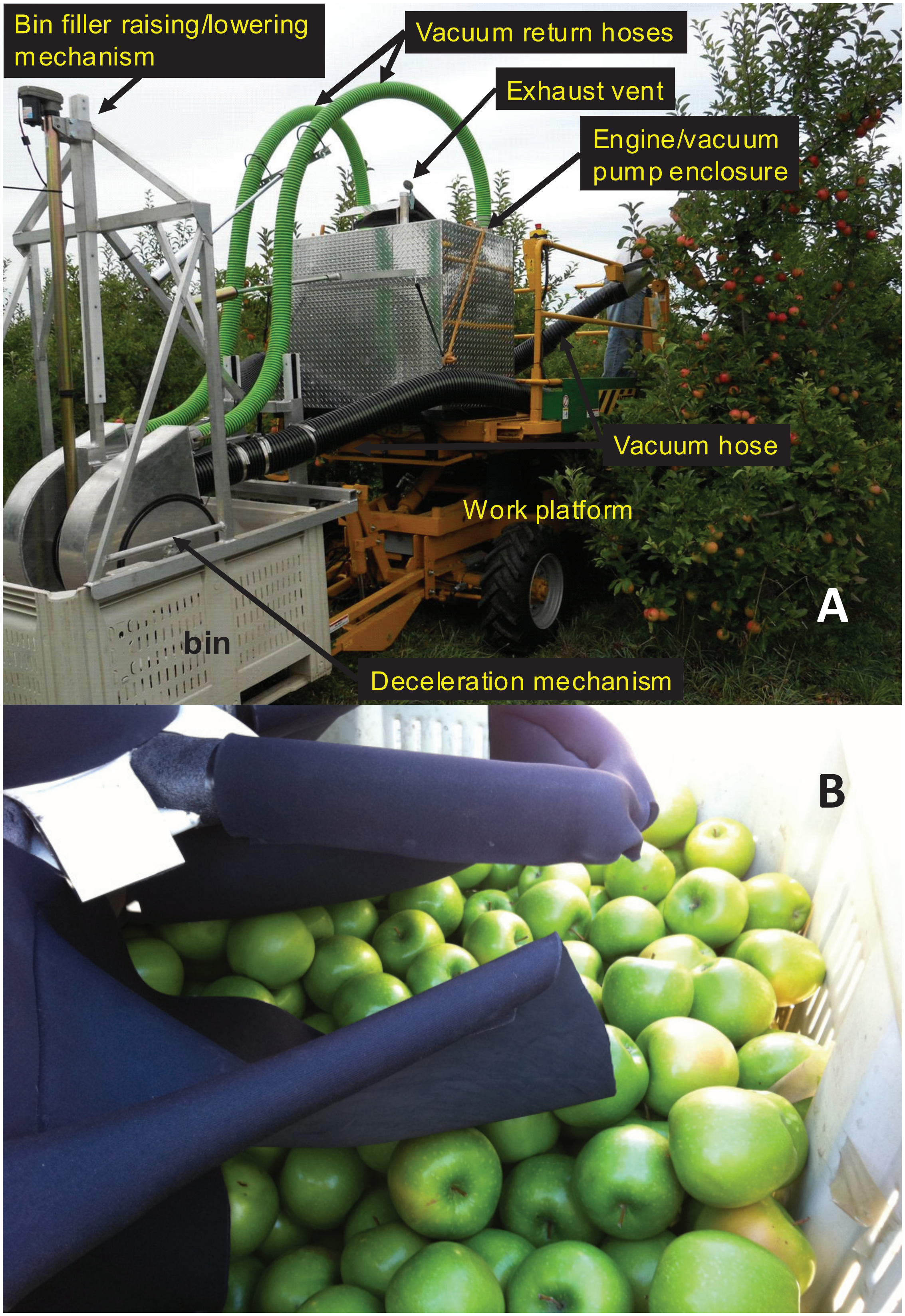

Figure 1. A. Components of vacuum-assisted harvest system. B. Elephant-ear distibutor in motion.

Current Research with Commercial Partner

In Fall 2011, with support from the Specialty Crop Research Initiative Project, "Comprehensive Automation for Specialty Crops" (Singh et al., 2011), our harvest team began working with a commercialization partner, DBR Conveyor Concepts, on a vacuum tube transport system and automated bin filler that could be retrofitted to existing grower equipment. Figure 1 shows the first prototype with the major components labeled.

Suction is provided by a pair of vacuum pumps driven by an internal combustion engine. The pumps and engine are in an enclosure mounted on the work platform. The vacuum pumps exhaust through a vent on the top of the enclosure. The exhaust pipe of the internal combustion engine is also at the top of the enclosure. Vacuum return hoses (green) lead from the pumps to the proprietary deceleration mechanism, which is the key innovation of this system. The vacuum pumps lower the internal pressure of the deceleration mechanism enclosure below ambient, causing air to flow through the vacuum hoses (black). Pickers place apples into the inlet to the vacuum hoses opposite the deceleration mechanism. The vacuum hoses are padded to prevent bruising of the fruit.

When a picker (partially hidden by the tree) places an apple into the vacuum hose, air flow into the hose is obstructed, leading to a differential pressure across the apple. The unequal pressure forces the apple through the hose. When it reaches the enclosure of the deceleration mechanism, its momentum propels into the deceleration mechanism, which has two functions. The first function is slowing down the apple and dropping it onto the flexible-flap bin filling mechanism (occluded by the bin in Figure 1A; shown in motion in Figure 1B). The second is to provide an airtight seal between the portions of the transport mechanism that are held below ambient pressure and the exit port of the deceleration mechanism of the enclosure.

Materials & Methods

Initial trials were conducted to assess fruit bruising at various stages in the augmented harvest system—(1) prior to entry into the vacuum tube (the control treatment), (2) after the vacuum tube and decelerator and before the elephant ears, (3) after the elephant ears but before the bin, and (4) after transport through the entire system. Bruising and corresponding USDA fruit grades were assessed as described in Kliethermes et al., 2010. Five replicates of either 15 or 20 fruit were randomly subjected to each of the treatments. The studies were first conducted on 'Honeycrisp' and 'Daybreak Fuji.' Based on the bruise findings, modifications were made to the harvest system to further prevent bruising, and a final study was conducted on 'Golden Delicious,' which is highly bruise-susceptible.

Commercial-scale efficiency trials were conducted on 'Golden Delicious,' 'York,' and 'Pink Lady' to assess labor productivity and fruit quality in apple orchard plots harvested with the vacuum assist system and a work platform compared to hand harvest and ladders. The same workers performed both treatments within a trial. The experimental design was randomized complete block with four multiple-tree replicates. Harvest times were compared for each treatment, and bruise evaluations were conducted on 100 fruit per treatment. Data from all trials were subjected to an analysis of variance and means were separated using Fisher's protected least significant difference test.

Results & Discussion

The initial two trials to assess fruit damage on apples collected at various stages in the augmented harvest system revealed that changes should be made to the elephant ears to prevent bruising (Table 1). With 'Honeycrisp,' bruise volume in fruit collected from the elephant ears was higher than control fruit collected prior to the vacuum tube, although the effect on fruit grade was insignificant. In the trials with 'Daybreak Fuji,' bruise volume in fruit collected from the bin was higher than fruit collected prior to the vacuum tube, and the portion of fruit that graded U.S. Extra Fancy was reduced from 99 percent to 92 percent. Machine modifications to further reduce fruit damage eliminated bruising in the final trial with 'Golden Delicious,' and fruit graded almost 100 percent U.S. Extra Fancy.

Commercial-scale investigations on 'Golden Delicious,' 'York,' and 'Pink Lady' demonstrated increases in efficiency per acre of 10 to 49% (Table 2). The quality of machine-harvested fruit was equal to hand harvested fruit in the 'Golden Delicious' and 'Pink Lady' trials and was better than hand harvested fruit in the 'York' trial (Table 2). The cost/benefit beyond hand harvest was $245 to $517 per acre (Baugher et al., 2011; data not shown; www.cascrop.com).

From an engineering perspective, the vacuum as-

Table 1. Bruise volume measured on apples collected at various stages in augmented harvest system and corresponding effects on fruit graded USDA Extra Fancy.

Cultivar	Location of Sample	Bruise volume (mm^3)	U.S. Extra Fancy[z] (%)
Honeycrisp	Before vacuum tube (control)	2.0 b	
	After vacuum and decelerator	12.8 ab	96.0 a[x]
	After elephant ears	20.1 a	94.7 a
	From bin	8.3 ab	96.0 a
Daybreak Fuji	Before vacuum tube (control)	0.0 b	
	After vacuum and decelerator	13.5 b	98.7 a
	After elephant ears	14.7 ab	98.7 a
	From bin	34.6 a	92.0 b
Golden Delicious[y]	Before vacuum tube (control)	2.5 a	
	After vacuum and decelerator	7.9 a	99.9 a
	After elephant ears	10.4 a	99.8 a
	From bin	17.0 a	99.9 a

[z] Mean separation within columns and cultivars by Fisher's protected least significant difference at P=0.05 (Five replicates in each trial; n=20, Golden Delicious; n=15, Honeycrisp, Daybreak Fuji).

[y] Vacuum tubes, decelerators, and elephant ears modified to further reduce bruising prior to Golden Delicious trial conducted on October 11, 2010.

bruising. The deceleration mechanism solves the important problem of isolating the vacuum from ambient pressure while providing a soft ejection for fruit. The modular design of the entire system makes it attractive to use with standard orchard equipment such as platforms and bin trailers.

At the same time there is room for further improvement. The biggest problems are that the vacuum pumps and the internal combustion engine are quite noisy, and working near the engine is hot. Another problem is that there are only two vacuum hoses. More hoses will be needed to allow more pickers to work at the same time to make the system cost effective. Our commercial partner is addressing these issues with their next prototype which will employ a single, larger but slower moving (and therefore quieter) vacuum pump driven by a hydraulic motor, with hydraulic power provided by the tractor towing the

sisted transport system addresses a number of design challenges well. The entire system is simple, uses readily available materials and parts, and thus it is easy to maintain or repair. The vacuum tube and deceleration mechanism effectively move apples from the picker to the bin filling device with minimal

Table 2. Labor efficiency and fruit quality in apple orchard plots harvested with vacuum assist system and platform compared to hand harvest and ladders.

Cultivar	Harvest System	Harvest Time[z] (h/acre/person)	Efficiency (% increase)	Fruit downgraded[y] (%)
Golden Delicious	Vacuum assist	33.35 b[x]	9.8	11.1 a
	Hand	36.98 a	--	15.6 a
York	Vacuum assist	24.69 b	49.2	6.0 b
	Hand	48.60 a	--	10.6 a
Pink Lady	Vacuum assist	37.47 b	19.4	5.3 a
	Hand	44.74 a	--	8.1 a

[z] Includes harvest of lower portion of trees by hand.

[y] Percentage of fruit downgraded determined from bruise evaluations conducted on 100 fruit per treatment from each of four replicates.

[x] Randomized complete block. Mean separation within columns by Fisher's protected least significant difference at P=0.05.

system. The new system will feature four vacuum hoses and deceleration devices. These improvements may be enough to make the vacuum assisted harvester not only viable technologically, but also economically profitable for growers.

Acknowledgements

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New Cherry Pruning Videos Available Online

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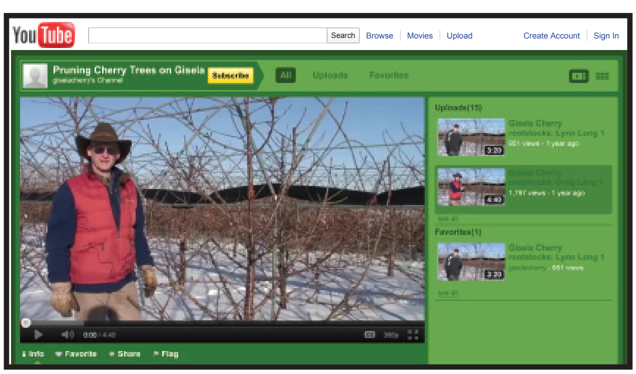

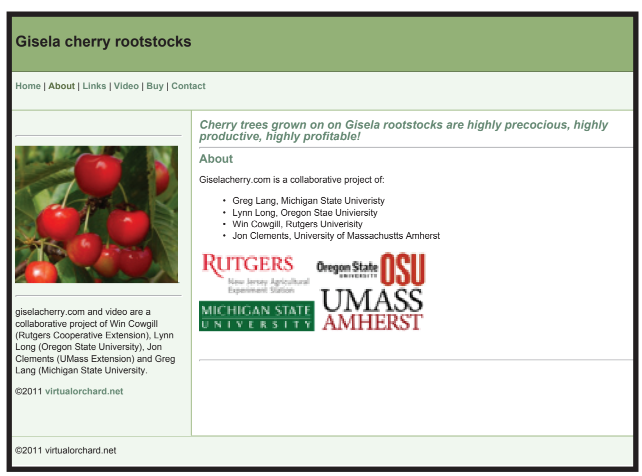

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Massachusetts Pick-Your-Own Apple Survey

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Orchardists have long recognized that a good awareness of what others are using for orchard practices is an excellent guide for the development of their own practices. This recognition extends to all aspects of the orchard operation, from tree planting to sales. To get a better understanding of how Massachusetts apple growers work with pick-your-own sales, at the December 2011 Massachusetts Fruit Growers' Association Directors Meeting, Alex Dows proposed that we survey Massachusetts apple growers. The Directors enthusiastically supported the idea, and a draft survey was distributed among the Directors in late December and early January. After some modification, the final survey was developed.

To aid in the process of distribution, SurveyMonkey.com was used to house the survey, distribute the survey, and collect the data. This tool allowed us to track responses and to follow up those who had not responded with additional requests. In all, survey requests were distributed to 110 individuals (members of the Massachusetts Fruit Growers' Association and subscribers to the UMass *Healthy Fruit* newsletter). Of those distributed, 83 responses (75%) were received (Table 1). Within the responses, 1798 acres of apple production were represented (about 42% of the Massachusetts total, Table 1).

Table 1. Pick-your-own survey distribution and response rate.

Surveys distributed (no. of orchards)	Survey responses (no. of orchards)	Survey responses (% of orchards)
110	83	75%
Massachusetts total acreage	**Survey responses (acres)**	**Survey responses (% of Mass. acreage)**
4287	1798	42%

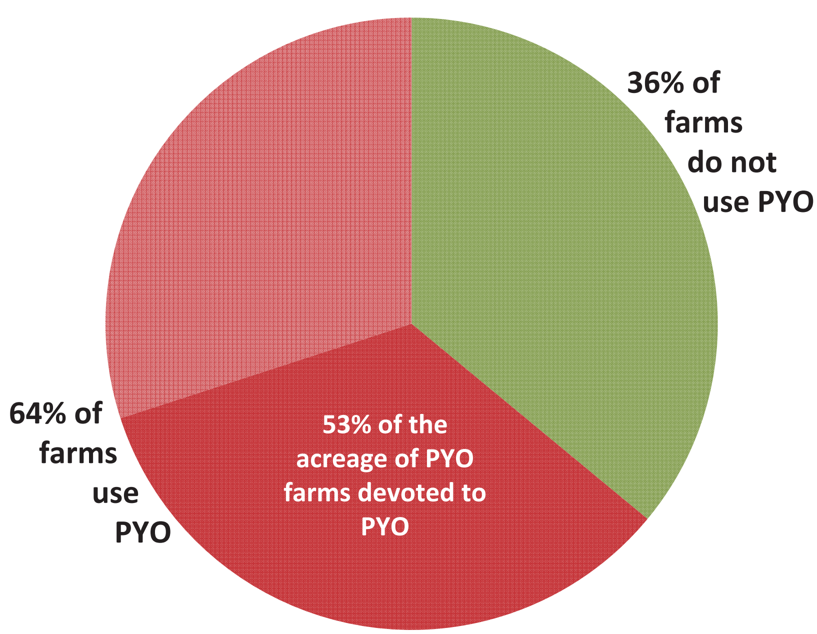


Figure 1. The extent of pick-your-own apple sales in Massachusetts, and the portion of farms devoted to pick-your-own trees.

Among responses, the average farm had 28 acres of apples. Sixty-four percent of farms used pick-your-own (PYO) sales, and on average more than half of the acreage of those farms was devoted to PYO (Figure 1).

About 30% of the PYO acreage is in dwarf trees, 53% in semidwarf, and 17% in standards (Figure 2). Most farms provide access

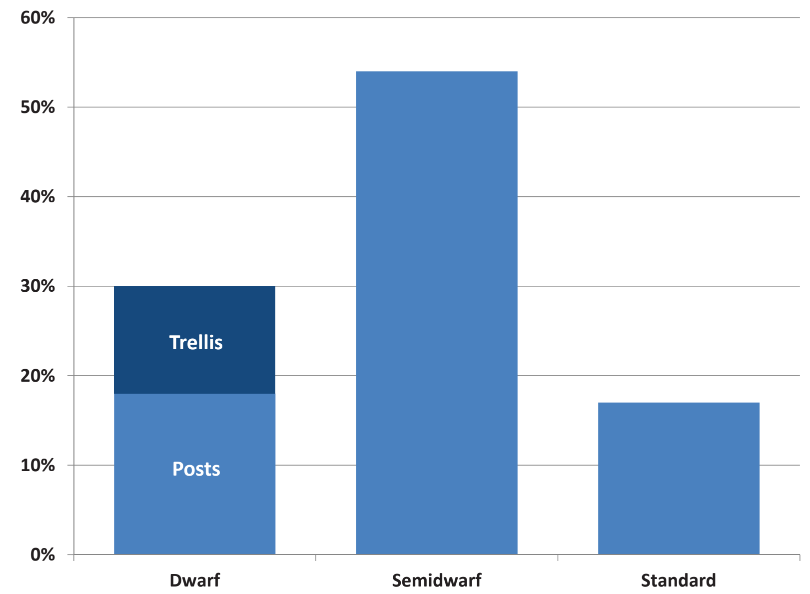


Figure 2. Percentage of Massachusetts PYO acreage using dwarf, semidwarf, or standard sized trees.

for handicapped people, and only 17% provide some form of access aid, such as ladders (Figure 3).

School tours are provided by 80% of PYO farms (Figure 4). On average, farms charge $5.17 per child for school tours. Many farms utilize other forms of entertainment to supplement PYO visits (Figure 4). Hayrides are made available to customers at 66% of PYO farms. Animals are an atrachtion at 36%. Live music is used at more than 20% of farms, and various types of mazes are part of the entertainment at just under 10%. Several other forms of entertainment are used, including walking trails, cider pressing, pony rides, rock climbing walls, kids games, BBQs, snack bars, farm stores, picnic areas, and speed dating.

Advertising is a critical part of nearly all PYO orchards (Figure 5). Everyone uses word-of-mouth advertising. Seventy-five percent use newspaper, 50% use email lists, 25% use radio ads, 15% use direct mailings, and 11% use television ads. Sixty-five percent of farms use other forms of advertising, such as the internet (43% use web-based tools), road signs, PYO guides, flyers, and brochures. Among the various techniques, the greatest portion of the advertising dollar (50%) is spent on newspaper ads (Figure 6). About 30% is spent on email lists, radio, direct mailings,

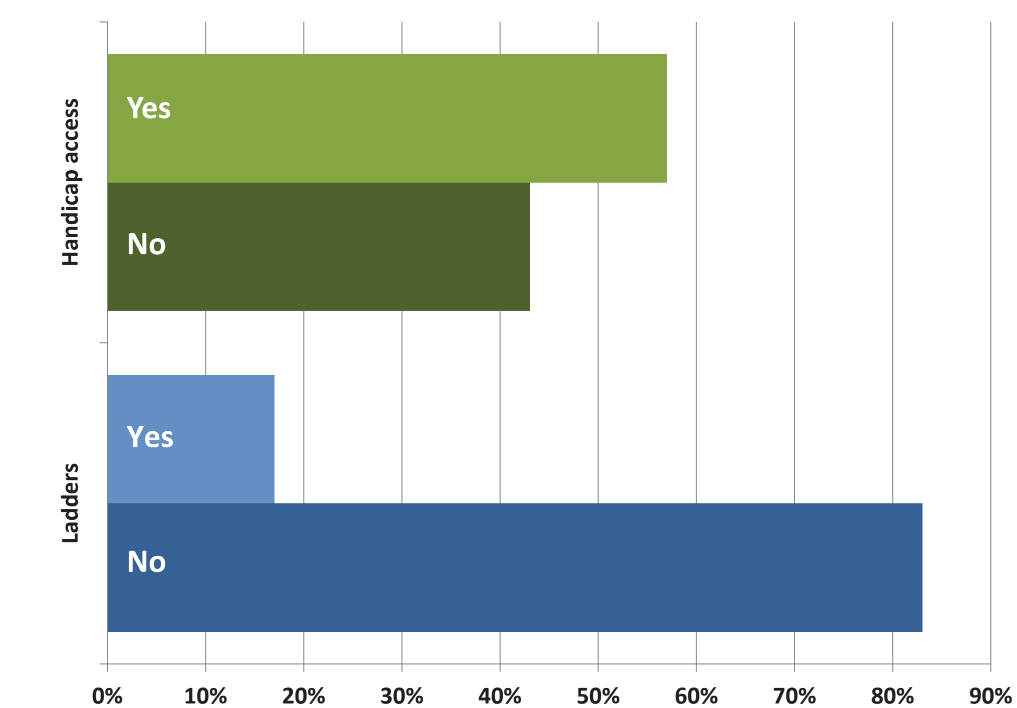


Figure 3. Percent of Massachusetts PYO orchards providing handicapped access and ladders.

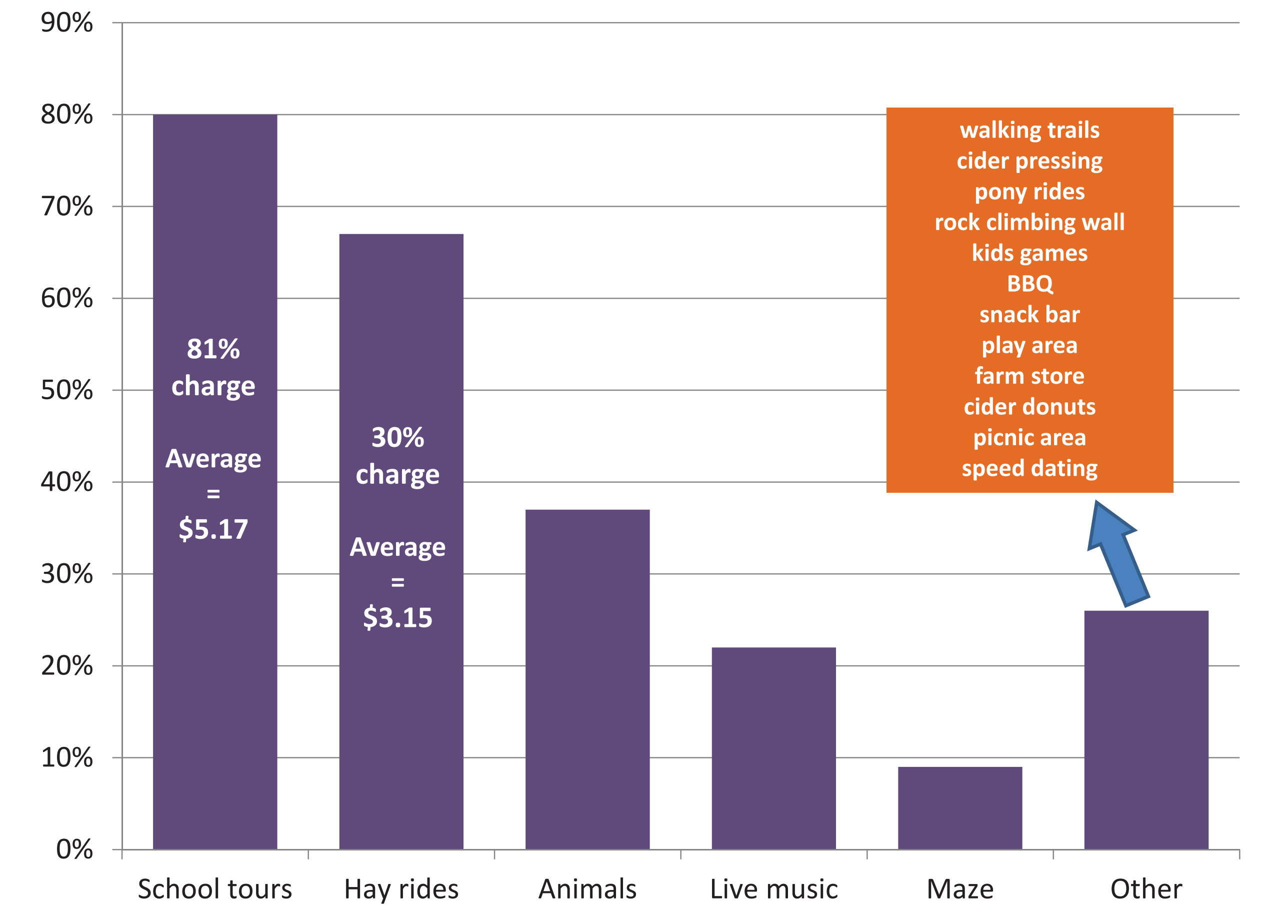


Figure 4. Percent of Massachusetts PYO orchards using school tours and various types of entertainment.

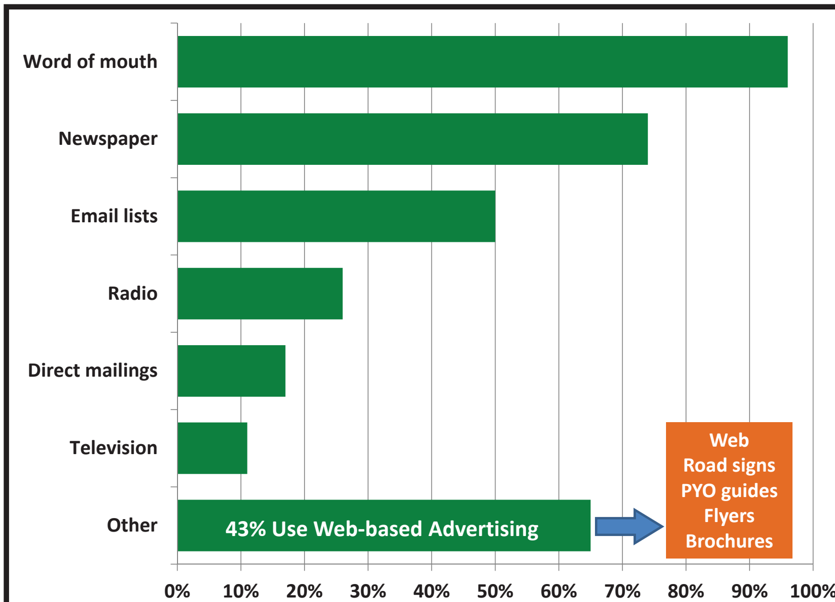


Figure 5. Percent of Massachusetts pick-your-own orchards using various advertising approaches.

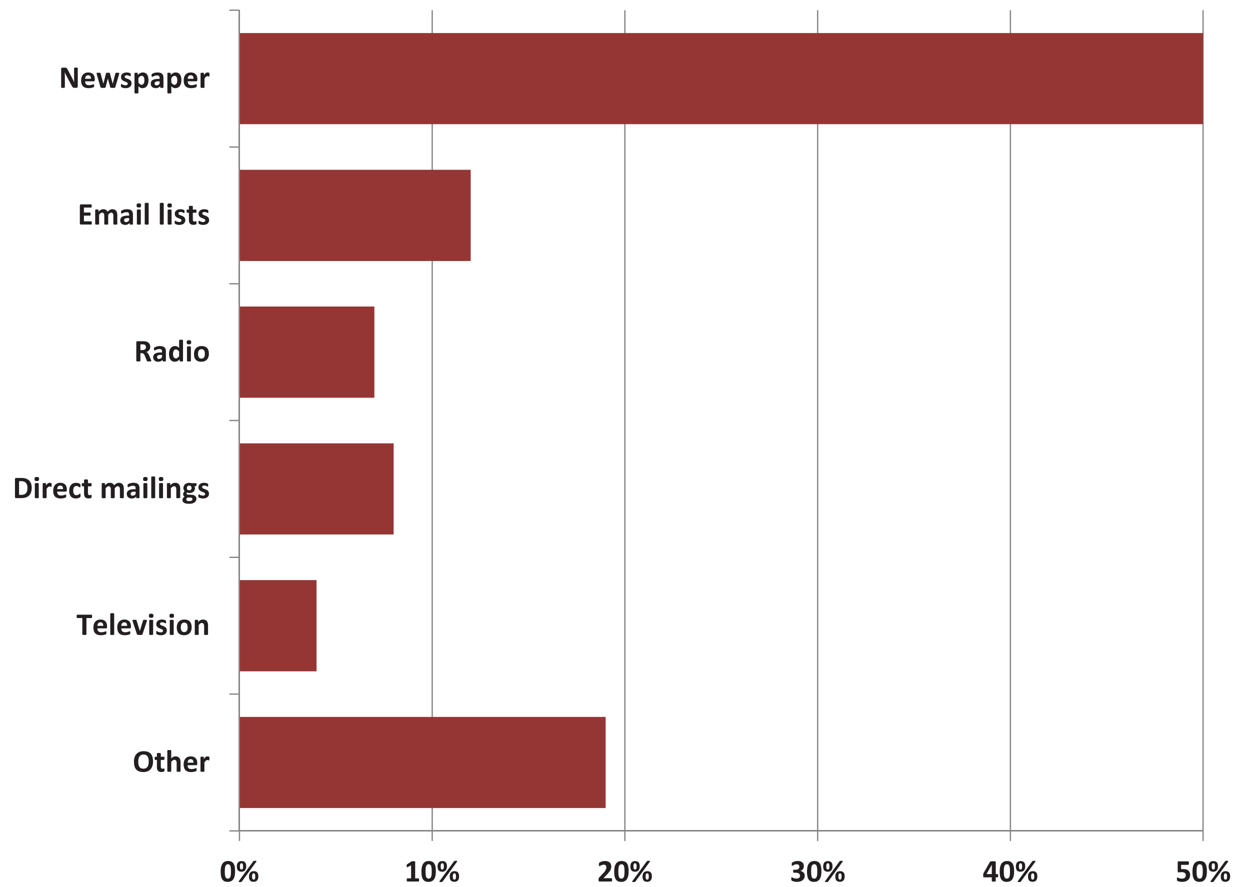


Figure 6. Percent of Massachusetts PYO orchard advertising expenses on various approaches.

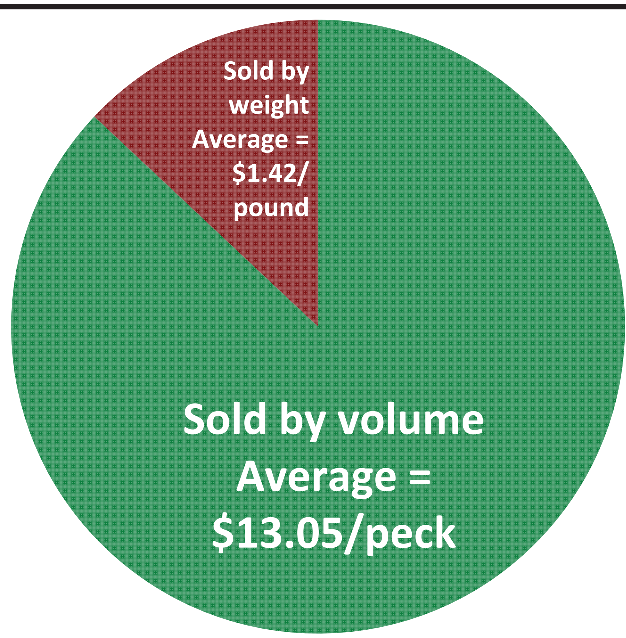


Figure 7. Fruit sales in Massachusetts PYO orchard by volume versus by the pound.

and television together.

Among PYO orchards, 87% sell fruit by the container, with an average charge of $13.05 per peck. Of the small number selling by the pound, the average charge is $1.42 per pound. Entry fees are charged by fewer than 10% of all PYO orchards, and 68% charge the customer for fruit prior to picking.

The survey included three very open-ended questions. The first asked farmers to list pros and cons associated with the PYO aspects of their farm (Table 2). The pros were all as you might expect, and included "happy customers," "great attraction," "less physical labor," etc. The cons also were as you might expect, and include the problems associated with crowds, theft, parking, and the weather.

A second open-ended question asked farmers what changes they were anticipating in the near future (Table 3). PYO orchards are considering more parking, more varieties, added entertainment, and better orchard management. One noted that their future plans primarily include retirement!

The third open question asked farmers to list their most serious concerns for the future of their PYO operation (Table 3). The three most serious concerns were regulation, food safety, and this survey encouraging

Table 2. Pros and cons (from the farmer's perspective) associated with pick-your-own sales as listed by Massachusetts PYO Survey respondents in 2011.

Pros	Cons
Beautiful views	Crowds
Easy access	Waste
Family friendly	The public
Entertainment	Theft
Repeat customers	Weather dependent
More time for sales	Vandalism
Freedom of choice	Risk
Just a "real orchard"	Parking
Happy customers	
Attracts customers	
Keeps farm viable	
Dog friendly	
Good return	
Less physical labor	
Great exposure	
Extends season	
Immediate cash flow	

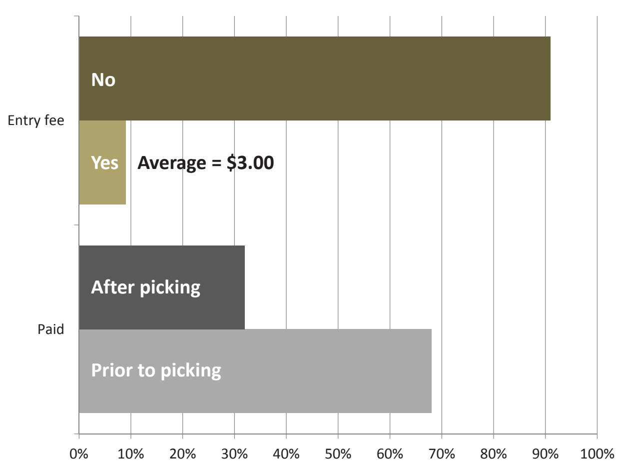


Figure 8. Extent of entry fee usage and the timing of payment in Massachusetts PYO orchards.

Table 3. Planned changes and concerns (from the farmer's perspective) associated with pick-your-own sales as listed by Massachusetts PYO Survey respondents in 2011.

Changes	Concerns
Better crowd control	Regulation
More parking	Food safety
Improvement of animal area	This survey
Enhanced handicap access	
New varieties	
Donut machine	
Increase price	
More dwarf trees	
One-price bags	
Improved stand	
Better signage	
Loyalty discounts	
Email lists	
Hay rides	
U-sort apples	
Expand plantings available	
More value-added products	
Better orchard management	
Retirement	

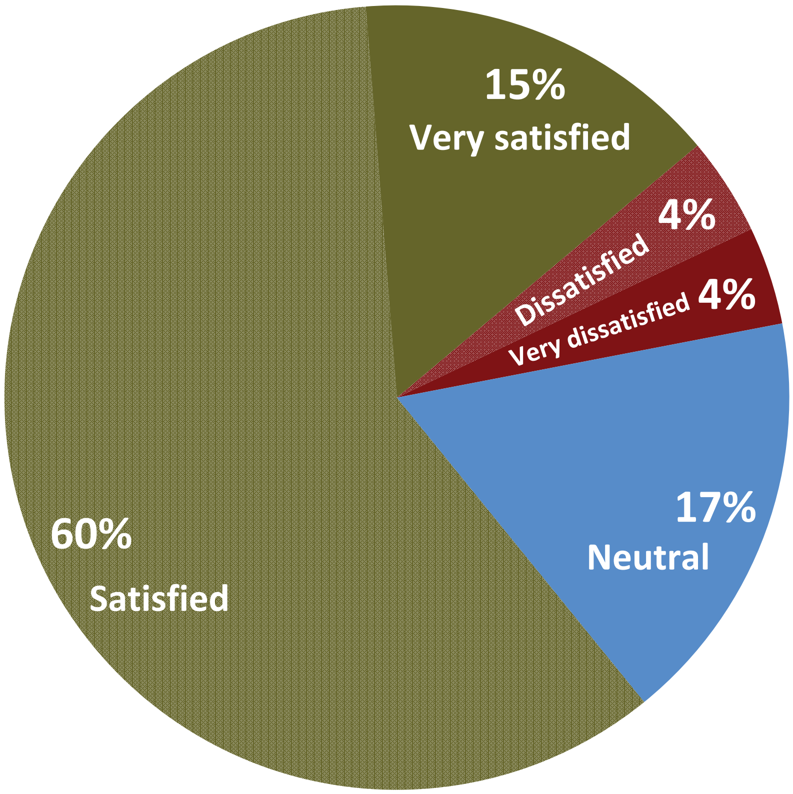


Figure 9. Levels of satisfaction with PYO sales among Massachusetts PYO orchards.

more competition.

The last question on the survey asks growers to rate their level of satisfaction with PYO on their farm (Figure 9). Overwhelmingly, orchards were satisfied or very satisfied with PYO. Seventeen percent were neutral, and 8% were dissatisfied with PYO.

We hope that this survey helps guide the future develop of PYO as an apple sales technique.

Blueberries - Making a Superb Fruit Even Better!

Stephanie Yao
Formerly with Agriculture Research Service, USDA

Blueberries are popular and versatile—you can put them in or on almost anything. But the berry would not be where it is today without the efforts ARS researchers. Today, ARS scientists are busy solving growers' problems with blueberry disease, firmness, splitting, and cold tolerance.

When U.S. Department of Agriculture botanist Frederick Coville started the world's first successful blueberry breeding program, did he envision it would grow into the multi-million dollar industry it is today? Maybe. But a century later, thanks to dedication by Coville, collaborator Elizabeth White, and other USDA and university scientists, blueberries are the second most popular berry consumed in the United States.

A member of the genus *Vaccinium*, blueberries are related to many commercially important and popular fruit species, like cranberry, lingonberry, and huckleberry. Blueberries are mainly native to North America and are lauded for their health benefits.

Coville began researching blueberries in 1906, when he started a series of experiments to learn fundamental facts about them, thinking they might be suitable for cultivation. Coville found that blueberries and many other plants require acid soils to grow, a fact not known to horticulturists prior to his experiments.

After a few years of study, Coville published in 1910 the first bulletin outlining how to successfully grow blueberries from seed to fruit. White, whose family at that time had a successful cranberry farm in New Jersey, helped Coville acquire some of the best wild blueberry plants to use as parents in his breeding experiments.

In 1911, Coville made the first cross of

Plant geneticist Mark Ehlenfeldt (left) and plant pathologist James Polashock examine blueberry plants and collect data on mummy berry fruit infection to evaluate resistance.

wild blueberry germplasm that eventually led to the release of several blueberry cultivars-ancestors of cultivars currently grown throughout the world–marking the beginning of USDA'S current breeding program.

Throughout the years, notable Agricultural Research Service blueberry breeders George Darrow, Donald Scott, and Arlen Draper have made significant contributions to the advancement of blueberries. Today, 100 years after Coville made his first successful cross, ARS researchers throughout the country continue that longstanding goal of improving blueberries so consumers can enjoy them for many more centuries to come.

Mitigating Mummy Berry Blight & Fruit Rot

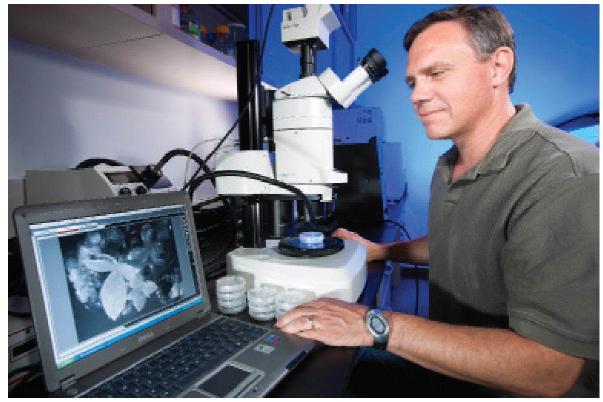
Geneticist Mark Ehlenfeldt and plant pathologist James Polashock are researching mummies– mummified blueberries, that is, which got that way because of a disease. The scientists are with the Genetic Improvement off Fruits and Vegetables. Laboratory in Beltsville, Maryland, and are stationed at the Philip E. Marucci Center for Blueberry and Cranberry Research and Extension in Chatsworth, New Jersey. One of ARS's flagship locations for blueberry research, Chatsworth houses the largest collection of potted and in-ground blueberry cultivars in the world.

In addition to releasing improved blueberry varieties, the researchers focus on screening for disease resistance, and mummy berry is one of the most important blueberry diseases in North America.

"Mummy berry is caused by the fungus *Monilinia vaccinii-corymbosi,"* says Polashock. "It occurs almost everywhere blueberries are grown and affects all cultivated species, including highbush, lowbush, rabbiteye, and some wild species."

Mummy berry disease is unique because it occurs in two distinct phases. During the blighting phase, small, cup-shaped structures bearing fungal spores sprout from mummified berries concealed in leaf litter on the ground. Wind spreads the spores to blueberry plants, infecting the newly emerging shoots and leaves. A second phase of spores, produced on blighted tissue, is carried by bees to the flowers, beginning the fruit-rotting stage. During this phase, the fungus fills the inside of the blueberry as it grows and causes it to shrink, shrivel, and turn whitish–hence the mummy reference. The mummified fruit drops to the ground and overwinters, waiting to begin the process again in the spring.

In an effort to mitigate this disease, Ehlenfeldt, Polashock, plant pathologist Allan Stretch (now retired), and statistician Matthew Kramer undertook two long-term, simultaneous studies examining cultivar response. The first study, published in the scientific journal *HortScience*, sought to predict cultivar resistance and susceptibility to both phases of the disease. The scientists examined more than 90 blueberry cultivars over 9 to 12 years.



James Polashock screens blueberry tissue cultures for plantlets that have transformed, or changed, their genetic makeup. These plantlets are easy to identify because they express a green fluorescent protein and glow under UV light in the procedure being used. In these transformed plantlets, the genes that respond to the fungus that causes mummy berry are likely to provide clues to resistance to the disease.

"We found that disease response had significant and large genotype-by-environment interactions," explains Ehlenfeldt. "This means that the 2-3 years of data typically used for publication aren't enough to reliably estimate disease resistance. Breeders should be evaluating resistance for 8 years to get a good estimate of cultivar response to this disease." The researchers found an important predictor of blighting to be either the average amount of precipitation at the end of January or rain frequency at the end of March. The average high temperature in late February was predictive for the fruit-infection phase.

Despite predictions of needing 8 years to estimate disease resistance, a second study, also published in *HortScience* analyzed data from 125 cultivars tested for 2-6 years for resistance to the blighting phase and 110 cultivars tested for 2-5 years for resistance to the fruit-infection stage. Using innovative statistics developed by Kramer, the researchers were able to rank resistances among the wide range of cultivars. "For breeding, one often needs only to know which cultivars are the most resistant on a relative basis," says Ehlenfeldt. They found several cultivars, such as Brunswick and Bluejay, to be resistant to both phases of mummy berry infection.

"Ultimately, documentation of resistance to each phase will help growers select which cultivars to plant," says Ehlenfeldt. "This will also help breeders develop strategies to produce cultivars with superior resistance."

Horticulturist Donna Marshall measures blueberry firmness to determine the correlation between fruit firmness and susceptibility to fruit splitting.

Preventing Fruit Splitting

The Thad Cochran Southern Horticultural Laboratory in Poplarville, Mississippi, joined ARS's blueberry research program in the 1970s. Led by horticulturist James Spiers (now retired), the program was started after the region's tung oil industry collapsed because of competition from imported petroleum and a devastating blow from Hurricane Camille in 1969. "Rabbiteye blueberries are native to the Southeast," says Spiers. "ARS has also introduced a southern highbush blueberry to the region. Combined, the two blueberry species have proven to be a viable specialty crop for this area."

So far, Poplarville scientists have released 15 cultivars for growers in the Southeast. But that's not all they do. The researchers also focus on solving problems growers face, such as rain-induced fruit splitting.

"Splitting and cracking occur in southern highbush and rabbiteye blueberries if they receive preharvest rainfall when fully ripe or approaching ripeness," explains horticulturist Donna Marshall. She works with Spiers, geneticist Stephen Stringer, and University of Southern Mississippi associate professor Kenneth Curry on this problem. "Researchers have studied rain-induced splitting in cherries, grapes, and tomatoes, but it hasn't been explored in blueberries."

ARS researchers in Corvallis, Oregon, are developing and improving blueberries for the Pacific Northwest. Shown here are Elliott blueberry plants in full bloom.

Splitting can be mild, in the form of a shallow crack in the skin, to severe, such as deep wounds that penetrate the pulp. But regardless of severity, all splitting renders the fruit unmarketable. Growers in Mississippi and Louisiana have reported as much as 20 percent crop loss on highly susceptible cultivars. That amounts to losses of $300 to $500

Close-up of blueberry flowers.

"Through our studies, we've shown that splitting is a cultivar-specific problem," says Marshall. "But there are still questions, such as what is going on at the cellular level that allows a cultivar to stay intact? With further research, we hope to find the answer."

Generating Genomic Tools for Blueberry Improvement

Geneticists Chad Finn, with the ARS Horticultural Crops Research Unit, and Nahla Bassil, with the ARS National Clonal Germplasm Repository—both in Corvallis, Oregon—are developing

per acre.

The researchers examined several aspects of fruit splitting in three studies published in HortScience. In the first study, published in 2007, the researchers developed a laboratory method to model rain-related splitting in blueberries. Many breeders throughout the country are using this method to more vigorously screen cultivars and selections for splitting susceptibility. The results from field and laboratory tests showed that the rabbiteye cultivar Premier had the lowest incidence of splitting, while widely grown cultivar Tifblue exhibited a high incidence of splitting.

Marshall and colleagues also investigated the correlation between splitting susceptibility and fruit firmness. Laboratory and field tests proved that, in general, firmer fruit has a higher tendency to split. But one selection, named "MS614," exhibited extreme firmness and splitting resistance. The results, published in 2008, suggest that breeders who select for firmness may inadvertently also be selecting for splitting. But the laboratory screening method Marshall and colleagues created has helped remedy this problem.

The most recent study, published in 2009, evaluated water-uptake thresholds in split-resistant Premier and split-susceptible Tifblue fruit at all stages of development. The researchers harvested and weighed the fruit, then soaked it in distilled water at room temperature for 24 hours. They found that Premier absorbs more water than Tifblue yet remains intact and experiences minimal splitting.

Fruit cluster of Draper, a cultivar released by Michigan State University and named in honor of Arlen Draper, a long-time blueberry breeder with ARS in Beltsville, Maryland.

and improving blueberries for the Pacific Northwest. Although Corvallis is the most recent ARS location to conduct blueberry breeding, Finn and Bassil are playing an important role in a nationwide, multi-institutional project aimed at developing genomic tools to help improve blueberries.

Funded by the Specialty Crops Research Initiative, the project is led by fellow ARS geneticist Jeannie Rowland in Beltsville, Maryland, and involves several university and international collaborators. Finn and Bassil are working with Michigan State University professor James Hancock in developing a genetic map for highbush blueberry.

"We are currently testing plants made from a cross between the northern highbush cultivar Draper and the southern highbush cultivar Jewel at various locations across the country where blueberry is grown," says Finn. "Our task is to compare the performance of each plant in the field. For the next couple of seasons, we will evaluate the plants for chilling requirement, cold tolerance, and fruit-quality traits."

In the lab, Bassil is processing leaf samples to extract DNA and genotype the plants. The researchers will then merge the field and lab data to determine whether genetic markers that predict a plant's performance can be identified. Bassil is also helping to develop genetic markers and following them through mapping populations and wild blueberry populations for genetic diversity studies.

The new tools, once available, should make blueberry breeding and cultivar development far more efficient.

Source: Agricultural Research -- *May-June 2011*
(*http://www.ars.usda.gov/is/AR/*)

Blackberry Variety Selection Opportunities

John R. Clark
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Blackberries offer another small fruit option for eastern US growers for a range of markets. The major issues for Pennsylvania and Mid-Atlantic growers when considering blackberry varieties include winter hardiness, maturity date, quality, yield, berry size, and overall adaptation. I will share some information in general about blackberries, some market and production changes in the US, and finally some variety thoughts for Mid-Atlantic growers.

Blackberry and raspberry plants are rather unique in the fruit world in that they have a perennial root system but have biennial canes. This means the canes live two years and then die. The two cane types are primocanes, or first-year canes, and floricanes, which are second-year canes. In red raspberry, primocane- and floricane-fruiting varieities exist and both have substantial commercial value. In blackberries, floricane-fruiting has been the basis of all blackberry production and commercial primocane-fruiting varieties did not exist prior to the release of Prime-Jim®, Prime-Jan®, and Prime-Ark® 45 by the University of Arkansas. Primocane fruiting offers the opportunity for late summer and fall production, to complement summer production of blackberries. However, there is much to be done in the improvement of primocane blackberries and all the answers are not in place yet for Mid-Atlantic growers.

Aspects of Blackberry Production History

A survey of eastern U.S. (east of the Rocky Mountains) production in 1990 indicated blackberries were marketed in the following ways: 62% pick-your-own, 36% pre-picked fresh market (mainly on-farm or local fruit stand sales), and 2% processed. The survey results did not indicate that any production was for shipping to distant markets or grocery stores. In this survey, production area increased 56% from 1980 to 1990, with a further projected 66% increase in production area from 1990 to 2000. Again, this increase was envisioned to be largely marketed locally. In the early 1990s, blackberries were not found on grocery store shelves across the U.S (some were present on the west coast), due mainly to the lack of postharvest handling capability of varieties released prior to that time, but also because blackberries had never made much headway into the competition for commercial grocery shelf space.

Some of the new varieties beginning to be planted in the early 1990s were found to have fruit firmness adequate for shipping. Chester Thornless displayed a good level of firmness and shelf life, and in the world picture became a major shipping berry later in the decade. The Arkansas-released Navaho was found to have excellent shelf life. Subsequent releases from Arkansas included 'Arapaho' and 'Apache', each of which had fruit capable of withstanding shipping. These varieties contributed to a major shift in the production outlook for shipping of blackberries from that of a local-marketed crop to one shipped for retail marketing.

A major development occurred during the 1990s: the shipping of blackberries to the U.S. from Chile and Guatemala. Soon thereafter, the development of production technology in Central Mexico increased availability of eastern US-developed blackberries. Mexican production is centered in the highlands of the state of Michoacan and Jalisco, and utilizes a number of techniques to force the Brazilian variety Tupy (an offspring of the Arkansas variety Comanche) to flower and fruit in an area of no chill. The fruit is harvested from mid October until May or early June in this region, and currently provides fresh blackberries for U.S. grocery shelves during the winter months. Mexican production has supplanted Chilean blackberry shipping to the U.S. due to less expensive transportation costs of trucking fruit from Mexico compared to air freight required to move blackberries from Chile. Production area in Mexico is estimated to be 6000-8000 acres. The presence of berries in the marketplace in the winter and late spring enhanced the consumer's awareness of blackberries as a grocery item rather than a local item picked on a farm or from wild plants. The bottom line is that now blackberries are a year-around produce item!

American berry shippers (in the eastern and western US) also took note of the expanded potential of blackberries in the shipping market, spurred by the success of the Mexican berries shipped and marketed during the "off" season. These marketers felt that if off-season sales could be this successful, why not have expanded marketing during the "normal" US berry production seasons? This has led to an expansion in acreage grown for shipping since the early to mid 2000s, particularly in southern Georgia, Arkansas, Texas, and North Carolina. California greatly increased production in recent years also.

Local production for pick-your-own, farmers markets, or on-farm sales has also increased recently, though it is difficult to determine trends in this area due to few production statistics being available. However, the expanding number of thornless variety options, enhanced fruit quality, and increased interest in berry consumption for human health benefits should positively impact this type of production.

Primocane-Fruiting in Blackberries

The first recorded occurrence of a primocane-fruiting blackberry that I am aware of was a wild plant found by L.G. Hillquist of Ashland, Va. There is no record of breeding with this plant until Dr. Jim Moore obtained it in the mid-1960s while accumulating germplasm for the University of Arkansas breeding program. Although primocane fruiting was not pursued for many years in Arkansas breeding, seedlings evaluated in 1997 resulted in Prime-Jim® and Prime-Jan®, released in 2004. Primocane fruiting has been vigorously pursued in Arkansas breeding since the late 1990s, and great headway has been made in improving fruit quality, incorporating thornlessness, and shifting the fruiting period to both earlier and later ripening.

Blackberry Varieties to Consider

Chester Thornless. Although I would like to recommend an Arkansas variety as my top choice for Mid-Atlantic growers, this variety has provided sustained high yields and good hardiness. The main disadvantage of the USDA-ARS-developed Chester Thornless is overall flavor and quality. It ships exceptionally well, but percent soluble solids is not as high as most fresh-fruit consumers desire and a tart taste is normally noted unless fully ripe. This is a semi-erect-caned type. There are other varieties of this cane type such as Hull Thornless, Black Satin, Thornfree, Dirksen Thornless, and Smoothstem, and all are likely adapted to the Mid Atlantic (they originated in southern Illinois or Maryland), but concerns of tart flavor are often expressed. These varieties tend to be later than Arkansas developments, fruiting in late June to early July in Arkansas.

Triple Crown. The last release of the USDA-ARS varieties, Triple Crown is renowned for exceptional flavor. Some consider this the best-tasting eastern US blackberry. It is moderate to high yielding, appears to have adequate hardiness for the Mid-Atlantic (maybe not quite as hardy as Chester Thornless?), and is earlier in ripening than Chester Thornless (ripens about June 25-30 in Arkansas). The biggest drawback to Triple Crown is berry firmness, and it is not considered a shipping berry. For local markets with short holding times, and pick your own, it is a winner.

Ouachita. If you are considering one Arkansas variety, you should consider this one. It is successful coast to coast in the US, although I have not heard confirmations of its hardiness potential across the entire Mid-Atlantic region. Ouachita produces high yields of high quality berries (6-7 g) with soluble solids of 10-11%. It has erect canes, and ripens about June 10 in Arkansas. It has shown broad adaptation, and has been a major variety in expansion of the domestic shipping blackberry industry.

Navaho. The first Arkansas thornless, Navaho is considered by some to be the best shipping blackberry available. It has medium berry size (5 g) and moderate yield capacity. Sweetness is very good, usually 11-12% soluble solids. Its hardiness has been found to be good in the lower Midwest, and in some areas of the Mid-Atlantic. It is susceptible to orange rust, a fungal disease. It has erect canes, and ripens about June 20 in Arkansas.

Apache. The large-fruited Apache (10-11 g) is admired by some growers, and it has high vigor, productive, and healthy plant characteristics. It averages 11% soluble solids, and ripens about June 25 in Arkansas. Hardiness is not fully known for the Mid-Atlantic, but possibly information exists on this in trials in the region. The major negative attribute of Apache is that white drupes are often seen on some berries, particularly early in the season. This is a very serious defect for shipping, but local sales are usually not impacted as greatly. Concerns among grower reports vary from major to none on this trait.

Natchez. The newest of the Arkansas thornless , Natchez ripens about June 5 in Arkansas. It has large, long berries, and is eye catching on the vine or in the clamshell. Hardiness is not known on this 2007 release, so care should be taken to determine if it is adapted to the Mid-Atlantic. It averages about 9.5% soluble solids, and berries can be tart if crop load is excessive as it can be in some southern plantings.

Prime-Ark® 45. The first shipping-quality primocane-fruiting blackberry released in 2009, it is hoped that Prime-Ark® 45 will provide the basis for developing a late summer to fall-fruiting blackberry production season in the US. It has large berries (up to 10 g) with good soluble solids (10% commonly) that stay black in storage along with good firmness retention. The floricane crop ripens June 5 in Arkansas, and the primocane crop in mid-August. However, the primocane crop ripe date depends on location. Along the Central Coast of California, first ripe is usually Sept. 1, and in Oregon's Willamette Valley mid-September. This variety has been tested at Penn State Univ. by Kathy Demchak, and a limitation has been getting good yields before cold temperatures develop. High tunnels have helped, but trials are continuing to determine if adequate yields can be attained in the region. Only trials of the variety are suggested at this time.

Prime-Jan®. Released as one of the first primocane-fruiting blackberries in 2004, this variety was originally intended for home garden use. However, limited trials have found it to have some commercial potential. Quality is acceptable, with moderate storage capability and soluble solids on average about 9%. It ripens earlier than Prime-Ark® 45 by about 2 weeks, so has a potential of maturing more of the fall crop prior to frost. However, its crop has not fully ripened (non-high tunnel grown) in upstate New York. Again, testing the variety for specific locations and management (high tunnel or not) is recommended prior to full commercial use is considered.

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